Appendix 9 Terrestrial and Aquatic Ecology Assessment

ASHTON COAL
DIVERSION OF BOWMANS CREEK

APPENDIX 9

RIPARIAN & AQUATIC ECOLOGY ASSESSMENT

REPORT PREPARED FOR
ASHTON COAL OPERATIONS LIMITED

MARINE POLLUTION RESEARCH PTY LTD
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1 INTRODUCTION

Ashton Coal Operations Pty Ltd (ACOL) currently operates a combined open cut and underground (longwall) mine in the middle reaches of the Hunter River valley at Camberwell, some 14 km north of Singleton. The underground mine is located south of the New England Highway, and is bounded by Glennies Creek to the east, and Ravensworth mine to the west. Details of the approved mine project plans are contained in the development consent (DA No 309-11-2001-i) dated 11 October 2002 (DoP 2002).

The underground operation comprises eight panels orientated north-south (Figure 1). Approval for mining within the Pikes Gully Seam for longwalls 1 to 4 (LW1 to LW4) was granted by the Department of Primary Industries (DPI) in February 2007, extraction commenced in March 2007, with extraction of LW4 currently underway.

The lower 6 km of Bowmans Creek runs through the mine lease area and ACOL originally proposed to divert Bowmans Creek as part of its Development Application. This was replaced with a Conditional Development Consent approval to longwall mine directly under the Bowmans Creek area. Subsequent detailed subsidence and groundwater investigations have shown that there are environmental benefits arising from an alternate mining plan which incorporates diversions of two shorter sections of Bowmans Creek whereby mining would provide reserve optimisation and business and employment security.

Thus the current proposal for diversion of Bowmans Creek seeks to maximise the extractable coal resource underlying the Bowmans Creek alluvium while complying with the objectives of the original consent. The key aspects of the proposal are as follows:

- Two sections of the 6 km long lower section of Bowmans Creek will be diverted onto areas of the alluvium that will be subject to minimal subsidence (see Figure 1). The location of these diversions has been strategically selected to maximise retention of the existing creek channel while maximising the opportunity for extraction of coal by means of longwalls.
- The Eastern Diversion comprising 830m of constructed channel and 125m of existing oxbow channel. This diversion will commence about 175m downstream of the New England Highway and connect back into the existing creek system via a section of oxbow channel on the northern side of the existing channel near a major bend in the creek known as “the oxbow”.
- The Western Diversion comprises 780m of constructed channel that commences about 70m downstream of the existing gauging weir.

Marine Pollution Research Pty Ltd (MPR) has been commissioned to provide a riparian and aquatic ecology assessment report for the study area, defined as the Bowmans Creek floodplain area above, and adjacent to Longwalls 5 to 8.

This report is to be submitted as part of the Environmental Assessment for Application DA 309-11-2001 MOD6 that includes *inter alia*:

> *two short realignments and associated rehabilitation of Bowmans Creek over sections of the western portion of the Ashton Coal Project underground mine to optimise minable reserves over four seams and maintain the economic viability of the operation.*

The report addresses the following Director General's Requirement's (DGRs):

A detailed assessment of the key issues specified below, and any other significant issues identified in this risk assessment, which includes:

- *A description of the existing environment, using sufficient baseline data.*
- *An assessment of the potential impacts of all stages of the proposal on this environment, including any cumulative impacts, taking into consideration any relevant laws, policies, guidelines and plans.*
- *A description of the measures that would be implemented to avoid, minimise, and if necessary offset the potential impacts of the proposal.*

The Key issues relevant to **Biodiversity** are:

- *Accurate predictions of any proposed vegetation clearing;*
- *A detailed assessment of the potential impacts of the proposal on any terrestrial species, populations, ecological communities or their habitats.*

The assessment has been undertaken taking into account relevant guidelines, policies and plans as follows:

- Draft Guidelines for Threatened Species Assessment under Part 3A of the EP&A Act 1979 (DEC/DPI 2005)
- NSW Groundwater Dependent Ecosystem Policy (DLWC 2002)
- Policies & Guidelines – Aquatic Habitat Management and Fish Conservation (NSW Fisheries 1999).

Figure 1 Proposed Diversion Channels and Existing Stream Health Sampling Sites

2 STUDY METHODS

In order to assess the possible impact on riparian and aquatic ecology of the proposed creek diversions, the following tasks were undertaken:

- A review of the terrestrial flora and fauna monitoring in the Ashton Mine lease area to summarise riparian and floodplain ecological attributes.
- A review of aquatic ecology monitoring conducted in Bowmans Creek to date to summarise creek aquatic ecology attributes.
- An update literature review of regional terrestrial biota and of aquatic biota information to assess the potential for threatened and protected species to utilise Bowmans Creek.
- An update review of threatening process information for terrestrial and aquatic biota and ecology.
- A review of the proposal, outlining potential impacts arising from the creek diversions and of the measures to mitigation and offset impacts.

This information has then been used to undertake an assessment of the possible impacts, leading to an outline of the measures to be implemented to prevent, mitigate or offset potential impacts arising from the diversions. The study then provides details of a monitoring program to assess success of the diversions and of associated creek plus riparian rehabilitation works.

Additional field investigations for aquatic habitat assessment were undertaken by MPR staff over two days (1 to 2 July 2008) during a period of moderate flow (around 37 ML/day – exceeded about 15% of the time). The survey extended the full length of Bowmans Creek between the New England Highway to the downstream limit of the lease area (400m above the Hunter River confluence).

Field notes and observations were made throughout the study area. Creek and channel riparian areas were inspected for attributes such as bank stability, bank undercutting, closeness of riparian trees to water, recently fallen trees, instream logs, pool retention devices, locations of shallow and deeper pool areas, and fish passage potential. All tributaries entering the creek within the study area were inspected from their confluences with Bowmans to the upper limits of creek structure, as indicated by channel incision, water availability or vegetation. Photographic records were made along the study area creek-line and tributaries, to support field notes and observations

3 RIPARIAN, FLOODPLAIN AND AQUATIC ECOLOGY

3.1 Literature Review

The literature review has been split into two sections. Section 3.1.1 summarises the flora and fauna studies undertaken on behalf of ACOL as they relate to the study area, and Section 3.1.2 documents the aquatic ecology and water quality studies that have been undertaken in Bowmans Creek.

3.1.1 Bowmans Creek Flora and Fauna Studies

Environmental Resources Management Australia Pty Ltd (ERM) provided a detailed geomorphology report for Bowmans Creek (ERM 2006a) based on survey and field work undertaken in the first half of 2006. The report was commissioned to address relevant consent conditions, namely to establish a geomorphology baseline for ongoing monitoring during and after the potential mining beneath Bowmans Creek. This report also provided a baseline of creek geomorphology against which the impacts of the major 2007 flood could be assessed.

Maunsell (2008) undertook geomorphology studies following the June 2007 flood. They concluded that in spite of there being bed scour of up to 0.7 m and deposition of up to 0.4 m, comparison of their cross-sections with the ERM (2006a) cross-sections indicated that the storm event did not materially alter the channel form or pool-riffle sequence.

Fluvial Systems (2009) described the geomorphic evolution of Bowmans Creek below the Highway as follows; *Bowmans Creek remains on a trajectory of incision and widening, which probably began up to 60 years ago. The rate of incision has been slowed by exposure of a number of bedrock outcrops. Bed material in the channel is predicted to be mobile during flood events of ≥ 1 – 3 yr ARI while the grass covered bars, benches and banks are mostly stable.*

ERM (2006b) prepared a baseline flora and fauna report for the ACOL lease area that included the Long-wall 5 to 8 area and Bowmans Creek and provided a pre-mining assessment of the riparian and aquatic habitat along Bowmans Creek. The report was prepared in accordance with the Ashton Coal Flora and Fauna Management Plan (Part 2 prepared in August, 2005). It provided the results of riparian flora and fauna habitat studies undertaken in Autumn 2005 and 2006 and the results of aquatic ecology surveys undertaken in December 2005 and May/June 2006 (see Section 3.1.2 below for more details of the aquatic ecology surveys). ERM (2009) have updated the baseline flora and fauna report and included additional results of riparian flora and fauna habitat studies undertaken in Spring and Autumn 2007 and 2008. The flora and fauna descriptions provided in Section 3.2.1 and 3.2.2 below have been extracted from these combined ERM reports.

3.1.2 Bowmans Creek Aquatic Ecology and Water Quality Studies

Aquaterra (2009) identified two distinct aquifer systems within or near the study area; the fractured rock aquifer system in the coal measures with groundwater flow mainly in the coal seams and a shallow granular aquifer system in the unconsolidated sediments of the alluvium associated with Bowmans and Glennies Creeks and the Hunter River. Groundwater flow for the shallow alluvium is dominated by rainfall recharge and discharge to the creeks/river. For the Permian layers, the sub-cropping coal seams are recharged by rainfall infiltration. Groundwater studies undertaken for the project show that creek flow is governed by upstream rainfall with minimal contribution from surrounding saline alluvium. The Bowmans Creek alluvium merges with colluvium along the flanks of its floodplain, and has an abrupt boundary with Hunter River alluvium at the southern end of the valley.

The bed of Bowmans Creek is incised directly into bedrock (Permian coal measures) in a small number of locations, and is overlain by alluvium in other places. There are three outcrops of Permian coal measures in the creek-bed of Bowmans Creek. All of these are located outside the area of proposed longwall mining. The upper outcrop is associated with elevated saline groundwater seepage sustained by seepage from the Permian rock outcropping beside and/or beneath a pool at monitoring site SM4 (see Figure 1 and Section 3.7 below). The middle rock bar section is located downstream of the large bend at the end of the oxbow, and includes the weir pool for the NSW Office of Water (NOW) stream gauging station. The third outcrop is located in the lower section of the creek outside the ACOL lease area.

With respect to aquatic ecological assessments within the Bowmans Creek study area and locality, a number of studies have been conducted to date. These studies are summarised below and the results of the studies in terms of summarising the aquatic ecology of the study area are provided where appropriate in the remaining sub-sections of Section 3:

- In 2001 Marine Pollution Research Pty Ltd (MPR) undertook a qualitative assessment of aquatic ecology (fish habitat) aspects for the Ashton Coal Project EIS (HLA 2001). The study incorporated a review of existing literature and field studies of fish passage potential in Bowmans and Glennies Creeks.

- ACOL has been undertaking monthly 'whole of mine' water quality monitoring of sites in Bowmans Creek, Bettys Creek, Glennies Creek and the Hunter River since September 2004. Water quality parameters include pH, electrical conductivity (EC), alkalinity (total hardness as mg/L $CaCO_3$), total dissolved solids (TDS), total suspended solids (TSS) and oil & grease.
- ERM (2006b) summarised initial aquatic ecology monitoring results for Ashton Mine for the spring 2005 to autumn 2006 period. The monitoring was undertaken by The Ecology Lab (TEL) and the full monitoring reports are contained as appendices to the ERM (2006b) report (TEL 2006a, 2006b). Monitoring included macroinvertebrate, fish (using electro-fishing) and water quality sampling. The TEL reports also provided an updated literature review for aquatic ecosystems in Bowmans Creek and confirmed that Bowmans Creek supported native fish populations (see Section 3.8.2 below).
- MPR undertook aquatic ecology monitoring as part of the EMP for Liddell Open Cut mine over the same survey period as the TEL studies (MPR 2005, 2007). Monitoring studies included macroinvertebrate, fish and water quality sampling from three sites located upstream of the Ashton lease area on Bowmans Creek. This study confirmed both the intermittent nature of surface flow and the persistence of shallow sub-surface seepage flow in Bowmans Creek.
- Walkover surveys of Bowmans Creek and tributaries within the study area were undertaken in July 2008. For the July 2008 field inspections surface flow was present throughout the whole creek length within the study area (stream flow 37ML/day).
- MPR have been undertaking bi-annual aquatic ecology monitoring studies within Bowmans Creek on behalf of ACOL, from 2007 onwards. To date there have been five ‘during mining’ aquatic ecology monitoring surveys conducted; in autumn and spring 2007, 2008 and autumn 2009 (MPR 2007, 2008a, 2008b, 2009). Monitoring studies will be continuing in Spring 2009.

3.2 Riparian & Floodplain Habitat Assessment

3.2.1 Riparian and Floodplain Vegetation Communities

The following descriptions have been compiled from ERM (2006a) and ERM 2009.

The study site area (being the area of Bowmans Creek floodplain under Longwalls 5 to 8 through to the Hunter River) has been previously disturbed by cattle grazing, weed encroachment, vegetation clearing and rubbish dumping. The riparian vegetation is characterised by *Casuarina* woodland with small sections of river red gum open forest. The area adjoining the creek riparian vegetation is characterised by continually grazed pasture and relatively isolated patches of open woodland. Surrounding land uses consist of rural properties with mining activities occurring immediately to the north of the New England Highway and west of Bowmans Creek.

Land use is predominantly livestock grazing, with some irrigation and cultivation on the Hunter River floodplain. Since European settlement, the most commonly constructed surface features within the site are fences and farm dams required for livestock grazing.

Beyond the Bowmans Creek floodplain there are also areas of revegetation within the northern portion of the ACOL underground mine lease area, including a section of woodland at the southern end of Longwalls 1 and 2 that has been established as a conservation area and has been the subject of biannual fauna surveys since 2005.

In general the soil throughout the ACOL underground mine lease area is characterised by the *Hunter soil landscape unit,* which covers the floodplains of the Hunter River and its tributaries. The main soils are formed in the alluvium. Minor stream bank erosion occurs on the watercourses with minor sheet and gully erosion on adjacent terraces. The site lies within the downstream limits of the Bowmans Creek catchment.

The Bowmans Creek riparian/floodplain corridor between the Highway and the Hunter River is characterised by three vegetation communities being *Casuarina cunninghamia* (river oak) riparian woodland along most of its length and occurring as a remnant to the east of the ox-bow, two small strips of river red gum open woodland near the Hunter River, and pasture grass. No threatened flora species have been identified within the site. The location of these vegetation habitats is indicated on Figure 2.

Riparian Woodland

The strip of riparian vegetation along the creek line are dominated by an overstorey of *Casuarina cunninghamia* (river oak) and there is a sparse to absent midstorey and moderate groundcover. This community is characteristic of the northern two thirds of the site, and of the remnant/regenerating area of riparian woodland to the east of the oxbow.

There is also sporadic regeneration evident in the riparian strip woodland. There are isolated occurrences of *Schinus areira* (pepper tree), *Angophora floribunda* (rough barked apple), *Populus alba* (white poplar) and *Salix babylonica* (weeping willow) throughout this community. The shrub layer is restricted to scattered thickets of *Lycium ferrosum* (African boxthorn) and the occasional stand of Arundo donax (giant cane).

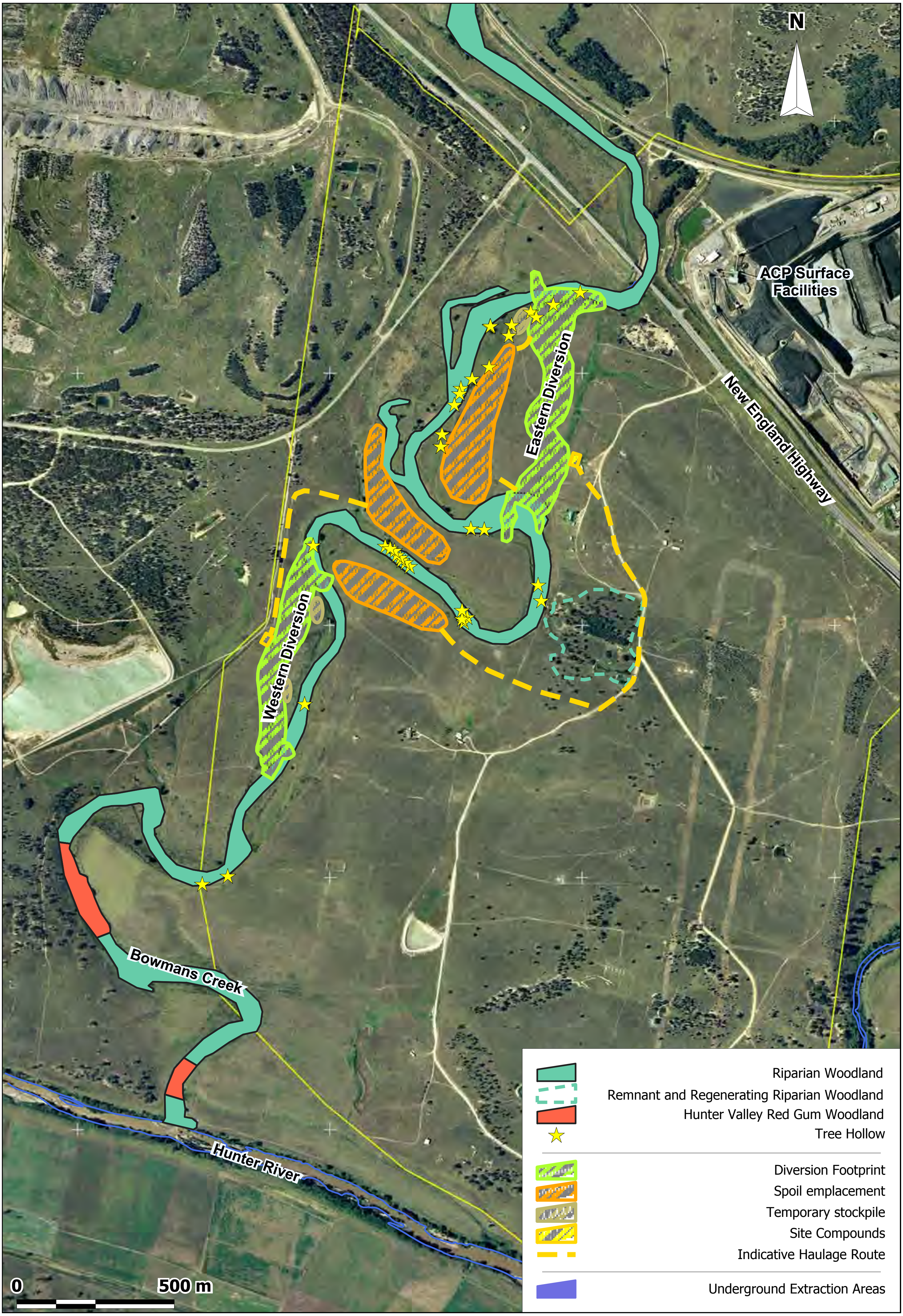


FIGURE 2 VEGETATION AND TREE HOLLOW MAPPING

The groundcover was dominated by *Verbena bonariensis* (purpletop), *Cynodon dactylon* (common couch), *Gomphocarpus fruticosus* (narrow-leaved cotton bush) and *Bidens pilosa* (cobblers pegs). In lower lying areas, sedges and rushes dominated the ground cover and included species such as *Juncus usitatus* and *Schoenus apogon* (river club rush). *Typha orientalis* (broad-leaved cumbungi) was commonly encountered in isolated pockets of the creek.

Grasslands

Two grassland sub-communities occur within the paddocks adjacent to the riparian vegetation corridor, namely dry pasture and pasture that has been improved in the past. Within the areas of dry pasture, isolated trees exist and some regeneration of riparian woodland is occurring around the sub-catchment drainage discharging to the easternmost reach of the Bowmands creek ox-bow (see blue stippled area on Figure 2). Scattered trees noted include *Allocasuarina luehmannii*, (bulloak) *Eucalyptus crebra* (narrow-leaved ironbark), *Eucalyptus melliodora* (yellow box) and *Eucalyptus moluccana* (grey box). Scattered shrubs of *Maireana microphylla* (eastern cotton bush) and *Acacia amblygona* (fan wattle) occur. Exotic species such as the woody weed *Lycium ferocissimum* (african boxthorn) occur below the canopy of the isolated trees.

The improved pasture community is located on the alluvial creek flats. Many exotic herbaceous species are present. Species used to improve the pasture for grazing value include *Lolium sp*. (rye grass), *Chloris gayana* (rhodes grass), *Paspalum dilatatum* (paspalum), *Medicago sativa* (lucerne), *Trifolium repens* (white clover) and *Pennisetum clandestinum* (kikuyu). Additional common pasture species noted include *Aristida vagans* (threeawn speargrass), *Cymbopogon refractus* (barbed wire grass), *Dichelachne rara, Microlaena stipoides* (weeping grass) and *Lomandra glauca* (pale mat rush).

River Red Gum Stands

ERM identified two narrow bands of *Eucalyptus camaldulensis* (river red gum) open woodland along the banks of Bowmans Creek near the Hunter River and outside the lease area (Figure 2). It is confined to the riparian corridor outside of the mining lease area, approximately 1km upstream from the Hunter River confluence. ERM (2009) note that no regeneration of *E. camaldulensis* is evident and the maximum diameter at breast height was 45 cm. The understorey species were similar to the remaining vegetation communities and were characterised by both native and introduced grass species. Relatively high levels of disturbance were noted along the entire length of the riparian corridor and included cattle grazing, clearing, weed invasion and erosion.

The ‘River Red Gum population in the Hunter Catchment’ is listed as an endangered population under the *Threatened Species Conservation Act 1995* (TSC Act), and the two strips of river red gum downstream of the diversions and outside the ACOL lease area are considered to be part of this endangered population (ERM 2006, 2009). Management of this endangered population forms part of an existing flora and fauna management plan for the approved underground mining activities (Ashton Coal 2006).

With regard to other threatened flora, the DECC (now DECCW) database search identified one threatened flora species, *Digitaria porrecta* (finger panic grass), within 10 kilometres of the site. Habitat for an additional three threatened flora species has been recorded on the DEWHA database within 10 kilometres being, *Diuris tricolor* (pine donkey orchid), *Eucalyptus glaucina* (slaty red gum) and *Thesium australe* (austral toadflax). However, no threatened flora species were recorded by ERM within the site during the various surveys.

3.2.2 Terrestrial fauna of the locality

The present creek has a narrow and interrupted band of riparian woodland along much of its length, but it cannot be termed Hunter River riparian woodland in its present state as it lacks the width (due to past clearing of the adjacent floodplain for pasture land) for the full development of this riparian woodland habitat. Notwithstanding, the remaining strip of riparian woodland provides habitat for a host of terrestrial fauna include a number of threatened woodland bird species that feed and forage there. The riparian woodland and isolated trees in the pasture fringing the riparian woodland also provide some tree hollow habitat that could be utilised by several bat species known from the locality (see Figure 2).

Whilst the myrtaceous trees in the area provide seasonal foraging resources for nectivorous birds and mammals; (e.g., *Eucalyptus camaldulensis (July to February)*, *E. crebra* (April to November) and *A. floribunda* August to November), their availability is relatively sparse due to the dominance of *Casuarina cunninghamia* (river oak).

The grasses and sedges provide seed and stem resources for granivorous and herbivorous species. *Casuarina cunninghamia,* that dominates the riparian corridor, provides a limited seasonal foraging resource for highly mobile granivorous fauna such as the glossy black cockatoo. Understorey species such as *Lycium ferocissimum* (African boxthorn) provide foraging resources for many species favouring fruits and berries. Eucalypts would also provide suitable feeding/foraging resources for folivorous fauna such as the common brushtail possum and insectivorous birds such as treecreepers.

The riparian habitat has a moderate layer of leaf litter (up to five centimetres deep), a variety of fallen logs and a few rock outcrops that provide sheltering resources for small ground-dwelling mammals and reptiles. Hollow resources are limited on the site, however small to medium hollow resources were recorded (see Figure 2) and would support a range of fauna species that utilise these smaller hollows. The grassy understorey and fallen timber also provides a suitable foraging substrate for the grey-crowned babbler and speckled warbler. Bowmans Creek provides habitat for water birds and frogs as well as a drinking resource for many native species.

Seven threatened fauna species listed under the TSC Act (three birds, three microchiropteran bats and a flying fox) have been identified as likely to occur within the study area or locality, *Pteropus poliocephalus* (grey-headed flying-fox), *Miniopterus schreibersii oceansis* (eastern bentwing-bat), *Mormopterus norfolkensis* (eastern freetail-bat), *Myotis macropus* (large-footed myotis), *Pyrrholaemus sagittatus* (speckled warbler), *Melanodryas cucullata cucullata* (hooded robin) and a breeding population of *Pomatostomus temporalis temporalis* (grey-crowned babbler eastern sub-species). Their likely relationship to the Bowmans Creek study area is described as follows:

- Four *Pyrrholaemus sagittatus* (speckled warbler) have been observed foraging in the southern woodland, to the south east of the ACOL lease area (ERM, 2006b). Speckled Warblers prefer a range of eucalypt dominated communities supporting a grassy understorey within gullies or rocky ridges and habitat ranges are up to 10 hectares. Bowmans Creek corridor is generally unsuitable breeding habitat for this species, however individuals may forage in the area as part of mixed flocks during winter.
- *Melanodryas cucullata cucullata* (hooded robin-south eastern form) has been identified in two locations within the southern woodland (ERM, 2007a) and are also likely to occur within the riparian corridor along Bowmans Creek. Home ranges of the Hooded Robin vary from 10 hectares in the breeding season up to 30 hectares outside of the breeding season. Hooded robins prefer eucalypt woodland supporting a diverse range of structures including mature eucalypt, saplings, shrubs and tall, native, grassy understorey (DEC, 2005b). The species is often recorded in agricultural areas along fertile creek lines and is known to inhabit regeneration areas. Roosting habitat includes fallen timber and low dead stumps. Breeding occurs between July and November during which cup-shaped nests are constructed one to five metres above the ground. Threats to survival include clearing resulting in habitat fragmentation and modification or destruction of habitat through heavy grazing, timber removal, frequent fire and exotic grass invasion (Robinson *et al*, 1996).

- *Pomatostomus temporalis temporalis* (grey-crowned babbler eastern sub-species) have been commonly encountered within the southern woodland and in or near Bowmans Creek in a patch of woodland to the east of the creek ox-bow. The family group occupying the southern woodland was reported to have increased from eight birds in September 2004 to twelve in January 2005 with the number of nests increasing from two to six respectively (Parsons Brinckerhoff, 2004b). The most recent monitoring survey (ERM, 2009) reported that the number of grey-crowned babblers within the site appeared to be stable at around 12 individuals, with a total of 13 nests identified.
- *Myotis macropus* (Large-footed myotis) were recorded within the southern woodland during previous surveys (ERM, 2006b; Parsons Brinckerhoff 2004b).
- The site provides potential hunting and roosting habitat for *Mormopterus norfolkensis* (eastern freetail-bat) and hunting/foraging habitat only for *Miniopterus schreibersii oceansis*, *Myotis adversus* and *Pteropus poliocephalus*.

