Appendix F

Ecology Report

Appendix F Ecology Report

Russell Vale Colliery – Underground Expansion Project:

Preferred Project Report – Biodiversity

FINAL REPORT

Prepared for Wollongong Coal Ltd

20 June 2014

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Summary

Wollongong Coal previously submitted an Environmental Assessment (EA) for the Russell Vale Colliery Underground Expansion Part 3A project to the NSW Department of Planning and Environment (DPE) in February 2013.

As a result of the submissions received, Wollongong Coal has made the decision to substantially modify the project application, including:

- Removal of Wonga West from the project application.
- Shortening of the Wonga Main drivage to not extend under the south arm of Cataract Reservoir through the known geological feature (in the Bulli Seam).
- Modification of the longwall layout in Wonga East.

Due to the substantive changes made DPE has requested Wollongong Coal prepare a Preferred Project Report (PPR) dated October 2013. This report has been updated to incorporate the final Groundwater Impact Assessment (Geoterra and GES 2014) and replaces the October 2013 report.

This report provides revised impact assessments for significant natural features previously recorded within the study area, based on the revised mine plan and associated revised subsidence predictions, as well as additional surveys and information that have been undertaken or has become available since the EA was submitted. This report also includes an assessment of likely historic impacts to these natural features based on past mining of the Bulli and Balgownie Seams.

The revised impact assessment concluded that there was a reduced risk of impact for many species and ecological communities due to the removal of Wonga West from the project application, the removal of longwalls from beneath Cataract Creek and a reduction in the number and extent of upland swamps being undermined.

The Preferred Project has significantly reduced potential impacts to biodiversity when compared to the original application. However, there remains a high risk of impact to upland swamp of 'special significance' CCUS4, including Giant Dragonfly habitat in this upland swamp, as well as a moderate risk of impact to upland swamp BCUS4.

A detailed Biodiversity Management Plan will be prepared for the Russell Vale Colliery which shall incorporate detailed mitigation and management measures in consultation with relevant regulators for these residual impacts.

1. Introduction

1.1 Project background

The Russell Vale Colliery is located at Russell Vale, to the west of Bellambi, in the Illawarra region of New South Wales (NSW). Wollongong Coal purchased the Colliery in December 2004, but extensive underground mining has been undertaken within the Colliery holdings dating from the late nineteenth century. However, a substantial volume of high quality coking coal resources remain, along with some potential thermal coal resources.

The Colliery holding includes a number of sub leases between Wollongong Coal and surrounding mine operators, including Consolidated Coal Lease (CCL) 745, Mining Purposes Lease (MPL) 271 and Mining Lease (ML) 1575, and covers a total area of approximately 6,973 hectares (ha).

Originally, Wollongong Coal intended to expand its operations in two stages. Stage 1 plans were included in the Preliminary Works Part 3A project application that was approved on 13 October 2011, allowing some first workings coal extraction and surface facility upgrades. On 24 December 2012, the Preliminary Works Part 3A project was modified to allow the extraction of Longwalls 4 and 5 and the establishment of Maingate 6.

The original Stage 2 application, known as the Underground Expansion Project Part 3A, was lodged with the NSW Department of Planning and Environment (DPE) on 12 August 2009 and contained an application to extract 11 longwalls in the Wonga East area and seven longwalls in the Wonga West area along with surface facilities upgrades to allow production up to 3 million tonnes per annum (Mtpa) for up to 20 years. Since that time it has been progressing through the Major Project approvals process and was placed on Public Exhibition on 18 February 2013. As a result of the submissions received on the application, Wollongong Coal has made the decision to substantially revise the application to facilitate the approval process and allow continuity in operations. Due to the scope of the changes, the DPE request Wollongong Coal prepare a Preferred Project Report (PPR) for the revised Underground Expansion Project Part 3A.

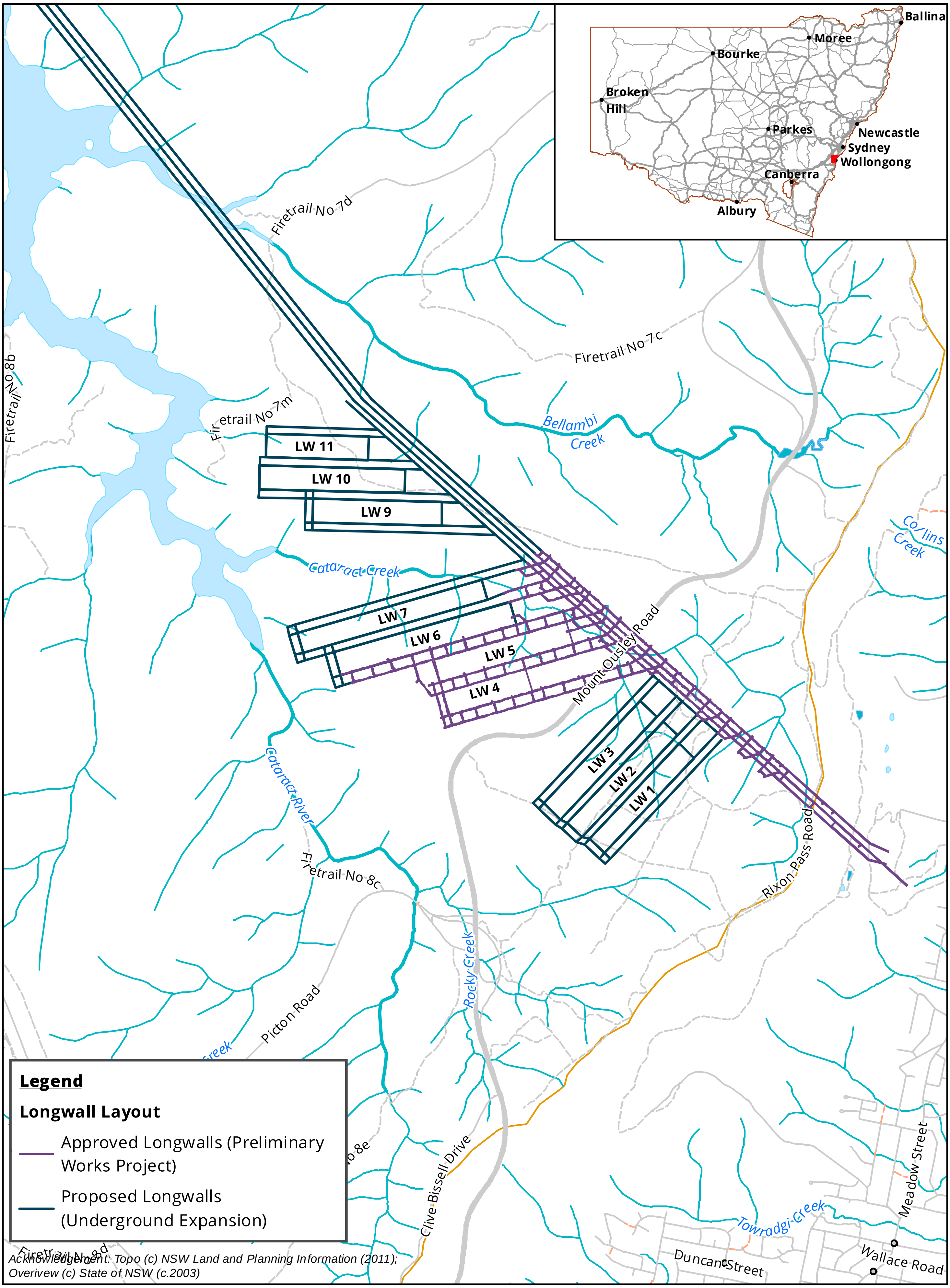
The Preferred Project Report (NRE 2013) outlines the revised Underground Expansion Project which has been reduced to a five year interim, staged project, with extraction of eight longwalls in the Wonga East area and upgrading of surface facilities to manage an extraction rate of up to 3 Mtpa run of mine (ROM) coal per annum. The original Wonga West longwall extraction will be resubmitted to DPE as a separate application.

This report produced in October 2013 to support the PPR has been updated in May 2014 and provides revised impact assessments for terrestrial ecology, aquatic ecology and upland swamps (Section 3). Measures to manage and mitigate impacts are discussed in Section 4. A response to submissions received is provided in Section 5. This report entirely replaces the October 2013 PPR ecology report.

1.2 Scope of assessment

The objectives of this report are to:

- Provide details of changes to the original project relevant to terrestrial ecology, aquatic ecology and upland swamps.
- Prepare revised impact assessments and management and mitigation measures based on these changes, including revised subsidence predictions and groundwater modelling results.
- Provide a response to submissions received on the 2013 Preferred Project Report for Biodiversity based on the changes outlined above.



Acknowledgement: Topo (c) NSW Land and Planning Information (2011); Overivew (c) State of NSW (c.2003)

Figure 1: Location of the Study Area, New South Wales

Scale 1:30,000 @ A4, GDA 1994 MGA Zone 55

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2. Preferred Project Changes

After serious consideration of the community and agency submissions, Wollongong Coal has decided to modify its Underground Expansion Project Part 3A application in the following manner:

1. The Wonga East longwall layout will be modified to minimise impacts to identified significant features while recovering the maximum volume of coal reserves possible.
2. The Wonga Mains driveage will not be extended northwards under the south arm of Cataract Reservoir through the known geological feature (in the Bulli Seam).
3. The Wonga West longwalls will be removed from the application.
4. No change to the Pit Top from the original proposal.

A more detailed summary comparing the original proposal presented in the Environmental Assessment with the Preferred Project is presented in Table 1 and Figure 2.

Table 1: Detailed Summary of Project Changes

Project Area	Original Project	PPR
Project Application Area	• As per Figure 1.2 of Underground Expansion Project Environmental Assessment	• No changes proposed
Production Limit	• 3 Mtpa	• No changes proposed
Pit Top	• Two new stockpiles of 140,000 tonnes capacity each (SP2 & SP3) with associated reclaim facilities • New truck loading facilities • Designated coal dispatch road • Progressive upgrading of trucking fleet • Continued road haulage of ROM coal to the Port Kembla Coal Terminal. • 6ML Settling Pond • Continuing use of No.4 Shaft for mine access, bathhouse, parking and offices • Ongoing maintenance and refurbishment of ventilation shafts, water and electrical facilities. • Ongoing geological and geotechnical investigations to determine coal quality and geotechnical conditions	• No changes proposed

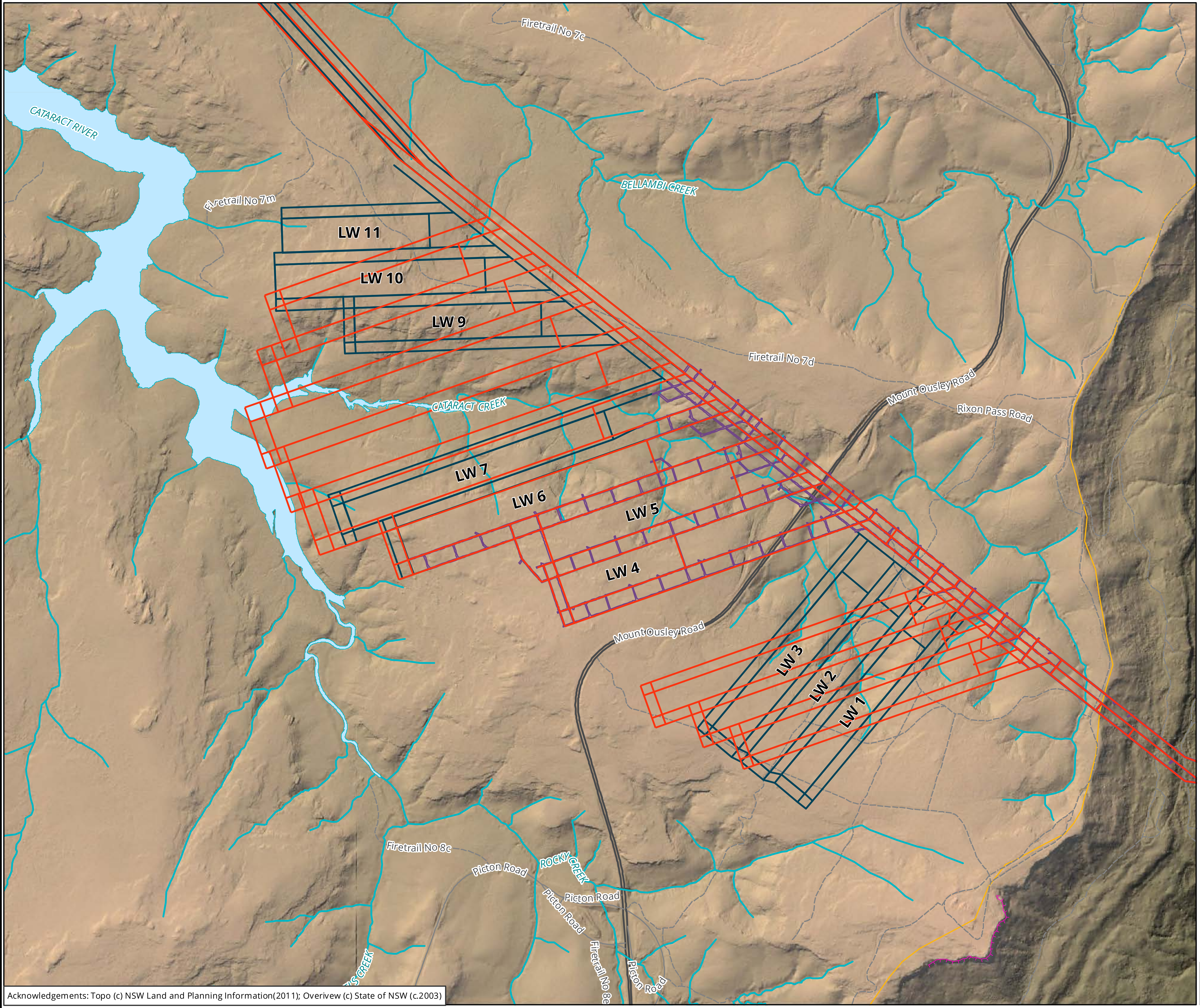
Project Area	Original Project	PPR
	using drilling and related techniques.	
Wonga East Longwalls	• 9 longwalls (LW) in two Areas – Area 1 – LW's 1-3 – Area 2 – LW's 6-11	• 8 longwalls in two Areas (see Figure 2). – Area 1 – LW's 1-3 shortened and reoriented to the southwest – Area 2 – LW 6 shortened – Area 2 – LW7 shortened and moved slightly south east – Area 2 – LW 8 removed – Area 2 – LW9-11 shortened and reoriented to the northwest
Wonga Mains	• Mains drivage from the end of the Preliminary Works approved drivage heading north west, beneath Cataract Reservoir to bisect the proposed Wonga West Areas 3 and 4.	• Mains drivage from the end of the Preliminary Works approved drivage heading west-northwest to what was the southern end of Wonga West Area 3.
Wonga West Longwalls	• 7 longwalls in two Areas – Area 3 – LW's 1-5 – Area 4 – LW's 6-7	• Removed from this application. To be resubmitted as a separate application to Department of Planning and Environment.
Bulli West - Bulli Seam 1st Workings	• 1st workings to the Bulli Seam to access the Bulli Seam in the western area of the Project Application Area.	• No changes proposed
Balgownie Seam 1st Workings	• 1st workings in the Balgownie Seam to access the Balgownie Seam in the western area of the Project Application Area.	• No changes proposed

For further detail see Section 1 of the PPR (NRE 2013).

These changes have resulted in the following changes to significant natural features in the Wonga East area:

- Cataract Creek will no longer be mined beneath.
- A reduction in mining beneath cliffs associated with Cataract Creek.
- Upland swamp CCUS1 will no longer be mined beneath.
- Minimisation of the extent of upland swamps CCUS5 and CCUS10 that will be mined beneath.
- Changes in impacts to significant natural features based on revised subsidence predictions.

These changes and their impacts are discussed further below.



Acknowledgements: Topo (c) NSW Land and Planning Information(2011); Overivew (c) State of NSW (c.2003)

Legend

Previous Wonga East Longwalls

Longwall Layout

Approved Longwalls (Preliminary Works Project)

Proposed Longwalls (Underground Expansion)

Figure 2: Proposed PPR mine plan

0 150 300 450 600 750

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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16646 PPR_F2_Mine Plan

3. Revised Impact Assessment

This section provides a revised impact assessment for ecological features within the Wonga East study area. The study area is defined as the area located within 600m of proposed secondary extraction for the revised longwall layout (Figure 3).

The Wonga East study area supports a wide range of ecological features, including the following significant natural features:

- Thirty-nine upland swamps (an Endangered Ecological Community (EEC)).
- Third and fourth order streams, including Cataract Creek and Cataract River.
- Rocky habitats, including rocky outcrops and cliffs.
- Threatened species and their habitats.

Significant natural features are shown in Figure 4. For a comprehensive discussion of these features see Section 2.4 of ERM (2013b).

This revised impact assessment focuses on those species, populations and communities listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and/or the NSW *Threatened Species Conservation Act 1995* (TSC Act) and deemed at risk of impact due to subsidence associated with longwall mining. This includes species that are reliant on natural features at risk of impact; particularly aquatic ecosystems (streams and creeks), upland swamps and rocky environments (including caves and overhangs) (DECC 2007a, DoP 2008). Past experience with longwall mining in the Southern Coalfield indicates that impacts to terrestrial ecosystems are generally less significant than those experienced by aquatic ecosystems, upland swamps and rocky environments, and terrestrial ecosystems are considered to be at negligible risk of impact from subsidence associated with longwall mining (DECC 2007a) and are not considered further.

3.1 Terrestrial ecology

A number of ecological assessments of the Wonga East area have been undertaken by ERM (summarised in ERM 2013b) and Biosis (2012a, 2012b, 2013). Together, these assessments provide a comprehensive inventory of the terrestrial biodiversity values present within the Wonga East area. A summary of these assessments can be found in ERM (2013a, 2013b).

Species, populations and communities either recorded during previous assessment, or deemed likely to occur within the study area, and considered vulnerable to impacts due to subsidence (DECC 2007a, ERM 2013b) are listed in Table 2.

Table 2: Threatened species, populations and communities likely to occur in the study area and vulnerable to indirect subsidence impacts (DECC 2007a, ERM 2013b)

E – Endangered, V - Vulnerable

Scientific name	Common name	EPBC Act status	TSC Act status
Flora			
Acacia baueri* ssp. *aspera	-	-	V
Epacris purpurascens* var. *purpurascens	-	-	V
Grevillea parviflora* ssp. *parviflora	Small-flowered Grevillea	V	V
Leucopogon exolasius	Woronora Beard-heath	V	V
Melaleuca deanei	Deane's Melaleuca	V	V
Persoonia bargoensis	Bargo Geebung	V	E
Pultenaea aristata	Prickly Bush-pea	V	V
Threatened ecological communities			
-	*Coastal Upland swamp in the Sydney Basin Bioregion*	-	E
Birds			
Pezoporus wallicus wallicus	Eastern Ground Parrot	-	V
Mammals (excl. bats)			
Cercartetus nanus	Eastern Pygmy Possum	-	V
Dasyurus maculatus maculatus	Spotted-tailed Quoll	E	V
Mammals - Bats			
Chalinolobus dwyeri	Large-eared Pied Bat	V	V
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	-	V
Myotis macropus	Large-footed Myotis	-	V
Reptiles			
Hoplocephalus bungaroides	Broad-headed Snake	V	E
Varanus rosenbergi	Rosenberg's Goanna	-	V
Frogs			
Heleioporus australiacus	Giant Burrowing Frog	V	V
Litoria littlejohni	Littlejohn's Tree frog	V	V
Pseudophryne australis	Red-crowned Toadlet	-	V
Mixophyes balbus	Stuttering Frog	V	E
Invertebrates			

Scientific name	Common name	EPBC Act status	TSC Act status
Petalura gigantea	Giant Dragonfly	-	E

These species are discussed further below in Sections 3.1.1 (flora) and Section 3.1.2 (fauna). A revised impact assessment is provided in Section 3.1.4.

Upland swamps are discussed further in Section 3.3.

3.1.1 Flora

ERM (2013b) identified seven threatened flora species at risk of indirect impact due to subsidence associated with extraction of coal from the Wonga East and Wonga West areas. Given the changes to the project, including the removal of the Wonga West area from the application, a reassessment of the potential for species to occur within the study area is required.

Table 3 provides a reassessment of habitat for these species, the potential for this habitat to occur within the study area, and a determination of the reliance of these species on microhabitats that are at risk of impacts from subsidence associated with the Preferred Project.

Species that are considered likely to occur within the study area and are considered to be at risk of impact from subsidence associated with the Preferred Project are considered further in Section 3.1.4.