With respect to species listed under the Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act 1999, seven migratory bird species are identified as having the potential to occur within 10 kilometres of the site. Five of these are terrestrial birds and two are wetland birds. Habitat for the wetland birds (Latham's Snipe and Painted Snipe) is not provided on the site. The terrestrial migratory birds are:

- *Haliaetus leucogaster* (White-bellied sea-eagle);
- *Hirundapus caudacutus* (White-throated needletail);
- *Monarcha melanopsis* (Black-faced monarch);
- *Myiagra cyanoleuca* (Satin flycatcher); and
- *Rhipidura rufifrons* (Rufous fantail).

3.3 Bowmans Creek Aquatic Habitats

Bowmans Creek is about 56 kilometres (km) long and the headwaters are located in the Little Brothers Range, at an elevation of about 650m Australian Height Datum (AHD). It has a catchment area of approximately 265 km^2. The lower section of Bowmans Creek between the New England Highway and the Hunter River confluence is 6 km long and approximately 4.5km of this section is located within the ACOL Mining Lease overlying LW 5-8. The elevation of the Bowmans Creek channel bed at the upper limit of the lease boundary is about 61m and the elevation at the confluence with the Hunter River is about 49m. Bowmans Creek experiences variable flow and it is generally perennial, although flow can cease during severe droughts (e.g., for several months preceding the July 2007 flood – see discussion in Section 3.6.1 below). The floodplain area immediately adjoining Bowmans

Creek contains several (generally dry) billabongs from earlier creek alignments and these plus most of the floodplain is characterised by continually grazed pasture and relatively isolated patches of open woodland. Surrounding land uses consist of agriculture with mining activities occurring immediately to the north of the New England Highway and to the west of Bowmans Creek. All studies, including the July 2008 walkover by MPR, noted that cattle have access to the creek along most of the study area creek banks, and riparian cattle tracks (parallel to the creek-line) were present along many sections, contributing to minor terracing on steep riparian slopes and facilitating active erosion of the banks.

The number of pools in the Bowmans Creek study area varies with flow conditions. In the 2006 geomorphology study, undertaken during low flow conditions, there were 44 separate pools identified (ERM 2006a). For the MPR June 2008 walkover inspection there was moderate surface flow (around 37ML/day of about 0.15 in 1 ARI), and there were around 24 pools within the study area (as a result of merging of individual pools identified in 2006), ranging in length from 10m to 500m. Most pools are wide (10m) and shallow (to 1m deep) with some deeper pools (to 2.5m deep). Several pools (the top pool and the weir pool) are located within exposed basement rock, although neither are rock-bar constrained. Most of the pools are connected by cobble riffle zones, and the remaining pools are structured as "chain-of-ponds" type (see Rutherford et al 2000), with more or less permanent pools (dependent on depth) separated by bars of sediment stabilised with vegetation. Many riffle or narrow pool sections are bordered by exposed cobble beds on one side, with steep sided banks on the other. Pools at the lower end of the study area are steep sided on both sides as the creek erodes down to the level of the Hunter River.

MPR (2001) concluded that ‘no major barriers to fish migration were found within the Bowmans Creek study area'. The small NSW Office of Water (NOW) gauging weir (located approximately 2.6km downstream from the New England Highway) and the rock bars below this weir were deemed to inhibit fish passage during drought or low flow conditions, and there were some minor impoundments noted upstream of New England Highway behind road crossings, however all structures were considered suitable for fish passage under a range of flow conditions. Subsequent surveys confirm that this remains the case (see for example MPR 2008a,b, 2009a).

Observations of water availability during 2006 drought periods noted minimal or zero surface water flow with only very shallow pools available in the upper reaches of the study area (i.e., for about 2.5km of creek immediately downstream of the New England Highway pool). From this point (at around Pool 21 in ERM 2006a), the surface water flow then resumed downstream to the Hunter River. That is, during drought there are disconnected pools in the upper half of the creek (between the Highway and Hunter River) that prevent fish passage.

The combined TEL and MPR 2005 to 2008 monitoring studies indicate that during dry times when pool water levels are low, the Bowmans Creek exposed channel is colonised by terrestrial species, such as spike rushes (*Juncus sp*), and Casuarinas. Grasses and weeds rapidly colonise previously wet bank areas or newly settled sediment deposits. The newly established in-stream vegetated areas have the potential to form islands or extended terrestrial banks, if flow conditions remain low for sufficient time for trees to develop to a mature enough stage, (as occurred in the extended drought period preceding the 2007 June flood), and can influence the localised formations of flow channels during and following subsequent high flow periods.

3.3.1 Creek Sections to be excised by the Proposed Eastern Creek Diversion

The upper creek section to be excised (from below the pool at site SM4/BC1 (see Figure 1) to the beginning of the oxbow under LW6B, consists of a series of broad, flat bottomed pools connected by constricted flow channels. Pool lengths range between 100m and 300m, and are generally straight with few backwaters or zones that would provide refuge in high flows. At least two retaining fences exist along sections of the western bank, in some parts actively stabilising the bank edge. Bank gradients are generally shallow with few steep areas along pool edges. Pool depths at the time of field inspection averaged 1m, with 1.5m maximum depths. Riffle section water depths averaged 0.3m. There were a series of small pools located within this zone during the ponding survey in March 2006 (ERM 2006a). This section includes the base-line monitoring site BCMW7.

The existing oxbow section of the creek (under LW6B and MW5 in Figure 1) is a meandering creek channel consisting of a series of short narrow pools 10 to 20m in length, separated by shallow constricted riffle sections. ERM (2006a) recorded two isolated pools overlapping into the area during March 2006 (ponds 11 and 12).

3.3.2 Creek Sections between the Proposed Eastern and Western Creek Diversions

The remaining oxbow reach of the creek to be retained (under MW5, MW6 and MW7 in Figure 1) is a meandering creek channel consisting of a series of short narrow pools 10 to 20m in length (in 2008), separated by shallow constricted riffle sections. This reach includes the base-line monitoring site BCMW5. Riparian banks are less than 1m high with a series of three man-made dams bordering the creek line to the north within a former creek bed. During the walkover survey (1 July 2008) seepage was noted along the bank edges adjacent to the dams. The eastern (outside) bank of the downstream oxbow creek section (west of MW7 in Figure 1) is very steep and approximately 5m high, eroded and with undercut banks. The inside bank is more depositional with lower gradient, and consists of a grassed cobble bed.

There was a continuous pool through the end of the oxbow and into the southern bend (towards the start of the proposed western diversion in Figure 1) in July 2008, coincident with the March 2006 geomorphology survey pond 16. The first section downstream of the oxbow section comprises a straight creek section and a small bend to where the NOW weir is located. The straight section is narrow, with short pool sections (to 1.5m deep) all connected by shallow, constricted cobble-riffle zones that alternate flow routes within the channel between consecutive pool sequences. In March 2006 there was one small pool (pond 20), and the start of a long pool (pond 21). In July 2008 a single narrow, straight pool extended for a distance of approximately 500m from the oxbow to the bend just upstream from the NOW stream gauge and weir, with sections of bank showing signs of recent slumping. Average pool depth along the pool section was around 1m, with maximum depths to 1.5-2m. Banks on both sides of the creek are relatively similar and vary between 2 and 3m height. Part of the western bank bordering the channel is steep with riparian trees abutting the bank edge, some of which were tilting and toppling into the stream.

There is a short cobble riffle section on the bend of the creek just upstream of the NOW weir pool that is bordered by large concrete blocks and a retaining fence on the western bank. The riffle coincides with the start of the creek section that turns due south and extends into a 1m deep pool (pond 22 in ERM 2006a), the weir pool. There are a number of bedrock outcrops through this creek section that would act as fish passage barriers during periods of low flows. The creek channel immediately below the NOW weir contains a number of boulders, with bedrock present in-stream and on the western bank. The pool extends for around 150m, and has a depth of 1.5 to 2m (pond 24 in ERM 2006a).

3.3.3 Creek Sections to be excised by the Proposed Western Diversion

The section of creek to be excised has pools that are relatively deep (to 2m) and are constrained in a narrow (to 5m width) incised flood channel with very steep banks, mostly along the eastern edges. Four ponds (ponds 24 to 27) were noted through this section in March 2006 (ERM 2006a).

3.3.4 Creek Sections below the Proposed Western Diversion

The downstream section of creek to be retained below the proposed Western Diversion is similar to that encountered immediately upstream and consists of a narrow channel, with steep eroding banks on the eastern pool edges. There were two pools separated by a riffle section, with the lower pool widening and the bank becoming steep along the western side. There were three ponds (ponds 28 to 30) in this creek section in March 2006 (ERM 2006a). The remaining section of Bowmans Creeks to around 400m upstream from the Hunter River confluence consists of a deeply incised channel 10-15m below the surrounding floodplain. The channel basin is relatively flat averaging 0.8 to 1m deep throughout the section, with an exposed cobble bar on the inside corner of the creek bend. Riparian banks are steep (~45°) and vegetated by grasses and weeds, with scattered riparian Casuarinas, Eucalypts and Willows. Bank undercutting is present along the outside edge.

3.4 Groundwater Dependent Ecosystems

Both the flora and fauna and aquatic reports (ERM 2009 and MPR 2009) report considered the occurrence of Groundwater Dependent Ecosystems (GDEs) in the Creek Diversion study area. Potential GDEs of the study area were identified using the eight-step rapid assessment (DLWC 2002) and it was concluded that there are no known or likely wetland, terrestrial or aquifer/cave ecosystem GDEs in the study area. Assessment of riparian vegetation did not indicate any specific riparian plant communities, which could be considered groundwater dependent.

Downstream of the study area, the two stands of *Eucalyptus camaldulensis* (river red gum) are restricted to the streams and the associated banks and there are no large floodplain remnants of *Eucalyptus camaldulensis* within the catchment. Accordingly these stands would be expected to get at least 50 % of their water directly from the stream with the balance derived predominantly from rain retained soil moisture in the banks and the remainder from groundwater.

With regard to aquatic vegetation in the creek, for most of the monitoring studies and for the July 2008 walkover inspection, cumbungi (*Typha sp.)* stands were the most commonly encountered emergent macrophytes, with curly pondweed (*Potamogeton crispus*) and watermilfoil (*Myriophyllum sp.)* the most common submerged macrophytes. An additional six submerged and emergent macrophyte species have been recorded over all Bowmans Creek surveys, they are; clasped pondweed (*Potamogeton perfoliatus*), sago pondweed (*Stuckenia pectinata*), slender knotweed (*Persicaria decipens*), maundia (*Maundia* *triglochinoides*), common reed (*Phragmites australis*) and the introduced watercress (*Nasturtium officinale*).

The Groundwater report (Appendix 9 for the EA - Aquaterra 2009) indicates that baseflow in the pre-mining condition generally results in small flows from the alluvium to the creek. Thus it is assumed that there is a hyporheic zone between the saturated alluvials and the creek bed. There is generally very little connection between the underlying Permian rock and the alluvium, although in some areas a slight upwelling results in moderately saline conditions in the alluvium. Given the lateral extent of saturated alluvials (as indicted on Figure 1), it is also concluded that there are probably some parafluvial zones in the creek.

With regard to the degree of dependency of possible aquatic or hyporheic GDEs to baseflow in the Bowmans Creek study area the following factors are relevant:

- The creek is perennial with some flow of alluvial groundwater to the creek. Water entering the alluvium generally occurs through rainfall runoff and recharge.
- Due to there being some surface flow most of the time, riparian and edge emergent vegetation plus riffle zone fauna are more dependent on fluctuating surface water levels than on groundwater inflow, although baseflow from the alluvium to the creek becomes more significant during prolonged drought conditions. .
- When there is no surface water during prolonged drought conditions such that the baseflow may start to become significant (as encountered in 2006 and 2007 prior to the 2007 flood), there are no riffles, there are only small disconnected pools remaining and the pool edge vegetation dies off. At that time salinity of the baseflow also becomes significant in some areas (see Section 3.7 below), thus limiting the remaining aquatic macroinvertebrate assemblages that could reside in the pools and limiting the microinvertebrate fauna that could reside in the hyporheic zone.

It is concluded that possible aquatic and hyporheic GDEs in Bowmans Creek within the study area would not be considered significantly dependent on baseflow groundwater.

3.5 Sub-catchment Tributaries

There are four main sub-catchments draining across the ACOL mining lease to Bowmans Creek from the east. These may generally be characterised as shallow, grassed drainage depressions, with some being subject to gully erosion, particularly as they near Bowmans Creek. There is a small area of remnant or regrowth river oak around the subcatchment drainage to the eastern edge of the oxbow section to be retained (Figure 2).

All of the tributaries would have intermittent surface flow for short periods after rainfall (i.e., they are ephemeral), with some volume of runoff being retained in in-line stock watering dams. The presence of submerged terrestrial vegetation in inundated shallow depressions and in holes within the tributary creek lines observed during the MPR July 2008 field inspection indicates that these ponds most probably dry out rapidly following rainfall.

Most of the site dams (in-line and elsewhere) allow direct stock access and appear to have high suspended-sediment concentrations. It is assumed that dam water may also have high nutrient concentrations. Very few dams had riparian cover or contained aquatic vegetation, and off-line dams generally collected drainage from extensive areas of open pasture. It is concluded that these semi-permanent to permanent standing water bodies overlying the ACOL underground mine offer little in the way aquatic habitat or favourable water quality for aquatic ecosystems.

The only tributary with any defined channel structure was a small tributary located on the western bank above proposed LW7B and LW8 draining to the section of Bowmans Creek between the proposed diversions. The section of this tributary above LW7B and LW8 is a shallow drainage line with intermittently occurring ponds, containing a combination of macrophytes (Cumbungi, Water Ribbons and Common Reed); suggesting at least a semi-permanent (and probably shallow submerged) water supply.

3.6 Seasonal Water Quality

The ecological value of the Bowmans Creek study area aquatic habitats is linked to both habitat availability and condition (summarised in Sections 3.1 and 3.2 above) and to the water quality attributes of the ponded waters. In this section, available water quality data is reviewed. Section 3.6.1 considers the 'whole of mine' monthly water quality collected by ACOL over the mining period and Section 3.7.2 considers the water quality data collected by the aquatic ecology teams. TEL and MPR sampled water quality in spring 2005, autumn 2006, and autumn 2007 to autumn 2009 at four to six sites in the study area.

3.6.1 ACOL Water Quality Data

With regard to understanding the various contributions of natural and human contributions to water quality in Bowmans Creek, ACOL have established a network of water quality monitoring stations (see Figure 1) most of which have been sampled since September 2004. In terms of Bowmans Creek inputs and outputs the following monitoring sites are relevant:

- Water quality monitoring sites above New England Highway are located on Bettys Creek (SM1 above all Ashton mining activities and SM2 above the confluence with Bowmans Creek) and in Bowmans Creek (SM3 upstream of the Bettys Creek Confluence).
- There are four sites in Bowmans Creek below the New England Highway (SM4 to SM6). SM4 and SM6 are located upstream and downstream of the proposed underground mining footprint and proposed creek diversions, Site SM4A is located within the section of creek to be excised for the upper (Eastern) diversion and site SM5 is located about mid way at the weir pool (just above the proposed Western diversion).
- There are two sites in the Hunter River, SM9 upstream and SM10 downstream of the Bowmans Creek confluence.

Full results of water quality monitoring are provided in ACOL monthly reports. Summary statistical results relevant to an understanding of aquatic ecology are provided in Table 1 below with graphed results contained in Annexure A. Table 1 provides summary statistics for five of the six ACOL water quality parameters from all the relevant Bowmans/Bettys Creek/Hunter River sites. The sixth parameter (oil and grease) was excluded as all data were reported as "less than detection limit".

Over the 42 months of sampling considered, the two up-stream Bettys Creek sites SM1 and SM2 were predominantly dry and only showed sufficient water levels for sampling following the June 2007 flood. Since then they have only been sampled three times, also when there was sufficient water for sampling. The additional Bowmans Creek site SM4A was established in March 2007 to aid in determining the cause/source of the water quality anomalies at Site SM4 (see further discussion below). The upstream Bowmans Creek site SM3 was sampled over the complete sampling period, but was dry over the period 13 March to 7 June 2007.

Inspection of the tabulated and graphical statistical summary results (Table 1 and Annexure

Figures A-1 to A-5) indicate that variations in mean electrical conductivity (EC), Total Dissolved Solids (TDS), alkalinity, and pH between sites were similar, with the exception of Site SM4. SM4 has had significantly higher mean values recorded for all parameters than all other sites.

Table 1
ACOL Life of Mine Monthly Water Quality Data
Summary Statistics from ACOL Monthly Data reports

Statistic	BCk Up	BCk Conf	Bow Up	Rock Pool	BowB Conf	Weir Pool	Bow Conf	Hunt Up	Hunt Dwn
Site	SM1	SM2	SM 3	SM4	SM 4A	SM 5	SM 6	SM 9	SM 10
Alkalinity (mg/L CaCO3)									
N	3	3	38	42	12	42	42	42	42
Min	39	71	102	97	106	105	107	131	112
Max	283	303	383	1590	334	363	371	358	356
Mean	147	159	301	683	251	291	241	218	221
SE of Mean	72	72	10	64	22	8	10	8	9
Total Suspended Solids (TSS mg/L)									
N	3	3	38	42	12	42	42	42	42
Min	8	18	2	2	2	2	2	1	2
Max	504	98	160	278	103	31	36	204	160
Mean	175	48	23	49	24	11	15	26	26
SE of Mean	165	25	5	8	9	1	1	5	4
Acidity (pH)									
N	3	3	39	43	13	43	43	42	42
Min	7.2	6.6	6.9	7.4	7.5	6.9	6.9	7.8	7.9
Max	7.9	7.6	7.9	9.1	7.9	8.1	8.3	8.5	8.5
Mean	7.6	7.1	7.5	8.0	7.7	7.7	8.0	8.1	8.2
SE of Mean	0.20	0.29	0.04	0.06	0.04	0.03	0.04	0.02	0.02
Conductivity (μS/cm)									
N	3	4	39	43	12	43	42	42	42
Min	277	574	421	428	434	432	453	304	319
Max	1800	1950	1750	14400	1980	2040	1850	1270	1290
Mean	951	1032	1375	4574	1263	1486	1001	740	767
SE of Mean	448	313	46	590	139	48	53	32	33
Total Dissolved Solids (TDS mg/L)									
N	3	3	38	42	12	42	42	42	42
Min	578	586	294	286	300	296	308	236	255
Max	1190	1120	976	8820	1130	1160	1080	658	672
Mean	919	791	818	2833	734	870	539	385	401
SE of Mean	180	166	25	364	76	27	31	18	18

Annexure Figures A6 to A10 compare the variations over time for each of the water quality parameters for the four Bowmans Creek sites (SM3, SM4, SM5 and SM6) for which complete data sets exist. The individual site variations over time for EC, TDS and alkalinity are reflected across all four sites. The pattern for Site SM4 indicates:

- A moderate increase in values up to June 2005 with two intervening decreases back to 'other site' readings in February 2005 and July 2005.

- From July 2005 on there is a continuous increase in the values of the three parameters through to March 2007, with some variation around this maximum through to the June 2007 survey.
- After the flood event, subsequent values for the three parameters are similar to the values at the other three sites for the remaining available sampling results.

Variation over time for pH is shown in Figure A9. Generally pH values were in the range 7 to 9 pH units. Over the sampling period there were three distinct patterns:

- September 2004 to December 2006: pH values ranged from 7.25 to 8.5 pH units.
- January 2007 to June 2007: pH at the SM5 and SM6 ranged from 7.6 to 8.4 pH units whilst pH readings at SM4 site values were elevated (8 to 9 pH units) and the upstream site SM3 values were depressed (7 to 7.25 pH units).
- Post June 2007 flood: pH values for all sites were similar, varying between 7 and 8.25 pH units.

TSS concentrations showed similar variations, but there were overall larger spatial and temporal variations which masked some of the pattern. Nevertheless TSS at site SM4 showed a similar net increase over time up to the June 2007 flood event and a similar decrease in July 2007. Temporal variation at the upstream site SM3 was high but there was a similar pattern to the SM4 rise, from May 2006 to June 2007.

ACOL collect rainfall data for the locality and provided monthly summary data for the duration of the study period. Figure A11 shows the monthly rainfall data superimposed over the monthly variation in EC, TDS, alkalinity and TSS for Site SM4 over the total sample period. Whilst it is clear from the figure that the variations in water quality parameters can be correlated in some way with rainfall there is insufficient correlation to show why the values of most parameters continued to rise between July 2005 and June 2007. However these raises most probably relate to evaporative losses.

Daily mean flow data for the Bowmans Creek Flow Gauging station (Foy Brook 210130) was accessed from the NSW Government Water Information Internet site: (http://waterinfo.nsw.gov.au/river-provisional-sites.shtml), and data for the period January 2004 to August 2008 downloaded for analysis.

Figure A12 shows a graph of the mean daily flow at the weir in ML/day. The range for this graph is set at 0 to 1800 ML/day to show all storm events other than the major storm events of 9 to 11 June 2007 (off the scale with mean daily flows of 8992, 17826 and 5498 ML/day respectively). Figure A13 shows the same data but with a more restricted range (0 to 15 ML/day) to highlight the variation in low flow events over the study period. The figure also shows the ACOL SM4 site monthly conductivity data.

From the combined graphs, it appears that the water quality at Site SM4 is directly related to creek flow rate. When flows are low, EC, alkalinity and TDS values at SM4 increase and when flow is very low or stopped, values peak. This correlation is demonstrated in the following discussion where changes in conductivity values at site SM4 are related to changes in mean daily flow conditions (see also Figure A13). Note that whilst values for conductivity are generally expressed as μS/cm, the data for Figure A13 were converted to mS /cm to match the flow and conductivity data ranges:

- Following small February and March 2004 storms and associated flow peaks there was an overall decrease in mean daily flow from around 2.5 ML/day to around 0.5 ML/day on 2 February 2005 (mean flow over this dry period was 1.8 ML/day for 313 days. This low flow period coincides with elevated conductivity of up to 4510 μS/cm) at Site SM4 between September 2004 and January 2005.
- The fall in conductivity for the 23 February and 30 March sampling events follow a 323 ML/day flow event on 3 February 2005 and this storm is followed by a period of relatively elevated daily flows (mean 10 ML/day) until the next storm on 19-29 March 2005 (137 ML total).
- From March to May 2005 there is another increase in EC as mean daily flow decreases to 3.1 ML/day over 102 days. EC peaked at 2520 μS/cm.
- Another fall in EC occurred on 12 July 2005 following a flow peak of 132 ML/day on 1 to 2 July 2005.
- There was no significant rainfall for the period 3 July 2005 to 8 June 2007 (706 days) and the mean daily flow for the period was only 1.1 ML/day, including a period of 74 days leading up to 7 June 2007 where the mean daily flow was generally zero or a trickle (mean 0.003ML/day). This period coincides with a dramatic increase in EC from around 1400 to a peak of 14,400 μS/cm (in March 2007). EC remained elevated above 11,000 μS/cm for the monthly water quality surveys in April to June 2007 with the June sample taken before the flood event (which started on 9 June 2007).

- Mean daily flow over the June 2007 flood period ranged from 17,826 ML/day on 10 June to 1561 ML/day on 20 June (mean of 3137 ML/day for 12 days).
- For the remainder of the (currently available) monthly conductivity sampling periods (July 2007 to March 2008) the SM4 EC values remained similar to those measured at the other Bowmans Creek sites, with one exception (in November 2007), when SM4 conductivity increased to 2220 μS/cm (approximately double the recorded values at the other sites). This rise followed a dry period of some 95 days from 25 August 2007 to the sampling date of 22 November 2007 over which time daily flow decayed from 233 ML/day to 1.3 ML/day.

A simple linear correlation analysis of the four SM4 water quality data analytes (see matrix of r^2 values below) showed that salinity, TDS and alkalinity were all highly correlated (as expected). There was some correlation between TDS and TSS (r^2 value of 0.71) and the remaining correlations were generally weak (r^2 values less than 0.65).

	Cond	TDS	Alk	TSS
TDS	0.98			
Alk	0.87	0.86		
TSS	0.65	0.71	0.45	
pH	0.60	0.66	0.51	0.58

Aquaterra (2008) found that salinity in the upper Permian coal measures ranged from 1,100 to 9,390 μS/cm EC and that some Bowmans Creek baseflow is derived locally from the Permian at site SM4. Thus, the increase in salinity within the SM4 pool is expected to be inversely related to overall flow in Bowmans Creek (as was the case). That is, when upstream surface contributed inflow rates are low, the contribution of Permian derived baseflow to the SM4 pool becomes more significant and conductivity in pool SM4 rises, with the rate of rise dependent on the preceding flow history. Further, when there is a long dry period with little to no surface water in-flow, conductivity in pool SM4 is expected to become highly elevated (as observed).

The monthly ACOL EC data for sites downstream from the SM4 pool and the daily EC data from the weir pool do not show any significant increases over the periods when the SM4 pool salinity is elevated, and it is concluded that the elevated EC in pool SM4 is generally confined to that pool by virtue of the correlation with low to no flow periods.

These results and inferences are in line with the more recent modelling of groundwater reported by Aquaterra (2009) who concluded:

- Bowmans Creek is not highly connected to its alluvium and there are not large quantities of baseflow travelling through the alluvial materials. In reality hydraulic conductivity is relatively low at around 0.5m/d.
- The water quality in the Bowmans Creek alluvium is sometimes poor as (pre-mining) groundwater levels in the underlying Permian are near or slightly above alluvium levels, resulting in upwards leakage in some areas (particularly in the SM4/BC1pool as discussed above).

3.6.2 Aquatic Survey Water Quality Data

Field water quality measurements were made at all aquatic ecology sites in Bowmans Creek sites during all aquatic ecology sampling programs undertaken to date and results are provided in the various monitoring reports). Water quality results obtained during these studies are summarised as follows:

- For All Bowmans Creek monitoring sites, salinity and pH values were within the default range set for Lowland Rivers by ANZECC (2000) guidelines.
- On three of the five surveys, mean dissolved oxygen (DO) values (measured as % saturation) were below the default range set by ANZECC Guidelines for Lowland Rivers of 85 to 110% saturation; TEL recorded mean DO values of 68.3 and 74.4% saturation in the low flow and drought periods (spring 2005 and autumn 2006 respectively). During high flow conditions (autumn 2007), MPR recorded a mean DO value of 59 %. Higher values were encountered in spring 2007 and autumn 2008 by MPR (mean DO % saturation values of 91.4 % and 91 % respectively).