Table 3: Terrestrial flora species vulnerable to impacts from subsidence (DECC 2007a) and an assessment of microhabitats within the study area

Species	Description	Does the species occur in, and is it reliant on, susceptible microhabitats within the study area?
Acacia baueri* ssp. *aspera	*Acacia baueri* ssp. *baueri* occurs in damp heaths associated with sandstone woodland (ERM 2013b) and often occurs in small depressions on rocky outcrops. Further, targeted and opportunistic surveys in the study area have not recorded this species. The Wonga East area does not contain many rocky outcrops, and suitable habitat for this species within the study area is limited.	Yes but limited Rocky outcrops
Epacris purpurascens* var. *purpurascens	*Epacris purpurascens* var. *purpurascens* is found within a wide range of habitat, usually associated with moisture, most of which have a strong shale influence (ERM 2013b, BHPBIC 2009). It is not considered to be a swamp specialist. This habitat is considered to be at negligible risk of impact. Further opportunistic surveys in the study area have not recorded this species.	No
Small-flowered Grevillea	Small-flower Grevillea grows in sandy or light clay soils, usually over thin shales, and occurs in a wide range of vegetation types (ERM 2013b). Habitat for this species is considered to be at negligible risk of impact. Further, targeted and opportunistic surveys in the study area have not recorded this species.	No
Woronora Beard-heath	Woronora Beard-heath occurs in a wide range of habitat types, including woodland, rocky hillsides and creeks (ERM 2013b). The wide range of habitats this species occurs in are considered to be at negligible risk of impact. Further, targeted and opportunistic surveys in the study area have not recorded this species.	No
Deane's Melaleuca	Deane's Paperbark grows in heath communities on sand, and has been recorded from ridgetops, dry ridges and slopes. It is often associated with sandy loam soils (ERM 2013b). This species is not considered to be reliant on microhabitats that are at risk of impact due to subsidence. Further, targeted and opportunistic surveys in the study area have not recorded this species.	No

Species	Description	Does the species occur in, and is it reliant on, susceptible microhabitats within the study area?
Bargo Geebung	Bargo Geebung grows in woodland and dry Sclerophyll forest on a wide variety of soils types. This species is not reliant on microhabitats at risk of impact from subsidence. Further, targeted and opportunistic surveys in the study area have not recorded this species.	No
Prickly Bush-pea	Prickly Bush-pea has been recorded within the study area from open habitats, including upland swamps and adjacent woodland. The species occurs where drainage is impeded (NPWS 2003), usually in areas where low degree slopes result in slowing of surface and groundwater flows (Biosis pers. obs.). Since the original EA (ERM 2013a) was submitted this species has been recorded at a number of additional locations and the species is known to be common and widely distributed in the study area.	Yes Upland swamps

3.1.2 Fauna

ERM (2013b) identified thirteen threatened fauna species at risk of impact due to subsidence associated with the original project. This assessment considered available habitat in the Wonga East and Wonga West area.

Given changes to the project, including the removal of the Wonga West area from the application, a reassessment of the potential for species to occur within the study area is required. Table 4 provides a reassessment of habitat for these species, the potential for this habitat to occur within the study area, and a determination of the reliance of these species on microhabitats that are at risk of impacts from subsidence.

Species that are considered likely to occur within the study area and at risk of impact from subsidence associated with the Preferred Project are considered further in Section 3.1.4.

Table 4: Terrestrial fauna species vulnerable to impacts from subsidence (DECC 2007a) and an assessment of microhabitats within the study area

Species	Description	Does the species occur in, and is it reliant on, susceptible microhabitats within the study area?
Eastern Ground Parrot	The Eastern Ground Parrot was previously thought to be extinct within the local area (DECC 2007b) prior to several observations of this species during surveys for the Metropolitan Coal Project and the Bulli Seam Operations Project. The Eastern Ground Parrot occurs in low heathlands and sedgelands, generally below one metre in height and very dense (OEH 2013b). Habitat within the study area is largely limited to MU 44 Upland swamp: Sedgeland-Heath Complex. This vegetation community is severely restricted and highly fragmented within the study area. The previous assessment (ERM 2013b) assessed that this species could potentially occur in the Wonga West area, but was unlikely to occur within the Wonga East area. This species is considered unlikely to occur within the study area.	No
Eastern Pygmy Possum	The Eastern Pygmy Possum occurs in a wide variety of habitat types, including rainforest, sclerophyll forest and heaths (DECC 2007b) and upland swamps (Biosis pers. obs., DECC 2007a). Given the wide range of habitat types that this species inhabits it is not considered to be at significant risk of impact from subsidence.	No
Spotted-tailed Quoll	The Spotted-tailed Quoll utilises a wide range of habitat types, with cliffs, rock benches or overhangs listed as habitat with potential to be impacted (DECC 2007a). Given the widespread nature of this species' habitat the risk of impact is considered to be negligible.	No
Large-eared Pied Bat	The Large-eared Pied Bat is considered rare within the local area and has narrow habitat requirements, including productive land close to suitable roosting habitats (DECC 2007b). The species roosts in caves and overhangs, and it is this habitat which is of high conservation significance (DECC 2007b). Cliffs that may provide suitable roosting sites within the study area are limited in extent, and restricted to an area over LW9.	Yes Cliffs over LW9
Eastern Bentwing-bat	The Eastern Bentwing-bat is common in the local area, being one of the most commonly recorded bats	Yes

Species	Description	Does the species occur in, and is it reliant on, susceptible microhabitats within the study area?
	during surveys (Biosis pers. obs.). This species has been recorded within the study area. The species forages within a wide range of habitat types and across a large area. The species roosts in caves and overhangs, and it is this habitat which is of high conservation significance (DECC 2007b). Cliffs that may provide suitable roosting sites within the study area are limited in extent, and restricted to an area over LW9.	Cliffs over LW9
Large-footed Myotis	The Large-footed Mytois is considered to be rare in the local area (DECC 2007b). The species forages along waterways, including disturbed waterways in urban environments, and is more common in more highly productive environments, although the species has been recorded on the Woronora plateau. The species roosts in caves and overhangs, and it is this habitat, which is of high conservation significance (DECC 2007b). Cliffs that may provide suitable roosting sites within the study area are limited in extent, and restricted to an area over LW9. Cataract Creek provides potential foraging habitat for this species. The species may be susceptible to changes in water quality or natural flow regimes (DECC 2007b).	Yes Cliffs over LW9 and Cataract Creek
Broad-headed Snake	The Broad-headed Snake occurs on exposed rocky outcrops with bedrock providing suitable winter sheltering habitat. This species is extremely rare in the local area (DECC 2007b). Due to the presence of this species on rocky outcrops that are susceptible to fracturing due to subsidence, the species is listed by DECC (2007a) as being at risk of impact from longwall mining. Biosis has previously undertaken monitoring of rocky outcrops for the Dendrobium, Wongawilli and Nebo mines. While subsidence effects, including fracturing of rocky outcrops, have been observed, no impacts to sheltering habitat for reptiles was observed in these areas. The Wonga East area does not contain many rocky outcrops, and suitable habitat for this species within the study area is limited. The risk of impact to this species is considered minimal. However, if specific locations for this species were identified these would be considered of high conservation value given the species' rarity. For this reason, the species is considered further below.	Yes Rocky outcrops

Species	Description	Does the species occur in, and is it reliant on, susceptible microhabitats within the study area?
Rosenberg's Goanna	Rosenberg's Goanna inhabits ridgetops with higher levels of rocks and shrubs that provide habitat for prey species (DECC 2007b). Although this species is located on rocky outcrops which are at risk of impacts from subsidence (DECC 2007a) the species or its prey do not rely on specific habitat features at risk of impact. Thus the species is considered at negligible risk of impact from the preferred project.	No
Giant Burrowing Frog	The Giant Burrowing Frog occurs in sandstone environments and is generally associated with first and second order intermittent creeks that provide suitable breeding pools (Biosis pers. obs.). Although often associated with upland swamps, DECC (2007b) assert that this association is not direct, rather that upland swamps are associated with minor drainage lines that provide suitable breeding pools and burrowing habitat for this species. Detailed habitat mapping was undertaken by Biosis (2012b, 2013a) with suitable breeding habitat for this species mapped at four locations in the study area (Figure 5). Targeted surveys undertaken by Biosis as a part of the ecological monitoring program for Wonga East in August and December 2012, February, April, August and May 2013 and January and February 2014 have detected tadpoles for the Giant Burrowing Frog in a tributary of CRUS2. A total of 17 tadpoles were observed in three breeding pools located along the 245 metre transect (Figure 5). This tributary of CRUS2 is located approximately 700 m from the nearest longwall (LW4) and is outside the active subsidence zone. The species has not been recorded elsewhere within the study area.	No
Littlejohn's Tree frog	Littlejohn's Tree Frog occurs in sandstone environments and is generally associated with first and second order intermittent creeks that provide suitable breeding pools (Biosis pers. obs.). The species has been recorded within a wide variety of vegetation types, all associated with more open habitat and intermittent creeks. This includes, but is not restricted to, upland swamps (Biosis pers. obs.). Detailed habitat mapping was undertaken by Biosis (2012b, 2013a) with suitable breeding habitat for this species mapped at four locations in the study area (Figure 5). Targeted surveys undertaken by Biosis as a part of the ecological monitoring program for Wonga East in August and December 2012, February, April, August and May 2013 and January and February 2014 have not recorded this species.	No

Species	Description	Does the species occur in, and is it reliant on, susceptible microhabitats within the study area?
Red-crowned Toadlet	The Red-crowned Toadlet is fairly common in preferred ridgetop habitat and first order ephemeral creeks below ridges (DECC 2007b) and has been recorded, using drainage lines, sheltering under bushrock on ridgetops and in depressions along fire trails (Biosis pers. obs.). Habitat for this species within the study area has not been mapped, as it is widely distributed and common. Targeted surveys for the Red-crowned Toadlet have been undertaken by Biosis as a part of the ecological monitoring program for Wonga East (Biosis 2013a). Surveys were conducted using auditory recording devices located in suitable breeding habitat along two ephemeral creeks below ridgelines above Longwall 4 and Longwall 5 (Figure 4). The Red-crowned Toadlet was recorded calling at both sites (Biosis 2013a). However, preferred habitat for this species is considered to be at limited risk of impact.	Yes Not reliant on microhabitat susceptible to impacts
Stuttering Frog	The Stuttering Frog is generally considered rare within the Sydney Basin bioregion and is now close to extinction in the local area (DECC 2007b). Detailed habitat mapping was undertaken by Biosis (2012b, 2013a) with suitable breeding habitat for this species mapped along Cataract Creek in the study area (Figure 5). Cataract Creek has been impacted by past mining of the Bulli and Balgownie coal seams, with an iron seep located along a tributary of Cataract Creek resulting in moderate to high levels of iron flocculent in the creek. This past impact is likely to reduce the suitability of the habitat for this species (ERM 2013b). Targeted surveys undertaken by Biosis as a part of the ecological monitoring program for Wonga East in October, November and December 2012, February and November 2013 and January and February 2014 have not recorded the Stuttering Frog along Cataract Creek.	No
Giant Dragonfly	OEH (2013d) identifies upland swamps with open vegetation and free water as preferred habitat for the Giant Dragonfly. Potential breeding habitat for the Giant Dragonfly can be identified based on the hydrogeomorphology, rainfall range and soils (Baird 2012). Breeding habitat is presumed to be associated with groundwater dependent habitat with some associated development of organic-rich or peaty soils. Swamp types with a negative water balance and prolonged periods of surface drying, or characterised by permanent or prolonged seasonal inundation, are not considered to provide	Yes Areas of upland swamp BCUS4, CCUS4 and CRUS1.

Species	Description	Does the species occur in, and is it reliant on, susceptible microhabitats within the study area?
	potential breeding habitat for this species. Based on this information, Biosis has undertaken a review of potential habitat within the Wonga East area and identified upland swamps CCUS1, CCUS4, CCUS5, CCUS10, CRUS1 and BCUS4 as potential habitat for this species based on presence of communities reliant on presence of groundwater and potential for organic-rich soils. Additional surveys of these areas were undertaken in December 2013 and January to February 2014. These additional surveys focused on identifying significant breeding habitat through surveys for exuviae of the Giant Dragonfly, as it is breeding habitat for this species that is likely to be susceptible to impacts from subsidence and consequent changes in soil moisture. Exuviae were located in upland swamps CCUS4, CRUS1 and BCUS4. In all upland swamps exuviae were located in areas with deep, organic soils. In CCUS4 and BCUS4 this was at the downstream extent of these swamps, where there was an accumulation of groundwater and open vegetation. In CRUS1 this was in pockets of groundwater dependent Tea-tree Thicket with an open overstorey, created by underlying geology. Of the locations where exuviae were observed only CCUS4 will be directly undermined. The potential for other locations listed above to support breeding habitat for this species cannot be discounted; however other locations will not be directly undermined.	

3.1.3 Assessment of historic impacts to terrestrial biodiversity from extraction of the Bulli and Balgownie seams

Sections 3.1.1 and 3.1.2 identify the following significant natural features at risk of impact due to subsidence:

- Rocky outcrops;
- Upland swamps;
- Cliffs over Longwall 9;
- Cataract Creek; and
- Threatened frog habitat as identified in Figure 5.

ERM (2013a) and ERM (2013b) provide a summary of potential impact mechanisms. This section assesses the potential impacts of past mining of the Bulli and Balgownie seams, before assessing the impacts of the original project versus the preferred project on these significant natural features

Extraction of the Bulli and Balgownie seams has occurred within the Wonga East area. Within the study area, the Bulli seam was extracted via hand workings and pillar extraction between 1890 and 1960. The Balgownie seam was extracted using continuous miner pillar extraction in 1969 and the retreat longwall mining method from 1970 to 1982. Assessment of subsidence data from the extraction of the Bulli and Balgownie coal seams has been undertaken by SCT Operations (2014).

Table 5 provides subsidence predictions for identified significant natural features from the extraction of the Bulli and Balgownie Seams in the Wonga East area.

Table 5: Bulli and Balgownie seam subsidence predictions for selected significant features in the study area

	Bulli seam and Balgownie seam Subsidence (m) (Balgownie Seam only in brackets)	Balgownie seam Tilt (mm/m)	Balgownie seam Max Tensile Strain (mm/m) and Typical (in brackets)	Balgownie seam Max Compressive Strain (mm/m) and Typical (in brackets)	Balgownie seam Closure (mm)
Selected natural features					
Threatened frog habitat CRUS2 Trib	0.5 (<0.1)	5	3	4	-
Threatened frog habitat CRUS1 Trib1	0.5 (<0.1)	5	3	4	-
Threatened frog habitat CRUS1 Trib2	0.9 (<0.1)	11	3	4	-
Threatened frog habitat CCUS4 Trib	1.2 (0.7)	18	8 (3)	14 (4)	-
Cliffs over LW9	0.5 (<0.1)	N/A	N/A	N/A	-
Cataract Creek	1.4 (1.2)	15	N/A	N/A	310
Giant Dragonfly habitat BCUS4	0.6 (0.1)	2	0.5	1	-
Giant Dragonfly habitat CCUS4	0.9 (0.8)	13	4	8	-
Giant Dragonfly habitat CRUS1	0.5 (0.1)	2	0.5	1	-

Available data indicates that past mining of the Bulli and Balgownie Seams is likely to have resulted in fracturing of bedrock beneath identified threatened frog habitat, and that closure in Cataract Creek is likely to have been sufficient to have resulted in diversion of surface flows using criteria identified by MSEC (DoP 2010). Fracturing of bedrock and changes in groundwater levels are likely to have occurred in upland swamps CCUS4 and CRUS1 (see Section 3.3.4 for further discussion).

Based on this data, it is likely that there are pre-existing impacts to identified natural features, as outlined above. There is evidence to support this conclusion, with iron seeping from a tributary of Cataract Creek resulting in a significant amount of iron flocculent in Cataract Creek. However, no impacts to the bed of Cataract Creek have been observed. Cliffs in the study area show signs of previous collapse, including some where likely mining-induced collapse has occurred (K. Mills pers. comm.).

This assessment of past mining in the Wonga East area indicates that natural features in the study area have been subject to subsidence resulting from extraction of the Bulli and Balgownie Seams. This data provides a baseline against which assessments of potential impacts resulting from extraction of the Wongawilli Seam, as part of the preferred project, must be assessed.

3.1.4 Revised impacts assessment for terrestrial biodiversity

A summary of subsidence predictions for extraction of the Wongawilli Seam in the Wonga East area is provided in Table 6. This table provides predicted subsidence parameters for each longwall, as well as predicted subsidence for significant natural features outlined above.

The extraction of the Wongawilli Seam in the Wonga East area will result in a maximum of 2.1 m of subsidence, with tilts between 24 and 51 mm / m, tensile strain of between 7 and 15 mm / m and compressive strains between 14 and 31 mm / m. Closure within Cataract Creek will be managed to minimise the risk of creek bed cracking and subsurface flow.

As can be seen from Table 6, the majority of significant natural features within the study area are at minimal risk of impact, with subsidence predictions indicating subsidence effects are likely to be minimal. The exception to this is threatened frog habitat in CCUS4 Trib, cliffs over Longwall 9 and Giant Dragonfly habitat in upland swamps BCUS4, CCUS4 and CRUS1.

Table 7 provides impact assessments, including an assessment of impacts from the original project compared to the preferred project, for natural features identified in Sections 3.1.1 and 3.1.2.

Tilts, tensile strains and compressive strains in CCUS4 Trib are sufficient to result in fracturing of the bedrock beneath this tributary. There is also potential for rockfall from and collapse of a sandstone formation at the downstream extent of this habitat. However, no threatened frogs have been recorded at this location to date. Known habitat for the Giant Burrowing Frog in CRUS2 Trib will not be impacted.

Subsidence predictions for cliffs over Longwall 9 are of sufficient magnitude to result in impacts to these cliffs. Impacts, including tensile cracking of the rock strata and collapse, are likely to occur, particularly where horizontal compression exceeds 50 – 100 mm per 20 m length of cliff formation. However, it is difficult to predict the location/s where impacts may occur. Given the limited extent of suitable roosting sites for microchiropteran bats the risk of impact is considered low, particularly when compared with the availability of suitable habitat in the local area. Risk of collapse is considered minimal (SCT Operations 2014).

Subsidence predictions for Cataract Creek indicate that this waterway is unlikely to be subject to negative environmental consequences. Closure will be managed to minimise the risk of creek bed cracking and subsurface flow, and tilts, compressive and tensile strains are unlikely to be of sufficient magnitude to result in fracturing of the bedrock of Cataract Creek. However, fracturing of tributaries of Cataract Creek may result in decreased inflow into Cataract Creek, and an increase in iron seepage at the base of these tributaries and resultant potential for increased iron flocculent in Cataract Creek (A. Dawkins pers. comm.).

The groundwater model indicates that the average daily stream flow from Cataract Creek to Cataract Reservoir is 11.2 ML/d, of which 3.5 ML/d is baseflow. The model predicts a 0.013 ML/d (0.12%) loss of stream baseflow following mining. This level of change is unlikely to be detectable and unlikely to result in observable changes to flow regimes in Cataract Creek. Increases in iron hydroxide flocculent are unlikely to result in observable changes to Cataract Creek above and beyond those present due to past mining.

Of the three upland swamps where exuviae of the Giant Dragonfly was observed, only CCUS4 will be directly mined under. Although impacts to Giant Dragonfly habitat in upland swamps BCUS4 and CRUS1 may be indirectly impacted through upper sections of these upland swamps being mined beneath, further discussion in Section 3.3.4 indicates the risk of impact to water availability in these upland swamps is low. The risk of changes in water availability impacting on habitat for the Giant Dragonfly in CCUS4 is considered high. However, any impacts are unlikely to result in a significant impact to the local population of this species, as the Giant Dragonfly has been recorded elsewhere in the immediate area, and the species has regularly been observed in previously undermined upland swamps, including upland swamps in Wallandoola Creek and Lizard Creek.

Further assessment and discussion of potential impacts is provided below.

Table 6: Wongawilli seam subsidence predictions for longwalls and selected significant features in the study area

	Overburden depth to Wongawilli Seam (m)	Subsidence predicted (m) and measured (in brackets)	Tilt predicted (mm/m) and measured (in brackets)	Tensile strain predicted (mm/m) and measured (in brackets)	Compressive strain predicted (mm/m) and measured (in brackets)	Closure on Cataract Creek (mm)
Longwall 1	260	2.1	40	12	24	-
Longwall 2	260	2.1	40	12	24	-
Longwall 3	255	2.6	51	15	31	-
Longwall 4	300	2.1 (1.6)	35 (30)	10.5 (7.5)	21 (14)	< 5
Longwall 5	265	1.9 (1.8)	36 (30)	11 (6)	22 (14)	130 (49)
Longwall 6	280	2.1	38	11	23	130
Longwall 7	270	1.5	28	8	17	200
Longwall 9	330	2.1	32	10	19	120
Longwall 10	340	1.6	24	7	14	20
Longwall 11	350	2.1	30	9	18	0
Selected natural features						
Threatened frog habitat CRUS2 Trib	300	0	0	0	0	-
Threatened frog habitat CRUS1 Trib1	320	0	0	0	0	-
Threatened frog habitat CRUS1 Trib2	320	0.02	0	0	0	-
Threatened frog habitat CCUS4 Trib	270	1.5	28	8	17	-
Cliffs over LW9	330	2.1	32	10	19	-

	Overburden depth to Wongawilli Seam (m)	Subsidence predicted (m) and measured (in brackets)	Tilt predicted (mm/m) and measured (in brackets)	Tensile strain predicted (mm/m) and measured (in brackets)	Compressive strain predicted (mm/m) and measured (in brackets)	Closure on Cataract Creek (mm)
Cataract Creek	260	< 0.2	1.0	0.0	N/A	200
Giant Dragonfly habitat BCUS4	295	1.0	23	6.8	13.6	-
Giant Dragonfly habitat CCUS4	290	1.4	31	9.2	18.5	-
Giant Dragonfly habitat CRUS1	300	1.4	22	6.7	13.4	-

Table 7: Impact assessment for species at risk of subsidence, including comparison of risks from the original project and preferred project

Species	Microhabitats at significant risk of impact from subsidence	Potential impacts to critical microhabitat	Notes	Risk of impact from original project (based on ERM 2013a and ERM 2013b)	Risk of impact from preferred project
Acacia baueri* ssp. *aspera	Rocky outcrops	Fracturing of the base of minor depressions in rocky outcrops, leading to reduced moisture in these areas and potential loss of individual plants.	The general risk of fracturing of rocky outcrops within the study area is considered moderately high; however suitable habitat (i.e. rocky outcrops with minor depressions) is limited within the study area	Low	Low
Prickly Bush-pea	Upland swamps	Fracturing of bedrock resulting in changes in water availability or changes in vegetation composition	The species is widespread and common within the study area, having been recorded at a greater number of locations since the submission of the EA (ERM 2013b).	Low	Low

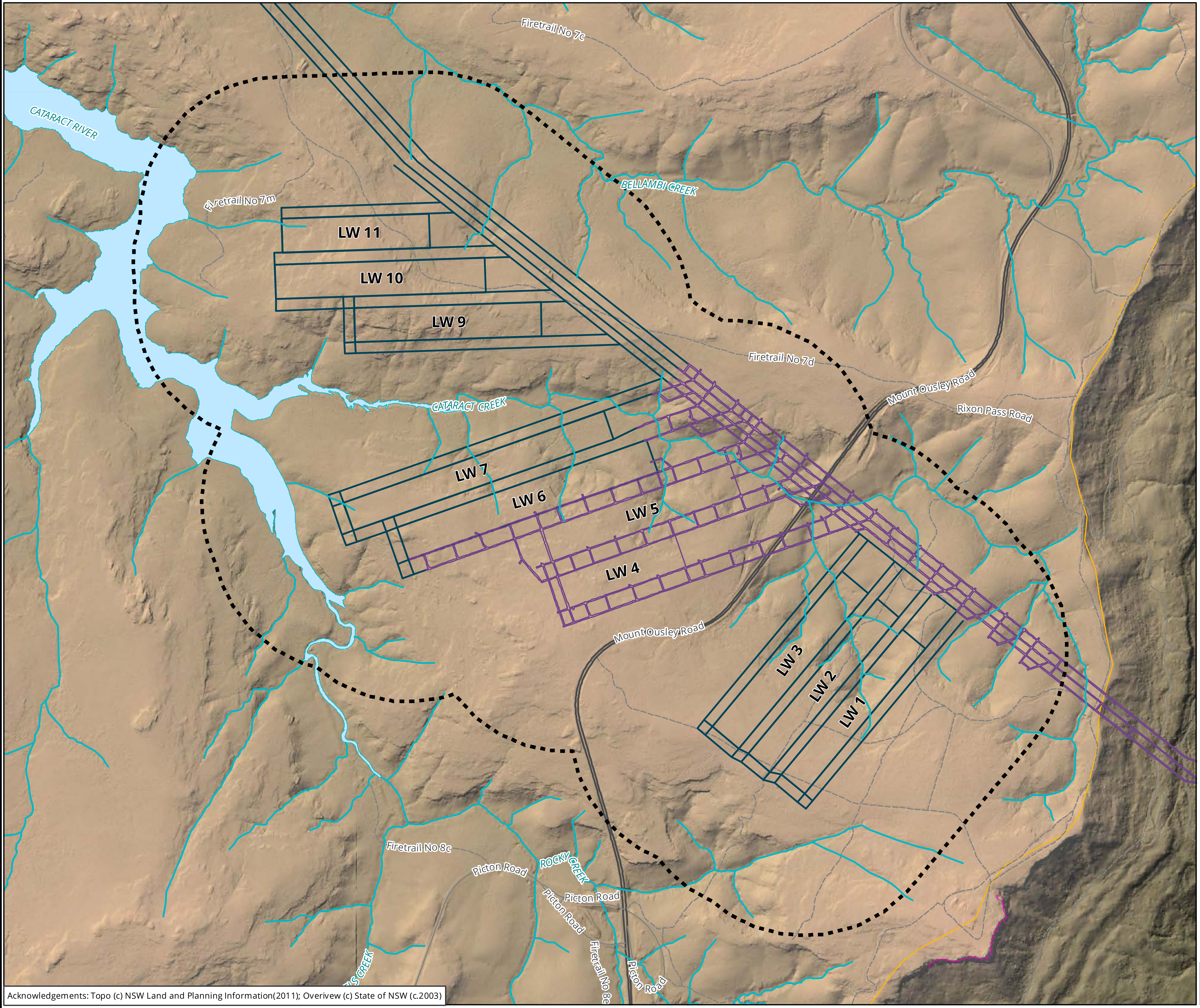
Species	Microhabitats at significant risk of impact from subsidence	Potential impacts to critical microhabitat	Notes	Risk of impact from original project (based on ERM 2013a and ERM 2013b)	Risk of impact from preferred project
		resulting in increased competition. Changes in slope gradient resulting in decreased water availability.	Although there is potential for fracturing of bedrock beneath suitable upland swamp habitat, and changes in hydrology, impacts to wider habitat are predicted to be minimal.		
Large-eared Pied Bat **Eastern Bentwing-bat** **Large-footed Myotis**	Cliffs	Overhang collapse resulting in destruction of roosting habitat.	Potential roosting habitat within the study area is limited in extent, and restricted to an area above LW9. Further, the risk of collapse of these cliffs is considered to be low (~5%; K. Mills pers. comm.). The removal of Wonga West from the project, where suitable habitat was much more prevalent along Lizard and Wallandoola Creeks, has resulted in a reduction in risk.	Moderate (Wonga West)	Low
	Cataract Creek (Large-footed Mytois only)	Fracturing of stream bed resulting in diversion of flows along sections of creeks. Increased iron entering the waterway, resulting in changes in water quality and choking of vegetation by iron flocculent.	The revision of the mine plan now avoids mining below Cataract Creek. No impacts to the bed of Cataract Creek are predicted to occur and diversion of flows is unlikely (A. Dawkins pers. comm.). There is potential for fracturing of the base of tributaries of Cataract Creek, resulting in diversion of flows, decreased inflow into Cataract Creek and iron seepage (A. Dawkins pers. comm.). The extent and magnitude of impact will be dependent on past impacts from extraction of the Bulli and Balgownie seams.	Low	Low

Species	Microhabitats at significant risk of impact from subsidence	Potential impacts to critical microhabitat	Notes	Risk of impact from original project (based on ERM 2013a and ERM 2013b)	Risk of impact from preferred project
Broad-headed Snake	Rocky outcrops	Fracturing of rocky outcrops leading to a loss or change in shelter sites for this species or its prey.	The general risk of fracturing of rocky outcrops within the study area is considered moderately high with perceptible cracking in up to 30% of bare rock areas located directly above longwalls (k. Mills pers. comm.). However suitable habitat (i.e. rocky outcrops with suitable shelter) is limited within the study area. Suitable habitat for the species, identified within the EA (ERM 2013b) was largely limited to Wonga West.	Moderate (Wonga West)	Low
Giant Burrowing Frog **Littlejohn's Tree frog**	Creeks shown in Figure 5	Fracturing of stream bed resulting in diversion of flows along sections of creeks providing breeding habitat, resulting in loss of breeding pools. Fracturing of the base and draining of breeding pools. Increased iron entering the waterway, resulting in changes in water quality and choking of vegetation by iron flocculent. Release of methane gas into the water column, resulting in vegetation dieback in riparian	Suitable habitat for these species has been identified in three tributaries of Cataract River and one tributary of Cataract Creek (Figure 5; Biosis 2012a, Biosis 2013a). Surveys undertaken as a part of the ecological monitoring program for Longwalls 4 and 5 have identified Giant Burrowing Frog tadpoles at one of these locations, in a tributary of Cataract River below CRUS2. This site is located outside of the predicted subsidence impact zone. These species have not been recorded at any other sites. Additional targeted surveys and the removal of Wonga West from the project application have resulted in a significant reduction in risk of impact to this species.	High	Low

Species	Microhabitats at significant risk of impact from subsidence	Potential impacts to critical microhabitat	Notes	Risk of impact from original project (based on ERM 2013a and ERM 2013b)	Risk of impact from preferred project
		environments and impacts to water quality.			
Stuttering Frog	Yes Cataract Creek (Figure 5)	Fracturing of stream bed resulting in diversion of flows along sections of creeks providing breeding habitat, resulting in impacts to suitable breeding habitat. Fracturing of the base and draining of breeding pools. Increased iron entering the waterway, resulting in changes in water quality and choking of vegetation by iron flocculent. Release of methane gas into the water column, resulting in vegetation dieback in riparian environments and impacts to	Suitable habitat for this species has been identified in Cataract Creek (Figure 5; Biosis 2012a, Biosis 2013a). Surveys undertaken as a part of the ecological monitoring program for Longwalls 4 and 5 have not recorded this species in the study area. Additional targeted surveys have resulted in a reduction in risk of impact to this species.	Moderate	Low

Species	Microhabitats at significant risk of impact from subsidence	Potential impacts to critical microhabitat	Notes	Risk of impact from original project (based on ERM 2013a and ERM 2013b)	Risk of impact from preferred project
		water quality.			
Giant Dragonfly	Yes Areas of upland swamp BCUS4, CCUS4 and CRUS1.	Fracturing of bedrock resulting in changes in water availability resulting in loss of habitat. Changes in slope gradient resulting in decreased water availability and loss of habitat.	Targeted surveys undertaken by Biosis in December 2013 and January to February 2014 identified habitat for this species in upland swamps BCUS4, CCUS4 and CRUS1. Of the locations where exuviae were observed only CCUS4 will be directly undermined. The potential for other locations listed above to support breeding habitat for this species cannot be discounted; however other locations will not be directly undermined.	Low	Moderate[1]

[1] Note: this is not an increase in impact from previous impact assessment. Recent targeted surveys have identified habitat for this species.



Legend

Longwall Layout

- Approved Longwalls (Preliminary Works Project)
- Proposed Longwalls (Underground Expansion)
- 600m Study Area

Figure 3: Wonga East study area

0 150 300 450 600 750

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

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Date: 09 September 2013,
Checked by: NMG, Drawn by: ANP, Last edited by: apritchard
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16646 PPR_F3_Study Area

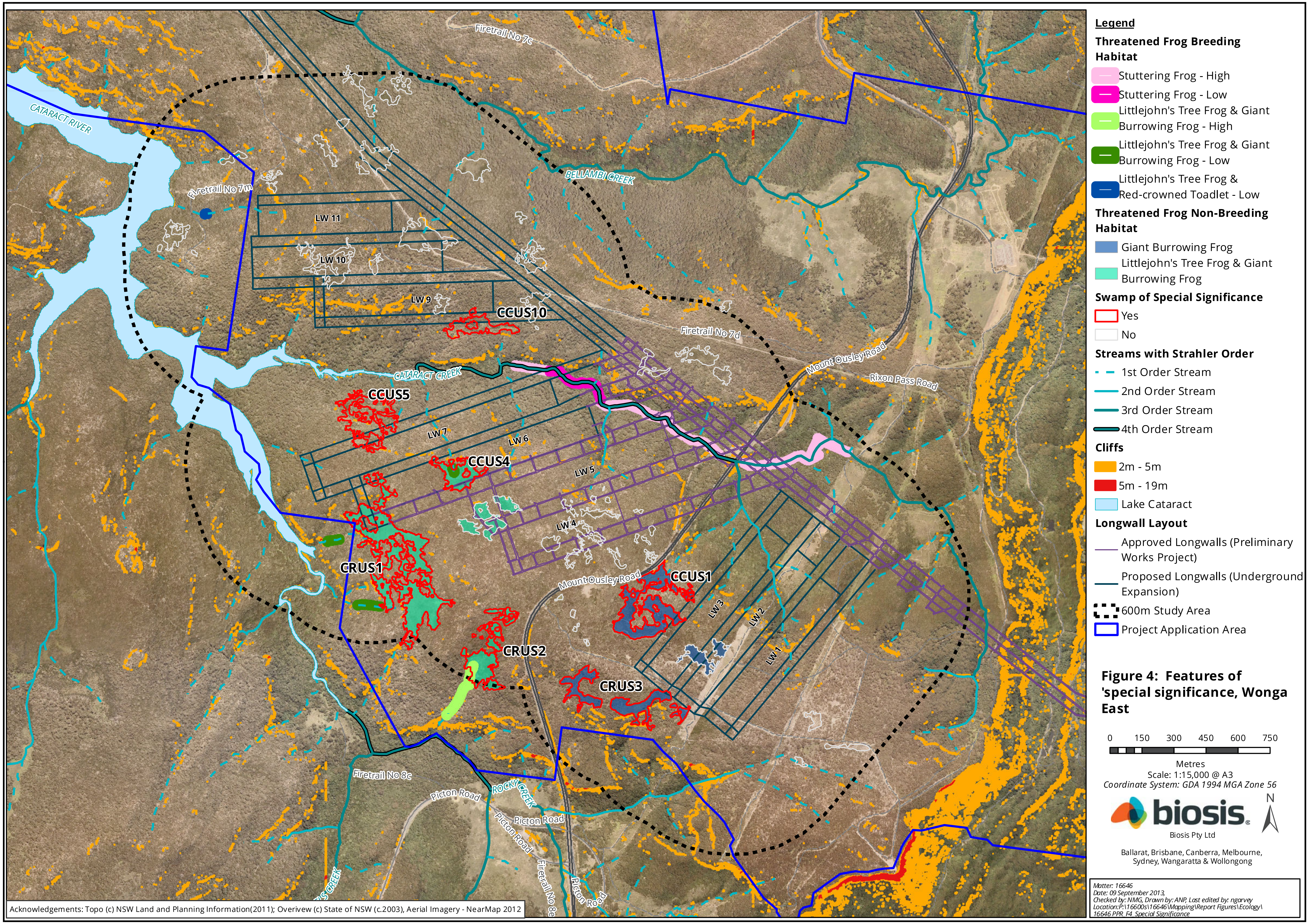

Figure 4: Features of 'special significance, Wonga East

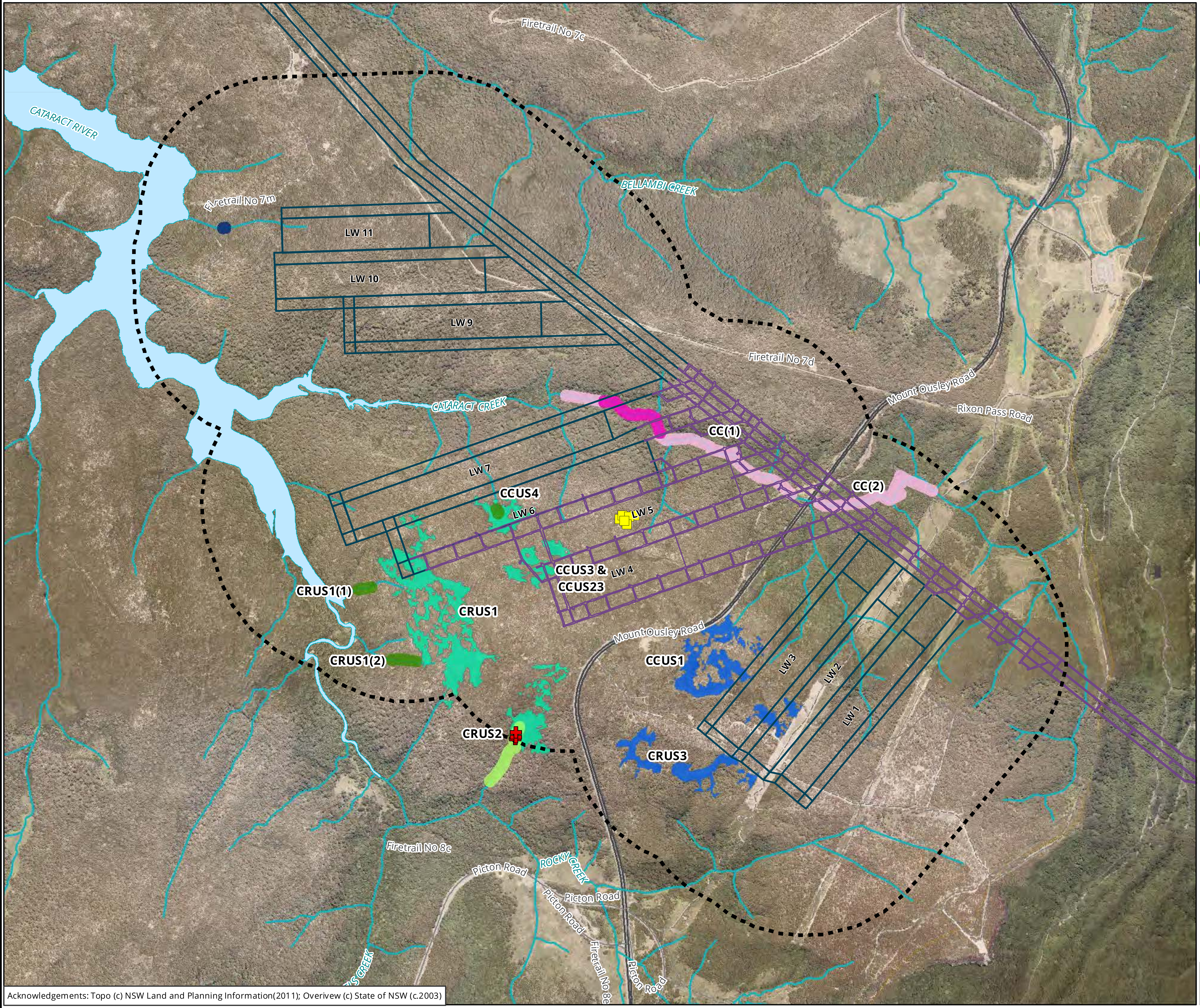

Figure 5: Breeding and non-breeding habitat for threatened frogs, Wonga East

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Location:P:\16600s\16646\Mapping\Report Figures\16646 PPR_F5_Frog Habitat

Acknowledgements: Topo (c) NSW Land and Planning Information(2011); Overivew (c) State of NSW (c.2003)

3.2 Aquatic ecology

Cardno Ecology Lab (2009; 2011a, b; 2012a, b) and Biosis (2014) have undertaken seasonal assessments of aquatic habitat condition and macroinvertebrate assemblages at impact and control monitoring reaches in spring and autumn each year since 2008. Table 8 and Table 9 provide a summary of work undertaken to date. These assessments provide a comprehensive inventory and understanding of the aquatic biodiversity values present in the Wonga East area.

Table 8: Aquatic ecology monitoring approach

Aquatic Ecological Value	Monitoring	Frequency
Aquatic Habitat	Habitat assessment (including photopoint monitoring).	Baseline monitoring has been conducted twice per year specifically during spring and autumn each year.
Aquatic Macroinvertebrates	Macroinvertebrates (AUSRIVAS) including threatened species.	Baseline monitoring has been conducted twice per year specifically during spring and autumn each year.
Fish	Targeted threatened fish surveys.	Surveys have been undertaken according to the 'Survey guidelines for Australia's threatened fish' (DSEWPaC 2011).
Water Quality	In-situ water quality provides a snapshot of each monitoring reach.	During each monitoring event.

Table 9: Overview of previous aquatic surveys in Cataract Creek (*n* = 2), Cataract River (*n* = 2) and Allen Creek (*n* = 2)

✓ = sampled, N/A = not sampled

	Spring 2008	Autumn 2009	Spring 2009	Autumn 2010	Spring 2010	Autumn 2011	Spring 2011	Autumn 2012	Spring 2012	Autumn 2013
Water Quality (*in situ*)	✓	✓	✓	✓	N/A	✓	✓	✓	N/A	✓
Aquatic Habitat Assessments (HABSCORE)	✓	✓	✓	✓	N/A	✓	✓	✓	N/A	✓
Aquatic Macronvertebrate Sampling (AUSRIVAS)	✓	✓	✓	✓	N/A	✓	✓	✓	N/A	✓
Threatened Fish Surveys	N/A	✓	N/A	Summer 2010	N/A	Summer 2011	N/A	Summer 2012	N/A	✓
Reference	Cardno Ecology Lab (2010)	Cardno Ecology Lab (2010)	Cardno Ecology Lab (2012a)	Cardno Ecology Lab (2012a)		Cardno Ecology Lab (2012a) Cardno Ecology Lab (2012b)	Cardno Ecology Lab (2012a) Cardno Ecology Lab (2012b)	Cardno Ecology Lab (2012a) Cardno Ecology Lab (2012c)	N/A	Biosis (2014)

3.2.1 Threatened aquatic species

Due to the potential presence of threatened aquatic species and the potential of suitable habitat for these species, targeted threatened species surveys were undertaken to confirm their presence/absence. An overview of the threatened species relevant to the Wonga East Domain is provided in Table 10 . An overview of the survey locations is presented in Figure 6.

Table 10: Aquatic species likely to occur in the study area and vulnerable to impacts due to subsidence

E = endangered, V = vulnerable

Scientific name	Common name	EPBC Act status	FM Act status
Fish			
Macquaria australasica	Macquarie Perch	E	E
Maccullochella macquariensis	Trout Cod	E	E
Maccullochella peelii	Murray Cod	V	-
Bidyanus bidyanus	Silver Perch	CE	V
Macroinvertebrates			
Archaeophya adamsi	Adam's Emerald Dragonfly	-	E
Austrocordulia leonardi	Sydney Hawk Dragonfly	-	E

Silver Perch have previously been captured from Lake Cataract (Cardno Ecology Lab 2012; Horrobin 1996) and these individuals would have resulted from a translocation of these species into this catchment. Targeted threatened fish surveys undertaken in the Wonga East area between Spring 2008 and Spring 2011 have confirmed the presence of Macquarie Perch and Silver Perch, and an unidentified freshwater cod, which was assumed to be either Murray Cod or Trout Cod, within the lower reaches of Cataract Creek (Cardno Ecology Lab 2010; 2011).