From the consideration of the combined ACOL water quality monitoring program and the aquatic ecology field water quality measurements, it is concluded that for all the sites where measurements were made (with the exception of site SM4), water quality was generally reasonable and acceptable for the maintenance of aquatic ecological function. Water quality and thus aquatic ecology, deteriorated during low flow and flood flow periods with the main aquatic stress arising from low dissolved oxygen concentrations (during low flows) and from excessive turbidity (during high flows). Site SM4 is highly stressed by elevated conductivity during low to no flow periods and this is likely to have had a significant (i.e. measurable) impact on the biotic assemblages of this pool.

It is also concluded that there are sufficient data available from the combined water quality sampling undertaken by ACOL that can be used as the benchmark for future monitoring of any change.

3.7 Macroinvertebrate and Fish Communities

To date there have been ten aquatic ecology surveys in Bowmans Creek (between spring 2001 and autumn 2009) that have incorporated sampling for macroinvertebrates and fish, including two that used electro-fishing techniques. Surface stream flow conditions varied between surveys, and even between sites within surveys. For references to flow condition in the following paragraphs the following flow descriptors have been adopted:

- ‘Dry’ represents no surface flows during time of sampling in the majority of site pools,
- ‘Low flow’ represents surface flow conditions encountered at all sites, with generally only trickle flow through riffle zones in the shallow cobble and boulder beds between pools.
- ‘Normal flow’ conditions are more representative of mean flow rates for Bowmans Creek, and
- ‘High flow’ includes periods with higher than mean flows following rainfall through to floodwaters (i.e., where normally exposed banks are submerged).

3.7.1 Aquatic macroinvertebrates

A total of 38 edge and 2 riffle habitat sites have been sampled over 10 surveys between spring 2001 and autumn 2009. Seasonal summary statistics for the sampled edge habitats are presented in Table 2 below. Unless otherwise stated, the following summary applies to edge habitat data only.

To date, a total of 70 aquatic macroinvertebrate taxa (taken to AusRivAS required family level) have been identified from the combined studies. Four of the taxa were recorded from riffle habitats only; riffle beetles (family Elmidae), water pennies (family Psephenidae), fly larvae (family Dolichopodidae) and dobsonflies (family Cordyalidae). The majority of the taxa are insects (67%), with the remainder being molluscs (12%) and crustaceans (9%). Arachnids, flatworms, annelid worms, leeches, roundworms and springtails made up all <3% of the total.

There were thirteen taxa that were found in Bowmans Creek during six or more of the ten surveys, and six of those taxa were also common throughout the creek (i.e. occurring at over 75% of total sites sampled); midge fly larvae (sub-family Chironominae), freshwater shrimp (family Atyidae), damselflies (family Coenagrionidae), mayflies (family Caenidae), water boatmen (family Corixidae) and caddis flies (family Leptoceridae).

Table 2
Macroinvertebrate Summary Statistics for Bowmans Creek (2005 to 2009)

Flow**	Dry	Low	Low	Dry	Dry	High	Medium-High	Medium	Low	Medium
Flow rate (ML/day	N/A	1.7	0.7-0.8	0.4	0.4	123-129	840-158	27.7-24.8	3.3-4.9	20-25.5
No of Sites	N=2	N=3	N=4	N=2	N=4	N=4	N=4	N=4	N=6	N=6
Season and Year	Sp01	Sp05*	Sp05	Au06*	Au06	Au07	Sp07	Au08	Sp08	Au09
Total number of invertebrate taxa:	8	33	33	31	31	25	30	32	37	44
Mean number of taxa per site:	5	23	20.5	16.3	15.5	14	17	18.8	18.8	19.8
Standard Error:	0	3	1.9	4.7	1.8	2.5	1.9	1.1	1.8	1.9
Creek SIGNAL score:	3.88	4.43	4.06	4.59	3.83	3.71	4.53	4.99	5.1	4.95

*Represents aquatic ecology surveys undertaken from upstream Bowmans Creek locations.
** Dry represents no surface flows during time of sampling between most site pools.
Low flow is when there is surface flow between all sites, but with generally only trickle flow through riffle zones in the shallow cobble and boulder beds between most pools.
Medium flow is when there is sufficient flow to allow fish passage through most to all of the site

High flow is when there is sufficient flow to allow fish passage through all of the site with no impediments

Individual site diversity ranged between 5 taxa (spring 2001 drought) to 26 taxa (spring 2005 dry with some flow). Comparisons of the seasonal mean number of taxa per site show reduced taxa diversity during high flow and dry periods when compared to low flow and normal flow conditions. Despite this, seasonal total number of creek taxa during high flow and dry flow periods are almost as high as those in periods of low flow to normal flow. That is, even though individual sites may not support as diverse an assemblage of aquatic macroinvertebrates under drought or flood conditions, the aquatic drought and flood refuges in the creek as a whole continue to support similar taxa diversities.

In terms of SIGNAL grades, the study area pools support diverse fauna with a full range of pollution tolerances, from the most sensitive taxa, Mayfly family Leptophlebiidae (grade 10) to the pollution tolerant snail family Physidae, Dragonfly family Lestidae and Springtails (grade 1). In general, the Bowmans Creek monitoring sites support a pollution tolerant macroinvertebrate fauna, as indicated by the AusRivAS model and validated by the SIGNAL index scores over consecutive surveys.

Prior to the major flood event in June 2007 (i.e., during or towards the end of extended drought), there were relatively low site SIGNAL scores (spring 2001, 2005 and autumn 2006). The combined site SIGNAL score for the survey immediately following the flood (autumn 2007) was also low and overall creek SIGNAL scores have improved over each consecutive sample season since then, peaking in spring 2008.

The stream health data indicate that the aquatic ecological habitats of Bowmans Creek have been in a state of recovery since the combined extended pre-June 2007 drought and since the major flood in June 2007. For at least one year prior to the flood, sections of Bowmans Creek within the study area were isolated and drying up and there was a marked reduction in the extent and variety of fish and macroinvertebrate fauna. The flood destabilised, swept away or smothered much of the remaining habitat features with silt and most likely scoured much of the macroinvertebrate fauna out of the creek as well. Since the floods, Bowmans Creek has sustained regular flows throughout the study area, enabling aquatic habitats (macrophyte beds, new logs and new detritus) to re-establish over time with increasing macroinvertebrate site diversity, SIGNAL scores and fish diversity recorded over consecutive seasonal surveys. Based on the number of new taxa encountered on each consecutive sample occasion since June 2007 it would appear that the recovery of the macroinvertebrate fauna assemblage in edge habitats in Bowmans Creek has not yet been achieved.

3.7.2 Fish and Other Fauna

To date there have been 14 fish species recorded from the Bowmans Creek catchment, 2 of which are introduced species (Table 3).

The introduced pest species, plague minnow (*Gambusia holbrooki*), has been the most commonly encountered fish during all aquatic ecology monitoring surveys, generally recorded at every monitoring site sampled in Bowmans Creek. Carp have also been commonly observed over all surveys, with the exception of high flow periods during autumn and spring 2007. The larger native fish species such as Australian bass, eel-tailed catfish, long-finned eel and mullet, have all been caught or observed in sections of Bowmans Creek within the study area (i.e., between BC1 and BCMW7) during periods of low surface flow (autumn 2006 survey) when there was no possibility of fish passage between pools.

Table 3
Fish Species Recorded from Bowmans Creek

Family	Species	Common name/s	Life cycle*	Recorded	Native/ Introduced
Anguillidae	*Anguilla australis*	Short-finned Eel	C	√	N
Anguillidae	*Anguilla reinhardtii*	Long-finned Eel	C	√	N
Atherinidae	*Craterocephalus amniculus*	Darling River Hardyhead	U	√	N (species of concern)
Cyprinidae	*Cyprinus carpio*	Common Carp	L	√	I
Eleotridae	*Gobiomorphus australis*	Striped Gudgeon	A	√	N
Eleotridae	*Gobiomorphus coxii*	Cox's Gudgeon	P	√	N
Eleotridae	*Hypseleotris compressa*	Empire Gudgeon	U	√	N
Eleotridae	*Philypnodon grandiceps*	Flathead Gudgeon	U	√	N
Eleotridae	*Philypnodon macrostomus*	Dwarf Flathead Gudgeon	U	√	N
Mugilidae	*Mugil cephalus*	Sea Mullet	A	√	N
Percichthyidae	*Macquaria novemaculeata*	Australian Bass	C	√	N stocked
Plotosidae	*Tandanus tandanus*	Freshwater Catfish	L	√	N (species of concern)
Poeciliidae	*Gambusia holbrooki*	Plague Minnow	L	√	I
Retropinnidae	*Retropinna semoni*	Australian Smelt	P	√	N

Key:
A- Amphidromous (fish that migrate between the estuary and the sea, but not for breeding purposes).
C- Catadromous (fish that spend most of their lives in freshwater but migrate to the sea to breed).
P- Potadromous (fish that migrate wholly within freshwater).
L- Local (species that require fish passage only in their immediate environment).
U- Unknown
Note*: Life cycle characteristics referenced from Thorncraft & Harris 2000.

MPR (2001) listed two species recorded in Glennies Creek that could also be expected to occur within Bowmans Creek, they are bullrout (*Notesthes robusta*) and the introduced goldfish (*Carassius auratus*). Although Australian smelt are listed above as potadromous, recent studies of populations in coastal drainages of south-eastern Australia showed that a majority of the fish analysed inhabited the sea or estuaries during early life stages (Crook *et al* 2008).

No species of fish or aquatic invertebrates, as currently listed under the NSW Fisheries Management Act 1994 (FMA), or under the Commonwealth Environment Protection &

Biodiversity Conservation Act 1999 (EPBC Act), were recorded in any of the Bowmans Creek monitoring conducted to date, and no protected fish, as listed under the FMA, have been found or observed in Bowmans Creek.

In May 2009 there was a report of Southern Purple Spotted Gudgeon (*Mogurnda adspersa*) in Goorangoola Creek, a major sub-catchment creek discharging to Glennies Creek (HCR-CMA Catchment News, Issue 17 May 2009). The Southern Purple Spotted Gudgeon is listed as endangered under the FMA. Since October 2008, up to 20 specimens have been found at five different sites. This species is known from both East Coast and Western flowing river systems and, up to the time of this discovery, the East Coast population was only known from coastal rivers north of the Clarence River. It is a common aquarium fish and there is a possibility that the Goorangoola Creek population is introduced.

The species is found in slow moving or still waters of creeks, rivers, wetlands and billabongs, and prefers slower flowing, deeper habitats. Current populations are correlated with low turbidity. It is a slow-moving ambush predator, consuming small fish and aquatic macroinvertebrates and also worms and tadpoles. It is a benthic species, usually associated with good cover such as cobble and rocks in the Queensland parts of its range, or aquatic vegetation in its southern range. As it is primarily a bottom dweller, it rarely swims continuously, with longer distances accomplished by a series of jerky darts. It is sedentary species and migrates from deeper water to spend winter in sheltered situations.

The reasons for its decline are unknown but its occurrence is thought to be inversely correlated with presence of plague minnow (*Gambusia holbrooki*) – although the Goorangoola population is coexistent with plague minnows. Other factors (abiotic parameters, other introduced species, flow regulation) are also suggested.

Whilst its location in upstream Bowmans Creek sites cannot be discounted, to date this species has not been recorded in the Bowmans Creek study area from any of the fish surveys undertaken between Spring 2005 and Autumn 2009. If there are southern purple spotted gudgeons in Bowmans Creek, then it is more likely that they would be found in the upper reaches of the creek. It is concluded that the proposed creek diversions are not likely to have an impact on any local population of this species.

Two species are listed as species of concern in Morris *et al* 2001; The Darling hardyhead and the Freshwater catfish.

- The Darling hardyhead (*Craterocephalus amniculus*) is listed due to its taxonomic uncertainty. It is endemic to streams in the upper

Darling River system. Specimens tentatively identified as *Craterocephalus amniculus* were collected from upper Bowmans Creek in 1976 and 1980, though no further individuals have since been collected (cited in Morris *et al* 2001). This species has not been observed or caught in any of the ACOL surveys (from 2005 onwards) and was not caught during the TEL electro-fishing survey of the creek in (2005-2006).

- Morris *et al* 2001 note that whilst the freshwater catfish (*Tandanus tandanus*) is not currently listed as threatened in NSW, its distribution and abundance has been significantly reduced throughout the southern parts of its known range. Freshwater catfish are generally found close to sand or gravel bottoms in slow moving streams, lakes and ponds with fringing vegetation (Allen *et al* 2002), habitat features consistent with that encountered in Bowmans Creek. This species has been recorded from refuge pools in the study area during the autumn 2006 drought, nests and adults were observed at site BSW8 in spring 2008 and juveniles were caught at Site BCdown in spring 2008.

The following conclusions are made with regard to overall fish habitat attributes:

- Bowmans Creek in its present state is perennial with flow only ceasing during extended drought periods. Most of the creek line is characterised by shallow elongated ponds separated by cobble or sediment riffles of banks.
- There are pools throughout the creek that provide drought refuge, even in extended drought periods as observed in 2001 and 2005/6.
- Many of the pools have gravel to cobble sized beds that provide suitable nesting areas for catfish.
- Habitat complexity is generally good with varying creek substrata (cobbles, sediments, detritus and rock), emergent and aquatic plants, and some overhanging edge vegetation.
- There are also areas of eroding banks where the riparian vegetation is limited or where banks are destabilised by stock access.
- There is no 'large woody debris' in the form of log-jams, only a few individual fallen trees associated with recent floods.
- During low flows there is often not sufficient depth over cobble riffles to connect pools for fish passage. Fish passage can also be limited by rock bars in the centre of the creek below the NOW weir pool. During moderate flows there is suitable fish passage through the creek and upstream. During high flows there is also

sufficient water depth for fish passage but passage for smaller species can be limited by the lack of resting or off-line pools.

With regard to other possible fauna associated with the Bowmans Creek aquatic habitats, the various studies (including the ERM terrestrial biota studies) have reported amphibians (tadpoles and frogs), ducks and other water birds, long-necked turtles, water dragons and water skinks. The following amphibians are reported from Bowmans Creek:

- *Crinia signifera,* common eastern froglet (all surveys),
- *Limnodynastes tasmaniensis*, spotted marsh frog (recorded once in summer 06),
- *Paracrinia haswellii*, red-groined froglet, (recorded once in spring 07),
- *Litoria peronii*, emerald spotted treefrog, (recorded, spring 07 to spring 08),
- Litoria latopalmata, broad-palmed frog, 3 times, (recorded, spring 07 to spring 08),
- Litoria leseuri, Leseur's frog (recorded once in spring 07),
- Uperoleia laevigata, smooth toadlet (recorded once in autumn 05).

Whilst Platypus and Australian water rat are known from the lower section of Glennies Creek below the Highway, there have been no records or sightings in the Bowmans Creek study area below the Highway.

3.8 Summary of Bowmans Creek Ecological Condition

The lower 6 km section of Bowmans Creek between the New England Highway and the Hunter River confluence provides the following important ecological functions:

- Fish passage between the Hunter River and the remaining 50 km of aquatic and fish habitat in Bowmans Creek plus other upper catchment tributaries upstream of the New England Highway;
- Off-line fish refuge habitat during extended Hunter River flood events;
- Fish nesting habitat in the form of gravel bars in pools;
- A measure of drought refuge habitat in the form of deeper pools;
- A complex of aquatic ecological habitats (cobble and sediment pools and riffles, rock bar pools) with varying depths and different aquatic and emergent plants to support a complex assemblage of aquatic macroinvertebrate fauna; and
- Riparian vegetation corridors that link the Hunter River riparian flora through to the upper Bowmans Creek and provide additional foraging and feeding habitat for woodland birds and other native fauna that live in remnant patches of woodland in the locality.

Whilst this section of the creek provides these important functions, the section is not pristine and some of these functions are compromised by past practices (e.g., engineered bank protection, realignments for the New England Highway plus Northern Railway bridges), by agricultural practices (clearing of riparian and floodplain vegetation, bank erosion and water quality deterioration exacerbated by loss of riparian vegetation and by stock damage) and introduction of exotic species (riparian species such as willows, pasture grasses and weeds plus aquatic pest species; carp and plague minnow). Fish passage is available intermittently owing to the combined intermittency of flow, and the shallow nature of some of the creek sections that dry out or where surface water flow is often through cobbles, thus isolating pools. Water quality is also affected by the natural occurrence of saline seepage from outcrops of Permian rock in the pool immediately below the New England Highway that can become very high in that pool during extended drought periods.

Accordingly, the provision of two diversion channels represents both a challenge to provide the important ecological functions of the existing creek and an opportunity to provide overall better ecological function by addressing some of the factors currently leading to creek channel deterioration.

This is not to say that bank erosion and channel variability should be restrained. Bowmans Creek downstream of the highway is an incised channel, and the degree of incision increases towards the junction with the Hunter River. That is, as outlined in the Geomorphology assessment (Appendix 7 of the Environmental Assessment – Fluvial Systems 2009), the creek is geomorphologically active within the incised corridor, redistributing bed material, and building and destroying bars, benches and banks.

4 IMPACT ASSESSMENT

Based on a consideration of the ecological values and deficits of Bowmans Creek presented in the above assessment and summarised in Section 3.8, the view adopted for the design of the diversions is that a degree of channel instability is ecologically favourable and that channel form variability is required for ecological significance. Thus, the diversion channels have been designed to have the same range of physical forms, bed material, and stability characteristics as the existing channel, i.e. they mimic the existing channel as closely as possible.

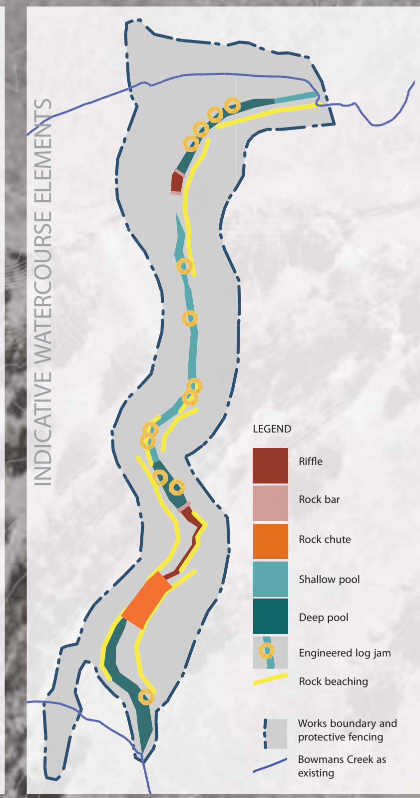
Additionally, provision of the diversion channels has provided the opportunity to address the other factors that have led to overall deterioration in riparian and aquatic ecological function in Bowmans Creek between the New England Highway and the Hunter River, mainly clearing of riparian and floodplain woodland and exacerbation in bank instability and water quality from stock access.

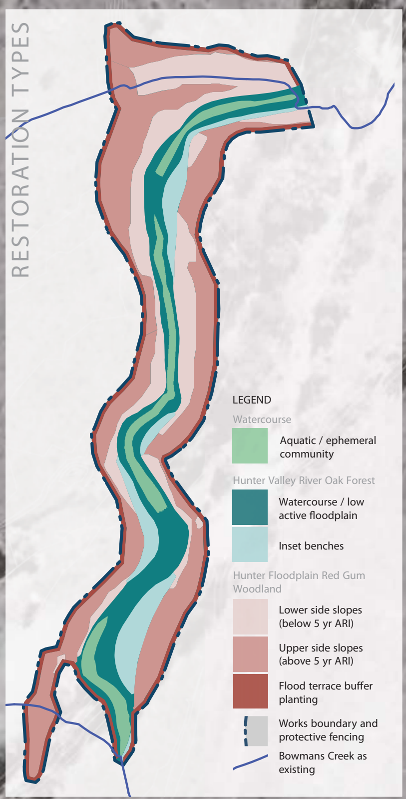
4.1 The Diversion Proposal

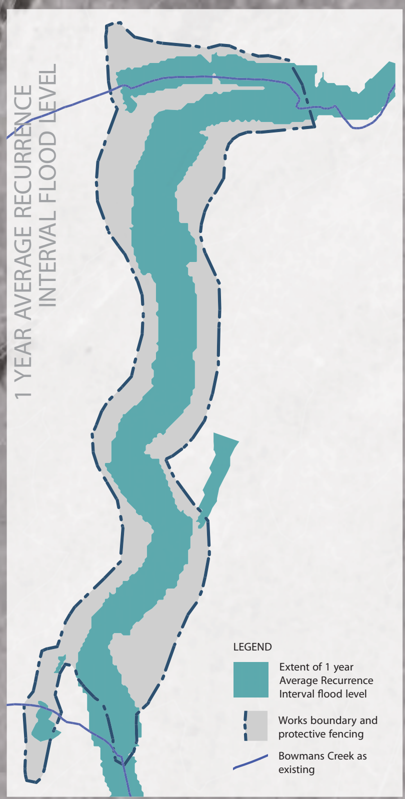
As noted in the Introduction and shown in Figures 1 and 2, there are two diversions proposed:

- An Eastern Diversion comprising 830m of constructed channel and 125m of existing oxbow channel (se Figure 3). This diversion will commence about 175m downstream of the New England Highway and connect back into the existing creek system via a section of oxbow channel on the northern side of the existing channel near a major bend in the creek known as “the oxbow”.
- A Western Diversion comprising 730m of constructed channel that commences about 70m downstream of the existing NOW gauging weir (see Figure 4).

The alignment, cross sectional geometry and geomorphology of the proposed diversion channels are described in Sections 7 and 8 in the Environmental Assessment (EA) report, and the detailed engineering designs for the diversions are presented in Appendix 15. The construction sequence is described in Section 11.3 for the EA report and the detailed landscape and habitat restoration for the diversion channels is described in Section 11.5 of the EA report with detailed drawings in Appendix 16. Figure 5 (below) shows the inter-relationship of the completed diversions with the Bowmans Creek floodplain and with the existing network of riparian and terrestrial corridors currently being developed within the ACOL lease area.







LEGEND

Watercourse Elements

- Engineered Log Jam
- Rock Beaching
- Rock Bar
- Rock Chute
- Riffle
- Deep Pool
- Shallow Pool
- Low Active Floodplain

Planting: Watercourse

- Aquatic / Ephemeral Community

Planting: Hunter Valley River Oak Forest

- Watercourse / Low Active Floodplain
- Inset Benches

Planting: Hunter Floodplain Red Gum Woodland

- Lower Side Slopes (Below 1 year Average Recurrence Interval Flood Level)
- Upper Side Slopes (Above 1 year Average Recurrence Interval Flood Level)
- Flood Terrace Buffer Planting
- Works Boundary and Protective Fencing
- Proposed Contours
- Existing Contours

EDAW | AECOM
LEVEL 8, 17 YORK STREET, SYDNEY NSW 2000 T 02 8023 9333 F 02 8023 9399

0 10 20 30 40 50 100m

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DRAWING NUMBER SK01
12 OCTOBER 2009

Figure 3 Bowmans Creek Eastern Diversion
Masterplan - Eastern Diversion

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LEVEL 8, 17 YORK STREET, SYDNEY NSW 2000 T 02 8023 9333 F 02 8023 9399

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DRAWING NUMBER SK03
12 OCTOBER 2009

Fig 4 Bowmans Creek Western Diversion
Masterplan - West Diversion

As summarised above, the proposed diversions will need to provide fish passage capabilities to link the Hunter River with the upstream aquatic habitats in Bowmans Creek. The diversions will also need to provide drought refuge pools for fish and suitable nesting habitat for catfish. There will need to be similar aquatic habitat resources to those found in the existing creek for supporting other aquatic biota (macroinvertebrates, aquatic plants, emergent edge plants, amphibians and terrestrial animals directly associated with creek habitats; e.g., copper skinks, long-necked turtles, Australian water rat, ducks and fishing bats). In effect, the diversion creeks will need to mimic the existing creek. Accordingly, the designs for the diversion channels have incorporated a high degree of geomorphic and landscape complexity which:

- Mimics the important (and differing) geomorphic characteristics of each of the sections of the creek to be excised;
- Provides comparable, or better quality aquatic habitat than the existing creek, including pools and riffles, supplemented with large woody debris log jams (which are largely absent from the existing creek);
- Provides comparable hydraulic conveyance to the existing creek.

To achieve this, Fluvial Systems (2009) used the ‘analog or carbon-copy approach’ with the two diversion channels being (as close a possible) carbon copies of the two sections of the existing channels that they would replace.

- The rationale for adopting this approach was that the diverted sections of Bowmans Creek should behave similarly to the existing sections that they would replace.
- Provision of near identical morphology and sediment transport processes would also mean minimal change to the availability of hydraulic habitat for biota.
- Due to space limitations, it was not possible to design the proposed Eastern Diversion to the same length as the existing channel it would replace, so it was shortened by about 35 percent. The proposed Western Diversion would be 7 percent shorter than the existing channel that it would replace.
- It was recommended to the design team that the diversions should contain large woody debris structures, rip-rap protection on the outside of the tighter bends, and large rock positioned within riffles to act as controls against incision.
- The bed material would be composed of material similar in size to that found in the existing creek.

Fluvial Systems (2009) also notes that: *the channel design incorporates elements that will reduce the risk of excessive geomorphic instability. These include one rock grade control structure on the downstream end of the Eastern Diversion, rock bars to stabilise the locations of riffles and prevent upstream migrating incision, rock beaching on the outside of meander bends, soft treatments (such as jute matting) on bare surfaces to provide temporary stability until vegetation becomes fully established, and a thicker channel bed sediment layer where local scour holes are expected to form in the vicinity of large woody debris structures.*

All the rock bar and rock grade control measures have been designed to be ‘fish friendly’ by incorporating minimal grades (generally less than 1 in 20) and by provision of irregular flow paths plus resting pools through the structures. Riparian vegetation will be planted to provide protection and shading for fish passing through these sections. The use of engineered log-jams will provide additional resting and shelter areas for passing fish.

Initially, flow will be directed into the diversion channels by means of low level temporary block banks across the existing creek), to direct all flows to around 1 in 6 months into the diversion channel. In order to minimise the risk of damage to the diversions as a result of flooding during the establishment phase, the permanent block banks will not be completed until about Year 4 (but see caveat below). The block banks will be constructed to a level approximately the same as the surrounding floodplain, which corresponds to about the 5 year ARI flood level. Floods in excess of 5 year ARI will spill over the block banks and floodplain and into the existing creek.

The timing for construction of the upstream block banks will also be dependent on the rate of leakage occurring to the mine. If groundwater monitoring indicates that significant leakage is occurring (or starting to occur) the permanent block banks would be constructed as soon as practical.