Biosis (2014) has undertaken surveys of additional sections of Cataract Creek upstream of the sites surveyed by Cardno Ecology Lab (see Fish Reach 19US in Figure 6 and Additional Fish Reach in Figure 7). These additional surveys did not record any threatened fish species.

Numbers of Macquarie Perch, Murray Cod, Silver Perch and Trout Cod recorded between 2009 and 2013 are presented in Table 11. The locations of Macquarie Perch and Murray Cod captured during the most recent survey undertaken in Cataract Creek (Biosis 2014) are presented in Figure 7.

Table 11: Numbers of threatened fish captured in Cataract Creek

	2009/2010	2010/2011	20011/2012	2012/2013
Macquarie Perch	30	90	18	14
Murray Cod	0	0	0	16
Silver Perch	9	9	0	0
Trout Cod	0	0	0	0

In order to ascertain the presence/absence of two species of threatened dragonfly listed under the NSW *Fisheries Management Act 1994* (FM Act), Adam's Emerald Dragonfly and Sydney Hawk Dragonfly, surveys undertaken in autumn 2013 included an assessment of habitat suitability for these two species, based on the habitat requirements outlined in DPI (2007) and DPI (2012), as well as targeted searches for exuviae.

Furthermore, the presence of individuals of the appropriate dragonfly family was assessed during live-picking of macorinvertabrates undertaken in the field. Neither of the two threatened dragonfly species have been recorded during aquatic surveys in the Wonga East area since 2008.

3.2.2 Aquatic macroinvertebrates (AUSRIVAS)

A summary of aquatic macroinvertabrate data is provided in Table 12.

Table 12: AUSRIVAS, OE50 Taxa and SIGNAL2 scores for Wonga East (including control sites)

a) AUSRIVAS data, 2008 – 2012

X = Invertebrate assemblage is richer than reference condition; A = equivalent to reference condition; B = below reference condition (i.e. significantly impaired); C= well below reference condition (i.e. severely impaired).

	Site	2008a	2008b	2009a		2009b	2010		2011		2012	
		Spring	Spring	Spring	Autumn	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Cataract Creek	WGE-AQ5	B	A	B	B	B	A	C	B	B	C	B
	WGE-AQ6	B	B	B	A	A	A	C	C	B	B	A
Cataract River	WGE-AQ9	A	B	A	A	B	B	B	C	B	A	B
	WGE-AQ10	A	A	B	A	A	X	C	B	A	B	B
Allen's Creek	WGE-AQ13	-	-	B	A	A	A	B	B	A	A	A
	WGE-AQ14	-	-	A	A	A	A	B	B	A	B	A

b) OE50 Taxa scores, 2008 – 2012

A score of 1 indicates that the observed water bug community is similar to the expected one and therefore equivalent to that of a reference or undisturbed stream. A score lower than 1 means that less water bugs were observed than expected and that the community is impoverished when compared to a reference site.

	Site	2008a	2008b	2009a		2009b	2010		2011		2012	
		Spring	Spring	Spring	Autumn	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Cataract Creek	WGE-AQ5	0.6	0.85	0.6	0.7	0.7	0.85	0.3	0.7	0.65	0.5	0.625
	WGE-AQ6	0.7	0.7	0.6	1.05	0.825	0.875	0.3	0.35	0.75	0.6	0.925
Cataract	WGE-AQ9	0.925	0.8	1.1	1.125	0.725	0.8	0.5	0.375	0.575	0.85	0.7

	Site	2008a	2008b	2009a		2009b	2010		2011		2012	
		Spring	Spring	Spring	Autumn	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
River	WGE-AQ10	0.925	0.925	0.575	1.1	1	1.2	0.35	0.6	0.8	0.575	0.5
Allen's Creek	WGE-AQ13	-	-	0.8	1.1	0.95	1.175	0.5	0.525	1	0.875	0.9
	WGE-AQ14	-	-	0.9	1.1	0.025	0.925	0.625	0.675	1.025	0.7	0.85

c) SIGNAL2 scores, 2008 – 2012

Score < 4 = severely polluted; 4-5 moderately polluted, 5-6 mildly polluted

	Site	2008a	2008b	2009a		2009b	2010		2011		2012	
		Spring	Spring	Spring	Autumn	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Cataract Creek	WGE-AQ5	4.9	4.6	4.9	6	5.8	4.9	4.5	4.6	5	5.2	5.8
	WGE-AQ6	4.9	4.8	4.5	5.2	5.1	4.9	4.8	3.6	4.9	5.1	5.1
Cataract River	WGE-AQ9	4.9	4.8	4.9	4.8	5.2	5.2	4.5	2.8	5.5	5.1	5.5
	WGE-AQ10	5	4.5	5.7	5.3	4.6	4.6	4.5	4	4.9	5.5	6
Allen's Creek	WGE-AQ13	-	-	5	5	5	4.7	4.9	4	5.2	4.8	5.5
	WGE-AQ14	-	-	5.2	5.4	4.8	4.9	5.2	2.9	5	5.2	5.5

The number of taxa collected at each monitoring reach varied at a temporal and spatial scale (Cardno Ecology Lab 2009; 2011a, b; 2012a, b; Biosis 2014). Samples collected from Cataract Creek were generally less diverse than those collected from Cataract River and Allen's Creek. However, AUSRIVAS and OE50 Taxa scores indicate that there is little difference in the macroinvertebrate assemblage present in Cataract Creek when compared to control sites. SIGNAL2 scores indicate that, while Cataract Creek is moderately polluted (potentially from upstream runoff from Mount Ousley Road and / or historic mining impacts), there is little difference in the presence or absence of pollution sensitive aquatic macroinvertebrate species when compared to control sites.

More detail on each of these surveys can be found in Cardno Ecology Lab (2009; 2011a, b; 2012a, b) and Biosis (2013a).

3.2.3 Impact Assessment

The main aquatic habitat present in the Wonga East area is along Cataract Creek, which provides habitat for several threatened fish species. Macroinvertebrate monitoring of Cataract Creek indicates that there is a lower diversity of macroinvertebrate taxa, but AUSRIVAS, OE50 Taxa and SIGNAL2 scores indicate that there is little difference between Cataract Creek and control sites in Cataract River and Allen's Creek. Lower diversity of macoinvertebrate taxa in Cataract Creek may be indicative of historic impacts to this waterway from extraction of the Bulli and Balgownie seams.

Extraction of the Bulli seam has resulted in up to 0.4 m of subsidence, whilst extraction of the Balgownie seams has resulted in subsidence of up to 1.3 m beneath Cataract Creek. Whilst disturbance to the overlying Hawkesbury Sandstone has resulted in release of iron hydroxide flocculent from tributaries of Cataract Creek, no observable physical disturbance, such as fracturing or iron hydroxide seeps, have been observed (SCT Operations 2014).

Extraction of Longwalls 6 – 9 will not result in direct subsidence of Cataract Creek. Subsidence adjacent will result in negligible tensile and compressive strains. Maximum total closure along Cataract Creek is predicted to be 279 mm at the completion of Longwall 9 (SCT Operations 2014). Based on Barbato *et al.* (2014) for Hawkesbury Sandstone this level of closure indicates there is a 25% probability of fracturing and flow diversion. However, it should be noted that the floor of Cataract Creek downstream of Mount Ousley Road is comprised of Newport Formation, Garu Formation and Bald Hill Claystone. Maximum total closure in the lower reaches of Cataract Creek where threatened fish have been observed is predicted to be 203 mm at the completion of Longwall 9 (SCT Operations 2014). This level of closure indicates there is a 12% probability of fracturing and flow diversion.

Tributaries of Cataract Creek are likely to be subject to higher levels of subsidence resulting in increased strains, tilts and valley closure. For some tributaries of Cataract Creek valley closures are expected to cause perceptible cracking and surface flow diversion, particularly in the upper reaches of the southern tributaries of Cataract Creek, particularly where it flows across Hawkesbury Sandstone outcrop above Longwall 1 (SCT Operations 2014).

As outlined above and in Section 3.1.4, there are unlikely to be any direct impacts to Cataract Creek; however additional fracturing of tributaries of Cataract Creek may result in decreased flow in the tributaries and reduced flow into Cataract Creek and an increase in iron hydroxide seepage at the base of these tributaries (Geoterra and GES 2014).

The groundwater model indicates that the average daily stream flow from Cataract Creek to Cataract Reservoir is 11.2 ML/d, of which 3.5 ML/d is baseflow. The model predicts a 0.013 ML/d (0.12%) loss of stream baseflow following mining. This level of change is unlikely to be detectable and unlikely to result in observable changes to flow regimes in Cataract Creek.

Increases in iron hydroxide flocculent has potential to smother eggs of threatened fish such as the Macquarie Perch and result in changes in water quality, whilst reduced flows into Cataract Creek have the potential to reduce the quality of habitat for threatened fish and result in changes to community composition of macroinvertebrate communities. However, given past mining, it is considered unlikely that these impacts will result in observable changes to Cataract Creek above and beyond those present.

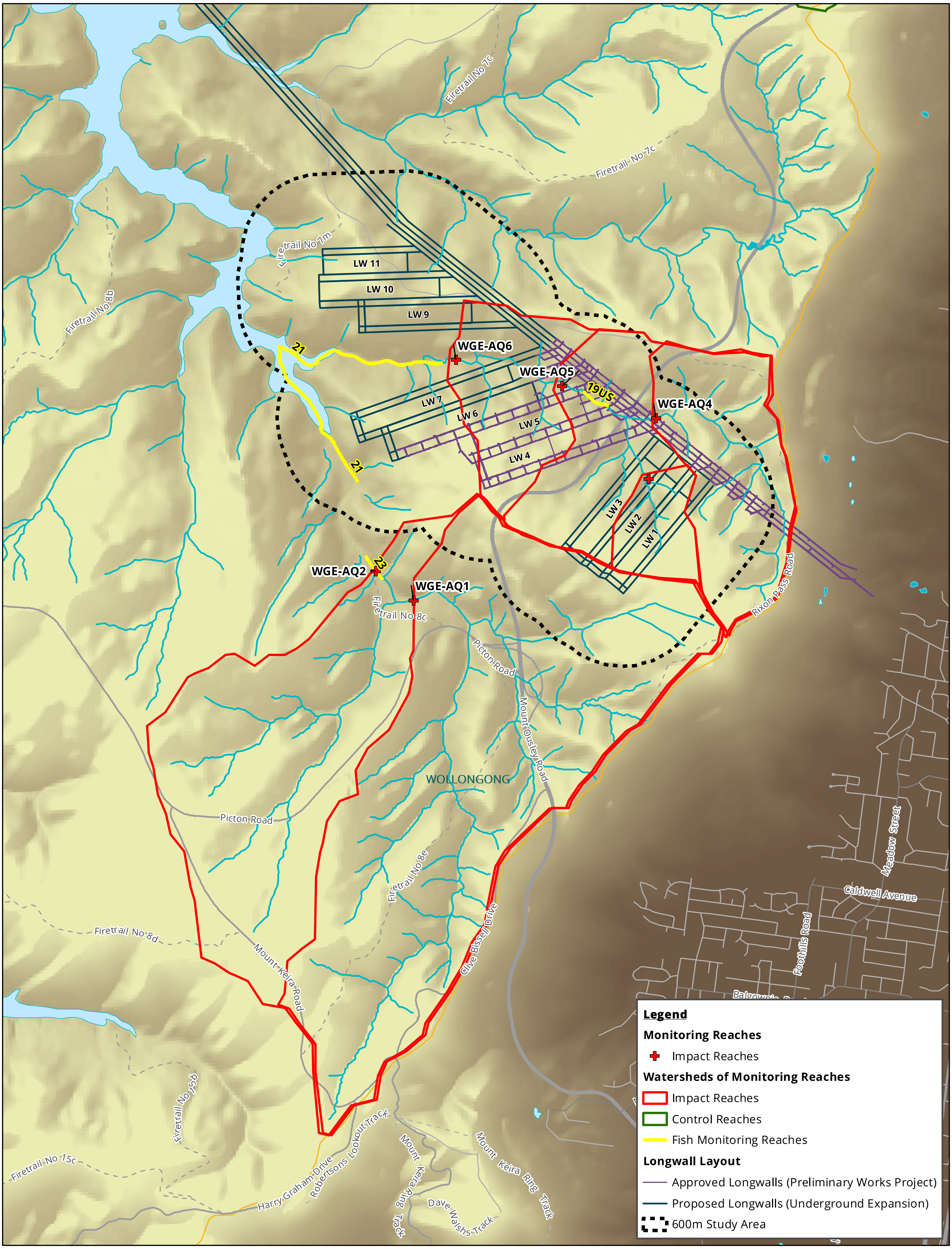

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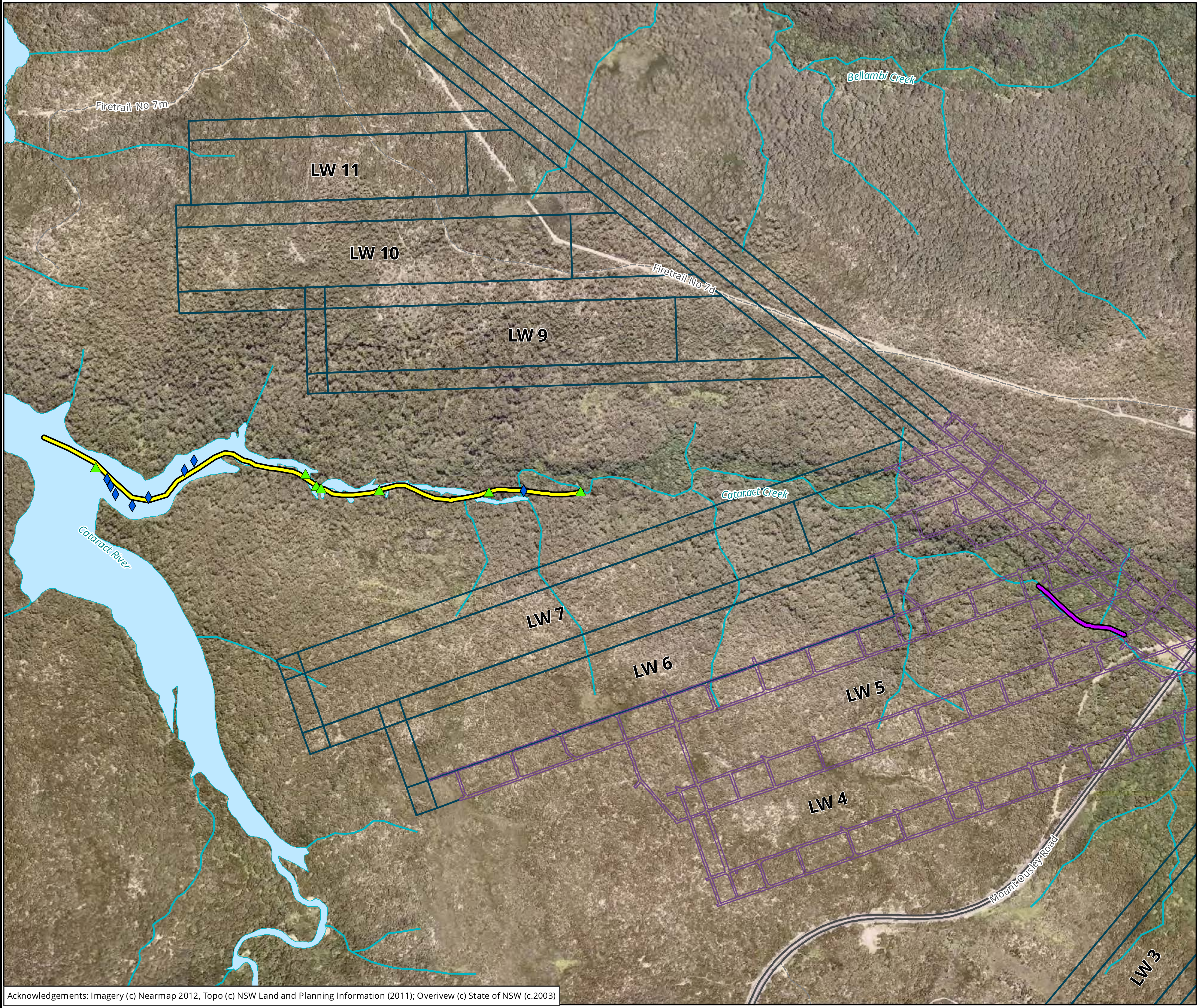
Figure 6: Study Area and Catchment of Monitoring Reaches

Acknowledgements: Topo (c) NSW Land and Planning Information (2012)

Matter: 16646
Date: 09 September 2013,
Checked by: KB/NMG, Drawn by: ANP/JMS, Last edited by: apritchard
Location:P:\16600s\16646\Mapping\Report Figures\
16646 PPR_F6_CatchmentOverviews

0 0.25 0.5 0.75 1 1.25
Kilometers
Scale 1:25,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56
N



Legend

- Fish Monitoring Reaches
- Additional Fish Monitoring Reach (Biosis in Prep.)

Recorded fish locations

- Macquarie Perch
- Murray Cod

Longwall Layout

- Approved Longwalls (Preliminary Works Project)
- Proposed Longwalls (Underground Expansion)

Figure 7: Threatened fish species locations in Cataract Creek

0 80 160 240 320 400

Metres

Scale: 1:8,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

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Date: 09 September 2013,
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Location:P:\16600s\16646\Mapping\Report Figures\16646 PPR_F7_FishMonitoring

3.3 Upland swamps

Mapping and characterisation of upland swamps in the Wonga East and Wonga West area was undertaken by Biosis (2012b). This assessment identified thirty-nine (39) upland headwater swamps, which meet the definition of the Coastal Upland Swamp EEC, within the Wonga East Study Area. No valley fill swamps are present at Wonga East.

The study highlighted the complexity and variability of the associated vegetation communities, with some swamps having a fully developed, saturated, humic sandy clay matrix up to 1.8 m deep, through to essentially dry, shallow sandy clay locations with a high degree of shallow or subcropping sandstone and a thin weathered, colluvial, sandy clay soil profile.

The Wonga East swamps are markedly different to other upland swamps on the Woronora plateau in that they are predominantly drier, generally smaller with shallower soils, have less humic material, have more interspersed sandstone outcrops within their outlines and are less spatially continuous than a "typical" humic, saturated swamp.

Swamps in the Wonga East Area have relatively small upstream catchments, with their saturation relying on rainfall recharge directly into the sandy sediments, seepage out of upslope Hawkesbury Sandstone and their organic (humic) content. The storage and water transmission characteristics of the surrounding and underlying Hawkesbury Sandstone is critical in sustaining these environments. Whilst in other areas of the Woronora plateau upland swamps occur along the riparian zone of the major creeks or in headwater valleys, upland swamps in the Wonga East area occur in headwater tributary valleys that are characteristically derived from colluvial sand erosion from Hawkesbury Sandstone dominated ridgelines only. They are only located over Hawkesbury Sandstone which provides a low permeability base on which the swamp sediments and organic matter accumulate. Regional groundwater flow within the Hawkesbury Sandstone is hydraulically beneath, and separated by approximately 15m from the surficial swamps.

The headwater swamps are predominantly located within gently sloping, shallow trough-shaped gullies although can partially extend onto steep slopes, benches or valley sides, where the plateau is not dissected by the Study Area creeks. The central axes of the swamps are generally saturated after substantial recharge events, though the margins can comparatively dry out after extended dry periods.

The sand and humic material increases the swamp's water holding capacity and subsequently discharges rainfall infiltration, groundwater seeps and low-flow runoff into the local streams. Rainfall saturates the swamp after storms and with a slow, delayed discharge due to the low slopes when the recharge exceeds evaporation. Sediments below and laterally lensing into the humic material are variable in nature and can be composed of fine to medium grained sands that can contain clayey bands and comprise a grey to mottled red-orange colour due to in-situ weathering.

This previous assessment by Biosis (2012b) included assessment of the 'special significance' of upland swamps in the project area using criteria outlined in OEH (2012). Biosis (2012b) identified that seven swamps in Wonga East are considered to be of 'special significance' using OEH (2012) criteria, including CCUS1, CCUS4, CCUS5, CCUS10, CRUS1, CRUS2 and CRUS3.

Biosis (2012b) included an assessment of impacts to upland swamps, based on the previous mine plan. This impact assessment included several steps:

- An initial risk assessment using criteria outlined in DoP (2010) and OEH (2012);
- A comparative analysis of impacts to upland swamps that have resulted from previous mining, as required by OEH (2012);
- A summary of available data on groundwater in upland swamps within the project area;

- An analysis of flow accumulation based on changes in water flow due to subsidence levels; and,
- Use of tensile and compressive strains to assess where fracturing of bedrock may occur, and potential resultant impacts to upland swamp vegetation communities.

This impact assessment identified a number of upland swamps considered to be at risk of negative environmental impacts. Based on this impact assessment, Biosis recommended a number of changes to the original mine plan with the objective of avoiding and mitigating impacts to upland swamps.

A number of submissions were received critiquing the methodology used in the upland swamp impact assessment process. Section 3.3.1 provides further information on how the methodology used addresses issues and recommendations raised in DoP (2008), DoP (2009), DoP (2010) and OEH (2012), while Section 3.3.2 provides a rationale for the upland swamps impact assessment and discusses how criticisms have been addressed in the updated assessment.

An assessment of potential impacts arising from historic mining of the Bulli and Balgownie Seams in the Wonga East area is provided in Section 3.3.3.

Section 3.3.4 provides an updated upland swamp impact assessment based on the revised mine plan and revised subsidence calculations.

3.3.1 Criticisms of the upland swamp impact assessment

The upland swamp impact assessment (Biosis 2012b) was the first upland swamp impact assessment to utilise the methodology outlined in OEH (2012). Although the impact assessment was commended by OEH for the mapping and characterisation of swamps as well as how upland swamps of 'special significance' were determined, a number of concerns and criticisms were raised. These criticisms, and our response to these criticisms, are provided below.

The previous assessment did not consider impacts to all swamps, only swamps of special significance

OEH (2012, p.3) sets out several steps that are required to undertake an environmental assessment of the level of significance and risks to upland swamps. Step 4 requires that, following the initial risk assessment and comparative analysis, the mine plan should be adjusted if damage to swamps of 'special significance' is predicted to occur. This is further detailed in Section 3 (p.12) of the guidelines, which states proponents must assess the following:

- *'If negative outcomes are predicted for a special significance swamp, the mining plan should be adjusted in advance so that no negative environmental outcomes are anticipated.*
- *If no negative environmental outcomes are predicted, then proceeding to mining, monitoring and adaptive management.'* (OEH 2012, p.12)

Given the focus of this section on swamps of 'special significance' Biosis understood the intent of the guidelines was to assess potential impacts to these 'special' swamps.

In the current impact assessment (Section 3.3.4) potential impacts to all upland swamps within the study area has been undertaken.

Consideration of measures other than the fracturing of bedrock, and resultant changes in hydrology, in the assessment of impacts to upland swamps

Section 3 of OEH (2012, p.11) defines six criteria used to identify upland swamps at risk of negative environmental outcomes. It is our understanding that these criteria come from values defined by MSEC to determine longwall setback distances from major creeks, and were used by DoP (2010) and OEH (2012) for assessment of upland swamps to be considered at risk of negative environmental impacts. As stated in DoP (2010), these criteria are a *'threshold for investigation – not a conclusion that the swamp will be impacted or suffer consequences*' (p. 120), i.e. these swamps are at risk and further assessment is required.

The use of multiple criteria in Biosis (2012b) is an attempt to address this requirement, by assessing other factors such as groundwater availability (and thus potential for draining), changes in flow accumulation (to assess risk of erosion and scouring and potential changes in water availability), orientation in relation to longwalls (to assess potential for ponding) and vegetation sub-communities (to assess the presence of species reliant on soil moisture and thus with greatest risk of change).

We believe this multi-criteria approach is valid, and have used a similar methodology in the current assessment. See Section 3.3.2 for a rational behind our methodology.

Reliance on flow accumulation modeling and poor definition of 'small' potential for change to flow accumulation

DoP (2009) identifies three potential impact mechanisms to upland swamps:

1. The bedrock below the swamp cracks as a consequence of tensile strains and water drains into the fracture zone. If the fracture zone is large enough or connected to a source of escape (e.g. a deeper aquifer or bedding shear pathway to an open hillside) then it is possible for sufficient water to drain to alter the hydrologic balance of the swamp.
2. Tilting of sufficient magnitude occurs to either re-concentrate runoff leading to scour and erosion, potentially allowing water to escape from the swamp margins (possibly affecting the whole swamp) or to alter water distribution in parts of the swamp, thus favouring some flora species associations over others.
3. Buckling and bedding shear enhances fracture connectivity in the host bedrock which promotes vertical then lateral drainage of the swamp. This mechanism is similar to redirected surface flow observed in subsidence-upsidence affected creek beds.

Flow accumulation modelling pre- and post-mining is undertaken by modelling flow pathways across a catchment using a digital elevation model (DEM) constructed from LiDAR data. Changes in surface topography are modelled by deducting predicted subsidence values (Smax) from the pre-mining DEM. Flow accumulation is then re-modelled. This is used to predict changes to surface and sub-surface flow through an upland swamp in relation to changes in ground level (tilt) and is unrelated to tilts and strains. This method directly addresses swamp impact mechanism 2 outlined above, and in particular addresses dot point 2 on page 116 of DoP (2010), which states that changes in water distribution in parts of the swamp can lead to changes in swamp health or vegetation composition.

In previous upland swamps assessments (BHPBIC 2009) changes in water flow through an upland swamp have been assessed using a single cross-section of an upland swamp. This methodology was criticised in DoP (2010) due to the reliance on a single cross-sectional representation. The use of flow accumulation modelling across an entire swamp addresses this concern.

In line with DoP (2010) Biosis (2012b) has used multiple criteria to determine the potential for impacts to upland swamps. These criteria have been developed with reference to the three potential upland swamp impact mechanisms outlined in DoP (2009) and outlined above. In this case we believe that the use of flow accumulation modelling in the assessment of impacts to upland swamps is valid.

Use of inexact subsidence predictions to determine potential zones of fracturing

Upland swamps form across a range of soil moisture gradients supporting different flora species and vegetation communities (Keith et al. 2006, NSW Scientific Committee 2012). The model of upland swamp response to climatic change outlined in Keith et al. (2006) describes a transition between MU43 Tea-tree Thicket to MU44c Cyperoid Heath and MU44a Sedgeland / MU44b Restioid heath / MU42 Banksia Thicket in response to changes on soil moisture. MU43 Tea-tree Thicket is likely to be reliant on semi-permanent to permanent waterlogging and MU44C Cyperoid heath on intermittent waterlogging, whilst the water table is likely to reach the root zone in other vegetation communities only following heavy rains. Similar changes in vegetation community composition within an upland swamp would be expected to occur due to changes in soil moisture resulting from fracturing of bedrock beneath an upland swamp.

Changes in soil moisture can occur in two ways; either through loss of water through fracturing of the bedrock and / or through changes in water flow through an upland swamp resulting in changes in water availability. Whilst we use the flow accumulation model to assess the second potential mechanism of change, we must use predictions for tensile and compressive strain to assess the potential for fracturing of the base of upland swamps and potential for loss of groundwater availability.

In light of this, we believe it is reasonable to use such parameters to assess potential for impacts to particular vegetation communities within an upland swamp, despite their inexact nature.

3.3.2 Rationale behind Biosis' approach to upland swamp impact assessment

DoP (2008) recognises that certain swamp characteristics mean some upland swamps are more susceptible to impacts from subsidence than others. For example, given their location in the landscape, valley infill swamps are more likely to be in direct contact with surrounding groundwater, and much more susceptible to fracturing due to valley closure and upsidence (swamp impact mechanism 3 above). DoP (2009) states that, other than one headwater swamp (Swamp 1) in Dendrobium Area 2, the panel was not aware of any other headwater swamps that have been negatively impacted. However, in DoP (2010) evidence of impacts to several other upland swamps were bought to the attention of the panel, and available data now indicates that changes in groundwater availability have occurred at Swamp 12 (also a headwater swamp) and Swamp 15B (a valley infill swamp).

Changes in groundwater availability through fracturing of bedrock beneath an upland swamp is one type of impact. Fracturing of the bedrock beneath upland swamps, and/or changes in groundwater availability have been observed at a number of upland swamps on the Woronora plateau. To date, secondary impacts, including erosion, gullying, changes in size of an upland swamp or changes in vegetation within an upland swamps have been observed at a limited number of undermined upland swamps. This may be due to a lack of suitable quantitative monitoring (DoP 2010). Given the long history of mining on the Woronora plateau, and evidence of significant, observable impacts to only a limited number of previously undermined upland swamps, we do not believe that the available scientific evidence supports a conclusion that this primary impact (our term) will lead to secondary impacts (our term) in all cases, or will result in the catastrophic loss of upland swamps.

In their submission OEH raise statistical analysis of Swamp 1 in Symbolix (2011), as discussed in Krogh (2012), and a lack of the use of this data by Biosis (2012b) in our comparative analysis. The Krogh (2012) paper is not currently available for Biosis to comment on, but further analysis of data available from Swamp 1 indicates a gradual change in species diversity and richness indices at two out of three monitoring sites between 2006 and 2012. However, this change has also been observed at a number of control sites over the same period, albeit not at the same rate. Further to this, the rate of change at Swamp 1 appears to be slowing, with an increase in both indices in recent years. To date, the data does not clearly indicate whether changes in groundwater in Swamp 1 have resulted in secondary impacts to vegetation or vegetation communities above and beyond what has been observed at control swamps, using a Before After Control Impact (BACI) design.

Biosis does not assert that subsidence associated with longwall mining does not result in impacts to upland swamps, or that a change in groundwater availability is not an impact to upland swamps. Rather, that the maintenance and persistence of upland swamps is much more complex than has been recognised, and that further research, monitoring and assessment is required to understand the complex processes that maintain upland swamps, particularly in relation to changes brought about by longwall mining.

The swamp impact assessment methodology employed by Biosis (2012b) assesses multiple upland swamp characteristics to determine the potential for impact, in line with the recommendation of DoP (2010) that upland swamps that exceed these thresholds indicating they are risk of negative environmental consequences require further investigation.

3.3.3 Assessment of the historic impacts to upland swamps in Wonga East

Extraction of the Bulli and Balgownie seams has occurred within the Wonga East area. Within the study area, the Bulli Seam was extracted via hand workings and pillar extraction between 1890 and 1960. The Balgownie Seam was extracted using continuous miner pillar extraction in 1969 and the retreat longwall mining method from 1970 to 1982. Table 13, Table 14 and Table 15 provide modelled subsidence data for upland swamps within the study area.

Table 13: Subsidence data from extraction of the Bulli seams for upland swamps within the study area (values in bold exceed subsidence criteria in OEH 2012)

Swamp	Subsidence (m)	Overburden Depth (m)	Longwall Panel Width	Ratio of Overburden to Panel Width	Max Tensile Strain (mm/m)	Max Compressive Strain (mm/m)	Max Tilt (mm/m)
CCUS1	0.7	285	945	**0.3**	**3.7**	**7.4**	**12**
CCUS2	0.1	285	-	-	0.5	1.1	2
CCUS3	1	300	55	5.45	**5**	**10**	**17**
CCUS4	0.1	290	50	5.8	0.5	1	2
CCUS5	0.5	272	230	**1.18**	**2.8**	**5.5**	**9**
CCUS6	1	285	605	**0.47**	**5.3**	**10.5**	**18**
CCUS7	1	270	276	**0.98**	**5.6**	**11.1**	**19**
CCUS8	0.1	270	20	13.5	**0.6**	1.1	2
CCUS9	0.1	293	25	11.72	0.5	1	2
CCUS10	0.5	280	185	1.51	**2.7**	**5.4**	**9**
CCUS12	0.5	355	185	1.92	**2.1**	**4.2**	**7**
CCUS13	0.1	335	195	1.72	0.4	0.9	1
CCUS14	1	275	-	-	**5.5**	**10.9**	**18**

Swamp	Subsidence (m)	Overburden Depth (m)	Longwall Panel Width	Ratio of Overburden to Panel Width	Max Tensile Strain (mm/m)	Max Compressive Strain (mm/m)	Max Tilt (mm/m)
CCUS15	0.1	325	40	8.13	0.5	0.9	2
CCUS16	0.5	300	-	-	**2.5**	**5**	**8**
CCUS17	0.1	325	45	7.22	0.5	0.9	2
CCUS18	0.1	325	30	10.83	0.5	0.9	2
CCUS19	0.1	325	10	32.5	0.5	0.9	2
CCUS20	1	290	570	**0.51**	**5.2**	**10.3**	**17**
CCUS21	1	280	490	**0.57**	**5.4**	**10.7**	**18**
CCUS22	0.5	317	150	2.11	**2.4**	**4.7**	**8**
CCUS23	0.1	310	45	6.89	0.5	1	2
CRUS1	0.5	300	310	**0.97**	**2.5**	**5**	**8**
CRUS2	0.5	210	280	**0.75**	**3.6**	**7.1**	**12**
CRUS3	0.4	295	45	6.56	**2**	**4.1**	**7**
BCUS1	1	270	270	**1**	**5.6**	**11.1**	**19**
BCUS2	0.5	285	40	7.13	**2.6**	**5.3**	**9**
BCUS3	0.5	265	80	3.31	**2.8**	**5.7**	**9**
BCUS4	0.5	295	230	**1.28**	**2.5**	**5.1**	**8**
BCUS5	0.5	273	105	2.6	**2.7**	**5.5**	**9**
BCUS6	0.1	308	15	20.53	0.5	1	2
BCUS11	0.5	335	225	1.49	**2.2**	**4.5**	**7**

Table 14: Incremental subsidence data from extraction of the Balgownie seams for upland swamps within the study area (values in bold exceed subsidence criteria in OEH 2012)

Swamp	Subsidence Used (m)	Overburden Depth (m)	Longwall Panel Width	Ratio of Overburden to Panel Width	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
CCUS1	0.8	295	130	2.27	**4.1**	**8.1**	**14**
CCUS2	1	295	130	2.27	**5.1**	**10.2**	**17**
CCUS3	1	310	170	1.82	**4.8**	**9.7**	**16**
CCUS4	0.8	300	170	1.76	**4**	**8**	**13**

Swamp	Subsidence Used (m)	Overburden Depth (m)	Longwall Panel Width	Ratio of Overburden to Panel Width	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
CCUS5	0.1	282	-	-	0.5	1.1	2
CCUS6	1	295	170	1.74	**5.1**	**10.2**	**17**
CCUS7	0.1	280	-	-	0.5	1.1	2
CCUS8	0.1	280	-	-	0.5	1.1	2
CCUS9	0.1	303	-	-	0.5	1	2
CCUS10	0.1	290	-	-	0.5	1	2
CCUS12	0.1	365	-	-	0.4	0.8	1
CCUS13	0.1	345	-	-	0.4	0.9	1
CCUS14	0.1	285	130	2.19	0.5	1.1	2
CCUS15	0.5	335	-	-	**2.2**	**4.5**	**7**
CCUS16	0.1	310	-	-	0.5	1	2
CCUS17	0.3	335	-	-	**1.3**	**2.7**	4
CCUS18	0.1	335	-	-	0.4	0.9	1
CCUS19	0.1	335	-	-	0.4	0.9	1
CCUS20	1	300	170	1.76	**5**	**10**	**17**
CCUS21	1	290	170	1.71	**5.2**	**10.3**	**17**
CCUS22	0.1	327	-	-	0.5	0.9	2
CCUS23	1	320	170	1.88	**4.7**	**9.4**	**16**
CRUS1	0.1	310	-	-	0.5	1	2
CRUS2	0.1	220	-	-	**0.7**	1.4	2
CRUS3	0.1	305	-	-	0.5	1	2
BCUS1	0.1	280	-	-	0.5	1.1	2
BCUS2	0.1	295	-	-	0.5	1	2
BCUS3	0.1	275	-	-	0.5	1.1	2
BCUS4	0.1	305	-	-	0.5	1	2
BCUS5	0.1	283	-	-	0.5	1.1	2
BCUS6	0.1	318	-	-	0.5	0.9	2
BCUS11	0.1	345	-	-	0.4	0.9	1

Table 15: Subsidence data from extraction of the Bulli and Balgownie seams for upland swamps within the study area (values in bold exceed subsidence criteria in OEH 2012)

Swamp	Relevant Workings	Subsidence Used (m)	Overburden Depth (m)	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
CCUS1	Bulli PE / Bg LW	2	285	**10.5**	**21.1**	**35**
CCUS2	Bulli 1st wkgs / Bg LW	1.1	285	**5.8**	**11.6**	**19**
CCUS3	Bulli 1st wkgs / Bg LW	1.1	300	**5.5**	**11.0**	**18**
CCUS4	Bulli 1st wkgs / Bg LW	0.9	290	**4.7**	**9.3**	**16**
CCUS5	Bulli PE, 1st wkgs / Bg 1st wkgs	0.6	272	**3.3**	**6.6**	**11**
CCUS6	Bulli PE / Bg LW	2	285	**10.5**	**21.1**	**35**
CCUS7	Bulli PE	1	270	**5.6**	**11.1**	**19**
CCUS8	Bulli 1st wkgs	0.1	270	**0.6**	1.1	2
CCUS9	Bulli 1st wkgs	0.1	293	0.5	1.0	2
CCUS10	Bulli PE, 1st wkgs / Bg LW	0.6	280	**3.2**	**6.4**	**11**
CCUS12	Bulli PE, 1st wkgs	0.5	355	**2.1**	**4.2**	**7**
CCUS13	Bulli 1st wkgs	0.1	335	0.4	0.9	1
CCUS14	Bulli PE / Bg LW	1.2	275	**6.5**	**13.1**	**22**
CCUS15	Bulli 1st wkgs	0.2	325	**0.9**	1.8	3
CCUS16	Corrimal wkgs	0.5	300	**2.5**	**5.0**	**8**
CCUS17	Bulli 1st wkgs	0.1	325	0.5	0.9	2
CCUS18	Bulli 1st wkgs	0.1	325	0.5	0.9	2
CCUS19	Bulli 1st wkgs	0.1	325	0.5	0.9	2
CCUS20	Bulli PE / Bg LW	2	290	**10.3**	**20.7**	**34**
CCUS21	Bulli PE / Bg LW	2	280	**10.7**	**21.4**	**36**

Swamp	Relevant Workings	Subsidence Used (m)	Overburden Depth (m)	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
CCUS22	Bulli PE, no wkgs	0.5	317	**2.4**	**4.7**	**8**
CCUS23	Bulli1st wkgs / Bg LW	0.9	310	**4.4**	**8.7**	**15**
CRUS1	Bulli PE	0.5	300	**2.5**	**5.0**	**8**
CRUS2	Bulli PE, 1st wkgs	0.6	210	**4.3**	**8.6**	**14**
CRUS3	Bulli PE, 1st wkgs	0.6	295	**3.1**	**6.1**	**10**
BCUS1	Bulli PE	1	270	**5.6**	**11.1**	**19**
BCUS2	Bulli 1st wkgs	0.5	285	**2.6**	**5.3**	**9**
BCUS3	Bulli PE	0.5	265	**2.8**	**5.7**	**9**
BCUS4	Bulli PE	0.6	295	**3.1**	**6.1**	**10**
BCUS5	Bulli PE	0.5	273	**2.7**	**5.5**	**9**
BCUS6	Bulli Headings	0.1	308	0.5	1.0	2
BCUS11	Bulli PE	0.5	335	**2.2**	**4.5**	**7**

NOTE: RV = Russell Vale Colliery, BG = Balgownie, PE = Pillar Extraction, LW = Longwall

Subsidence data for upland swamps in the study area from extraction of the Bulli and Balgownie seams indicates that all upland swamps in the study area, except CCUS9, CCUS13, CCUS18, CCUS19 and BCUS6, have been subject to subsidence criteria sufficient to have placed these upland swamps at risk of negative environmental consequences, according to criteria outlined in DoP (2010) and OEH (2012).

This assessment of past mining in the Wonga East area indicates that natural features in the study area have been subject to subsidence resulting from extraction of the Bulli and Balgownie Seams sufficient to have placed the majority of upland swamps in the study area at risk of negative environmental consequences. This data provides a baseline against which assessments of potential impacts resulting from extraction of the Wongawilli Seam, as part of the preferred project, must be assessed.

3.3.4 Revised upland swamp impact assessment

Following on from the swamp impact assessment undertaken by Biosis (2012b), a recommendation was made suggesting a number of changes to the original mine plan with the objective of avoiding and mitigating impacts to upland swamps. Wollongong Coal has now redesigned the mine plan for Wonga East and have removed Wonga West from the project application. This revised impact assessment follows the methodology outlined in Biosis (2012b), and is based on the revised mine plan and revised subsidence predictions.

In summary, 39 upland swamps have been mapped as occurring within the study area (Figure 8). Section 3.1 and Appendix 1 of Biosis (2012b) provide a summary of upland swamps within the study area, while Table 6 in Biosis (2012b) provides an assessment of 'special significance' against criteria outlined in OEH (2012).

This assessment identified that seven upland swamps in the Wonga East area meet the criteria of 'special significance', including CCUS1, CCUS4, CCUS5, CCUS10, CRUS1, CRUS2 and CRUS3. Swamps of 'special significance' are shown in Figure 9.

Initial risk assessment

Following step 1 of OEH (2012), a risk assessment has been undertaken to determine upland swamps at risk of negative environmental consequences. To address concerns raised by OEH (2012), the risk assessment has been undertaken for all upland swamps within the study area (Table 16). Subsidence values for upland swamps are presented in Figure 10.

Table 16: Initial Risk Assessment for Wonga East (Swamp names in italics indicate 'special significance'

Figures in bold are greater than criteria outlined in OEH (2012).