Construction and initial revegetation of the diversion channels will occur over a total time of about six months, commencing with the Eastern Diversion. Bulk earthworks construction will be undertaken using scrapers that will place the extracted alluvial material in stockpiles for subsequent filling of depressions in the landscape that result from subsidence. Following bulk earthworks, excavators and trucks will be used to excavate the base of the channel, place a layer of geosynthetic clay liner beneath the base of the channel and recreate a complex topography of cobble bars, pools and riffles that mimic the geomorphic characteristics of the existing creek (see Figures 3 and 4). Revegetation of the diversion channels will be undertaken progressively and will follow immediately after the construction of the base of the channel.

The downstream block banks are required to prevent backflow into the excised portions of creek, once significant leakage from the alluvial to the mine commences. Once significant leakage starts to occur, the excised portions of creek will no longer provide much useful aquatic habitat and will start to revert to floodplain woodland. The downstream block banks would not be constructed until around four years after construction of the diversion channels, in order to allow aquatic fauna to utilise the sections of excised creek and continue to move down steam from the blocked sections of the existing channel during floods. The construction of the downstream block banks will also be delayed until monitored groundwater levels indicate that leakage of groundwater to the Permian rocks is occurring or immediately prior to mining of the Upper Liddell seam, whichever occurs first (see Section 4.1.2 below). They will each incorporate a culvert with a flap gate to allow rapid drainage after floods.

Once the diversions have been constructed, Bowmans Creek between the New England Highway and the Hunter River will comprise the following sections (working downstream):

- Approximately 175m of existing channel incorporating the large pool at the SM4/BC1 sampling sites.
- 830m of the Eastern Diversion running in a southerly direction (see Figure 3).
- 125m of an existing “off line” lagoon.
- 1200m of existing creek channel running generally in a westerly direction
- 780 m of the Western Diversion running in a north-south direction (see Figure 4)
- 2535m of the remaining existing creek channel running in a southerly direction to join the Hunter River.

4.2 Proposed Mining

Mining will be undertaken by means of 210m wide longwall panels over four seams. As shown in Figure 1, none of the full width longwall panels will run under the diversions or the sections of the creek that will be retained. Where mining occurs under sections of the existing creek that are retained, mini-walls will be used to connect between full width longwalls. Subsidence will occur progressively in four phases with an interval of approximately four years between successive phases (see Appendix 4 Subsidence Assessment of the EA).

As a subsidence trough is formed, the ground surface is subjected to certain tilts and strains depending on the geology, depth of cover, panel dimensions and position above the panel. Sub-surface cracking can then influence both surface water behaviour (by diverting water into the ground and possibly into the mine) and groundwater (by alteration to groundwater conductivity and by loss of groundwater to the mine works).

For purposes of assessment of subsidence impacts, panels were assumed to have a worst-case configuration in which panels in each successive seam are stacked vertically beneath the one above. Maximum subsidence, tilt and strain over the centre of full width longwall panels would increase incrementally as summarised below (Section 2.3 in the EA and Appendix 4 to the EA).

Seam	Max Subsidence (m)	Maximum Tilt (mm/m)	Maximum Strain (mm/m)
Pikes Gully	1.6	70	30
Upper Liddell	3.7	150	70
Upper Lower Liddell	5.8	240	110
Lower Barrett	8.3	350	160

With stacked arrangements, subsidence above the chain pillars would be less than 0.6 m (provided the chain pillars remained stable). If the full-width longwall panels in the lower seams are offset, the subsidence profile is expected to be generally smoother and the total subsidence may be slightly less as a result. The proposed mining geometry is expected to maintain subsidence at less than 0.2m along the edge of the excavation for either of the diversion channels. Subsidence beneath the low flow channel is expected to be minimal.

As a result of subsidence, parts of the creek diversion would be elevated above the adjacent flood plain. Therefore rainfall or water overtopping Bowmans Creek during a flood event would flow down into the subsidence troughs.

Aquaterra (2009) described the groundwater resources of the study area (summarised in Section 3.1.2 above). Their assessment of the effects of multi-panel mining on groundwater resources provides the following conclusions:

- The Bowmans Creek alluvium would be largely de-watered by the end of full-width longwall mining, with saturated alluvium remaining in a small area of creek between the two diversions and at the southern end of the creek, between the Hunter River confluence and the western diversion (but with drawdown impacts between 0.5 to 2m).
- There are minimal impacts on the Hunter River alluvium.
- Whilst there will be some minor decreases in post-mining recovery base flows, the lack of saline upflow at the end of the post-mining recovery period represents an

improvement in water quality in comparison to the baseline condition. This has implications for Bowmans Creek water quality during drought and low flow periods in that the lower base flows will result in an improvement in water quality compared to baseline conditions.

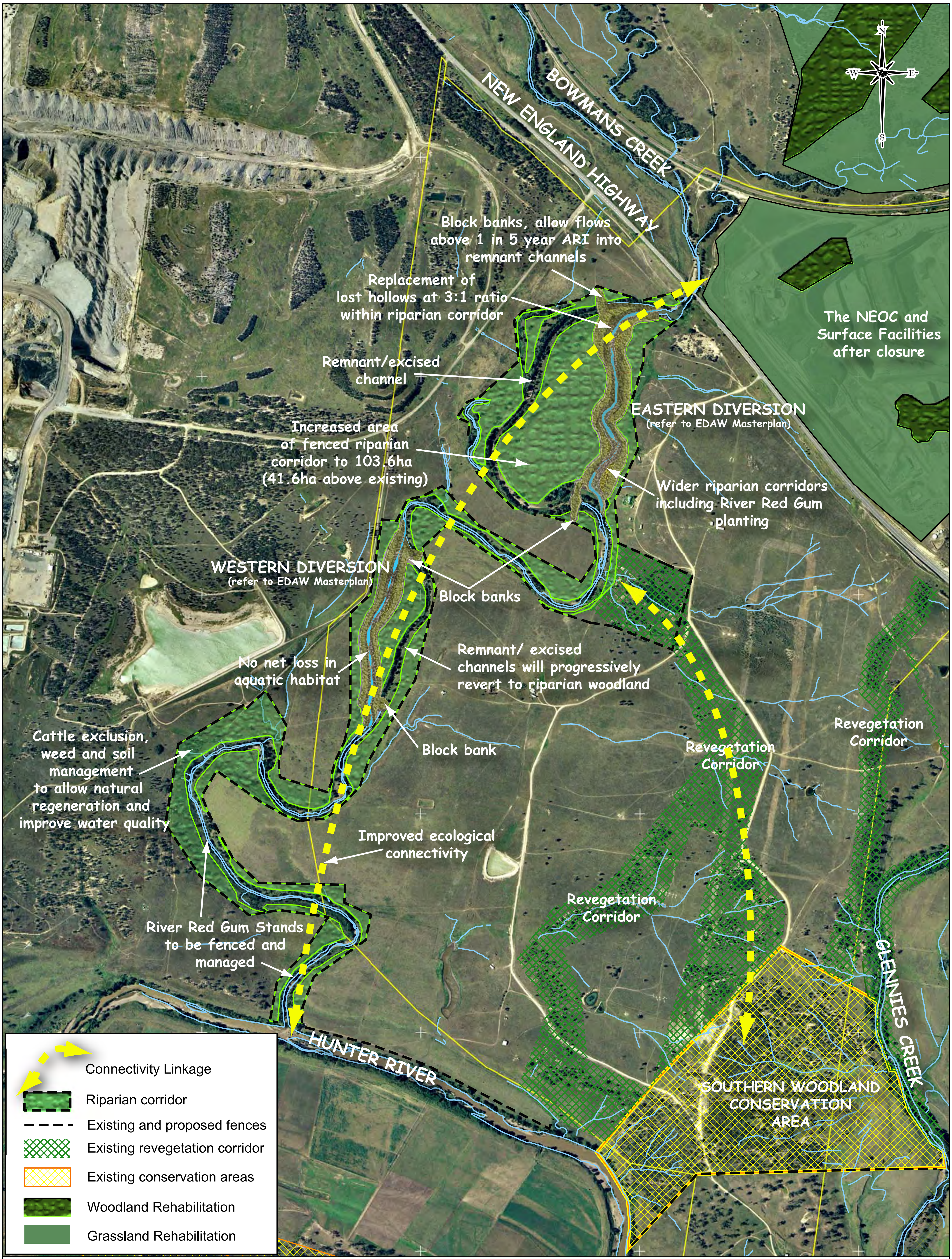
For the remaining creek sections not being excised and that overlay miniwalls (MW5, MW6 and MW7), there will also be progressive subsidence but not at the levels expected from the full-width panels. Thus maximum subsidence (after mining the Lower Barrett seam) would be about 0.4 m. The following actions will be implemented to minimise physical impacts from subsidence:

- Installation of a low permeability clay barrier beneath the diversion channel in order to minimise the loss of flow from the creek into the alluvium.
- Small scale draining works and filling of subsided areas of the floodplain will be undertaken to create a free draining landscape and obviate the potential for pooling of water on the surface.
- Inspection for surface cracking and stepping after completion of each panel in each seam and remediation where required to reduce the potential for water ingress or to prevent trapping animals.

4.3 Impacts on Riparian and Aquatic Ecosystems

This section summarises the potential alterations to riparian and aquatic ecosystems and Section 4.4.1 quantifies potential losses and gains of habitat. Figure 5 shows the inter-relationship of the completed diversions with the total Bowmans Creek and ACOL underground mining lease area including the inter-relation of riparian corridors to existing ACOL terrestrial Conservation areas and corridors. The main physical impacts of the diversion proposal and the proposed mitigation measures are as follows:

- Disturbance and loss of pasture grass habitat to the construction footprint of the two diversion channels. This will include the channel alignments themselves, associated roadways into the construction zone, construction compounds and stockpile placement (see Figure 5). Much of this loss will be mitigated by conversion of excised pasture land to new riparian and aquatic habitat and to floodplain grassy woodland.



AshtonCoal

Bowmans Creek Diversion Project

Figure 5
Post Mining Landscape and Connectivity

Prepared by Wells Environmental Services
CAD FILE: WES.ai

- There will also be a loss of some riparian fringing woodland habitat at the start and end sections of the diversion channels where they are to be integrated into the existing creek channels. This loss will be minimised by avoidance where possible and the remaining area will be rehabilitated as riparian woodland and extended up slope as part of the diversion landscaping plan.
- Potential disturbance of some creek aquatic habitat to construction impacts associated with dust, construction site and stockpile surface water runoff. These will be mitigated to insignificance by normal construction mitigation measures as outlined in Section 11 of the EA.
- Progressive physical disturbance and alteration of some fringing riparian woodland habitat along the sections of excised creek to floodplain woodland, arising from both mining subsidence impacts (cracking, tilting) and altered water balances. This will be mitigated by both including this land into the existing riparian corridor system for ACOL and by active rehabilitation management measures for the corridors as detailed in the existing ACOL Flora and Fauna Management Plans.
- Temporary loss of pasture grass habitat to filling on the floodplain in order to create a free draining landscape. This loss will be mitigated by restoration of some of the land to active pasture land and by incorporating some of the land into the existing ACOL flora and fauna corridor system that will be managed as part of the ACOL Flora and Fauna Management Plans.

Alteration to the aquatic ecology of the portions of excised creek arising from changes in the water cycle, prevention of upstream fish passage and limitations or barriers to downstream fish passage. This will change progressively as multi-seam mining progresses, as subsidence/cracking impacts increase incrementally, and as block banks are progressively constructed to prevent water drainage to the working mine. These changes will be complex as there are a number of factors at play to change the water balance of the creek pools:

- As a result of drainage of the alluvial groundwater and of surface water loss to cracking from subsidence, there will be progressive increasing leakage from the excised sections of the creek.
- As the excised portions of creek channel will not be filled, the bases of some pools in the existing creek sections will subside relative to the riparian banks, deepening any remaining pools.
- Lowering of the water table can be expected to result in some additional loss of trees around the excised portions of the creek, which, whilst not dependent on

groundwater pre-mining and diversion, could become dependent on groundwater when their main surface water sources have been altered due to the diversions.
- The relationship/interconnection of pools remaining within the excised portions of creek will change, as subsidence impacts are not uniform over each mining panel. Thus there will be much less subsidence in creek sections overlying longwall edges (e.g., the section of creek between LW6B and 7B).

Following cessation of mining, post-mining subsidence and of fill placement to achieve self-draining of non-creek areas, there will be further complex changes to the riparian and aquatic ecology of the excised sections of creek in the Bowmans Creek floodplain as water losses to the mine works become progressively less due to 'self-healing' via a number of mechanisms including clay and silt plugging of small cracks and fissures. Also, there will be progressive change in both the Permian and the shallow alluvial water tables as similar mechanisms of self-healing reduce overall conductivity leading to changes in the balance of infiltration and down-dip flow losses.

With regard to aquatic and riparian ecosystems in the remaining creek sections not being excised but overlying mining (i.e., overlying miniwalls MW6 and MW7), it is considered that this will not exacerbate the diversion related impacts discussed above in any significant way:

- Lowering of sections of creek above miniwalls results in slightly deeper pools, new pools or steeper riffle sections between pools, depending on the location of miniwalls with respect to overlaying pool morphology. Both miniwalls underlie existing shallow pool sections and the predicted minor subsidence can be expected to deepen these pools (by up to 0.4 m extra depth) without affecting inter-pool connectivity. Overall this is considered to be a positive impact.
- Destabilisation of steep unconsolidated banks with resultant accelerated bank erosion and increased sedimentation from subsidence within the creek bed above miniwalls is not expected as there are no steep banks. Thus there is not expected to be any significant impact on riparian banks or on riparian vegetation.
- Miniwalling will not result in any significant fracturing or increased conductivity between the alluvium and the Permian. However, the overall drawdown of the water table in the alluvium arising from adjacent full-width longwall mining could result in some water loss from the creek to the alluvium. Given the increase in creek pool volumes (as noted above) this loss is likely to be balanced out, resulting in an overall neutral impact.
- Altered water quality arising from increased leakage water percolating laterally through fractured rock or alluvium and re-emerging further downstream. In this

respect, mining under Bowmans Creek and the associated predicted subsidence will have the effect of reducing base flow from the Permian sediments to Bowmans Creek and therefore mining will cause a net salinity decrease in Bowmans Creek.

4.3.1 Quantification of Potential Habitat Losses and Gains

With regard to creek-line aquatic habitat losses and gains, Table 4 provides an account of the existing and final connected aquatic habitats in terms of creek length.

Table 4 Existing and Proposed Reaches of Bowmans Creek

Reach		**Existing Length (m)**	**Proposed Length (m)**
A	Channel downstream of New England Highway (to ED confluence)	176	176
B	Creek between ends of Eastern Diversion (proposed length is new constructed length)	1,480	955
B1&B2	Creek Eastern Diversion backwaters	0	260
B3	Old oxbow to be reconnected for diversions	0	125
C	Existing channel flowing east – west (Eastern Diversion to Western Diversion)	1,196	1,196
D	Creek between ends of Western Diversion	838	779
D1&D2	Creek Western Diversion backwaters	0	125
E	Channel from Western Diversion confluence downstream to Hunter River	2,535	2,535
Length of Creek (Hunter to NE Highway)		**6,225**	**5,641**
Length of Off-line Creek Habitat		**0**	**385**
Total Length of Connected Creek Habitat		**6,225**	**6,027**

The existing creek has a thalweg distance of 6225m between the New England Highway and the Hunter River. The proposed diversions will excise 1933m of Bowmans Creek riparian and aquatic habitat and replace it with 1509m of constructed creek-line in two diversion channels. These lengths have been achieved by mimicking the existing channel sinuosity.

By directing the lower end of the Eastern Diversion into an existing section of oxbow creek and reconnecting this to the existing creek, an additional 125 m of in-line creek length is obtained making the overall direct line connection from the Hunter River to the New England Highway 5,641m. By offsetting the upper and lower block banks for both the diversions, up- and down stream from their respective confluences, an additional 385m of off-line creek and riparian habitat will also be retained, resulting in a total of 6026m of creek and offline lagoon riparian and aquatic habitat.

Thus, there will be a net loss of 198m of aquatic habitat (or about 3.2% reduction compared to the existing creek. However, this loss is being offset by incorporation of the following design elements:

- Ensuring that there is no reduction in actual aquatic habitat area; thus under the 1in1year ARI flood condition and comparing two sections of creek that include both diversions, there is 8.3ha of available aquatic habitat in the existing creek and following construction of the diversions there will be 8.4ha of aquatic habitat (i.e., a net increase in aquatic habitat within the diversions of 0.1ha).
- Incorporation of off-line 'resting pools' (absent in the existing creek) that will be available for fish migrating upstream during low to moderate flow events (up to a 1 in 5 year ARI flood event). These will be located at four well-spaced places along the route from the Hunter River to the New England Highway. This is an important feature as, under the current condition, fish need to traverse these creek lengths against channel velocities of up to 1.9m/s (for 1in1y ARI) and up to 3m/s (for 1in100y ARI).
- A significant improvement in riparian habitat condition and cover (see below).
- Incorporation of fish friendly riffle and rock bar structures that will ensure fish passage is available under similar medium flows to the existing creek (that is, as is currently available).

The remaining excised sections of creek will be retained as high flow channels. For the early years whilst the new creek diversions are settling and whilst the riparian revegetation is establishing, it is intended that the excised creek will take a proportion of the flood flows above the 1in six month ARI flood level. At final configuration, when all the block banks are in place, the excised creek channels will take a proportion of flood flows above the 1in5 year ARI. As there will be mining under the excised portions of creeks, the ability of these creek portions to retain water will become progressively less over the mining sequence. Accordingly, there will be less viable aquatic habitat available and the excised creek sections will revert to floodplain woodland. The excised sections of creek plus the floodplain lands between the excised creeks sections and the diversions will be incorporated into the overall conservation lands established by ACOL. This will be actively managed as part of the existing ACOL Environmental *Management Strategy (ACOL 2006a)* and the EMPs established under the EMS such as the *Subsidence Management Plan*, and the *Flora and Fauna Management Plan* (ACOL 2006c).

Table 5 sets out the losses and gains in terrestrial habitat arising from the proposed creek diversions. In broad terms and before application of offset measures, construction of the proposed diversions, as shown in Figure 5 will result in the excision of about 28.5ha of predominantly pasture grass habitat (for combined diversion construction and material stockpiles plus up to 1.8ha of mixed aquatic and riparian habitat:

- The diversions will be built over pasture habitat and there will be a net loss of 13.9ha of pasture habitat to the diversion footprints.
- The interconnection of the diversions to the existing creek plus the construction of the block banks would affect up to 1.8 ha of riparian woodland habitat although the actual area to be lost would be less, as parts of the construction works would be able to be undertaken without affecting riparian vegetation (e.g., on the banks opposite to the connections).
- There will be an additional 14.6 ha of pasture grass land alienated for stockpiling materials excavated from the diversions channels and for construction related activities (access tracks and a construction compound).

Table 5 Vegetated Habitat Losses and Gains

Construction	Losses (ha)			Mitigation/offset (ha)			
Item	Pasture Grass	Aquatic & Riparian habitat	Total	Pasture Grass	Aquatic & Riparian habitat	Floodplain Woodland	Total
Diversions*	13.9	<1.8	<15.7	0.0	15.7	0.0	15.7
Stockpiles	14.6	0.0	14.6	9.9	0.0	4.7	14.6
Totals	28.5	<1.8	<30.3	9.9	15.7	4.7	30.3

Both the partial loss or alteration of creek aquatic and fringing riparian woodland habitat will be off-set by the provision of similar or better aquatic and riparian habitat along the proposed creek diversions:

- Whilst the provision of diversion channels to ‘short-cut’ sections of the existing creek result in the overall shortening of the creek length between the Hunter River and the New England Highway, the actual resultant creek length with regard to aquatic habitat directly available to passing fish will be reduced by less than 200m. This is achieved by offsetting the block banks with regard to the diversion channel confluences, to retain the long T shaped confluence pools at both the upstream and downstream ends (see Figures 3 and 4).

- The inclusion of the offset channels ensures that there is no significant reduction in actual aquatic habitat area; thus under the 1 year ARI flood condition, whilst there is a reduction in the lower active floodplain area from 6.7ha to 6.4ha, the design provides a net increase of an estimated 0.19ha in the area of pools available (from 0.91ha to 1.10ha).
- The net balance in riparian woodland habitat will be improved as a result of the creek diversions, as the width of the riparian woodland zone along the banks of the diversion sections will be increased compared to the narrow existing fringes along the sections of excised creek (around 45m for total width of creek plus both riparian banks). Thus for the Eastern Diversion the riparian vegetated width will be planted out to a minimum of 93m and for the Western Diversion the riparian width will increase to a minimum of 75m. Thus the 13.9ha of pasture grass to be lost to the diversions will be rehabilitated/constructed as 13.9ha of aquatic and associated riparian woodland habitat.
- The proposed diversion will also be planted out to achieve an overall net increase in Hunter River riparian woodland and in Hunter River Red Gum populations. For the diversions alone there will be 15.7ha of this combined high quality aquatic and riparian habitat.

Additional fencing for stock exclusion will provide a greater buffer area of (current) floodplain pasture where natural regrowth of grassy floodplain woodland can occur. This land will be managed under the existing ACOL Environmental Management Strategy (ACOL 2006a) and the relevant Environmental Management Plans (EMPs) established under the EMS (ACOLb,c,d,e). The fencing-off will have the effect of converting 54ha of pasture land to combined riparian woodland and grassy floodplain woodland (Figure 5):

- The expanded width riparian zones along the diversions channels and along the complete creek will be incorporated into the existing ACOL vegetation and terrestrial corridors that have already been fenced off and in which woodland re-vegetation is currently being managed (ACOL 2006c).
- The proposal also incorporates fencing of the complete riparian zone through the ACOL lease area (around the diversions, the excised creek and the remaining creek) to exclude stock, with both active and managed riparian revegetation to increase the current existing average riparian vegetated strip width of 45 m (bank to bank).
- Stock damage to riparian creek edges and to the creek bed will be further minimised by reducing access to the creek to as few points as possible for overcrossing. Stock access for watering will also be minimised by provision of on-demand watering points away from the protected riparian zones.

- The excised sections of creek plus the floodplain lands between the excised creeks sections and the diversions will also be incorporated into the overall riparian and terrestrial corridor system already established by ACOL. These lands will be actively managed as part of the existing ACOL Subsidence Management Plan and the ACOL Flora and Fauna Management Plan (ACOL 2006).
- Areas of fill placed on the floodplain to maintain self-draining will also be planted out as floodplain grassy woodland.

In summary, the loss of up to 1.8 ha of riparian and aquatic habitat plus 82.4 ha of actively stocked pasture grass habitat (to the diversions, construction lands, stockpiles and fenced off corridor land) will be replaced with 15.7 ha of combined aquatic and riparian woodland habitat plus 58.7ha of mixed riparian woodland and grassy floodplain woodland and 9.9 ha of land lost to temporary stockpiles will be restored as actively stocked pasture land.

4.5 Threatened Species, Communities and Processes

The sections of creek to be excised currently provide viable fish passage for native fish and aquatic habitat for aquatic plants and invertebrates. The creek sections provide fish passage between the Hunter River and upstream Bowmans Creek catchment and fish breeding habitat (e.g., for catfish *Tandanus tandanus*). The fringing riparian woodland habitat, whilst narrow and fragmented in places, provides foraging and feeding resources for a variety of terrestrial animals including seven threatened species known from the locality.

Threatened Species Conservation Act 1995

The ‘River Red Gum population in the Hunter Catchment’ is listed as an endangered population under the *Threatened Species Conservation Act 1995* (TSC Act), and the two strips of River red gum downstream of the diversions and outside the ACOL lease area have been identified to be part of this endangered population for previous mine related surveys (ERM 2006, 2009). Management of this endangered population forms part of an existing flora and fauna management plan for the approved underground mining activities (Ashton Coal 2006). The relationship of the two river red gum stands to the study area is summarised in Section 3.2 above. Seven-part testing for the Red Gum Endangered Population is included at Annexure B to this report. Whilst the creek diversion works would not affect the downstream Red Gum Endangered Population, the seven-part testing provides a number of measures to improve the overall health of the remaining stands including protection from browsing stock. These measures have already been included into the overall ACOL EMS and EMPs and are being implemented under the existing Flora and fauna Management EMP (ACOL 2006b).

Seven threatened fauna species listed under the TSC Act have been identified as likely to occur within the study area or locality, *Pteropus poliocephalus* (grey-headed flying-fox), *Miniopterus schreibersii oceansis* (eastern bentwing-bat), *Mormopterus norfolkensis* (eastern freetail-bat), *Myotis macropus* (large-footed myotis), *Pyrrholaemus sagittatus* (speckled warbler), *Melanodryas cucullata cucullata* (hooded robin) and a breeding population of *Pomatostomus temporalis temporalis* (grey-crowned babbler eastern sub-species.

The relationship of the seven listed species to the study area is summarised in Section 3.2 above. Seven part testing for the threatened species are included at Annexure B to this report, and it is concluded that whilst the subject habitats provide foraging and feeding habitat for the listed fauna, the habitats are not prime habitat and therefore the loss of the habitats are not likely to result in the loss of local populations. The conclusion of the seven part testing is that safeguards can be incorporated into the management of the diversion construction to minimise disruptions to the local populations of the species and that the provision of overall increased riparian and floodplain woodland habitat will benefit all the species. The seven-part testing also recommends harvesting, management and reuse of species-specific resources such as, e.g., fallen logs, trees with roosting hollows and old fence poles. This is in line with provisions already incorporated into existing ACOL EMPs (ACOL 2006a,b,c,d,e), particularly the Flora and Fauna Plan of Management (ACOL 2006b) and the Landscape and Revegetation Management Plan (ACOL 2006d).

Fisheries Management Act 1994

As noted in Section 3.7, no species of fish or aquatic invertebrates, as currently listed under the NSW Fisheries Management Act 1994 (FMA) were recorded in any of the Bowmans Creek monitoring conducted to date, and no protected fish, as listed under the FMA, have been found or observed in Bowmans Creek. It was also noted in Section 3.7 that southern purple spotted gudgeon (*Mogurnda adspersa*) have recently been reported in the next major creek system to the east of the upper Bowmans Creek; in Goorangoola Creek, a major sub-catchment creek discharging to Glennies Creek (HCR-CMA Catchment News, Issue 17 May 2009). Section 3.7 includes consideration of the likelihood of this species being found in Bowmans Creek:

- Whilst its location in upstream Bowmans Creek sites cannot be discounted, to date this species has not been recorded in the Bowmans Creek study area from any of the fish surveys undertaken between Spring 2005 and Autumn 2009.