Swamp	Maximum subsidence within swamp boundary (m)	Adjacent subsidence used to calculate strains and tilts (m)	Overburden Depth (m)	Longwall panel width (m)	Ratio of Overburden to Panel Width	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
BCUS1	< 0.2	0.1	270	-	-	0.5	1	2
BCUS2	< 0.2	0.1	285	-	-	0.5	0.9	2
BCUS3	< 0.2	0.1	265	-	-	0.5	1	2
BCUS4	1.0	1.5	295	150	1.97	**6.8**	**13.6**	**23**
BCUS5	< 0.2	0.1	273	-	-	0.5	1	2
BCUS6	< 0.2	0.1	308	-	-	0.4	0.9	1
BCUS11	1.4	1.5	335	150	2.23	**6.1**	**12.2**	**20**
CCUS1	0.6	1.5	285	-	-	**7**	**14.1**	**23**
CCUS2	1.8	2.0	285	150	1.90	**9.4**	**18.8**	**31**
CCUS3	1	1.5	300	125	2.40	**6.7**	**13.4**	**22**
CCUS4	1.4	2.0	290	150	1.93	**9.2**	**18.5**	**31**
CCUS5	1.2	1.5	272	131	2.08	**7.3**	**14.7**	**24**
CCUS6	2	2.0	285	125	2.28	**9.4**	**18.8**	**31**
CCUS7	< 0.2	0.1	270	-	-	0.5	1	2
CCUS8	< 0.2	0.1	270	-	-	0.5	1	2

Swamp	Maximum subsidence within swamp boundary (m)	Adjacent subsidence used to calculate strains and tilts (m)	Overburden Depth (m)	Longwall panel width (m)	Ratio of Overburden to Panel Width	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
CCUS9	< 0.2	0.1	293	-	-	0.5	0.9	2
CCUS10	0.8	0.8	280	150	1.87	**3.8**	**7.6**	**13**
CCUS11	1.8	2.0	340	150	2.27	**8.8**	**18**	**29**
CCUS12	1.2	1.5	355	150	2.37	**5.8**	**11.5**	**19**
CCUS13	< 0.2	0.1	335	-	-	0.4	0.8	1
CCUS14	< 0.2	0.1	275	-	-	0.5	1	2
CCUS15	< 0.2	0.1	325	-	-	0.4	0.8	1
CCUS16	< 0.2	0.1	300	-	-	0.4	0.9	1
CCUS17	< 0.2	0.1	325	-	-	0.4	0.8	1
CCUS18	< 0.2	0.1	325	-	-	0.4	0.8	1
CCUS19	< 0.2	0.1	325	-	-	0.4	0.8	1
CCUS20	< 0.2	0.1	290	-	-	0.5	0.9	2
CCUS21	< 0.2	2.0	280	-	-	**9.5**	**19**	**32**
CCUS22	< 0.2	0.1	317	-	-	0.4	0.9	1
CCUS23	0.2	1.5	310	125	2.48	**6.5**	**13**	**22**
CRUS1	1.4	1.5	300	150	2.00	**6.7**	**13.4**	**22**
CRUS2	< 0.2	0.1	210	-	-	0.6	1.2	2

Swamp	Maximum subsidence within swamp boundary (m)	Adjacent subsidence used to calculate strains and tilts (m)	Overburden Depth (m)	Longwall panel width (m)	Ratio of Overburden to Panel Width	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
CRUS3	< 0.2	0.1	295	-	-	0.5	0.9	2

Reassessment of subsidence predictions following monitoring of Longwalls 4 and 5 indicates that past mining has resulted in the softening of the bridging capacity of the underlying rock strata, and that subsidence is largely restricted to immediately overlying the goaf. Whilst this means that subsidence movements occur over a smaller area, it also means that tilts and strains are greater than previously predicted (SCT Operations 2014). The revised subsidence predictions for all upland swamps within the predicted impact subsidence zone, except upland swamp CCUS10, are greater than previously predicted.

Upland swamps outside of the predicted subsidence impact zone are not discussed further. To address criticisms received on the previous upland swamps impact assessment (Biosis 2012b), all upland swamps within the predicted subsidence impact zone are considered further.

Comparative analysis

A comparative analysis was undertaken in Biosis (2012b). Additional data has become available following the completion of mining in the Wongawilli domain at Wongawilli Colliery. Table 17 provides a summary of observed subsidence values for four upland swamps located above the Wongawilli longwalls.

Table 17: Observed subsidence for four upland swamps located above the Wongawilli domain

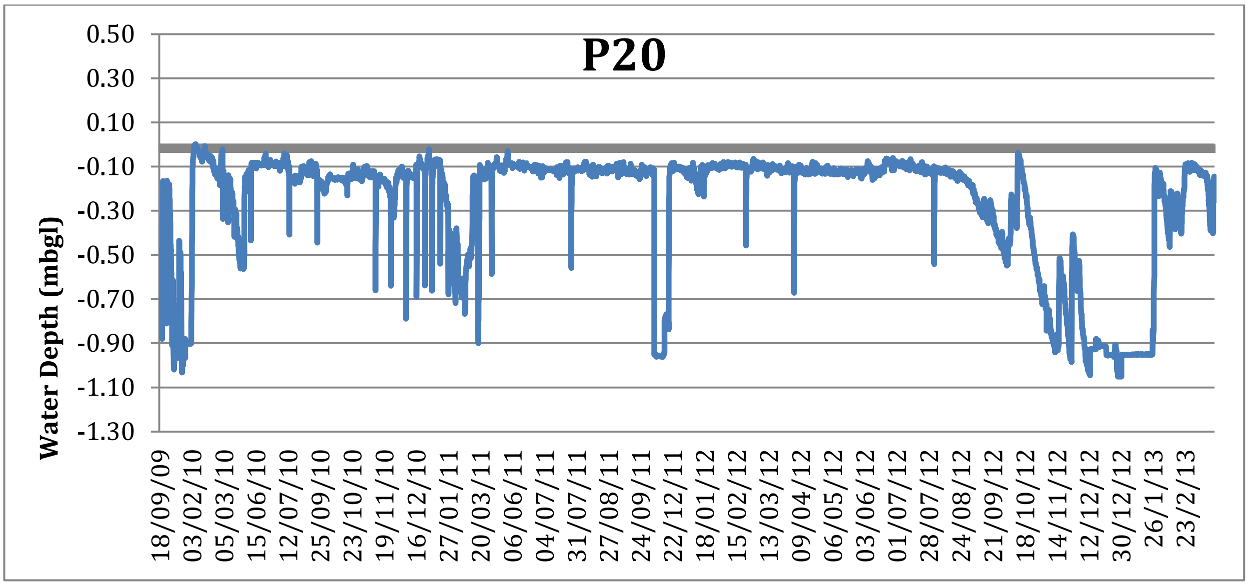
Swamp	Subsidence (mm)	Tensile strain (mm / m)	Compressive strain (mm / m)	Tilt (mm / m)
20	387	**0.6**	0.3	**(6.8)**
21a	170	0.2	0.5	1.1
24	270	0.3	0.3	2.2
46	285	0.3	0.8	2.0

Note: Figures in bold are greater than criteria outlined in OEH (2012). No measured tilts are available for Swamp 20, so predicted tilt is provided in brackets.

Subsidence predictions outlined above indicate that predictions for Swamp 20 exceeded criteria in OEH (2012), and thus upland swamps would be considered at risk of negative environmental consequences from extraction of Longwalls 11 and 20. Observed values for tensile strain are above these thresholds, although observed compressive strain is below. One swamp piezometer is located approximately 100m east of Longwall 20 and overlies the eastern end of Longwall 11. Data from this piezometer is presented in Graph 1. This data indicates that "*no sustained change in groundwater levels in Swamp 20 due to subsidence induced impacts from extraction of Longwalls 11, 12, 19 and 20 has been observed*" (Geoterra 2012a, p.8). Further, no impacts to vegetation within Swamp 20 have been observed (Biosis 2013b). Although Swamp 20 has been undermined previously by the Elouera Colliery, mining under the swamp used a bord and pillar mining method, resulting in negligible subsidence. Extraction of Longwalls 11 and 20 was undertaken using longwall mining techniques.

This data indicates that, despite subsidence predictions exceeding criteria in DoP (2010) and OEH (2012) for determining risk of negative environmental consequences, no observable adverse impacts to the swamp groundwater level variation or vegetation have been observed.

Graph 1: Swamp piezometer, P20, groundwater levels



In addition, the recent extraction of Longwalls 4 and 5 in the Wonga East area allow for some, limited, assessment of impacts to upland swamps CCUS3 and CCUS6. Longwall 4 underlies upland swamp CCUS6, whilst Longwall 5 underlies upland swamp CCUS3. In addition, Longwall 5 underlies the colluvial sandy clay soil piezometers SP1 and SP2.

Monitoring of water levels in the two swamp and two soil piezometers over Longwalls 4 and 5 did not indicate any adverse effects on the swamp / soil water holding capacity due to extraction of Longwall 4 or Longwall 5. In the period of Longwall 4 / 5 extraction, and after, the piezometer water levels have principally responded to rainfall recharge into the swamp / soil profile, or the lack of it, with no evidence of adverse effects due to extraction and subsidence associated with Longwalls 4 and 5. Ecological monitoring of swamp CCUS3 does not indicate any changes in any monitored ecological parameters.

No effects or impacts on swamp water levels, water retention, outflow discharge or ecological parameters due to mining induced subsidence have been observed on any swamps in the Wonga East area.

Hydrogeological investigations

Swamp piezometers

Eight shallow piezometers have been installed at Wonga East, with five auger holes not completed with piezometers as they were too shallow, dry or did not encounter swamp materials within a designated swamp domain. In addition, 2 shallow soil piezometers (SP1 and SP2) were installed down slope of two swamps as shown in Table 18 and Figure 8.

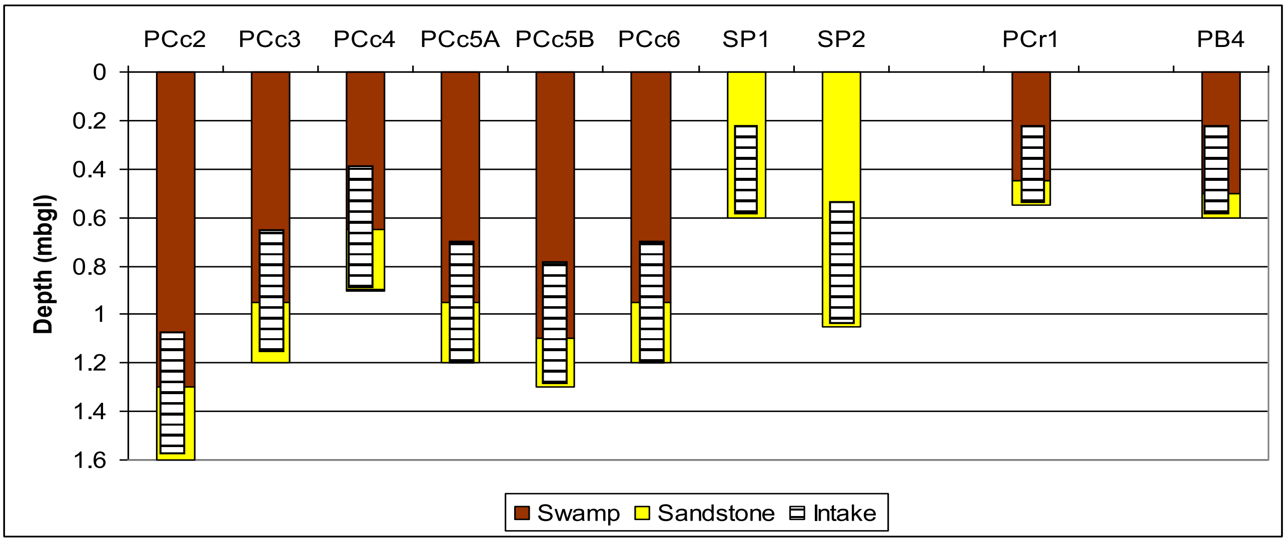
Table 18: Wonga East Piezometers (# indicates dry hole with no piezometer)

Bore	Swamp	Installed	Easting	Northing	Total Depth (mbgl)	Intake Screen (m)	Intake Lithology
PCc2	CCUS2	May 12	303745	6196095	1.60	1.1 – 1.6	humic sandy clay / weathered sandstone
	CCUS2#	May 12	303735	6196100	-	Dry at 0.75	weathered sandstone

Bore	Swamp	Installed	Easting	Northing	Total Depth (mbgl)	Intake Screen (m)	Intake Lithology
	CCUS2#	May 12	303730	6196080	-	Dry at 0.75	weathered sandstone
PCc3	CCUS3	Mar 12	302820	6196810	1.2	0.7 – 1.2	sandy clay / weathered sandstone
PCc4	CCUS4	Mar 12	302615	6196925	0.95	0.45 – 0.95	sandy clay / weathered sandstone
PCc5A	CCUS5	May 12	302110	6197135	1.24	0.7 – 1.2	humic sandy clay / weathered sandstone
	CCUS5#	May 12	302135	6197155	-	Dry at 0.3	weathered sandstone
	CCUS5#	May 12	302135	6197160	-	Dry at 0.5	weathered sandstone
	CCUS5#	May 12	302105	6197130	-	Dry at 1.6	weathered sandstone
PCc5B	CCUS5	May 12	302245	6197250	1.31	0.8 – 1.3	humic sandy clay / weathered sandstone
PCc6	CCUS6	Mar 12	303165	6196790	1.2	0.7 – 1.2	weathered sast
PCr1	CRUS1	Mar 12	302290	6196625	0.55	0.3 – 0.55	humic sandy clay / weathered sandstone
PB4	BCUS4	May 12	302485	6198060	0.6	0.25 – 0.6	humic sandy clay / weathered sandstone
SP1	No swamp	Mar 12	303245	6196955	0.60	0.1 – 0.6	sandy clay / weathered sandstone
SP2	No swamp	Mar 12	302830	6196905	1.05	0.55 – 1.05	sandy clay / weathered sandstone

Drill hole depth and piezometer construction details are shown in Graph 2.

Graph 2: Wonga East Swamp Piezometers

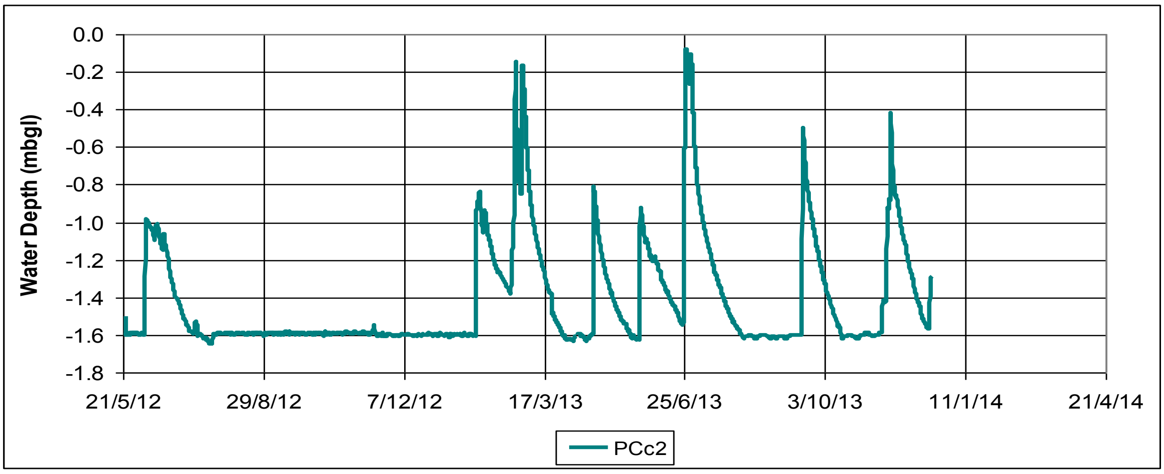


Swamp water levels

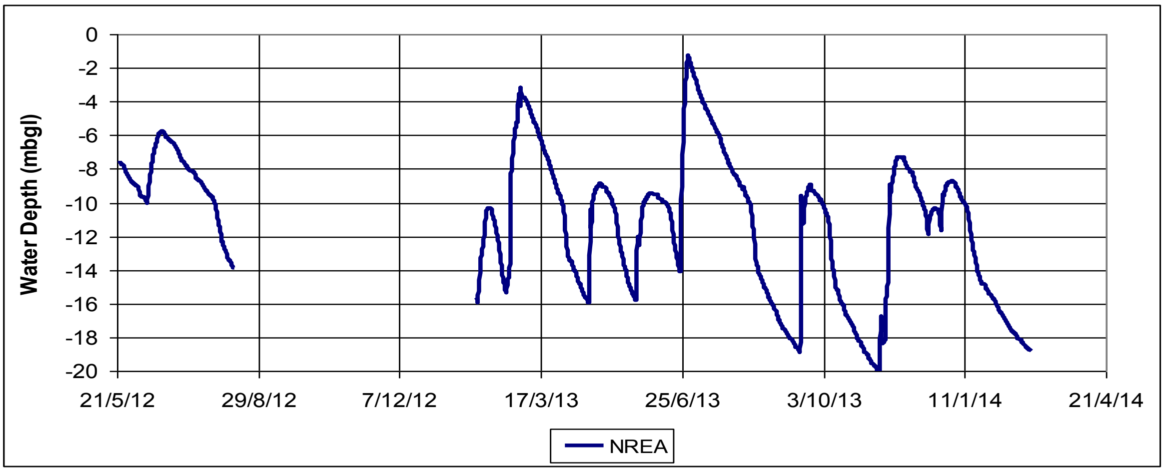
The upland swamps are perched systems that are hydraulically separated from the deeper, regional groundwater table in the Hawkesbury Sandstone by an unsaturated zone.   This is illustrated in two examples below.

Paired swamp and Hawkesbury Sandstone monitoring at PCc2 and NRE-A, as shown in Graph 3 and Graph 4 respectively, indicate the two systems have variable separation thicknesses of unsaturated sandstone, which ranges from 1.3 - 18.4m. Recharge following rain events through the sandstone to the regional aquifer is apparent, with the swamp and regional sandstone aquifer having similar temporal, although different quantum responses to rainfall recharge.

Graph 3: Hydrograph – Upland Swamp CCUS2

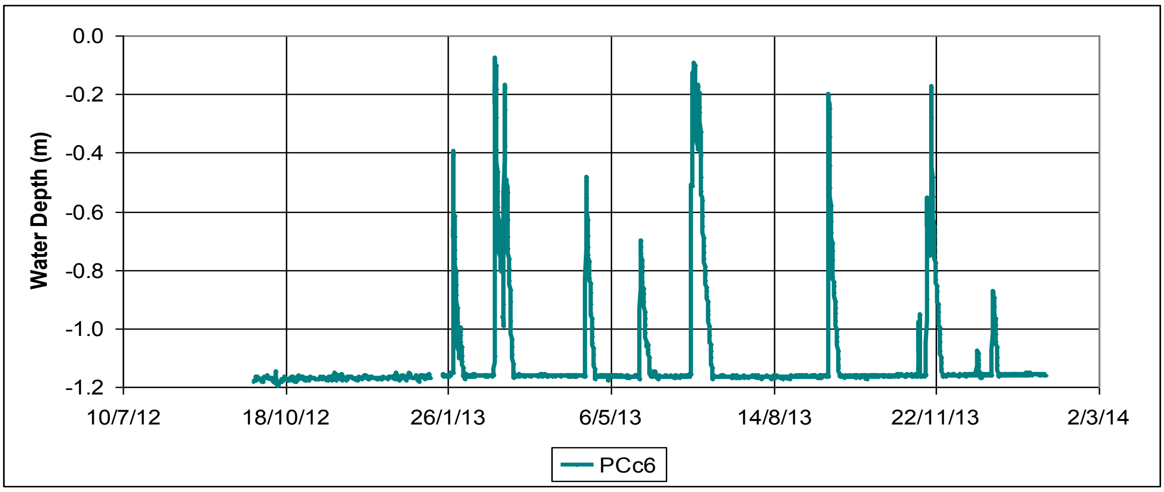


Graph 4: Hydrograph – Borehole NRE-A

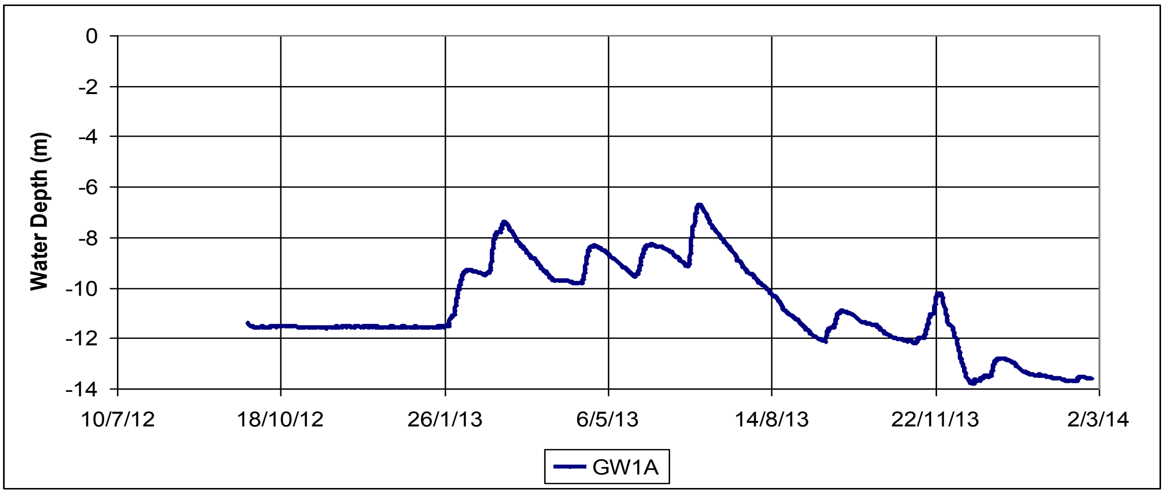


Although they are not immediately adjacent to each other, comparison of water levels in GW1 and PCc6 in swamp CCUS6, as shown in Graph 5 and Graph 6 respectively, indicate a 6.8 – 11.9m unsaturated sandstone separation thickness. Recharge following rain events through the sandstone to the regional aquifer is apparent, with the swamp and the regional sandstone aquifer having similar temporal, although different quantum responses to rainfall recharge.

Graph 5: Hydrograph – Upland Swamp CCUS6



Graph 6: Hydrograph – Borehole GW1A



Although hydraulically separated from the deeper, regional groundwater table in the Hawkesbury Sandstone, upland swamps can, however, be connected to shallower, ephemeral seepage from the upper Hawkesbury Sandstone where bedding discontinuities or low permeabilities enhance horizontal flow into a swamp after high rainfall periods. Depending on the relative height of the ephemeral, perched and regional water tables, groundwater seepage can supplement swamp moisture or, alternatively, unsaturated swamp moisture can seep into the underlying shallow ephemeral sandstone aquifer. In turn, the shallow bedrock aquifers are also usually ephemeral, and are hydraulically disconnected via an unsaturated zone from the deeper, regional aquifers within the Hawkesbury Sandstone.

The water table within the swamps is dependent on surface inflow recharge after rain and can be supported by ephemeral seepage of near surface groundwater from the Hawkesbury Sandstone. Water storage is usually limited within the humic, clayey, rich sandy sediments, although this can allow relatively small inflows to support a highly variable ephemeral water table in the more organic layers.

Recharge into the Hawkesbury Sandstone shallow aquifer that seeps into a swamp is generally moderated by connate water stored in a swamp, which is also recharged by rainfall. Water can enter a swamp from ephemeral seeps located at the upper and lower section of any topographic or basement steps that may be present.

Episodes of inundation and surface run off within a swamp are directly related to the extent and duration of storm events, with the short term, post storm drainage occurring within indistinct channels or dispersed flow paths in the swamp.

Groundwater seepage into a swamp is usually transmitted within the more sandy or humic layers and can "daylight" where the water table extends to surface. Water accumulation within a swamp is a balance between:

- rainfall / surface runoff recharge;
- horizontal seepage and downstream outflow;
- swamp storage capacity, based on the size and depth of the swamp, its humic organic material as well as sand and clay composition;
- vertical seepage rates into the underlying weathered sandstone; and,
- swamp evapotranspiration.

Groundwater levels within the Wonga East swamps have been monitored since February 2012. Hydrographs for all monitored swamps, two shallow soil piezometers and rainfall data are presented in Graph 7 to Graph 12. Data from this monitoring indicates that swamp water levels are variable, and can range from fully saturated to dry. Some of the swamps have been essentially dry since piezometers were installed.

Analysis of the swamp hydrographs shown in Graph 7 to Graph 9 indicates;

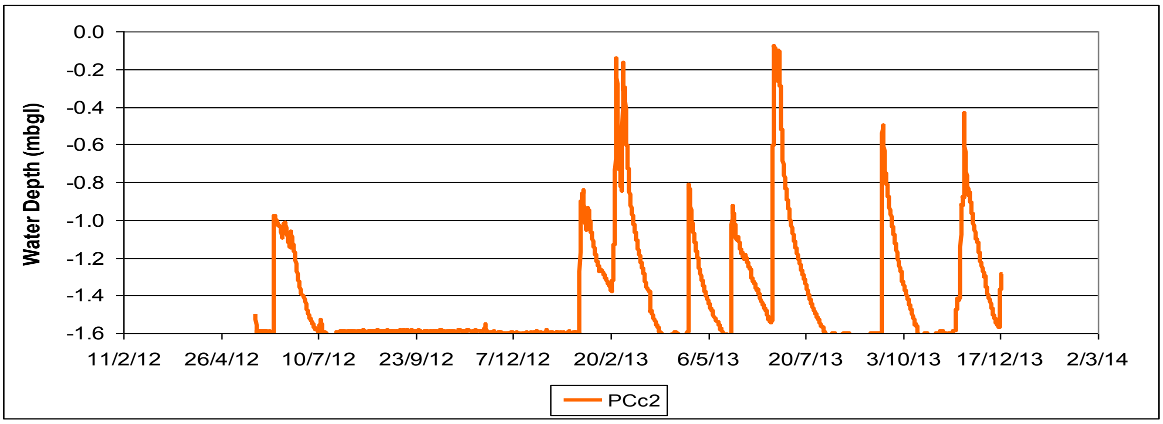
- PCc2 in swamp CCUS2 overlies first workings in the Bulli Seam as well as the end of LW4 in the Balgownie workings, undergoes evapotranspiration as well as gradual drainage after rainfall with overland seepage outflow to a northerly draining gully then to Cataract Creek. No evidence of adverse effects due to prior subsidence are evident in this swamp.
- PCc5A and PCC5B in swamp CCUS5 overlies both first workings and pillar extraction in the Bulli Seam as well as first workings in the Balgownie workings, undergoes evapotranspiration as well as gradual drainage after rainfall with overland seepage outflow to a northerly draining gully then to Cataract Creek. No evidence of adverse effects due to prior subsidence are evident in this swamp.
- PB4 in swamp BCUS4 overlies only pillar extraction in the Bulli Seam, also undergoes evapotranspiration as well as gradual drainage after rainfall with overland seepage outflow to a southerly draining gully then to Bellambi Creek. No evidence of adverse effects due to prior subsidence are evident in this swamp.
- PCc4 in swamp CCUS4 overlies first workings in the Bulli Seam as well as LW11 in the Balgownie workings, undergoes evapotranspiration as well as drainage after rainfall with overland seepage outflow to a northerly draining gully then to Cataract Creek. Possible adverse effects due to prior subsidence may be evident in this swamp due to its enhanced drainage recession rates.
- PCr1 in swamp CRUS1 overlies pillar extraction workings in the Bulli Seam, undergoes evapotranspiration as well as drainage after rainfall with overland seepage outflow to a southerly draining gully then to Cataract River. Possible adverse effects due to prior subsidence may be evident in this swamp due to its enhanced drainage recession rates. However, as the swamp has limited humic matter with numerous shallow outcropping or subcropping sandstone outliers, it is equally possible that the swamp has little storage capacity and drains / evaporates rapidly as a result.

Monitoring of water levels in the vicinity of the Longwalls 4 and 5 in the Wonga East Area, as shown in Graph 10 and Graph 11, indicates that;

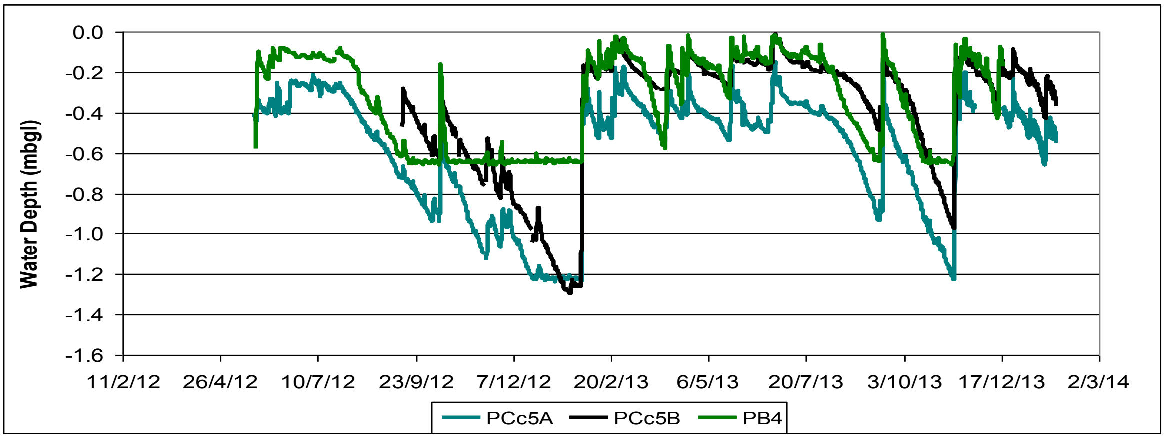
- PCc3 in swamp CCUS3 overlies first workings in the Bulli Seam as well as LW10 in the Balgownie workings, undergoes evapotranspiration as well as rapid drainage after rainfall with overland seepage outflow to a northerly draining gully then to Cataract Creek. Possible adverse effects due to prior subsidence may be evident in this swamp due to its enhanced drainage recession rates. However, as the swamp is small, has essentially no humic matter with numerous shallow outcropping or subcropping sandstone outliers, it is equally possible that the swamp has little storage capacity and drains / evaporates rapidly as a result.
- PCc6 in swamp CCUS6 overlies pillar extraction in the Bulli Seam as well as LW8 in the Balgownie workings, undergoes evapotranspiration as well as rapid drainage after rainfall with overland seepage outflow to a northerly draining gully then to Cataract Creek. Possible adverse effects due to prior subsidence may also be evident in this swamp due to its enhanced drainage recession rates. However, as the swamp is also small, has essentially no humic matter with numerous shallow outcropping or subcropping sandstone outliers, it is equally possible that the swamp has little storage capacity and drains / evaporates rapidly as a result.

- SP1, which is not located in a swamp, is located to the west of the freeway, and overlies the edge of a pillar extraction area in the Bulli Seam as well as LW9 in the Balgownie workings. The piezometer, which is located down gradient of swamp CCUS6, undergoes evapotranspiration as well as rapid drainage after rainfall with overland seepage outflow to a northerly draining gully then to Cataract Creek. It is possible that adverse effects due to prior subsidence may be evident. However, as the piezometer is located in a sandy clay soil / weathered sandstone profile, with no humic matter and numerous shallow outcropping or subcropping sandstone outliers, it is interpreted that the colluvial soil profile has little storage capacity and drains / evaporates rapidly as a result.
- SP2, which is also not located in a swamp, is located to the west of the freeway, and overlies the edge of a pillar extraction area in the Bulli Seam as well as LW10 in the Balgownie workings. The piezometer, which is located down gradient of swamp CCUS3, undergoes evapotranspiration as well as rapid drainage after rainfall with overland seepage outflow to a northerly draining gully then to Cataract Creek. It is possible that adverse effects due to prior subsidence may be evident. However, as the piezometer is located in a sandy clay soil / weathered sandstone profile, with no humic matter and numerous shallow outcropping or subcropping sandstone outliers, it is interpreted that the colluvial soil profile has little storage capacity and drains / evaporates rapidly as a result.

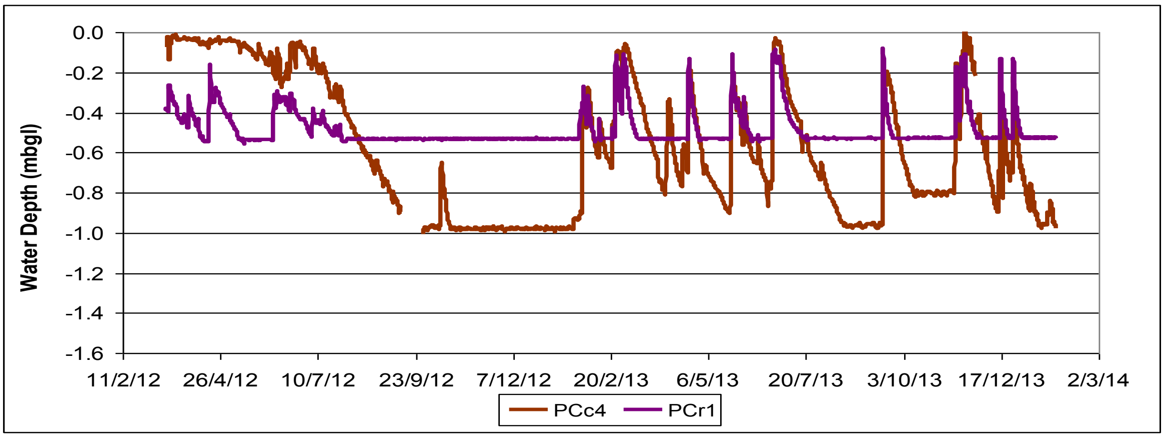
Graph 7: Hydrograph – Upland Swamp CCUS2



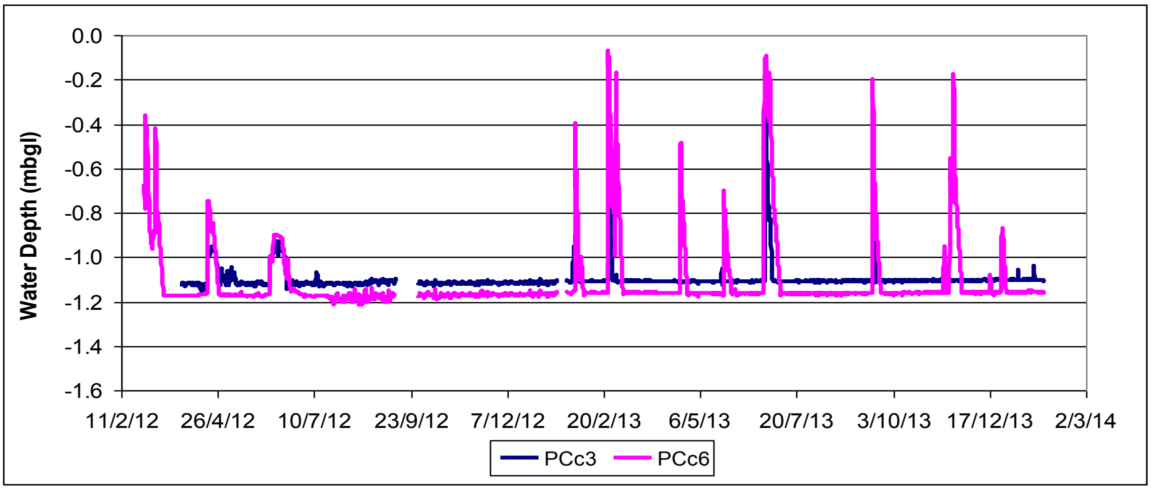
Graph 8: Hydrograph – Upland Swamps CCUS5 and BCUS4



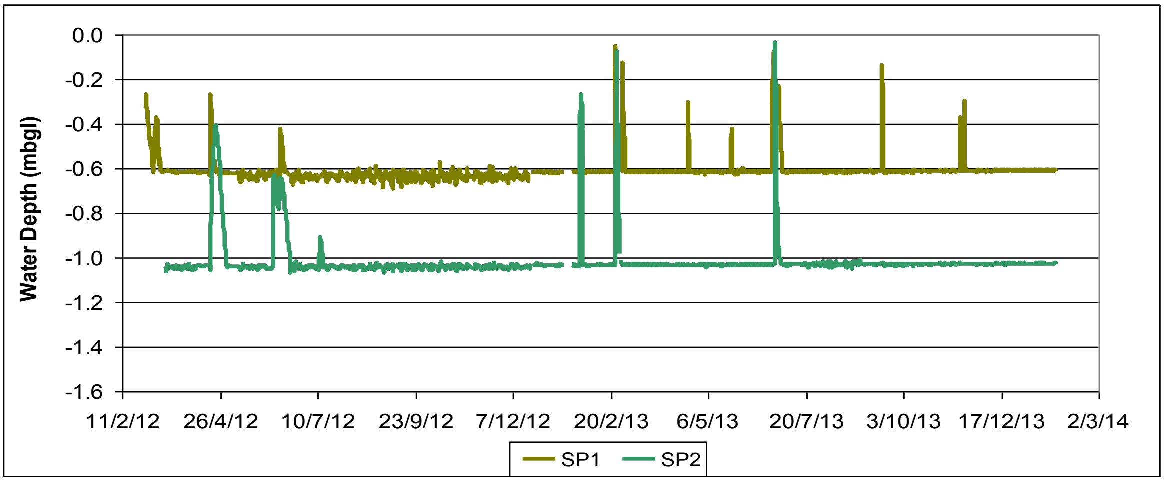
Graph 9: Hydrograph – Upland Swamps CCUS4 and CRUS1



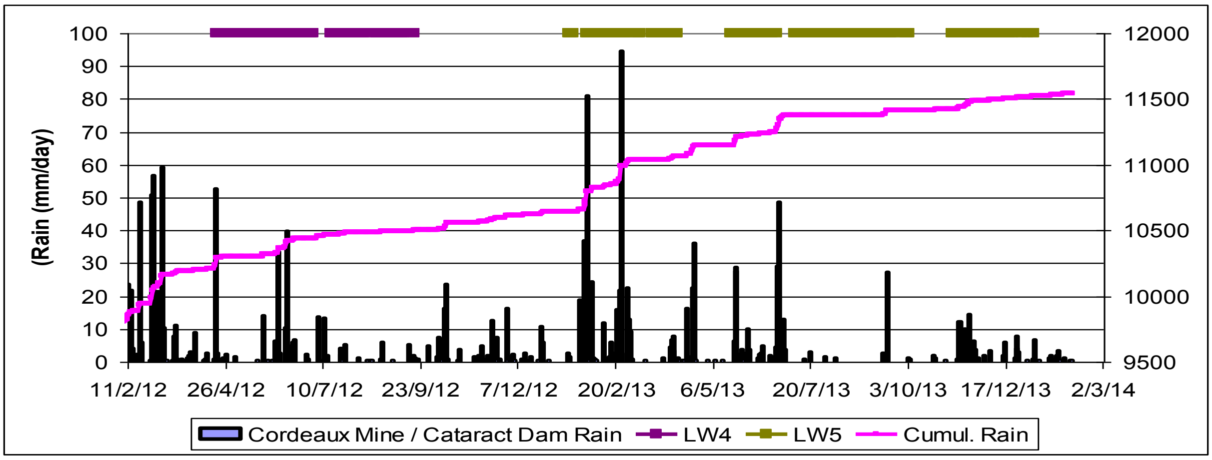
Graph 10: Hydrograph – Upland Swamps CCUS3 and CCUS6



Graph 11: Hydrograph – SP1 and SP2



Graph 12: Rainfall



Groundwater data from piezometers located in upland swamps within the study area indicates that there are varying water levels in these upland swamps. The monitored locations within swamps CCUS4 and CCUS5 show sustained groundwater levels for prolonged periods following rainfall, CCUS2 shows gradual recession of groundwater following rainfall, while CCUS3 and CCUS6 show little groundwater recharge following rainfall. This corresponds with the vegetation communities within these upland swamps, with CCUS4 and CCUS5 supporting areas of MU43 Tea-tree Thicket (both upland swamps) and MU44c Cyperoid Heath (CCUS4 only), which both rely on permanent to intermittent waterlogging. In contrast, CCUS2, CCUS3 and CCUS6 support MU42 Banksia Thicket (CCUS3 and CCUS6) or MU44a Sedgeland and MU44b Restioid Heath (CCUS2) which are less reliant on waterlogging. CRUS1, which supports a mix of MU42 and MU43, is an anomaly. This upland swamp has shallow soils and some areas of MU43 are known to be located in "bowls" within the underlying geology, resulting in water accumulation in depressions in bedrock.

It is worth noting that all of the upland swamps listed above have been subject to significant tilts and strains from past mining (see Table 13 and Table 14), substantially above what has been predicted by MSEC to result in fracturing of bedrock in waterways (DoP 2010) and the criteria listed in OEH (2012) for assessing the risk of negative environmental consequences to upland swamps. These levels of tilts and strains are likely to have resulted in fracturing of the bedrock beneath these upland swamps from past mining. However, monitoring data is not available to confirm whether this has occurred.

Groundwater model

Geoterra and Groundwater Exploration Services (2014) have recently completed the groundwater modelling and associated revised groundwater assessment for the Preferred Project Report for the Underground Expansion Project. Aspects of the model that are of relevance to upland swamps are discussed below.

The model indicates that the depressurisation zone may reach the surface over the eastern and central sections of Longwall 6 and 7 and over the eastern and central sections of Longwalls 1 to 3. It should be noted that although the depressurisation "halo" may extend to the surface this does not mean that this will result in a "full" direct connection between the perched ephemeral water table associated with upland swamps and the mine workings. This is supported by the model predicting depressurisation over the extracted Longwalls 4 and 5; however there have not been any observable adverse change in piezometric water levels in upland swamps above Longwalls 4 and 5 (Graph 10: Hydrograph – Upland Swamps CCUS3 and CCUS6).

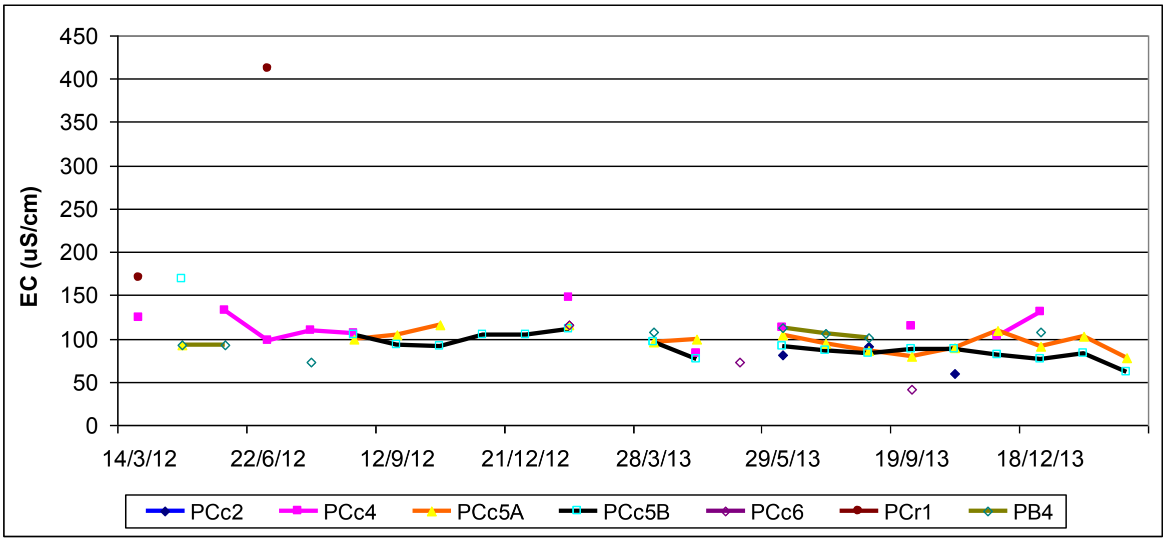
Given the location of likely depressurisation there is an increased risk of drainage for upland swamp CCUS2 and upland swamp of 'special significance' CCUS4. However, for other upland swamps in the Wonga East area the risk of depressurisation is low.