- If there are southern purple spotted gudgeons in Bowmans Creek, then it is more likely that they would be found in the upper reaches of the creek.

It is concluded that the proposed creek diversions are not likely to have an impact on any local population of this species.

Two fish species known or reported from Bowmans Creek are listed as species of concern in Morris *et al* 2001; The Darling hardyhead and the Freshwater catfish:

- The Darling hardyhead (*Craterocephalus amniculus*) is listed due to its taxonomic uncertainty. It is endemic to streams in the upper Darling River system. Specimens tentatively identified as *Craterocephalus amniculus* were collected from upper Bowmans Creek in 1976 and 1980, though no further individuals have since been collected (cited in Morris *et al* 2001). This species has not been observed or caught in any of the ACOL surveys (from 2005 onwards) and was not caught during the electro-fishing surveys of the creek in (2005-2006). Accordingly the possibility of this species being found in the study area is considered unlikely.
- Morris *et al* 2001 note that whilst coastal river freshwater catfish (*Tandanus tandanus*) populations are not currently listed as threatened in NSW, this species' distribution and abundance has been significantly reduced throughout the southern parts of its known range. This species has been recorded from a refuge pool located between BC1 and BCMW7 during the autumn 2006 drought, nests and adults were observed at site BCMW8 and juveniles were caught at Site BCdown, both sightings in spring 2008. Accordingly, the proposed creek diversion will be incorporating cobble bottom pools suitable for catfish nesting.

Key threatening Processes under the TSC and FMA

Of the possible likely threatening processes listed in Section 9.1.5 the proposed creek diversion works would 'alter the natural flow regimes of rivers, streams, floodplains & wetlands', would involve 'clearing of native vegetation' and could involve removal of dead wood and dead trees'. In regard to the possible impact on threatened species arising from these actions, the proposal has incorporated design and safety features to ensure that:

- The project will not alter the flow regime in Bowmansa Creek (except for minor increase loss to groundwater).
- There will not be any deterioration in key aquatic and fish habitat attributes arising from the proposal;

- Managed harvesting and reuse of dead wood and dead trees will be undertaken and the overall roosting facilities of the site will be increased,
- There will be more riparian and floodplain woodland habitat available to support local populations of threatened species; and,
- The new habitats will be an improvement over the present degraded or limited habitats, e.g., providing more habitat complexity, incorporating specific species' requirements (such as roosting sites, tree hollows and resting pools). Aquatic habitats will have better riparian bank stability and cover.

Accordingly it is concluded that the key threatening processes arising from the project construction will not impact local threatened species and that the design, rehabilitation and restoration works will enhance the feeding, foraging and roosting attributes for local populations of listed species.

Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act 1999

With respect to species listed under the EPBC, seven migratory bird species are identified as having the potential to occur within 10 kilometres of the site. Five of these are terrestrial birds and two are wetland birds. Habitat for the wetland birds (Latham's Snipe and Painted Snipe) is not provided on the site.
The terrestrial migratory birds are:

- *Haliaetus leucogaster* (white-bellied sea-eagle);
- *Hirundapus caudacutus* (white-throated needletail);
- *Monarcha melanopsis* (black-faced monarch);
- *Myiagra cyanoleuca* (satin flycatcher); and
- *Rhipidura rufifrons* (rufous fantail).

These species are wide-ranging with generalist habitat requirements and may occasionally use the site as foraging habitat. However, as the distribution of vegetation communities that occur on the site is not confined to the site, it is concluded that the proposed creek diversion works will have no significant impact on these migratory species.

5 MITIGATION AND MONITORING OF POSSIBLE IMPACTS

The net balance in regard to biodiversity conservation arising from the creek diversion proposal was summarised in Section 4.4.1 above. There will be a marginal loss of existing viable aquatic habitat area of some 200 m length, with a net gain of viable fringing riparian woodland habitat area along Bowmans Creek of at least 16 ha. In area terms, the loss of up to 1.8 ha of riparian and aquatic habitat plus 82.4 ha of actively stocked pasture grass habitat (to the diversions, construction lands, stockpiles and fenced off corridor land) will be replaced with 15.7 ha of combined aquatic and riparian woodland habitat plus 58.7ha of mixed riparian woodland and grassy floodplain woodland and 9.9 ha of land lost to temporary stockpiles will be restored as actively stocked pasture land.

Both fish passage and aquatic habitat values are expected to be improved by virtue of the design features of the diversion creeks and as a result of the improved riparian habitats along the diversion creek banks which will have overall greater complexity, provide greater bank stability and provide better creek shading. In order to protect water quality in Bowmans Creek, livestock will be excluded from the riparian and creek areas with provision for on-demand stock watering facilities away from the riparian zone where required. There will be progressive management including targeted revegetation, harvesting and re-use of tree hollows plus fallen logs and any isolated rocks within the creek riparian corridors as per the existing ACOL Environmental Management Strategy (ACOL 2006a) and the relevant Environmental Management Plans(EMPs) established under the EMS (ACOL 2006b,c,d,e). Section 5.1 provides a summary of the relevant plans.

The sections of excised creek and riparian woodland habitat will continue to provide some aquatic habitat and riparian woodland function and will progressively change to a combination of riparian and grassy floodplain woodland, which will be flooded during flood events over 1 in 5 year ARI:

- The viability of the remaining aquatic habitats and fringing riparian woodland in these sections of excised creek will be protected by stock exclusion and targeted riparian plus floodplain planting based on monitoring of mining related impacts to achieve overall retained pond bank stability, plus stability and enhancement of retained riparian woodland to include provision of shade over the ponds to inhibit algae growth. This work will be done under the existing ACOL EMS and related EMPs (ACOL 2006a,b,c,d,e).
- Where subsidence induced pond formation occurs in the excised creek sections, riparian revegetation techniques (stock exclusion and provision of edge and emergent vegetation) would also be undertaken as necessary, under the existing

ACOL EMPs. As per the EMPs, field assessments would be made of the areas overlying longwalls and miniwalls at the completion of each mining pass, to ascertain the extent of subsidence impacts on excised creek and riparian channel ecosystems and targeted riparian or habitat enhancement/protection measures would be recommended.

In order to ensure the viability of the River Red Gum population and of the identified threatened fauna in the locality that utilise the woodland resources of the study area, active management - as detailed in the ACOL EMS and the related EMPs (ACOL 2006 a.b.c.d.e) - will be undertaken on the remaining floodplain areas impacted by mining or mining related activities (such as filling to achieve self-draining). These include the following:

- There will be fencing of the identified lower creek riparian habitat and River Red Gum communities with exclusion of stock access to improve juvenile River Red Gum recruitment to the area. The overall River Red Gum (*E. camaldulensis)* population will be enhanced by planting on the stream and upper banks of the Bowmans Creek Diversions.
- Provide connecting woodland corridors to other riparian and grassy woodland remnants (as already being undertaken by ACOL). The width of the woodland in the existing riparian corridor habitat will increase and the regeneration of the riparian corridor will include structural diversity at all strata.
- Additional floodplain grassy woodland habitat will be created on the areas of fill by selected planting to enhance the foraging habitat for listed woodland birds (particularly the Grey-crowned babbler), bats and flying foxes known from the locality. These woodland habitats, particularly those with unimproved pasture and an intact native ground plant layer will be fenced off and incorporated into the ACOL corridor system.
- The creation of new woodland on the floodplain will also include the creation of perch sites for the Hooded Robin, such as small piles of fallen timber (transported here from a felling site) and the re-erection of old fence posts along the Bowmans Creek. Dead timber will be left on the ground in open woodland areas and firewood collection will be prohibited.
- Regeneration of planted grassy woodland habitat will be encouraged by fencing remnant stands. This will enhance the habitat for the Speckled Warbler populations.
- Stock will be excluded from the Bowmans Creek riparian corridor in the lease area and down to the Hunter River where possible to protect the integrity of the riparian banks and prevent excessive nutrient inputs to the stream. Stock will also be

excluded from floodplain grassy woodland rehabilitation areas. On-demand watering will be provided for stock on adjacent lands as required.

5.1 Ashton Coal Project Environmental Management Strategy

The ACP EMS (ACOL 2006a) sets out the objectives for improving ecological values within the Ashton Coal Project lease areas (ACP):

- *Improving the quality of existing vegetation by the control of weeds, planting and allowing natural revegetation by managing grazing; and*
- *Improving habitat for fauna by improving connectivity between remnants, rehabilitating mined areas and the control of feral animals.*

The long term objective is to increase the present area of woodland, including areas of revegetation that will be woodland once mature, whilst maintaining and enhancing the current level of prime agricultural land. Appropriate planting of tree corridors will assist fauna migration without significant detriment to the agricultural value of the land.

The EMS outlines a set of Environmental Management Plans (EMPs) that contain specific strategies to encourage and enhance the natural ecology within the ACP lease area. The success of these strategies is being monitored on a periodic basis and plans developed to address any identified issues would be implemented in a timely and professional manner. They also include strategies to control feral animals, noxious weeds or agricultural practices that may degrade the habitat value of remnant or existing vegetation.

Key Environmental Strategies relevant to the Bowmans Creek Diversion project in the EMS are specified as follows:

Some sections of Bowmans Creek will be subjected to subsidence as a consequence of the underground mining that will occur in the vicinity. This will result in a chain of ponds that will provide drought refuge for aquatic fauna.

- *Selective planting of vegetation will enhance the riverine ecology.*
- *Stream Monitoring and Aquatic Habitat Monitoring programs will be established to measure the success of this concept and to identify any improvements that may enhance the ecological outcomes*. This has included baseline flora and fauna (and aquatic ecology) surveys plus physical base-line surveys of Bowmans Creek to identify all pools, ripples, rock structures etc.

Mine subsidence has the potential to cause erosion through nick points, slumping or scouring within and along the banks of Bowmans Creek.

- *Tree, shrub and grass planting will be increased around potential pressure points whilst erosion will be controlled via the implementation of the approved Erosion and Sediment Control Management Plan and the Landscape and Revegetation Management Plan.*
- *Planned fencing of Bowmans Creek for livestock exclusion will include provision of alternative stock watering points (if required) and the development of a weed management strategy that accounts for areas not subjected to grazing pressure.*
- *Stock shade trees will also be planted where required.*

Endangered Flora and Fauna.

- *A Habitat Monitoring Program has been established to document the habitat areas on site. This has been extended to address on-site aquatic habitats in Bowmans Creek.*
- *The planting of trees in both the southern and northern areas of the project will provide long-term habitats for endangered fauna, such as the grey-crowned babbler, squirrel glider, glossy black cockatoo and speckled warblers.*
- *The planting of trees will accord with the concepts presented in the Upper Hunter*
- *Synoptic Plan developed by DMR. This will provide travel routes via habitat corridors for a variety of fauna.*

Relevant EMPs that have been established under the EMS include the following:

- Ashton Coal (2006b) Flora and Fauna Management Plan. An EMP prepared to meet Condition of Approval 3.46:

  > *"The Applicant shall prepare and implement a Flora and Fauna Management Plan(FFMP) for the DA area. The Plan is specifically required to outline procedures for clearing or disturbing vegetation and other habitat types, along with measures for habitat reinstatement and management".*

  This EMP details the basis for biannual terrestrial, riparian and aquatic flora and fauna monitoring programs to be undertaken pre-, during and post long-wall mining and these programs have been underway since 2005 - see ERM and MPR biannual reporting in References.

- Ashton Coal (2006c) Landscape Management Plan. An EMP prepared to meet Condition of Approval 3.58:

  "The Applicant shall, prepare a Land Management Plan (LMP) for the areas of the proposed surface facilities, and its holdings in the DA area, to provide for proper land management in consultation with DLWC, NSW Agriculture, NPWS, and SSC, and to the satisfaction of the Director-General.".

  This EMP sets out the objectives and performance outcomes for landscape management.
- Ashton Coal (2006d) Landscaping and Revegetation Management Plan. An EMP prepared to meet Condition of Approval 3.52:

  "The Applicant shall carry out rehabilitation of all mine areas in accordance with the requirements of any Mining Lease granted by the Minister for Mineral Resources and ensure the progressive rehabilitation of the area is also to the satisfaction of DLWC."

  This EMP sets out the objectives and performance outcomes for landscaping and revegetation management.

5.2 Suggested Monitoring Program

There is an existing ACOL monitoring program for flora and fauna, stream-health and water quality and availability in Bowmans Creek, \established under the ACOL EMS and the associated EMPs. These will be continued in order to detect any possible mining or diversion related impact over the life of the mine, so as to determine the need for any specific mitigation measures as required. For example, monitoring could determine if there is a noticeable increase in saline water contribution to Bowmans Creek stream flows at any location within the study area. Also, as per the existing monitoring programs, monitoring will be extended to confirm the continuing prime functioning of the diversion creeks for fish passage and aquatic habitat provision over the critical Construction, Stream bed plus bank stabilisation and Revegetation periods.

Monitoring will be undertaken using the guiding set of criteria and protocols developed to establish the circumstances under which additional mitigation measures would be required, as already specified in the ACOL Environmental Management Plans and in existing 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 (mine-related or other cause) of deteriorating aquatic conditions;
- If mining 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 ACOL 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.

5.2.1 Stream health monitoring

With regard to water quality monitoring the existing water quality monitoring programs plus some additional site specific monitoring be undertaken:

- The combined monthly water quality monitoring program at the present 'whole of mine' ACOL Bowmans Creek, Bettys Creek and Hunter River sites will be continued. The location of monitoring sites within Bowmans Creek will be adjusted as the creek diversions come on line.
- Field water quality monitoring during the biannual aquatic ecology monitoring program will be continued and will include depth profile monitoring of field water quality parameters.
- Additional periodic field monitoring of the water quality in the subsidence-induced ponded areas within the excised portions of the creek will be undertaken.

With regard to creek surface water quantity monitoring for stream health purposes, it is considered that the present NOW weir gauge monitoring data are important (and sufficient) for enabling the interpretation of Bowmans Creek water quantity change.

With regard to aquatic ecology (stream health) monitoring, there are currently six aquatic ecology monitoring sites sampled bi-annually in Bowmans Creek (see Figure 1 above). The selection of these sites was based on the layout of an earlier mine plan. Long-term monitoring for impacts arising from the adopted mine plan and from the diversion proposal will require sequential adjustments of some of the sites and inclusion of other sites. The following modifications to the existing long term aquatic ecology (stream health) monitoring program will be incorporated into the existing program:

- The locations of the existing six long term stream health monitoring sites will be adjusted as necessary to provide up and downstream reference sites outside the lease area, and base line monitoring sites for the creek sections to be retained.
- New long term stream health monitoring sites will be established in the creek sections to be excised and in each of the proposed diversion channels to monitor developing aquatic habitat attributes against existing creek habitat attributes.
- Additional fish trapping sites will be established throughout the creek to monitor fish passage during times when the creek has sufficient flow to allow fish passage and to monitor pool refuge usage during low to no flow periods.

The existing stream health monitoring plan has a number of short-term monitoring sites that were to be introduced into the aquatic ecology monitoring program on a staged basis, that is, relative to the progression of underground mining. The number and location of these sites would also be adjusted to the new mine plan.

As per the existing monitoring program sampling of the short-term sites would be scheduled into the regular bi-annual sampling program to incorporate before, and at least two after samples from each site according to the scheduled mining program, to enable direct assessment of mining impacts on individual pools as mining proceeds and also to facilitate the interpretation of long-term monitoring results. This schedule would also be applied to the fish sampling sites. As in the existing monitoring plan any decision to continue monitoring of the short term sites beyond the two post-mining studies would be made on a site by site basis, and only if there was evidence of localised mining or diversion related impact arising from the before/after comparisons.

6 SUMMARY

The proposed creek diversions are located on the lower 6 km section of Bowmans Creek between the New England Highway and the Hunter River confluence, and this section of the creek provides the following important ecological functions:

- Fish passage between the Hunter River and the remaining 50 km of aquatic and fish habitat in Bowmans Creek plus other upper catchment tributaries upstream of the New England Highway;
- Off-line fish refuge habitat during extended Hunter River flood events;
- Fish nesting habitat in the form of gravel bars in pools;
- A measure of drought refuge habitat in the form of deeper pools;
- A complex of aquatic ecological habitats (cobble and sediment pools and riffles, rock bar pools) with varying depths and different aquatic and emergent plants to support a complex assemblage of aquatic macroinvertebrate fauna; and
- Riparian vegetation corridors, that link the Hunter River riparian flora through to the upper Bowmans Creek, and provide additional foraging and feeding habitat for woodland birds and other native fauna that live in remnant patches of woodland in the locality.

Whilst this section of the creek provides these important functions, the section is not pristine and some of these functions are compromised by past practices (e.g., engineered bank protection, realignments for the New England Highway plus Northern Railway bridges), by agricultural practices (clearing of riparian and floodplain vegetation, bank erosion and water quality deterioration exacerbated by loss of riparian vegetation and by stock damage) and introduction of exotic species (riparian species such as willows, pasture grasses and weeds plus aquatic pest species; carp and plague minnow).

Fish passage is available intermittently owing to the intermittency of surface flow, arising from the shallow nature of some of the creek pond reaches that dry out and from flows confined to cobble riffles that isolate pools. Water quality is also affected by the natural occurrence of saline seepage from outcrops of Permian rock in the pool immediately below the New England Highway that can become locally significant during extended drought periods.

The proposed creek diversions will result in the excising of two sections of existing creek line (1933m) which will continue to function as high flow overflow channels for floods above the 1 in 5y ARI flood level and will be actively managed to revert to floodplain woodland as part of the overall riparian corridor lands being set aside by ACOL.

The diversions have been designed to provide sufficient aquatic habitat so that the actual loss of creek length is confined to 199m. This is achieved by incorporating a number of off-line channel sections that will provide valuable and connected aquatic habitat, fish refuge and fish passage resting ponds, particularly during moderate flow events. In this way the design provides an overall slight increase in available aquatic habitat, from 8.3 to 8.4ha.

The diversion creek design mimics the sections of creek to be excised thus providing similar aquatic habitat features and there is an overall improvement, as the proposed riparian revegetation will enhance the creek aquatic attributes by, e.g., providing more shade from a denser and more complex riparian edge vegetation and providing overall more stability to riparian banks than the existing banks that are sparsely unvegetated in many areas.

Overall aquatic habitat improvement will be also be achieved by stock exclusion from the creek riparian zone and active management of stock in buffer zones (including provision of on-demand stock watering points away from the protected riparian zones.

The proposed diversion and associated stockpiling of spoil from the excavated channels will alienate 28.7ha of pasture grassland and up to 1.8ha of combined aquatic and riparian woodland. The 13.9ha of pasture grassland lost to the creek diversion will be offset by the provision of 13.9ha of aquatic and riparian woodland habitat to incorporate river red gum habitat as detailed in the landscaping proposal (Section 11.5 plus Appendices 10 and 16 of the Environmental Assessment).

The remaining 14.8ha of pasture grassland temporarily alienated for stockpiles will be progressively managed towards grassy floodplain woodland habitat and will be managed under the existing ACOL EMS and EMPs, principally the Flora and Fauna Management Plan (ACOL 2006b).

Overall fauna habitat requirements, and particularly habitat requirements for the listed woodland birds and bats known from the locality, will be protected and enhanced by active management, also as specified in the existing flora and fauna management plan. All the creek aquatic, riparian and floodplain grassy woodland habitats will be incorporated into the existing ACOL terrestrial and riparian corridor system.

The construction of the diversion channels, the incorporation of the block banks and the associated landscaping plans have been staged to allow proper settlement of the new creek segments and of the riparian banks, and the Landscape Restoration Plan (Appendix 10 of the Environmental Assessment) incorporates active management over the life of the mine to ensure the continuing viability and proper functioning of the aquatic and riparian sections of the diversion creek sections. The remaining retained creek segments in the lease area plus the remaining flooodplain lands between the diversions and the portions of excised creek will be managed via the existing EMS and associated EMPs (ACOL 2006a.b.c.d.e).

The ACOL management plans incorporate existing flora and fauna plus aquatic ecology (stream health) monitoring programs and these will be utilised to:

- Determine that the combined Bowmans Creek existing plus new diversion aquatic and terrestrial habitats are providing the design habitat functions and,
- Provide timely advice for active management of aquatic and riparian habitats should there be any negative deviation from the accepted habitat functions.

7 REFERENCES

Ashton Coal (2006a)
Environmental Management Strategy. Phase 2 Underground Mining Operations. Issue B August 2006.
Ashton Coal (2006b)
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ANNEXURE A

ACOL 'WHOLE OF MINE''

WATER QUALITY DATA

&

SUMMARY ANALYSIS

SEPT 2004 TO MARCH 2008

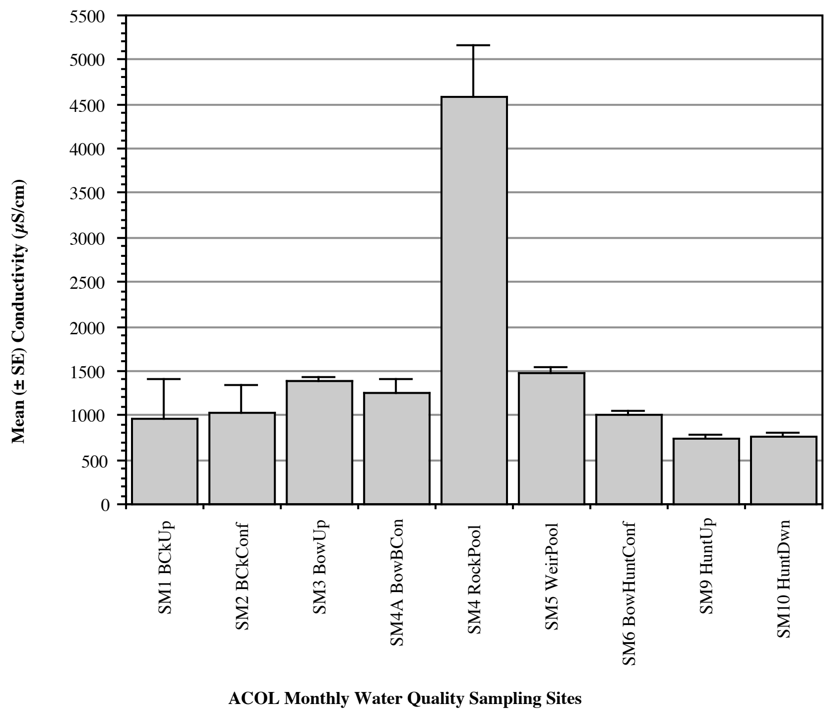


Fig A-1 ACOL Site Mean Conductivity Results

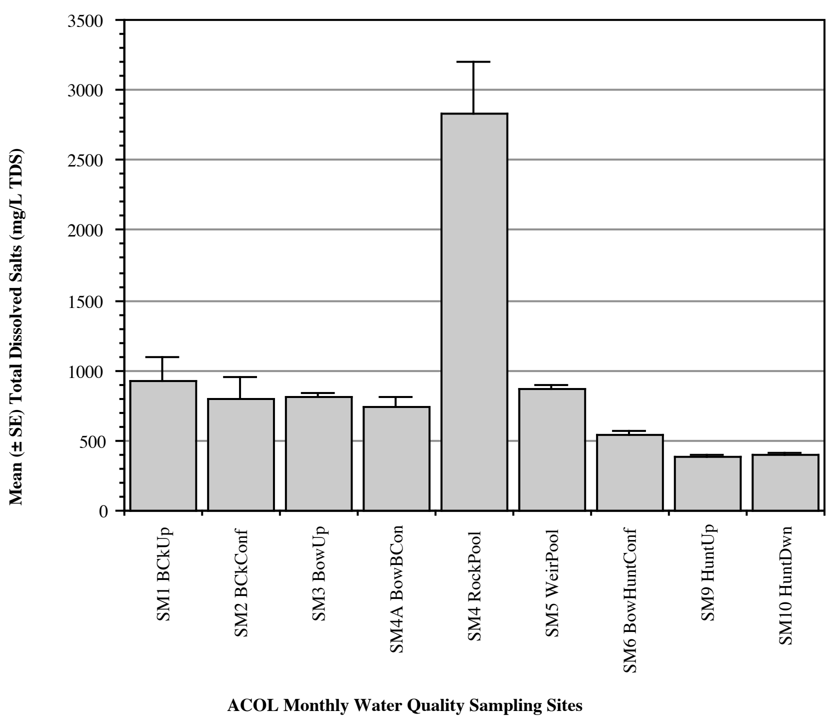


Fig A-2 ACOL Site Mean TDS Results

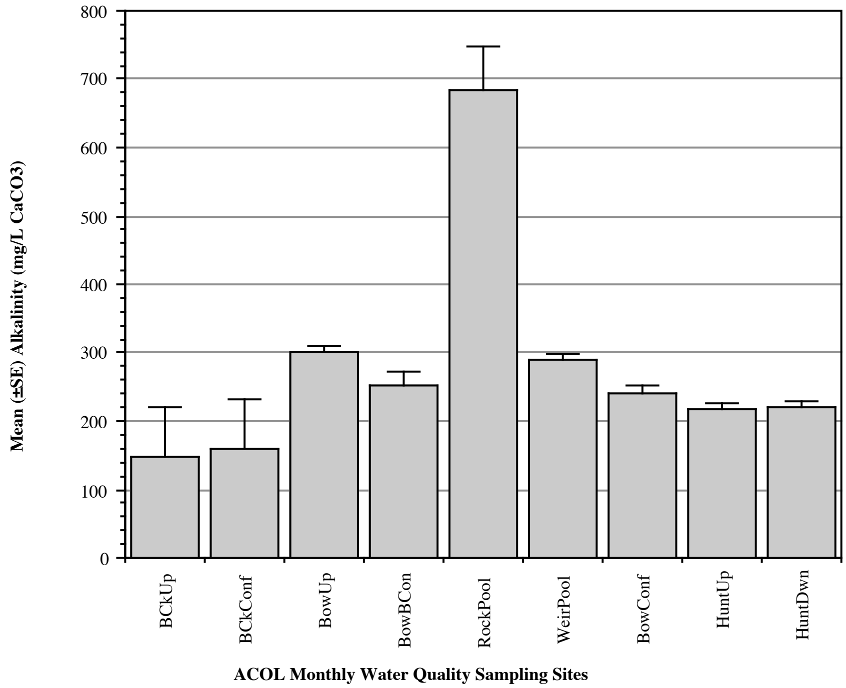


Fig A-3 ACOL Site Mean Alkalinity Results

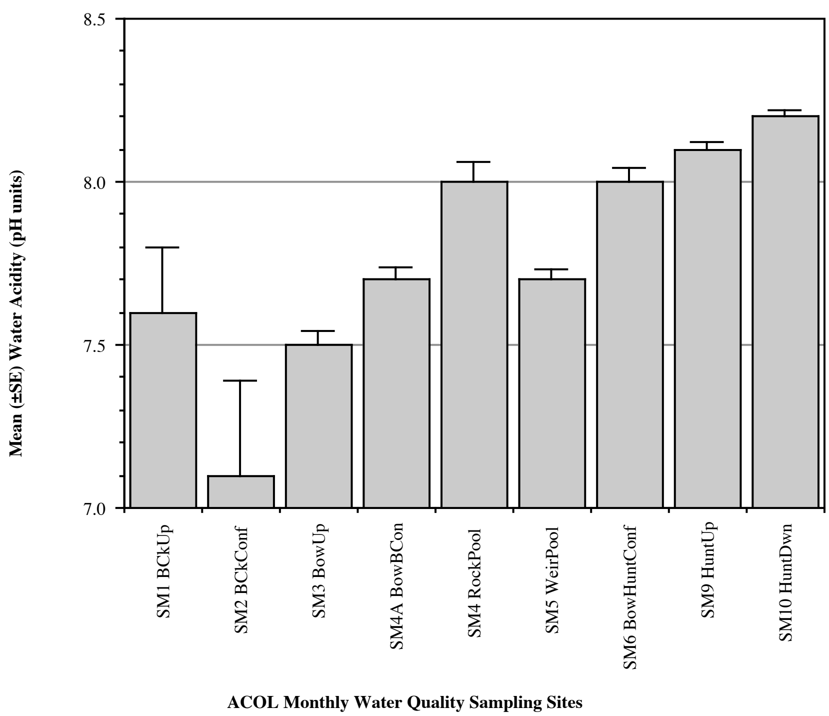


Fig A-4 ACOL Site Mean pH Results

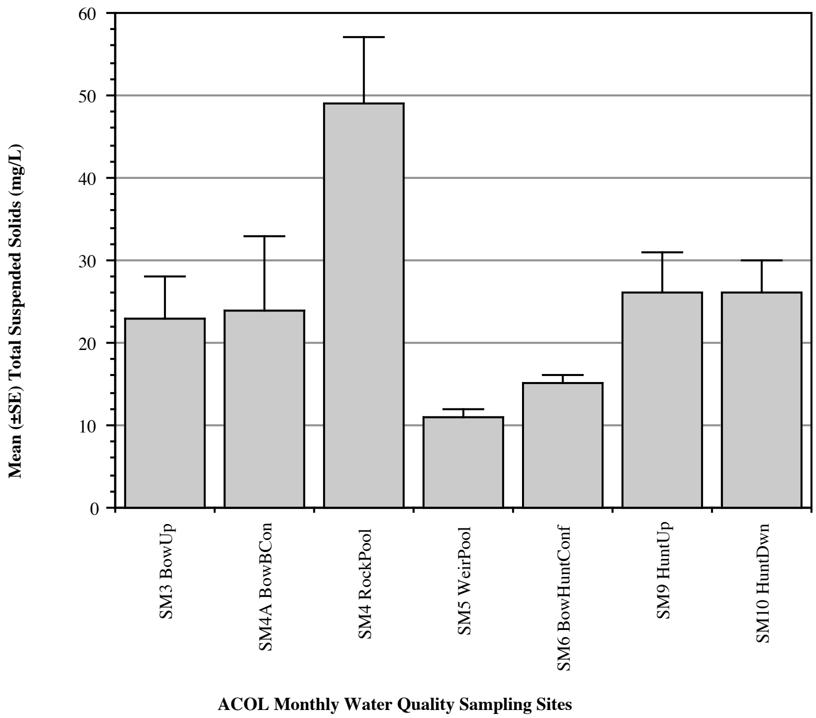


Fig A-5 ACOL Site Mean TSS Results

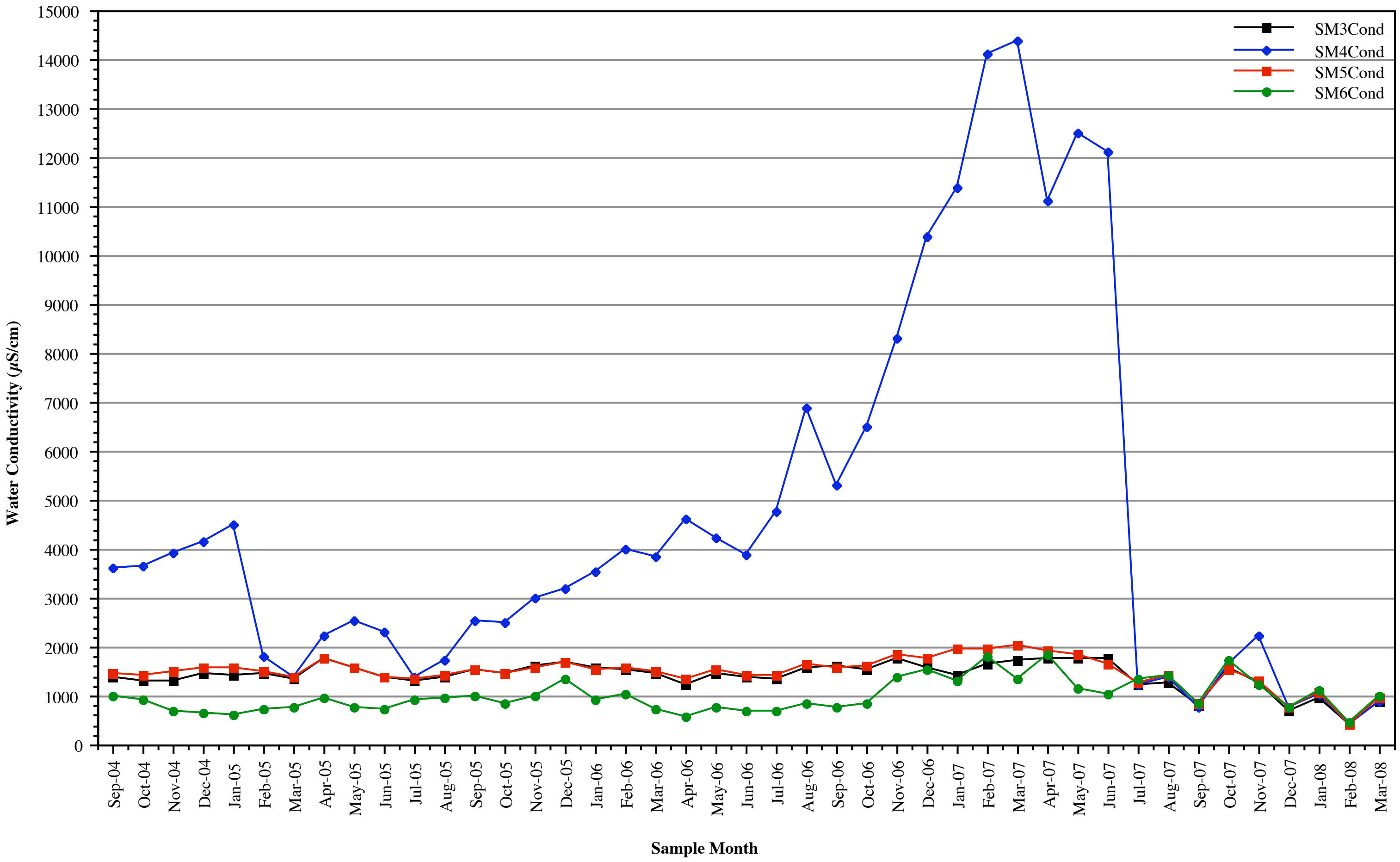


Fig A6 Monthly Water Conductivity (Sites SM3, SM4, SM5 and SM6

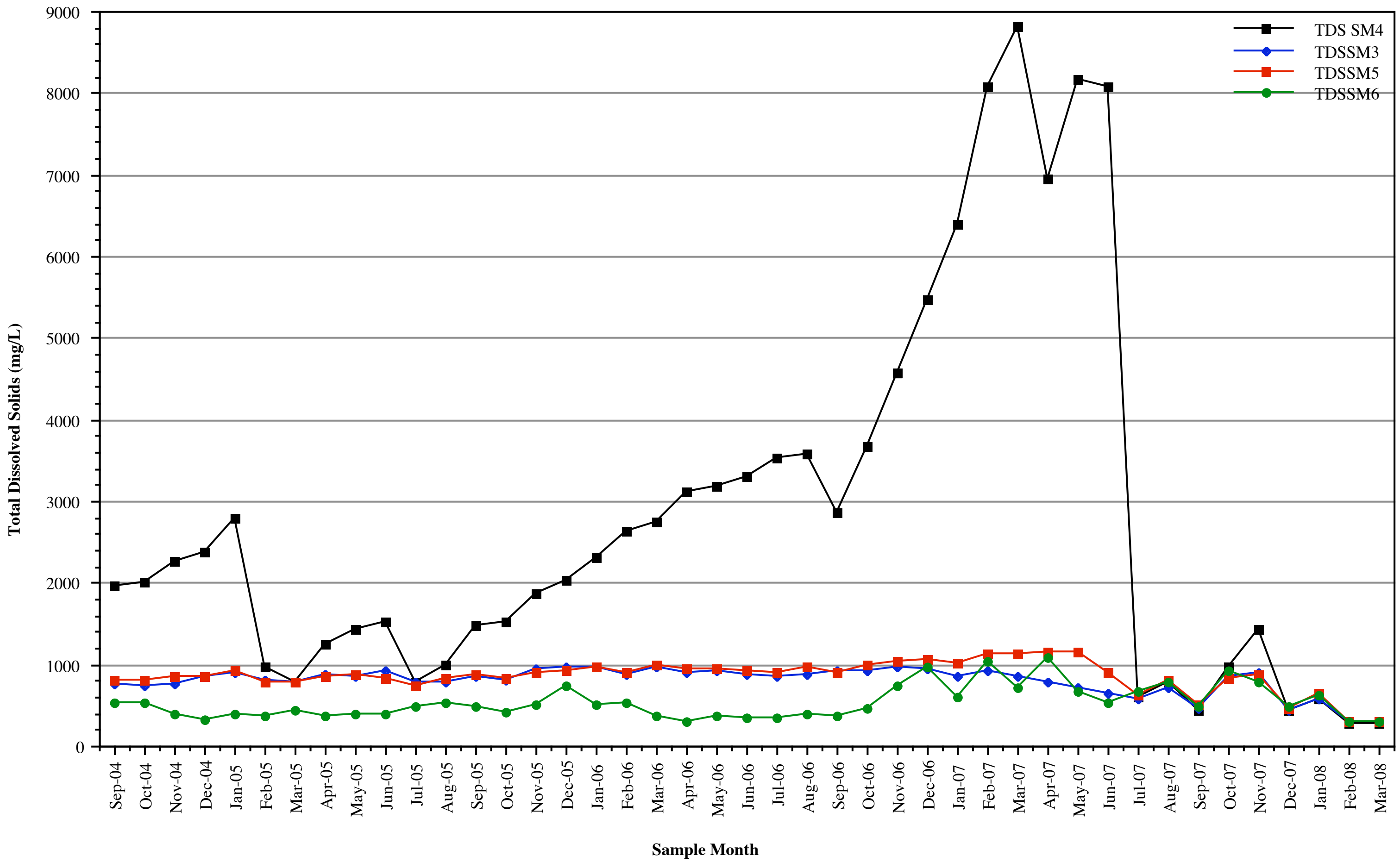


Fig A7 Monthly Total Dissolved Solids (Sites SM3, SM4, SM5 and SM6)

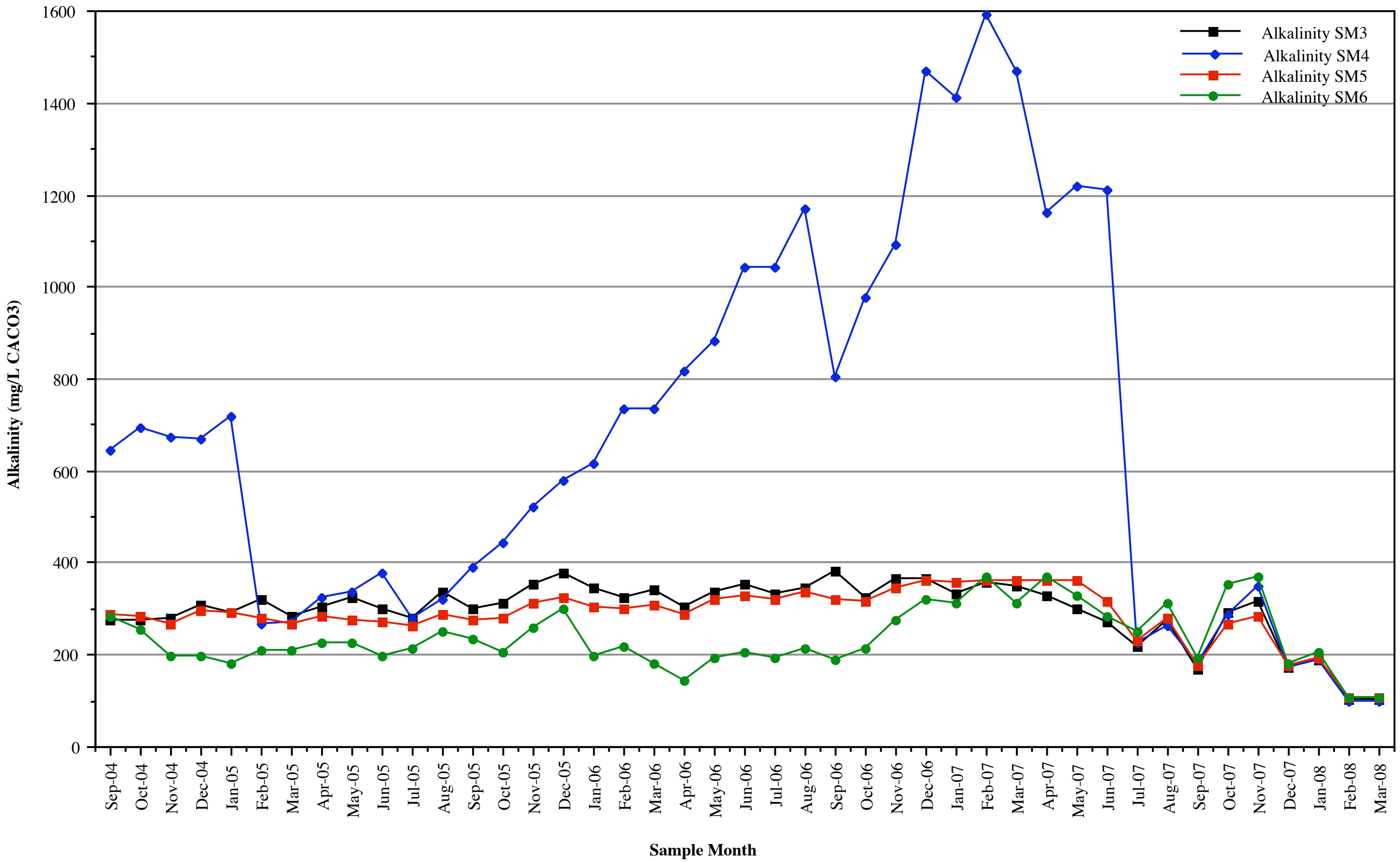


Fig A8 Monthly Water Alkalinity (Sites SM3, SM4, SM5 and SM6

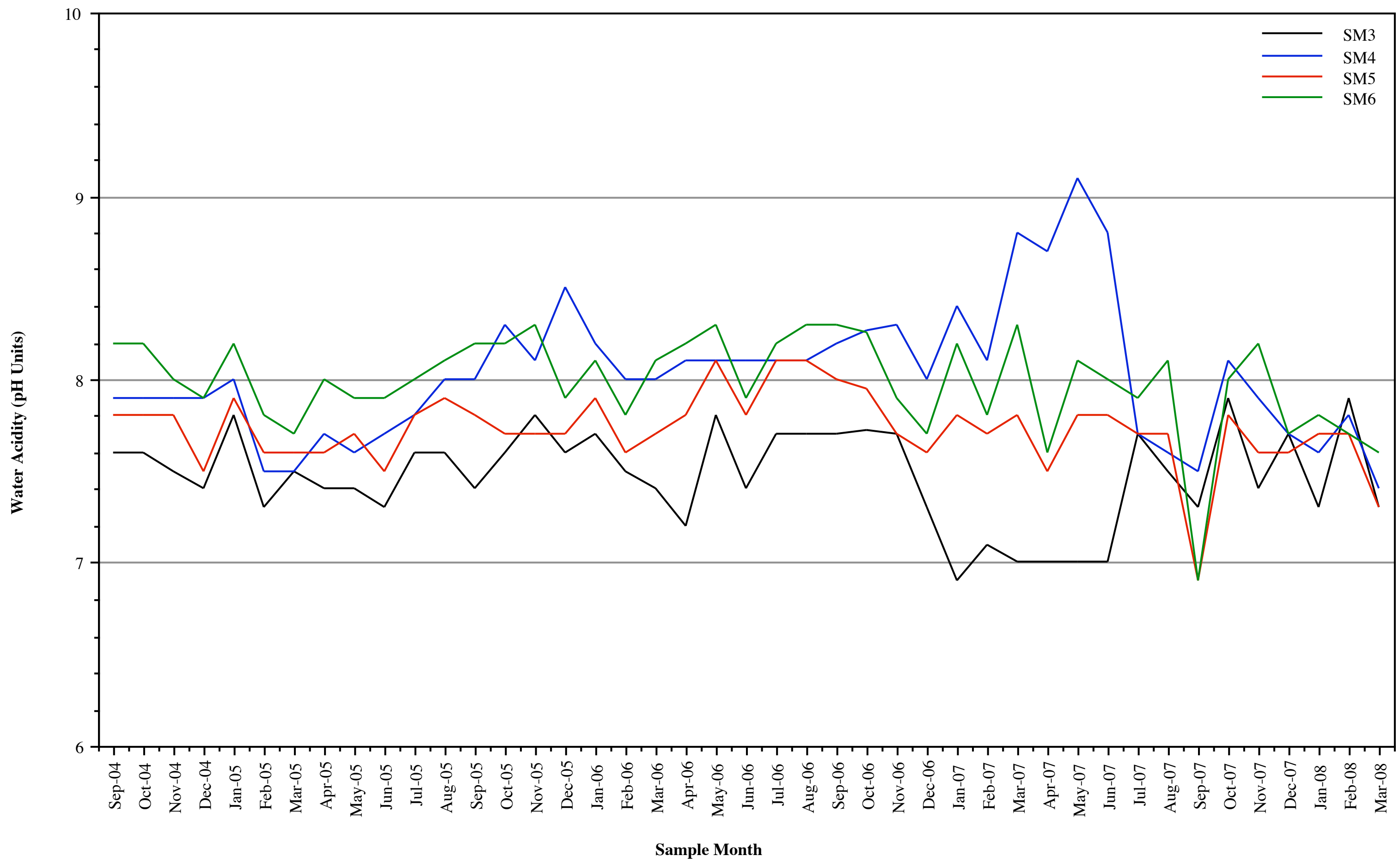


Fig A9 Monthly Water Acidity (Sites SM3, SM4, SM5 and SM6

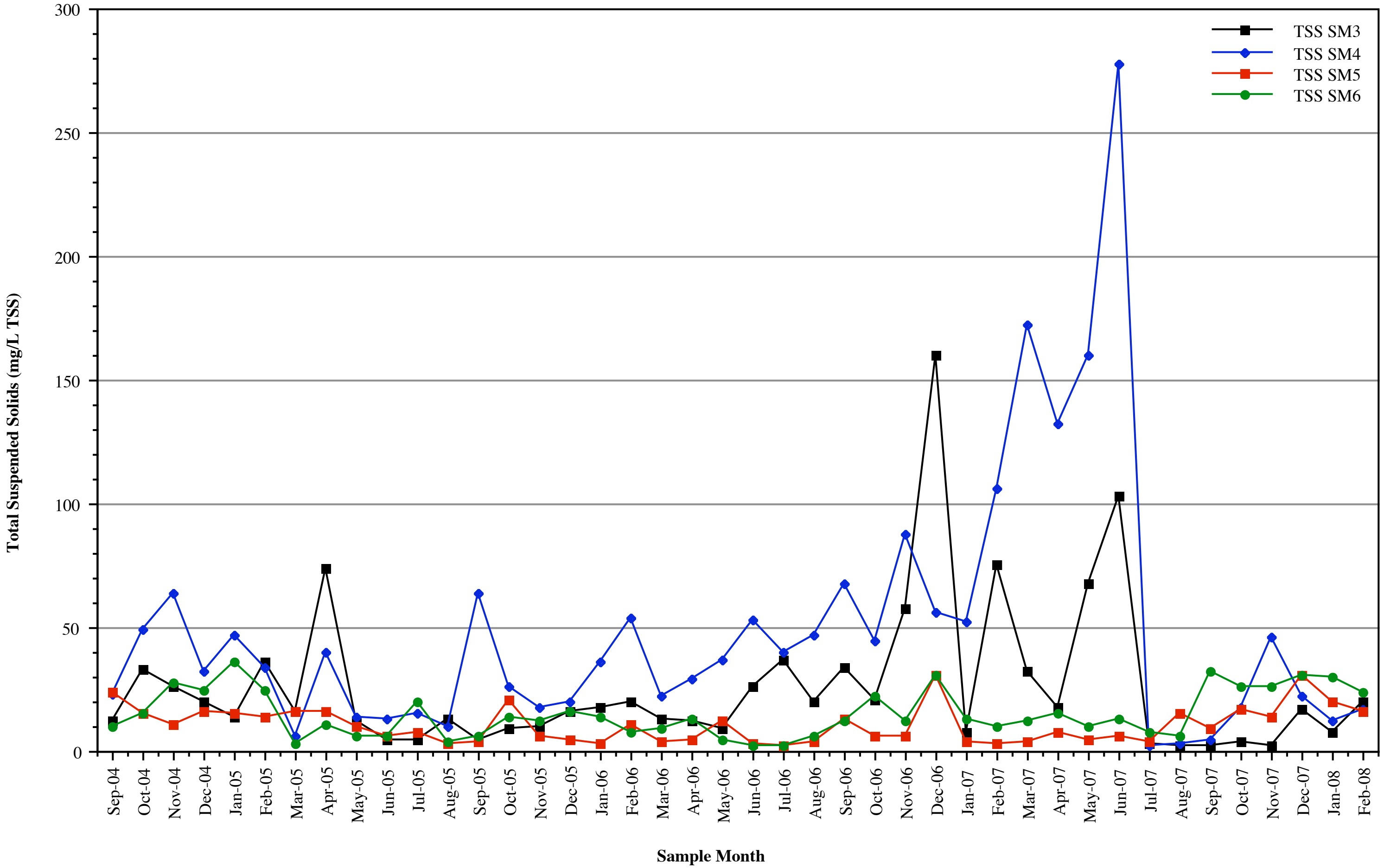


Fig A10 Monthly Total Suspended Solids Concentrations (Sites SM3, SM4, SM5 and SM6)

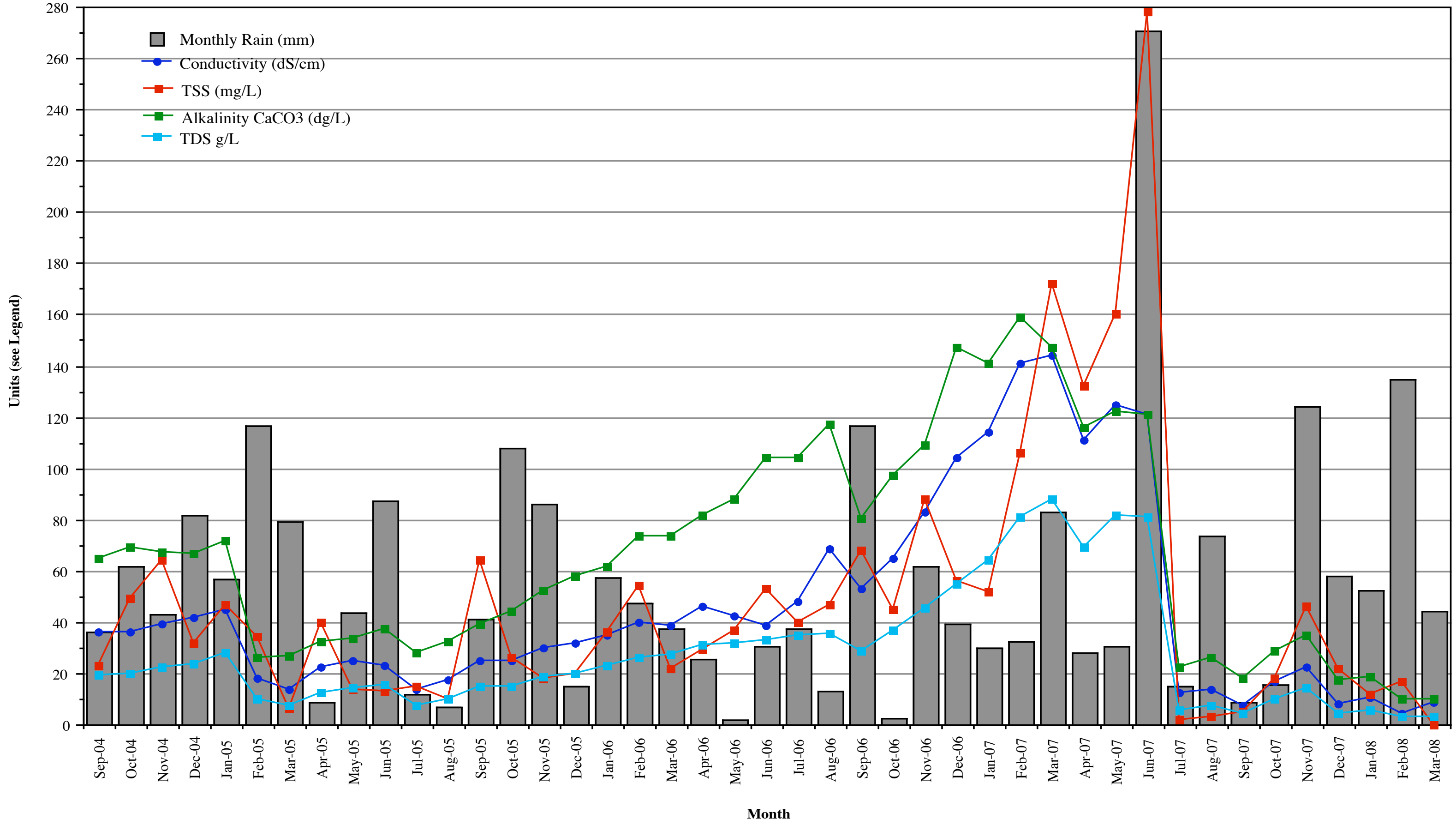


Fig A-11 ACOL Monthly Rainfall & Water Quality at Site SM4 September 2004 to March 2008

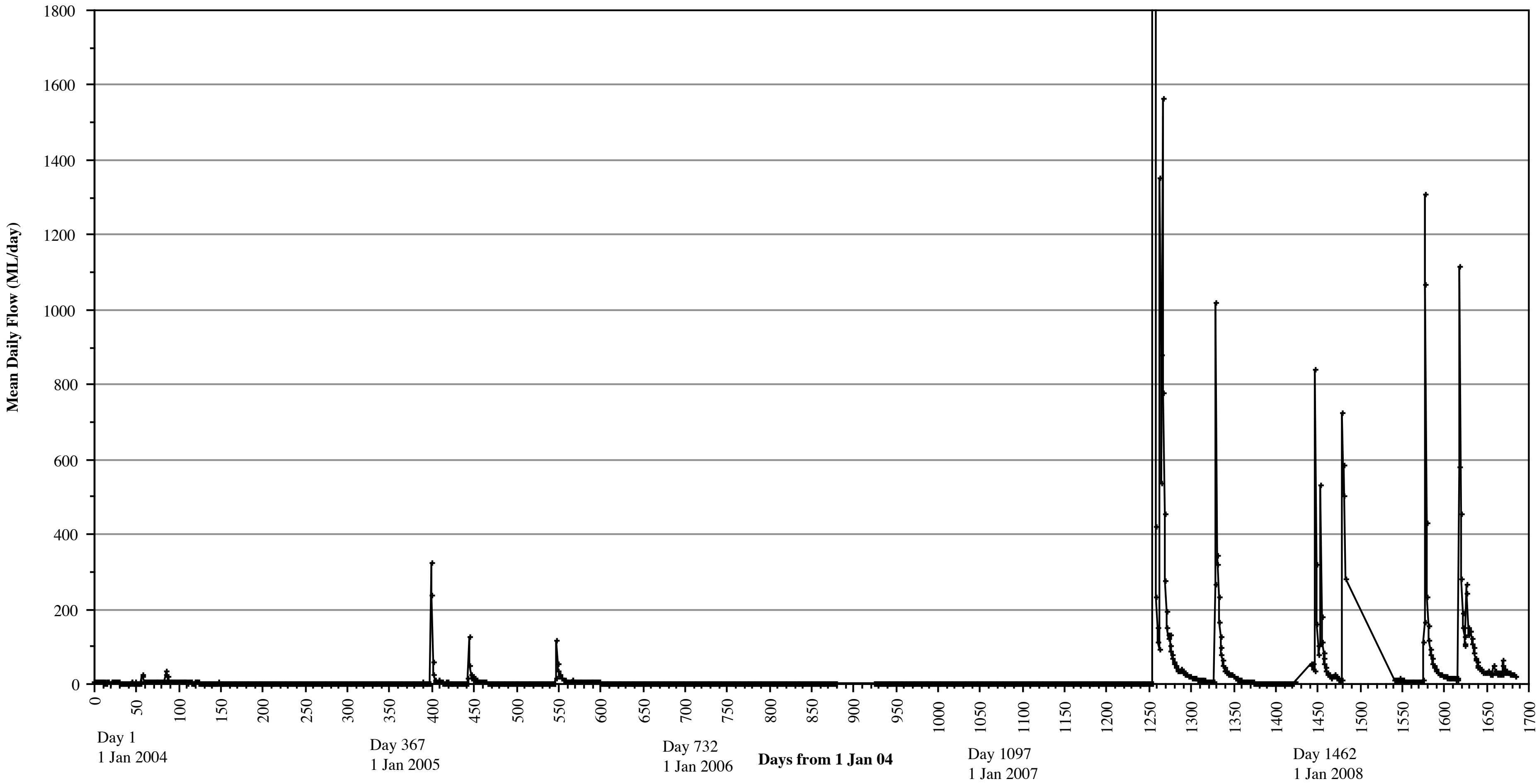


Fig A-12 Daily Flow (ML/day) at Bowmans Creek Gauging Station (showing Storm events)

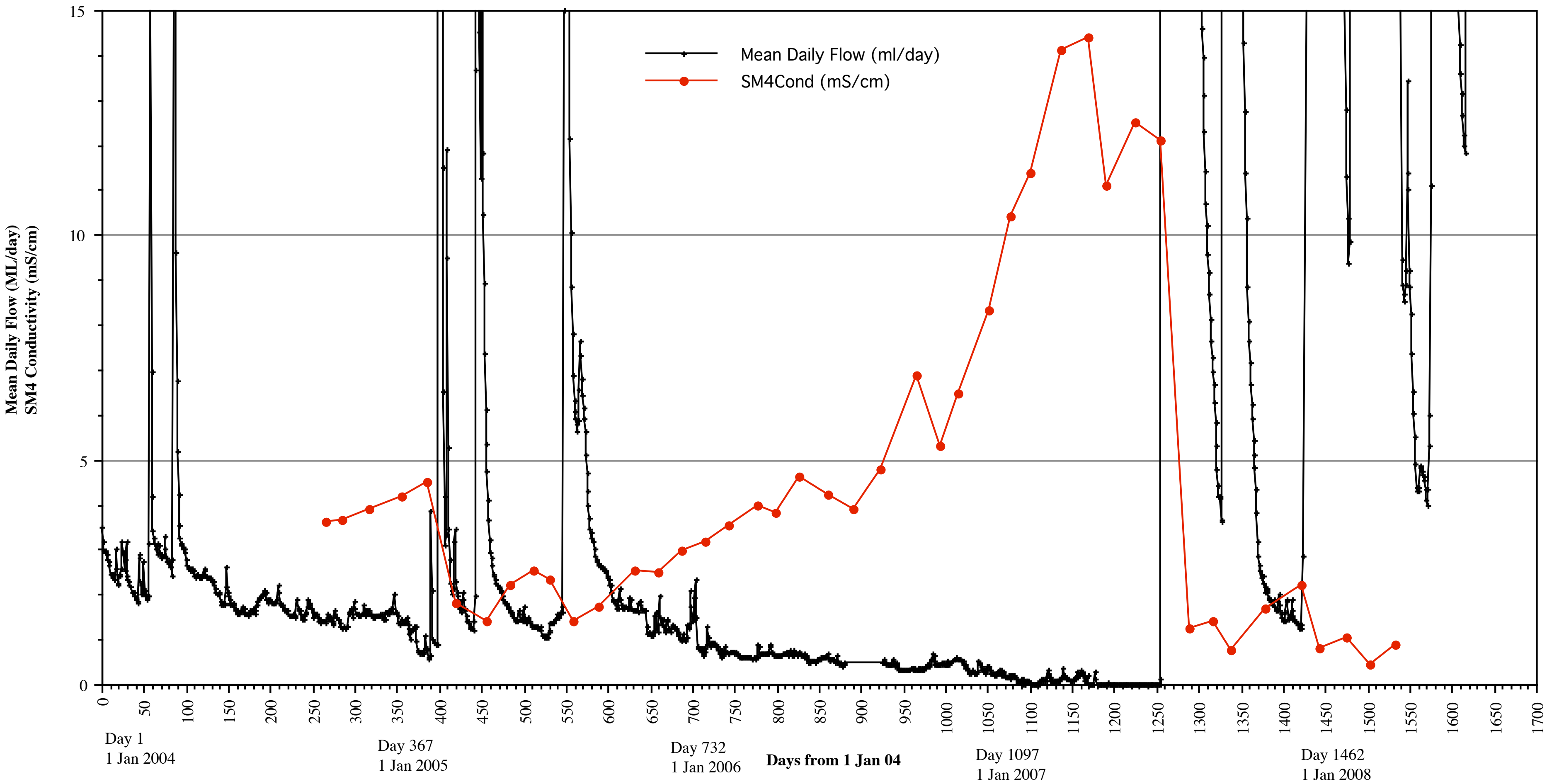


Fig A 13 Daily Flow (ML/day) at Bowmans Creek Gauging Station and site SM4 Conductivity (in mS/cm)

ANNEXURE B

SEVEN-PART TESTING

FOR

ENDANGERED POPULATIONS

AND

THREATENED SPECIES

Prepared for ACOL

By

John-Paul King

ECOHUB PTY LTD

Unit 17/26 Balook Drive Beresfield NSW 2323

Section 5A EP&A Act – Seven Part Test

Section 3.2 identified one Endangered Population and seven significant species requiring further assessment under the EP&A Act based on the level of impact predicted to affect the species.

Impact Species/Populations Seven Part Tests:

Eucalyptus camaldulensis population in the Hunter catchment

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable to populations.

(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

The regional distribution of this population occurs from the west at Bylong, to the east at Hinton on the bank of the Hunter River in the Port Stephens local government area. It has been recorded in the local government areas of Lithgow, Maitland, Mid-Western Regional, Muswellbrook, Port Stephens, Singleton and Upper Hunter.

Surveys of the local area identified 10 stands of *Eucalyptus camaldulensis* within the local area (ERM 2009). In total, the whole Hunter population has been recorded to have only 19 known stands (as determined by the Scientific Committee- Final determination River Red

Gum population in the Hunter Catchment), with a total number of individuals estimated to be between 600 - 1000 mature or semi mature trees (NPWS 2009). It should be noted that recent investigations by ERM for the Hunter Valley South Operations and Ashton have identified at least 13 stands have been indentified within 10km of the site suggesting a greater population than initially estimated by the Scientific Committee. Based on recent findings it is clear that the number of stands is greater than 19. Two stands of *Eucalyptus camaldulensis* (river red gum) open woodland were identified adjacent to Bowmans Creek to the west of the subsidence impact zone during previous investigations by ERM (ERM 2008). They are confined to the riparian corridor outside of the mining lease area, approximately 1km upstream from the Hunter River confluence.

All stands including the two in the Bowmans Creek are restricted to within streams and the associated banks. No large floodplain remanents of *Eucalyptus camaldulensis* are within the catchment. The proposal will not directly impact on the population by removing individuals, however any potential impacts from hydrological modifications warrant investigation.

River Red Gum obtains its water from four main sources:

1. Groundwater (Wen *et al* 2009, Mensforth *et al*., 1994, Thornburn and Walker 1994)
2. River Flooding (Roberts and Marston, 2000; Robertson *et al*., 2001)
3. Rainfall
4. Stream flow (Wen *et al* 2009, Thornburn and Walker 1994)

Within semi-arid Australia it is over-bank flow (flooding) that sustains large floodplain populations. Eamus (*et al*., 2006) found that winter and spring floods supplied half to two-thirds of the water requirements. This overbank flow is not that relevant to the local population however, because the population is restricted to streams. Therefore the influence of stream water and groundwater are more important to sustaining the local population. In research on the importance of stream water and groundwater Thornburn and Walker (1994) found that trees at distances greater than about 15 m from the stream used no stream water, they used groundwater in summer and a combination of groundwater and rain derived surface soil water (0.05-0.15 m depth) in winter. Trees adjacent to the stream where found to use stream water directly in summer, but may also use stream water from the soil profile in winter, after the stream had risen and recharged the soil water. In conclusion Thornburn and Walker (1994) concluded that *E. camaldulensis* appears to be partially opportunistic in the sources of water it uses.

Managing the condition of trees in the local area fits into the model developed by Wen et al (2009). They found that for Communities located closer to permanent waters (either the river channel or groundwater, i.e. riparian forest and River Red Gum), they require less flooding to sustain good condition than floodplain populations.

The long-term (e.g. over decades) exposure of the trees to surface water determines the importance of that water source to the trees. Trees within channels have been shown (Thornburn and Walker 1994) that even with continuous access to stream water, generally they will only uptake 50% of the available water from that source. For trees in ephemeral streams with access to surface water 50% of the time, on average, and stream water accounted for no more than 30% of the water used by the trees when the stream carried water (Thornburn and Walker 1994). The remaining water would be sourced from groundwater and rainfall surface water (soil water).

There may be ecological advantages in using soil water and groundwater, rather than stream water. Firstly, groundwater is a highly reliable source of water for these trees and the level of stress imposed on the trees by relying on soil water and groundwater may, in the long term, be less than that imposed by committing resources to utilise the irregularly available surface water. This appears to be so even where groundwaters are highly saline (Mensforth et al. 1994). Finally, the use of surface soil water would benefit the trees by aiding in the acquisition of nutrients (Rundel and Nobel 1991).

River Red Gum health has also recently been correlated with the abundance of Dwarf cherry (*Exocarpos strictus*) in the understorey. Sinclair (2006) found that there was a decrease in health of red gums as the abundance of cherry increased. It is known that cherry along with other Santalaceous appropriate water (Sinclair 2006). In localities where cherry is abundant and the flooding regime has been reduced through floodplain modification a double sword effect may occur.

For *E. camaldulensis* populations within streams, such as found in the local area, the hydrological regime requirements of individuals are predicted to be:

- They are dependent on stream water for up to 50% of their water supply;
- The balance is a combination of groundwater, surface water and soil water;
- Groundwater with high saline levels are still accessed by individuals;
- Individuals within permanent streams use stream water over seasons more so than channel (ephemeral) and floodplain populations which are more dependent on groundwater and floodplain water in winter; and,
- They are adoptable to water supply more so than channel and floodplain populations.

The groundwater behaviour in the catchment of Bowman's Creek was studied by Aquaterra (2008). They found that the Bowmans Creek alluvium contributes some baseflow to Bowmans Creek although the contribution from the planned mining area is very small. In addition, it is also predicted that baseflow contribution from saline groundwaters to Bowmans Creek will be reduced during mining and for a period after the completion of mining until groundwater aquifers recover. Loss from alluvium would be in the order of 1.2L/s. Accordingly, there would be negligible lowering of the alluvial water table in the vicinity of the actual creek (less than 0.1 m) and it is expected that water quality in Bowmans Creek would not be adversely impacted by mining and could even improve during low and no flow conditions. Based on these parameters the local population would not be disturbed by the proposal. The following mitigation will be implemented so that the local extent of the community will not be disturbed by the proposal and so that the local population can be improved:

- Surface and groundwater monitoring of Bowmans Creek will continue and the existing Flora and Fauna Management Plan will include measurements of the health of *E. camaldulensis* following the methods of Thornburn and Walker (1994);
- The Landscape plan for the proposed diversion includes planting of the stream and banks of Bowmans Creek and planting will be completed at a ratio of at least 4:1 (within the site yet outside the area of activity) with *E. camaldulensis* in the coming Autumn; and,
- Subsidence impacts on *E. camaldulensis* will be monitored and compared with health assessment (as described above).
- Fencing of identified communities and exclusion of stock access will be implemented with a view to improving juvenile recruitment.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> ***i.*** ***is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be removed or modified as a result of the action.***

> ***ii.*** ***is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.***

Not applicable to populations.

(d) in relation to the habitat of a threatened species, population, or ecological community:

> ***i.*** ***the extent to which habitat is likely to be removed or modified as a result of the action proposed, and***

The proposal will not directly remove any local extent of this community. There is a small predicted change in the groundwater baseflow that represents as reduction of less than 0.1m. The surface flow change is predicted to be of a similar magnitude.

The individuals represented are a small yet significant component of the local population and the mitigation described above is recommended to conserve this local population.

> ***ii.*** ***whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and***

The project includes the modification of the creek line to retain flow within a potentially subsided landscape. This diversion will include the construction of new channels that will be established and restored upon completion. The vegetation existing in the redundant channel will remain and be enhanced with floodplain vegetation communities. Over time, the combination of restoration of the creek line and the planting of floodplain communities surrounding the stream will result in increased connectivity and reduced fragmentation.

> ***iii.*** ***the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.***

All sub-populations of the population are considered important. There are up to 11 sub-populations within 10 kilometers of the study area. Although, NPWS (2009) have identified 19 stands within the Hunter endangered population, based on recent surveys this may be an underestimate of the true size of the population. None of the habitat of the population will be removed by the proposal. The area is outside the underground mining area and as such, is not likely to be directly impacted by mining. The management of water supply and creek stability as proposed will maintain baseflows in Bowmens creek with approximately 12% decrease in flow.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The proposal area is not identified as critical habitat and no critical habitat has been identified in the local area.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery or threat abatement plan.

The objectives and priorities for management of the population include:

1. Support local Landcare groups.
2. Undertake strategic grazing or grazing exclusion in conjunction with weed control.
3. Retain or reintroduce periodic water inundation of habitat.
4. Protect areas of known and potential habitat from clearing.
5. Encourage regeneration of remnants or disturbed areas of habitat.
6. Use locally-sourced seed in revegetation or regeneration projects.

The recommendations included within list priority 2,4,5 and 6 as actions that will be undertaken as part of the project.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Threatening processes relevant to the proposed modification are discussed below.

Alteration of Natural Flow Regimes
Subsidence will alter the topography, potentially impacting on surface catchment flow patterns and altering the minor drainage lines. It will cause a marginal decrease in the water inflow to Bowmans Creek and temporarily increase the percolation characteristics of the strata. Localised ponding of water could result in concentrated water flows and associated erosion. Monitoring for surface drainage impacts, such as ponding, will be carried out before, during and after mining, utilising visual monitoring, and existing topographic surveys. Given the proposed monitoring and management procedures, the alteration of natural flow regimes is unlikely to be of a significant scale.

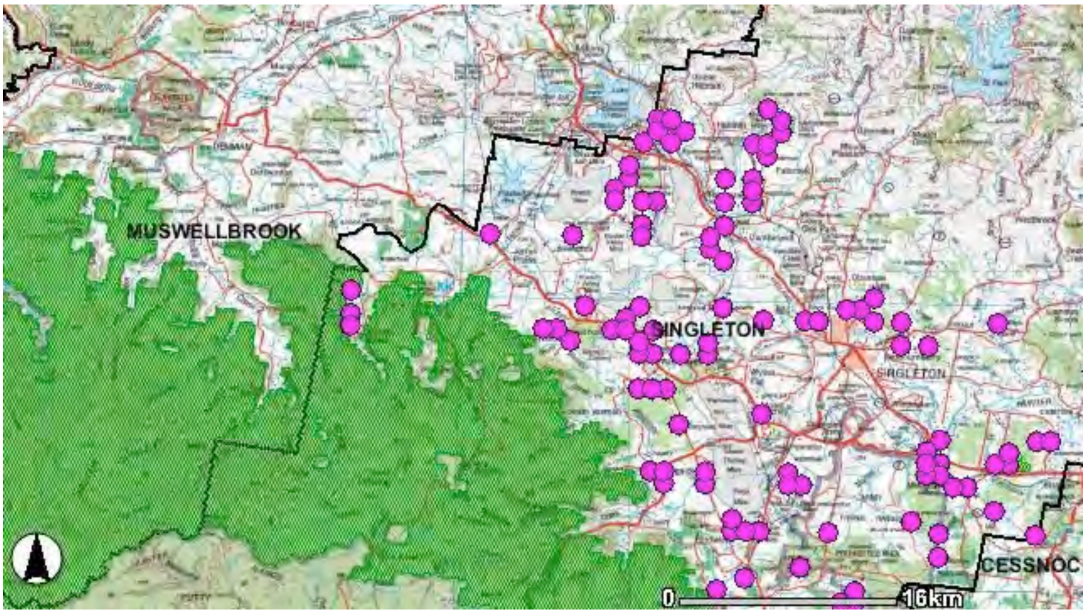
Clearing of Native Vegetation
The proposed longwall mining may result in isolated disturbance to vegetated areas as a result of subsidence induced erosion or surface cracking although it is not expected that clearing of vegetation associated with significant remediation works will be required. The disturbance will not result in significant impact to the habitat available within the site. Clearing of pastures and limited riparian vegetation for the construction of diversions and block banks, clearing of pastures also required for diversion spoil emplacement.

Pomatostomus temporalis (Grey-crowned Babbler)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction

Surveys in the study area identified three sub-populations of Grey-crowned Babbler. One troop was recorded utilising the degraded riparian woodland associated with the Bowmens Creek corridor. Further surveys on adjoining sites located another three sub-populations. Local records for the species are extensive with over 200 sightings on the Atlas database for the LGA (See map below).

In unpublished research collected by the author, we found that Grey-crowned Babbler was one of the most common woodland birds in the lower hunter in moderately fertile woodland and modified forest communities. Grey-crowned Babbler is often recorded in yards of semi-rural lots and golf courses on good soils in the Hunter.



There is a strong population in the local area that is connected and viable. In total surveys conducted on site and in the local area recorded over 50 individuals. Given the tendency of the species to relocate in close proximity to previous breeding sites and to expand their home ranges at different times of the year, individuals would be expected to use the proposal area. Nonetheless, the activity will only involve the removal of a small area of habitat (1.8ha), which will be mitigated with the regeneration of the grassland areas with woodland and forest on moderately fertile soils. We consider that this removal **will not** reduce the viability of *Grey-crowned Babbler* in the local area, to a degree that could put the local population at risk of extinction.

(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

This factor applies a similar test as in factor (a) to endangered populations.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be removed or modified as a result of the action.

Not applicable to *Grey-crowned Babbler*.

ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not applicable to *Grey-crowned Babbler*.

(d) in relation to the habitat of a threatened species, population, or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed action **would** result in the loss of 1.8 hectares of potential habitat from the activity area.

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposal will not contribute to the cumulative loss of habitat and the increased fragmentation or isolation of habitat.

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

It is currently difficult to quantify the importance of the habitat, however the species is often recorded in the local area in similar habitats. Given that the proposal will remove only a small area of the potential marginal habitat, it is predicted that this would not constitute a loss of significant habitat.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The proposal would not have any adverse effect on critical habitat. There is a capacity for critical habitats to be gazetted under the Threatened Species Conservation Act 1995. No such habitats have yet been gazetted for the *Grey-crowned Babbler*.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery or threat abatement plan.

At this point in time no recovery plan has been prepared for this species by DECCW.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The NSW DECCW have identified that the following threatening processes are acting upon this species:

- Clearing of woodland remnants.
- Heavy grazing and removal of coarse, woody debris within woodland remnants.
- Nest predation by species such as ravens and butcherbirds may be an issue in some regions where populations are small and fragmented

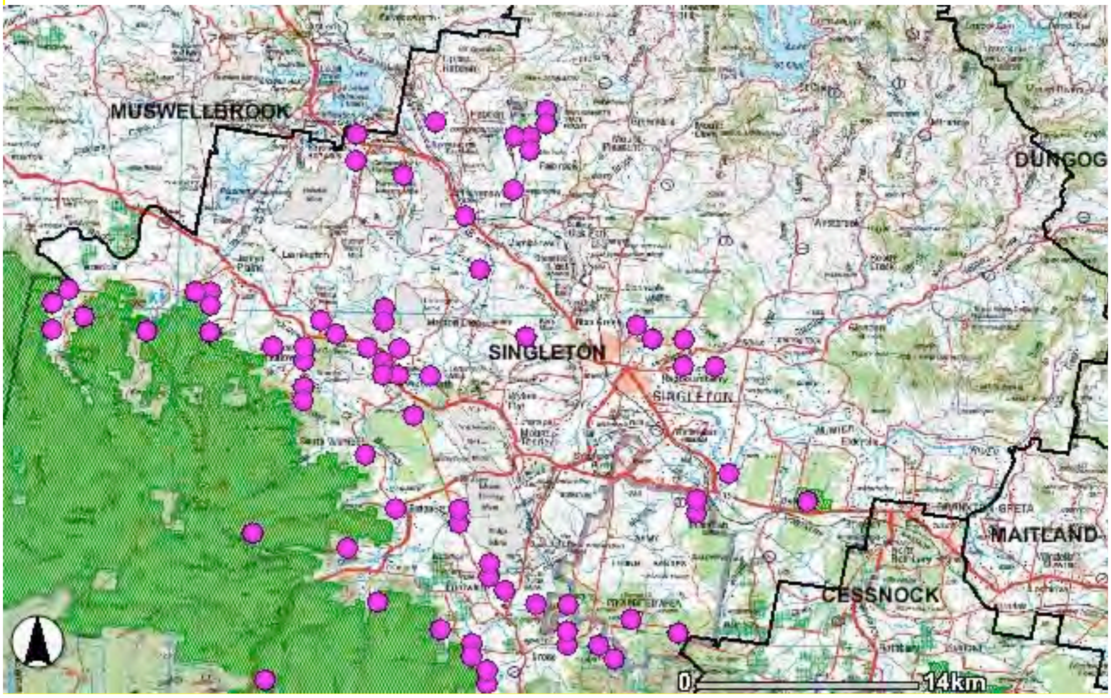
The proposed action constitutes a key threatening process, and it is considered to contribute to the increased impact of a threatening process.

Speckled Warbler (*Pyrrholaemus sagittatus*)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction

Surveys in the local area identified two sub-populations of Speckled Warbler. Further surveys on adjoining sites located another additional sub-population. Local records for the species are extensive with over 60 sightings on the Atlas database for the LGA (See map). Unlike the Babbler this ground foraging bird requires larger remnants for survival. In a recent study looking at the occupation of regeneration plots by woodland birds Barrett et al (2008) found that Speckled warbler was only recorded in very large patches of remanent vegetation (>400ha). In a comparative study on the succession of woodland birds in regeneration areas Fisher (2007) found that Speckled warbler moved into the area in the early to mid regeneration phase of the woodlands.

The background local knowledge on this species suggests that in large (>50ha) forests/ woodlands either in gullies or ridgelines where there is a mixture of grasses and a open structure in the understorey Speckled warbler is likely to be present. Relating this model to the local area proves this true. The sub-populations are known to the two largest patches in the local area. The proposal will not remove or modify any habitat which forms part of the sub-populations home range. The proposal will overtime increase the patch size of an existing remanent by 4 times and given the species ability to colonise regenerating patches (Fisher 2007) the proposed mitigation may increase habitat in the local area for the species. We consider that this proposal **will not** reduce the viability of *Speckled warbler* in the local area, to a degree that could put the local population at risk of extinction.



Speckled Warbler records in the local area.

(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

This factor applies a similar test as in factor (a) to endangered populations.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

iii. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be removed or modified as a result of the action.

Not applicable to Speckled warbler.

iv. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not applicable to Speckled warbler.

(d) in relation to the habitat of a threatened species, population, or ecological community:

iv. the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed action **will not** result in the loss of potential habitat from the activity area.

v. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposal will not contribute to the cumulative loss of habitat and the increased fragmentation or isolation of habitat.

vi. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

It is currently difficult to quantify the importance of the habitat, however the species is often recorded in the local area in similar habitats, but only in larger remnants. Given that the proposal will remove only a small area of the potential marginal habitat, it is predicted that this would not constitute a loss of significant habitat.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The proposal would not have any adverse effect on critical habitat. There is a capacity for critical habitats to be gazetted under the Threatened Species Conservation Act 1995. No such habitats have yet been gazetted for the Speckled warbler.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery or threat abatement plan.

Key recovery priorities for the species are:

1. Keep domestic dogs and cats indoors at night. Desex domestic dogs and cats. Assess the appropriateness of dog and cat ownership in new subdivisions.
2. Undertake fox and feral cat control programs.
3. NPWS should be consulted when planning development to minimise impact on populations.
4. Retain dead timber on the ground in open woodland areas.
5. Limit firewood collection.
6. Retain existing vegetation along roadsides, in paddocks and remnant stands of native trees.
7. Encourage regeneration of habitat by fencing remnant stands.
8. Fence suitable woodland habitats, particularly those with unimproved pasture and an intact native ground plant layer.
9. Increase the size of existing remnants, planting trees and establishing buffer zones of unimproved uncultivated pasture around woodland remnants.
10. Assess the importance of the site to the species' survival. Include the linkages the site provides for the species between ecological resources across the broader landscape.
11. Report any new sightings of the speckled warbler to the DECCW.

The proposal will assist in the recovery of this species by providing resources to 1,2,3,4,5,7,8, and 9. As stated a key requirement for this species is remanent size. A major priority of the mitigation for the proposal is to restore and increase the Riparian corridor and Floodplain area of Bowmans Creek.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The NSW DECCW have identified that the following threatening processes are acting upon this species:

- Due to the fragmented nature of the populations and their small size the species is susceptible to catastrophic events and localised extinction.
- Clearance of remnant grassy woodland habitat for paddock management reasons and for firewood.
- Poor regeneration of grassy woodland habitats.
- Modification and destruction of ground habitat through removal of litter and fallen timber, introduction of exotic pasture grasses, heavy grazing and compaction by stock and frequent fire.

- Habitat is lost and further fragmented as land is being cleared for residential and agricultural developments. In particular, nest predation increases significantly, to nest failure rates of over 80%, in isolated fragments.

- Nest failure due to predation by native and non-native birds, cats, dogs and foxes particularly in fragmented and degraded habitats.

Key recommendations proposed here to reduce the impact of these threats on the local population include:

1. Increasing the size of the riparian corridor and creating floodplain woodland habitat;
2. Undertaking long term feral animal control;
3. Controlling grazing;
4. Controlling fire; and,
5. Connecting larger potential habitat sites by creating stepping stones between home ranges.

Hooded Robin (*Melanodryas cucullata cucullata)*

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction

Maron (2008) found that Hooded Robin was commonly found in patches of just a few Hectares . Maron also found that there was no evidence that nestedness correlated with patch area. He suggested that the presence of native Noisy Miner *Manorina melanocephala* is the strongest drivers in the local distributions of small passerine birds in eastern Australia. This may certainly the case for Hooded Robin a species which inhabits similar habitats to Noisy miner by occupying open edge type habitats with diverse structure.

Many species which rely on woodland still forage well out into paddocks from remnants, yet remain within retreating distance of woody vegetation. Thus, the effective area of a remnant from the perspective of a bird is often greater than the area that humans perceive and researchers typically measure. With this in mind the potential range of the Hooded Robin in the local area could include the Riparian corridor and enhancement of this habitat is recommended to provide additional resources to the local population. These recommendations include:

- Regeneration of the riparian corridor must include structural diversity at all strata;
- The creation of new woodland on the floodplain must also include the creation of perch sites for the species, such as small piles of fallen timber (transported here from a felling site) and the re-erection of old fence posts along the Bowmans Creek.

Given an undertaking of the above recommendations, we consider that this proposal **will not** reduce the viability of Hooded Robin in the local area, to a degree that could put the local population at risk of extinction.

(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

This factor applies a similar test as in factor (a) to endangered populations.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

v. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be removed or modified as a result of the action.

Not applicable to *Hooded Robin*.

vi. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not applicable to *Hooded Robin*.

(d) in relation to the habitat of a threatened species, population, or ecological community:

vii. ***the extent to which habitat is likely to be removed or modified as a result of the action proposed, and***

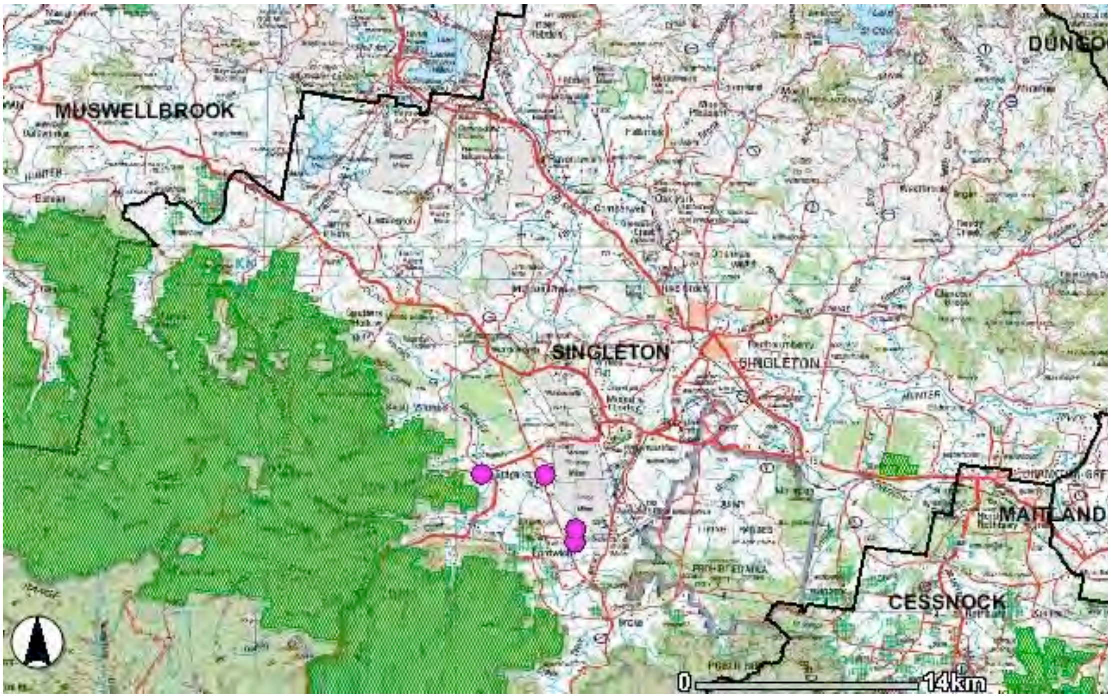
The proposal **will** result in the loss of 1.8 hectares of potential habitat from the activity area.

viii. ***whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and***

The proposal will not contribute to the cumulative loss of habitat and the increased fragmentation or isolation of habitat.

ix. ***the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.***

Several individuals including juveniles have been recorded in the study area within the ACOL Southern Woodland Conservation Area. The habitats provided by Bowmans Creek are suitable to the requirements of Hooded Robin. NPWS atlas results (2009) show that there are only four records in the sub-regional area (see Map). All these records are approximately 10 kilometres south of the study area. Given the limited distribution of the species in the sub-regional area (based on NPWS records) and the breeding records made on this site, we consider the individuals to be part of isolated and disjunct population that is significant. Notwithstanding the importance of the habitat in the study area, the proposal will only result in the short term loss of a small area of habitat and result in the long term increase in potential habitat for the species.



Hooded Robin records in the regional area (NPWS Atlas records September 2009)

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The proposal would not have any adverse effect on critical habitat. There is a capacity for critical habitats to be gazetted under the Threatened Species Conservation Act 1995. No such habitats have yet been gazetted for the *Hooded Robin*.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery or threat abatement plan.

The following outlines the key objectives for the recovery of the species:

- Retain dead timber on the ground in open woodland areas.
- Enhance potential habitat through regeneration by reducing the intensity and duration of grazing.
- Fence habitat to protect from long-term, intense grazing.
- Increase the size of existing remnants, by planting trees and establishing buffer zones of un-modified, uncultivated pasture around woodland remnants.

At this point in time no recovery plan has been prepared for this species by DECCW.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The NSW DECCW have identified that the following threatening processes are acting upon this species:

- Clearing of woodlands, resulting in loss and fragmentation of habitat.
- Modification and destruction of ground habitat through heavy grazing and compaction by stock, removal of litter and fallen timber, introduction of exotic pasture grasses and frequent fire.

No woodlands will be lost as part of the proposal, and the proposal includes the enhancement of linkages between remnants and the expansion of suitable habitat for the species.

Eastern Bentwing-bat *Miniopterus schreibersii oceanensis*

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction

The Eastern Bentwing-bat has chocolate to reddish-brown fur on its back and slightly lighter coloured fur on its belly. It has a short snout and a high 'domed' head with short round ears.

The Eastern Bentwing-bat exhibits a biomodal activity pattern where they leave the cave around sunset to feed and return to the roost between 2400 – 0100 to digest before leaving again after an hour to forage until dawn (Codd *et al.* 1999). Hoye (2000) estimated whilst they are highly mobile they generally forage within a radius of 20km from their roost site in a night. Eastern Bentwing-bats are often found in well-timbered valleys where it forages above the canopy on small insects and moths (Strahan 1995).

The primary roosting habitat for the Eastern Bentwing-bat is caves but is also known to utilise man-made structures such as old mines, bridges, stormwater drains, and buildings etc (Strahan 1995). Eastern Bentwing-bats migrate annually to a maternity cave each spring and summer to birth and rear young (DEC 2006).

Maternity caves have very specific temperature and humidity regimes (DEC 2006). Juvenile Bent-wing bats disperse from maternity caves between February and March (Dwyer 1995) and once young become independent females leave the colony. Given the breeding patterns of this species, the proposal is unlikely to have a significant impact on breeding.

Throughout the rest of the year Eastern Bentwing-bats are widely dispersed, usually with a few colonies within a single large watershed (Strahan 1995). Dispersal between roosts and maternity caves is triggered by changing seasonal needs and local climatic conditions. As a result of migratory habits of this species, defining a local population is nearly impossible. Breeding or roosting colonies can number from 100 to 150,000 individuals.

Females migrate large distances (Strahan 1995) to reach certain caves where they form maternity colonies. The areas surrounding maternity colonies are resource rich in order to support the higher energetic requirements of females during pregnancy and lactation (Kunz et al. 1995; Kurta et al. 1989; Speakman and Racey 1987).

Males however undertake a smaller migration into areas with lower resource availability as they have lower energetic demands. As a result of migratory habits of this species, defining a local population is nearly impossible.

A study by Codd *et al.* (1999) reported that within their cave-dwelling environment Eastern Bentwing-bats spend an average of 62% of its time at rest (not moving), 16% grooming(scratching, licking, preening) and 22% of the time active (head raised, alert, stretching).

No potential roosting habitat was recorded within the study, however suitable foraging habitat for the species was recorded on the site, and a small area of this will be removed as part of the proposal. This removal **will not** reduce the viability of Eastern Bentwing-bat in the local area, to a degree that could put the local population at risk of extinction.

(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

This factor applies a similar test as in factor (a) to endangered populations.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be removed or modified as a result of the action.

Not applicable to Eastern Bentwing-bats.

ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not applicable to Eastern Bentwing-bats.

(d) in relation to the habitat of a threatened species, population, or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed action **would** result in the loss of 1.8 ha of potential marginal habitat from the subject site.

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposal will contribute to the cumulative loss of habitat and the increased fragmentation or isolation of habitat.

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

It is currently difficult to quantify the importance of the habitat, however the species is often recorded in the local area in similar habitats. Given that the proposal will remove only a small area of the potential marginal habitat on the site, it is predicted that this would not constitute a loss of significant habitat.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The proposal would not have any adverse effect on critical habitat. There is a capacity for critical habitats to be gazetted under the Threatened Species Conservation Act 1995. No such habitats have yet been gazetted for the Eastern Bent-wing Bat.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery or threat abatement plan.

At this point in time no recovery plan has been prepared for this species by DEC. DEC (2006) have identified that the following actions need to be followed in order to recover this species:

- Control foxes and feral cats around roosting sites, particularly maternity caves.
- Retain native vegetation around roost sites, particularly within 300 m of maternity caves.
- Minimise the use of pesticides in foraging areas.
- Protect roosting sites from damage or disturbance.

The proposal is consistent with all the recovery objectives for this species.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The NSW DEC have identified that the following threatening processes are acting upon this species:

- Damage to or disturbance of roosting caves, particularly during winter or breeding.
- Loss of foraging habitat.
- Application of pesticides in or adjacent to foraging areas.
- Predation by feral cats and foxes.

The proposed action constitutes a key threatening process, and it is considered to contribute to the increased impact of a threatening process.

Eastern Freetail-bat (*Mormopterus norfolkensis*)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction

Mormopterus norfolkensis is a tree-dwelling insectivorous bat which is often found in dry eucalypt forest and coastal woodlands. They have also been captured within riparian zones, wet sclerophyll forest and rainforest (Allison and Hoye 1995). They forage above the canopy or in unobstructed corridors in open areas (Allison and Hoye 1995) on either winged or wingless ants (Allison 1989).

The habitat requirements of *M. norfolkensis* are not very well known or understood. They are tree dwelling bats (Allison and Hoye 1995) which roost together in small colonies in hollows or under loose bark (Australian Museum 2004b).

This species has been recorded in the ecotone between cleared corridors and eucalypt forest/woodland and in forest/woodland habitats often in the vicinity of open water (EEC 1996). Thus, it is can be suggested that forest edges adjacent to cleared land provides important habitat for this species as it provides unrestricted flight and minimal clutter whilst near a potential food source. Foraging activity may be concentrated over small areas of open water, such as dams and creeks, in forest (EEC 1996).

Little is known of the reproductive cycle of *M. norfolkensis*, but the capture of a number of females and no males at one site indicates that there may be some sexual segregation at certain times of year (Allison and Hoye 1995). Seldom has more than one individual been captured from the locations where the species is known to occur, suggesting population densities, even in suitable areas, are low (EEC 1996). These factors make it nearly impossible to determine the extent of any local population; low population densities may suggest that the local population would cover a large geographical area.

The Eastern Freetail-bat was recorded foraging within the vegetation remnants contained on the subject site. Potential roosting habitat occurred on the subject site, and the early detection of calls (just after dusk) suggests that this species may be resident onsite. Tree hollow surveys (see Figure 5 in the main report) identified three potential habitat trees within the footprint area. The proposal will impact on 1.8 hectares of foraging habitat; however the changes in habitat over time as a result of the proposed creek diversion could, if not mitigated, reduce the area of habitat for the species. Notwithstanding, the proposal includes the rehabilitation and creation of new and suitable habitat so that there is no short-term or long-term loss of habitat for this species. The follow specific recommendations are made for Eastern Freetail-bats on the subject site:

- Regeneration of the riparian corridor must include 10 tree dwelling micro-bat nest boxes;
- The removal of the three hollow bearing trees (Figure 5) will be supervised by an ecologist;
- The hollows will be salvaged and re-installed within retained habitats; and,
- The creation of structural diversity in the understorey as described for some of the above species will also provide habitat for prey species of this micro-bat.

Given an undertaking of the above recommendations, we consider that this proposal **will not** reduce the viability of Eastern Freetail-bat in the local area, to a degree that could put the local population at risk of extinction.

(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

This factor applies a similar test as in factor (a) to endangered populations.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

~~i.~~iii. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be removed or modified as a result of the action.

Not applicable to Eastern Freetail-bat.

~~ii.~~iv. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not applicable to Eastern Freetail-bat.

(d) in relation to the habitat of a threatened species, population, or ecological community:

~~i.~~iv. the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed action **would** result in the loss of 1.8 hectares potential marginal habitat from the subject site.

~~ii.~~v. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposal will not contribute to the cumulative loss of habitat and the increased fragmentation or isolation of habitat.

~~iii.~~vi. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

It is currently difficult to quantify the importance of the habitat, however the species is often recorded in the local area in similar habitats. Given that the proposal will remove only a small area of the potential marginal habitat, it is predicted that this would not constitute a loss of significant habitat.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The proposal would not have any adverse effect on critical habitat. There is a capacity for critical habitats to be gazetted under the Threatened Species Conservation Act 1995. No such habitats have yet been gazetted for the Eastern Freetail-bat.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery or threat abatement plan.

At this point in time no recovery plan has been prepared for this species by DECCW. DECCW (2006) have identified that the following actions need to be followed in order to recover this species:

- Retain hollow-bearing trees and provide for hollow tree recruitment.
- Retain foraging habitat.
- Minimise the use of pesticides in foraging areas.

The proposal is consistent with all the recovery objectives for this species.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The NSW DECCW have identified that the following threatening processes are acting upon this species:

- Loss of hollow-bearing trees.
- Loss of foraging habitat.
- Application of pesticides in or adjacent to foraging areas.

The proposed action constitutes a key threatening process, and it is considered to contribute to the increased impact of a threatening process.

Large-footed Myotis (*Myotis macropus*)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction

Myotis macropus generally roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage. They forage over streams and pools catching insects and small fish by raking their feet across the water surface. In NSW females have one young each year usually in November or December.

Barcley *et al* (2009) recently published a study on the population genetics of *Myotis macropus*. They found that due to the species highly specialised feeding ecology, that it restricts the distribution of *M. macropus* to coastal regions and inland waterways. Genetic analysis of individuals from many populations showed that the movement of *M. macropus* throughout the landscape is constrained by the availability of permanent waterways and associated riparian habitats, and as such, genetic diversity between spatially close populations is large; suggesting limited genetic interaction. These findings represent important considerations for the conservation of this specialist species and the management of riparian vegetation, particularly on private land (Barcley *et al*, 2009).

Roosting sites is also an important factor for this species. Roost selection by *M. macropus* appears to be proximity of suitable waterways for foraging (Campbell 2009). Retention and maintenance of extensive riparian habitat, as well as the preservation of other structures used for roosting, are the most important conservation strategies for management of the day-roosting habitat of *M. macropus*. (Campbell 2009).

M. macropus exhibits variable roost-selection behaviour based on unique site characteristics, and also makes use of various artificial structures for maternity roosting. Such structures, particularly bridges, are susceptible to human disturbances and construction activities, and should therefore be checked thoroughly (preferably during summer) for any signs of bat occupation. Appropriate protection or translocation of colonies can then take place if necessary, incorporating the knowledge gained from recent successful colony relocations (Williams 2006; Marshall 2007). Because *M. macropus* regularly forms colonies in mad-made structures it may assist the species' conservation as these structures are quicker to construct relative to the time it takes for revegetated habitat to form hollows (Campbell 2009). The highly specialised foraging mode of *M. macropus* appears to influence roost-selection behaviour. Day-roosts, including maternity roosts, are primarily selected on the basis of their location close to permanent water. Therefore the protection and continual recruitment of trees close to water bodies is essential to ensure that the favoured roosting sites of *M. macropus* are maintained.

As discussed above, water permanency within potential habitat areas is important to the viability of a population. As the proposal stands, there will be no significant changes in water permanency within Bowmens Creek (Aquaterra 2008).

There are no structures within the proposal area that will be impacted, and although three potential roosting trees within the area will be impacted, these will be managed to limit interference with roosting sites, this includes:

- The removal of the three hollow bearing trees (Figure xx) will be supervised by an ecologist;
- The hollows will be salvaged and re-installed within retained habitats; and,
- The creation of structural diversity in the understorey as described for some of the above species will also provide habitat for prey species of this micro-bat.

The proposal includes the rehabilitation and creation of habitats so that there is no short-term or long-term loss of habitat for this species. The follow specific recommendation is made for *M. macropus* on the subject site:

- Regeneration of the riparian corridor must include 10 tree dwelling micro-bat nest boxes to be located adjacent to permanent water.

Given an undertaking of the above recommendations, we consider that this proposal **will not** reduce the viability of Large-footed Myotis in the local area, to a degree that could put the local population at risk of extinction.

(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

This factor applies a similar test as in factor (a) to endangered populations.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

~~iii.~~v. ***is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be removed or modified as a result of the action.***

Not applicable to Large-footed Myotis.

~~iv.~~vi. ***is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.***

Not applicable to Large-footed Myotis.

(d) in relation to the habitat of a threatened species, population, or ecological community:

~~iv.~~vii. ***the extent to which habitat is likely to be removed or modified as a result of the action proposed, and***

The proposed action **would** result in the loss of 1.8 hectares of potential habitat from the subject site.

~~v.~~viii. ***whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and***

The proposal will not contribute to the cumulative loss of habitat and the increased fragmentation or isolation of habitat.

~~vi.~~ix. ***the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.***

It is currently difficult to quantify the importance of the habitat, however the species rarely recorded in the local area in similar habitats, and recent research has highlighted the importance of continues riparian corridors and water permanency (Barcley *et al* 2009). Given that the proposal will remove only a small area of the potential habitat on the site, not impact on water permanency or increase fragmentation of habitat, it is predicted that this **would not** constitute a loss of significant habitat.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The proposal would not have any adverse effect on critical habitat. There is a capacity for critical habitats to be gazetted under the Threatened Species Conservation Act 1995. No such habitats have yet been gazetted for the Large-footed Myotis.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery or threat abatement plan.

At this point in time no recovery plan has been prepared for this species by DECCW. DECCW (2006) have identified that the following actions need to be followed in order to recover this species:

- Control foxes and feral cats around roosting sites, particularly maternity caves.
- Retain native vegetation around roost sites, particularly within 300 m of maternity caves.
- Minimise the use of pesticides in foraging areas.
- Protect roosting sites from damage or disturbance.

The proposal is consistent with all the recovery objectives for this species.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The NSW DECCW have identified that the following threatening processes are acting upon this species:

- Reduction in stream water quality affecting food resources;
- Loss or disturbance of roosting sites;
- Clearing adjacent to foraging areas; and
- Application of pesticides in or adjacent to foraging areas.

Long term post mining groundwater quality, and contribution to stream flows is expected to be similar to pre-mining conditions (Aquaterra 2008). Roosting sites will managed as detailed above and pesticides use is not an issue in this proposal.

The proposed action constitutes a key threatening process- clearing of native vegetation, and it is considered to contribute to the increased impact of this threatening process.

Grey-headed Flying-fox *Pteropus poliocephalus*

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction

The Grey-headed Flying Fox occurs in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps (Churchill 1998; Hall and Richards 2000; NPWS 2009). Urban gardens and cultivated fruit crops also provide habitat for this species. The main threats to the survival of this species are on-going habitat clearance particularly along the northern NSW coast. Un-regulated culling may also pose a threat to this species (DECCW 2009).

Roost sites (camps) can occur within rainforest patches, *Melaleuca* stands, mangroves, riparian woodland or modified vegetation in urban areas (NPWS 2009). Within the sub-regional area two Grey-headed Flying-fox camps occur at Blackbutt Reserve, Newcastle and at Singleton. The protection of camp sites is a major factor in the successful management of this species as it has been shown to have a high fidelity for such sites. For example, some camps in NSW have been used for over a century (Eby 2000b cited in NPWS 2001).

No camp sites were identified on the subject site and no Grey-headed Flying-foxes were observed during the survey period. Reproductive age is reached between 2-3 years with only one offspring (generally) produced each year (Martin *et al.* 1996). They return annually to traditional camps to give birth and rear young (Lunney and Moon 1997; Augee and Ford 1999 cited NPWS 2004).

Grey-headed Flying Foxes forage in the nectar and pollen of native trees, in particular *Eucalyptus*, *Melaleuca* and *Banksia* (Eby 2000a cited in NPWS 2001), and fruits of rainforest trees and vines.

Foraging movements are related to food availability, with movements of hundreds of kilometres being recorded (NPWS 2001). However, opportunistic foraging generally occurs at distances < 30 km from camps (occasionally < 60–70 km when food resources are inconsistent) per night (Augee and Ford 1999; Tidemann, *et al.* 1999 cited NPWS 2004).

Between May and June the Grey-headed Flying Fox occurs in northern NSW and Queensland feeding on winter-flowering trees such as Swamp Mahogany (*Eucalyptus robusta*), Forest Red Gum (*E. tereticornis*) and Paperbark (*Melaleuca quinquenervia*) (Eby *et al.* 1999; P. Birt and L. Hall pers. comm. cited NPWS 2004).

A small area of marginal foraging habitat was recorded within the subject site. Given the small area of limited habitat potential of the site, the removal of these resources **will not** reduce the viability of Grey-headed Flying-fox in the local area, to a degree that could put the local population at risk of extinction.

(b) ***in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.***

This factor applies a similar test as in factor (a) to endangered populations.

Not applicable for this species.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> ***iii. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be removed or modified as a result of the action.***

Not applicable to Grey-headed Flying-fox.

> ***iv. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.***

Not applicable to Grey-headed Flying-fox.

(d) in relation to the habitat of a threatened species, population, or ecological community:

> ***iv. the extent to which habitat is likely to be removed or modified as a result of the action proposed, and***

The proposed action **would** result in the loss of 1.8 hectares of potential marginal habitat from the subject site.

> ***v. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and***

The proposal will not contribute to the cumulative loss of habitat and the increased fragmentation or isolation of habitat.

> ***vi. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.***

It is currently difficult to quantify the importance of the habitat, however the foraging records made nightly during these surveys, indicates that the species utilizes the site occasionally. Given the small scale of removal it is predicted that this would not constitute a loss of significant habitat.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

The proposal would not have any adverse effect on critical habitat. There is a capacity for critical habitats to be gazetted under the Threatened Species Conservation Act 1995. No such habitats have yet been gazetted for Grey-headed Flying-fox.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery or threat abatement plan.

At this point in time no recovery plan has been prepared for this species by DECCW. DECCW (2006) have identified that the following actions need to be followed in order to recover this species:

- Protect roost sites, particularly avoid disturbance September through November.
- Identify and protect key foraging areas.
- Manage and enforce licensed shooting.
- Investigate and promote alternative non-lethal crop protection mechanisms.
- Identify powerline blackspots and implement measures to reduce deaths.

In addition DECCW (2006) have developed 29 priority actions which can be viewed at the DECCW website.

The proposal is not consistent with all the recovery objectives for this species. The proposal seeks to ameliorate any impact through the implementation of regeneration or restoration programs wherever suitable.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The NSW DECCW have identified that the following threatening processes are acting upon this species:

- Loss of foraging habitat.
- Disturbance of roosting sites.
- Unregulated shooting.
- Electrocution on powerlines.

The proposed action constitutes a key threatening process, and it is considered to contribute to the increased impact of a threatening process.

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