The modelling indicates that although the perched, ephemeral groundwater water table associated with upland swamps could undergo a water level reduction it is not anticipated to have a significant overall effect on stream baseflow or stream water quality. However, temporary, localised effects may be observed.

Groundwater chemistry

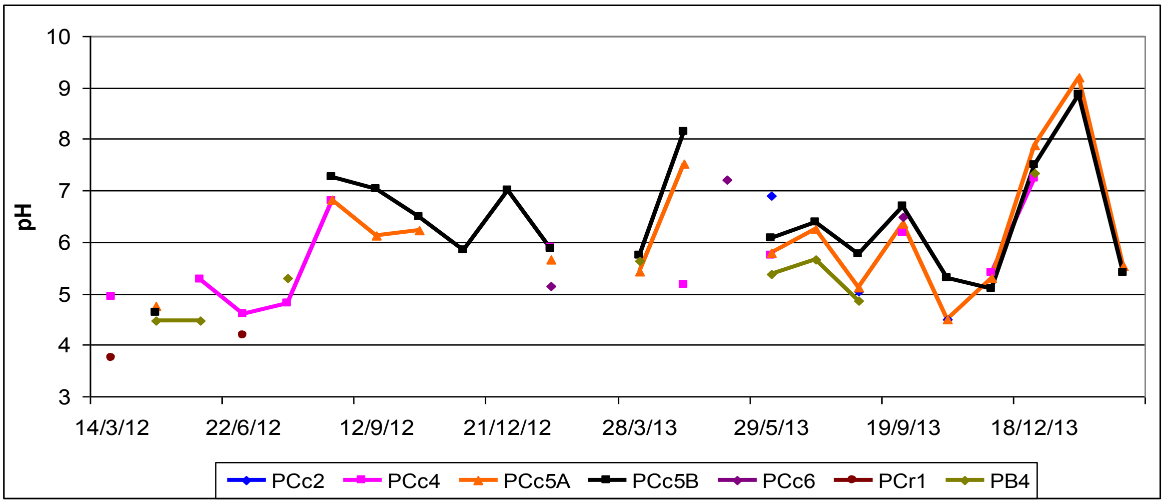
The Cataract Creek, Bellambi Creek and Cataract River swamps at Wonga East have electrical conductivities ranging from 70 – 170µS/cm (Graph 13), with the salinity varying in relationship to rainfall recharge that occurs prior to sampling, along with the degree of brackish seepage from the weathered Hawkesbury Sandstone.

Graph 13: Electrical conductivity – Wonga East upland swamps



The pH ranges from 3.8 – 7.3 as shown in Graph 14.

Graph 14: pH – Wonga East upland swamps



Monitoring indicates the swamp salinity is within the acceptable range for potable water; however it is generally outside the ANZECC 2000 South Eastern Australia Upland Stream criteria for pH and can be above the ANZECC 2000 95% Species Protection Level for Freshwater Aquatic Ecosystem Guidelines for:

- Filtered copper, lead, zinc, nickel, and occasionally aluminium (where its pH exceeds 6.5, which it rarely occurs), as well as.
- Total nitrogen, and total phosphorous.

Flow accumulation

Flow accumulation modelling was undertaken based on the revised longwall layout and revised subsidence predictions (SCT Consultants 2013). The methodology for undertaking flow accumulation modelling is presented in Biosis (2012b). To address criticism regarding quantification of impacts from flow accumulation modelling, the percentage change in flow accumulation following mining is presented in Table 19, in addition to a discussion on flow accumulation.

Table 19: Discussion of changes in flow accumulation pre- versus post-mining for upland swamps in Wonga East (swamps of 'special significance' are shown in italics)

Swamp	Percentage change in flow accumulation following mining	Discussion of changes in flow accumulation
BCUS4	114.64	Flow accumulation modeling for BCUS4 pre-mining indicates that there is a dispersed flow through this upland swamp, with four exit points from the base of the upland swamp. Modeling of post-mining flow indicates an increase in catchment yield of 14.64%. There are minimal changes to the exit points within this upland swamp; however a redistribution of water within the swamp may result in decreased water flow through a small patch of MU43 Tea-tree Thicket. This may result in changes to vegetation composition in this area.
BCUS11	108.29	Flow accumulation modeling for BCUS11 pre-mining indicates that this small upland swamp has three flow pathways through the swamp. Following mining, changes in tilt are likely to result in a very minor increase in summed flow within this upland swamp of 8.29%. There is unlikely to be any change to flow pathways through the upland swamp. Changes are predicted to be negligible.
CCUS1	98.32	Flow accumulation modeling pre-mining indicates the presence of two main flow pathways through this upland swamp – one exiting the swamp in the northeast section of the swamp and one in the southeast section of the swamp. These exit points coincide with area of MU42 Tea-tree Thicket and MU44c Cyperoid Heath. Flow accumulation modeling post-mining indicates that tilts associated with Longwall 3 will result in a minor change to the flow pathway through the southeast section of the upland swamp with a minor (8.32%) increase in catchment area. This is likely to result in an increase in water availability for a small section of MU44a Sedgeland in this southeastern section.

Swamp	Percentage change in flow accumulation following mining	Discussion of changes in flow accumulation
		Any changes are likely to be minor.
CCUS2	99.62	Pre-mining flow accumulation modeling for CCUS2 indicates a dispersed flow of water through this upland swamp. Tilts associated with Longwalls 2 and 3 will result in only a negligible (0.38%) change to water availability across the swamp. Flow pathways through the swamp are likely to change following mining; however there are no significant concentrations of water, and given the dispersed nature of flow prior to mining this is predicted to result in minor changes.
CCUS3	99.18	Modeling of pre-mining flow accumulation through CCUS3 indicates the presence of two main flow pathways through this upland swamp, largely through areas of MU42 Banksia Thicket. Tilts associated with extraction of Longwall 5 are likely to result in only negligible (0.72%) changes in overall catchment yield for this upland swamp, and a minor re-direction of flow from the western edge of CCUS3 to the centre. This change will result in any negligible impacts to this upland swamp.
CCUS4	95.23	Flow accumulation modeling pre-mining indicates the presence of two main flow pathways through this upland swamp. One minor flow path passes through the eastern section of the swamp, while the main flow pathway passes through the western section of the swamp. The western flow pathway corresponds with areas of MU43 Tea-tree Thicket and MU44c Cyperoid Heath. Post-mining, tilts will result in a minor (4.77%) decline in overall catchment yield. Only negligible changes in the western flow accumulation pathway are predicted to occur, with minor changes in flows through the patches of MU43 and MU44c. Tilts will result in result in a new flow pathway through the centre of this upland swamp, with resultant increases in water availability to patches of MU42 Banksia Thicket. A shift in the flow pathway through the eastern section of the swamp will result in a minor redistribution of water in this eastern section. This may result in minor impacts to vegetation communities reliant on permanent and intermittent waterlogging.
CCUS5	73.49	Pre-mining flow accumulation modeling indicates that this upland swamp has a dispersed flow accumulation, with numerous flow pathways through the swamp. There is a significant flow pathway through the eastern section of the swamp, corresponding with an area of MU43 Tea-Tree Thicket. Substantial benching within this swamp appears to be correlated with vegetation sub-communities; with areas of Tea-Tree Thicket (MU43) corresponding with the location of rockbars within the swamp, and it is likely that community composition in this swamp relates to a combination of flow and these rockbars allowing pooling of water at these locations. Tilts associated with Longwall 7 are likely to result in a significant (26.51%) decline in overall water availability within this swamp. This decline is likely to

Swamp	Percentage change in flow accumulation following mining	Discussion of changes in flow accumulation
		impact most on the eastern section of this upland swamp, diverting flow away from the major flow pathway mentioned above, resulting in a decrease in water availability for a patch of MU43. This may result in changes to vegetation composition within this swamp; however it is predicted to impact on a small section of the swamp only.
CCUS6	97.69	Flow pathways through CCUS6 prior to mining are dispersed, with multiple entry and exit points reflecting the disconnected nature of this upland swamp. Tilt associated with extraction of Longwall 4 and 5 may result in a minor (2.31%) decrease in flow accumulation, but is unlikely to result in any significant changes in these pathways. Minor changes are predicted to occur.
CCUS10	106.91	Flow accumulation modeling pre-mining indicates a dispersed flow accumulation across this upland swamp. This swamp has a small catchment area that commences just above Longwall 9. Vegetation sub-communities appear to correspond with area of benching down the slope, with these rockbars resulting in accumulation of water in these areas. Post-mining flow accumulation modeling indicates a small (6.91%) increase in catchment yield, and only minor changes in flow pathways through this swamp.
CCUS11	50.35	Flow accumulation modeling indicates that this upland swamp has a small catchment, with the upland swamp likely to be reliant on terracing and accumulation of water. Post-mining modeling indicates a significant (49.65%) decline in this catchment yield. Tilts associated with extraction of Longwall 8 are likely to result in a diversion of this flow pathway around this upland swamp, reducing water availability. There is potential that this decline in water availability may result in impacts to this upland swamp.
CCUS12	103.58	CCUS12is located at the boundary between the catchments of Cataract Creek and Bellambi Creek, and as a result, has a very small catchment area. Pre- versus post-mining flow accumulation modeling indicates that only minor (3.58%) increases in catchment yield and no change in flow pathways. Negligible changes are predicted to occur.
CCUS23	97.06	Given the orientation of the flow pathway perpendicular to the longwall, flow accumulation modeling pre- versus post-mining indicates only a minor (2.94%) increase in catchment yield for this upland swamp. There is unlikely to be any change in flow pathways through this swamp. Negligible changes in water availability due to flow are predicted.
CRUS1	100.21	Only the upper northern section of CRUS1 is located above Longwall 6. An assessment of pre- versus post-mining flow accumulation through the upland swamp indicates a negligible (0.21%) increase in catchment yield and negligible changes in flow pathways through this upland swamps.

Swamp	Percentage change in flow accumulation following mining	Discussion of changes in flow accumulation
		No changes in water availability are predicted to occur.

Flow accumulation modelling for upland swamps within the study area indicates that, for the majority of upland swamps, only negligible or minor changes in both cumulative flow and flow pathways are likely to occur following mining. No significant reconcentration of flows that may result in increased erosion risk, are likely to occur. For the majority of upland swamps mining is likely to result in only minor changes in water availability.

Flow accumulation modelling indicates that BCUS4, CCUS5 and CCUS11 are at risk of impact due to changes in water availability, particularly to vegetation communities sensitive to decreases in water availability. Of these, only CCUS5 is considered to be of 'special significance'.

Compressive and tensile strain

Reassessment of subsidence predictions following monitoring of Longwalls 4 and 5 indicates that past mining has resulted in the softening of the underlying rock strata, and that subsidence is occurring over a much shorter distance than has previously occurred in un-mined areas, with subsidence largely restricted to immediately above the goaf. Whilst this means that subsidence movements occur over a smaller area, it also means that tilts and strains are greater than previously predicted (SCT Operations 2014).

Maximum subsidence within the bounds of the swamp may not necessarily be a good indicator of the maximum subsidence parameters of strain and tilt given that maximum strain and tilt typically occur on the fringes of a subsided area. The maximum strain and tilt values have been estimated based on the level of subsidence within the general proximity of a swamp that would contribute to maximum strains and tilts within the swamp boundary (SCT Operations 2014).

When strains are greater than about 1-2 mm/m in tension and 2-3 mm/m in compression, perceptible fracturing of the sandstone strata below swamps may occur (SCT Operations 2014).

Subsidence predictions are presented in Table 16. This data indicates that tensile and compressive strains and tilts are of sufficient magnitude to result in fracturing of bedrock beneath upland swamps within the Wonga East area. Table 20 assesses the risk of a significant impact to these upland swamps based on vegetation communities present, and recorded response to groundwater (for upland swamps with groundwater data available).

Table 20: Discussion of tensile and compressive and strains for upland swamps within the study area (swamps of 'special significance' are shown in italics)

Swamp	Discussion of tilts and strains
BCUS4	BCUS4 is located over the edge of Longwall 9. Soils in BCUS4 are up to 160 cm in depth and consist of humic sandy clay. Tilts and strains affect a small section of MU43 Tea-tree Thicket. Lower sections of the upland swamp are unlikely to be subject to strains of sufficient magnitude to fracture bedrock.

Swamp	Discussion of tilts and strains
	Undergoes evapotranspiration as well as gradual drainage after rainfall. No evidence of adverse effects due to prior subsidence are evident in this swamp. Risk is assessed as low due to impacts to a small section of this swamp.
BCUS11	BCUS11 does not support vegetation communities reliant on waterlogging. No groundwater data is available. Risk is assessed as low.
CCUS1	Given changes to the longwall layout, impacts are likely to be restricted to a very small section of this upland swamp at the eastern end. Any changes here are likely to be limited in extent, and are unlikely to result in a significant impact to this upland swamp. No groundwater data is available. Risk is assessed as low.
CCUS2	CCUS2 does not support vegetation communities reliant on waterlogging. Undergoes evapotranspiration as well as gradual drainage after rainfall. No evidence of adverse effects due to prior subsidence are evident in this swamp. Risk of impact is considered low.
CCUS3	CCUS3 supports MU42 Banksia Thicket and MU44a Sedgeland, which are not reliant on waterlogging and are thus deemed less susceptible to decreased groundwater availability. Groundwater data indicates rapid recession to basement levels following rainfall. Risk is assessed as low.
CCUS4	CCUS4 supports MU43 Tea-tree Thicket and MU44c Cyperoid heath, which are reliant on permanent to semi-permanent water availability, as well as MU42 Banksia Thicket. Soils are 15 – 179 cm in depth and consist of humic sandy clays to minerals sands. Strains and tilts have increased following the revision of subsidence data by SCT Operations (2014). The location of water-dependent communities, including MU44C Cyperoid Heath and MU43 Tea-tree Thicket at the base of the longwall, in areas of lowest strain and tilt, are likely to mitigate impacts to some degree. Undergoes evapotranspiration as well as gradual drainage after rainfall. An overhanging sandstone formation, approximately 7.1 m high, forms a waterfall at the base of CCUS4. This sandstone formation forms a rockbar at the downstream extent of upland swamps CCUS4. There is evidence of impacts from previous mining, including collapse of a section of this sandstone formation and some cracking of the sandstone outcrop, to the west of the waterfall below CCUS4. Horizontal compression of this sandstone formation has the potential to result in rockfall or tensile cracking of this sandstone formation (SCT Operations 2014). As this sandstone formation forms a rockbar at the downstream extent of CCUS4 any fracturing is likely to result in changes in hydrology. Any rockfall that impacts on the integrity of the sandstone formation may result in significant impacts to the water holding capacity of CCUS4. No evidence of adverse effects due to prior subsidence are evident in this swamp. Risk is assessed as high.
CCUS5	CCUS5 supports a mix of MU43 Tea-tree Thicket, which depends on permanent water availability, and MU42 Banksia Thicket and MU44a Sedgeland. Upper sections overlying Longwall 6 consist of MU42 and MU44a. Soils in this section of CCUS5 are up to 80 cm in depth and consist of a mix of humic sandy clay and sandy clay to minerals sands.

Swamp	Discussion of tilts and strains
	Following revision of the longwall layout only a small section of this swamp will be subject to subsidence, and areas of MU43 Tea-tree Thicket are located in areas of lower strain. Undergoes evapotranspiration as well as gradual drainage after rainfall. No evidence of adverse effects due to prior subsidence are evident in this swamp. Risk is assessed as low.
CCUS6	CCUS6 supports MU42 Banksia Thicket, which is not reliant on waterlogging and is thus deemed less susceptible to decreased groundwater availability. Groundwater data indicates rapid recession to basement levels rapidly following rainfall. Risk is assessed as low.
CCUS10	CCUS10 supports a mix of MU43 Tea-tree Thicket and MU44c Cyperoid Heath, which depends on permanent water availability, and MU42 Banksia Thicket. Following revision of the longwall layout only a small section of this swamp will be subject to subsidence, and areas of MU43 Tea-tree Thicket and MU44c Cyperoid Heath are located in areas of lower strain. Soils in the section of CCUS10 overlying Longwall 9 are up to 75 cm in depth and consist of sandy clay. No groundwater data is available. Risk is assessed as low.
CCUS11	CCUS11 supports MU42 Banksia Thicket, which is not reliant on waterlogging and is thus deemed less susceptible to decreased groundwater availability. No groundwater data is available. Risk is assessed as low.
CCUS12	CCUS12 supports MU42 Banksia Thicket, which is not reliant on waterlogging and is thus deemed less susceptible to decreased groundwater availability. Soils are between 5 and 85 cm in depth and consist largely of minerals sands with little organic material. No groundwater data is available. However this upland swamp is unlikely to support significant groundwater. Risk is assessed as low.
CCUS23	CCUS23 supports MU42 Banksia Thicket and MU44a Sedgeland. No groundwater data is available. Risk is assessed as low.
CRUS1	CRUS1 supports a mix of MU43 Tea-tree Thicket and MU42 Banksia Thicket. Based on shallow soil profile, MU43 Tea-tree Thicket is likely to persist in areas of water accumulation resulting from rock terracing, as evident from analysis of slope and testing of soil depths. Only the upper section of this upland swamp is located within the predicted subsidence zone. Soils in this area are between 25 and 70 cm, and consisting of mineral sands. These areas are unlikely to support significant groundwater. Undergoes evapotranspiration as well as gradual drainage after rainfall. Possible adverse effects due to prior subsidence may be evident in this swamp due to its enhanced drainage recession rates. However, as the swamp has limited humic matter with numerous shallow outcropping or subcropping sandstone outliers, it is equally possible that the swamp has little storage capacity and drains / evaporates rapidly as a result. Risk is assessed as low.

Final risk assessment

Potential impacts

Potential impacts to upland swamps in the Wonga East area may result from the following mechanisms:

- Fracturing of bedrock beneath upland swamps, resulting in increased secondary porosity and permeability, with potential to drain into deeper sandstone strata.
- Tilting in and upland swamps resulting in the re-distribution of perched water levels and surface run-off. This may result in changes in in-flow to upland swamps and / or changes in saturation of vegetation sub-communities.
- Titling in upland swamps resulting in increased potential for development of nick points, scouring and erosion.
- Changes in baseflow discharge and from upland swamps.

Subsidence could affect upland swamps directly overlying the proposed longwalls due to either transient and/or spatial changes in secondary porosity and permeability of a swamp or its underlying weathered sandstone substrate through generation of cracks or differential displacement of the perched aquifer. If a swamp overlies an extracted panel, it may undergo temporary extensional "face line" cracking (perpendicular to the long axis of the panel) as a panel advances, followed by re-compression as the maximum subsidence occurs at any one location. In addition, where a swamp overlies a longwall, it may also undergo both longer term extensional "rib line" cracking (parallel to the long axis of the panel) along the outer edge and compression within the central portion of a panel's subsidence trough. The more susceptible portions of a swamp to increased secondary porosity and / or permeability changes are where it undergoes "rib line" cracking. Any adverse effects, if they occur, would be related to the extent and degree of cracking that occurs in the underlying weathered sandstone, as cracking is unlikely to manifest in a swamp due to its saturated, clayey, humic, plastic nature.

It should be noted that the headwater swamps at Wonga East have undergone up to an estimated 3.8 m of subsidence in the centre of Longwall 4 with up to 1.0 m of subsidence estimated for mining in the Bulli Seam 1.0 measured during mining in Balgownie Seam, and 1.8 m measured during mining in Wongawilli Seam. This level of subsidence would be expected to cause up to an estimated 21 mm/m of tensile strain, 41 mm/m of compressive strain, and 68 mm/m of tilt. Bulli Seam mining occurred from the late 19th Century through to about 1950. Balgownie Seam longwalls were mined between 1970 and 1982. Longwalls 4 and 5 in the Wongawilli Seam were mined in 2012 and 2013.

Where a swamp straddles a chain pillar, or is on the edge of the subsidence bowl, it could experience temporary, localised, re-distribution of perched water levels through differential subsidence of the ground. Tilting of a swamp could also potentially re-distribute surface runoff, resulting in a re-distribution of water flow and storage, thereby causing changes to the saturation characteristics which may alter the vegetation associations within a swamp.

Changes in flow regimes within swamps can result in changed flow paths or runoff characteristics within a swamp, with the potential for development of nick points, scouring and erosion. Dewatering and drying of swamps due to subsidence fracturing of the bedrock may increase the erosion potential of swamps. Negative environmental consequences may be caused by erosion and drying out of the swamp via channel erosion, by redistribution of water, or by water diversion through connected pathways exposed by buckling or shearing of the underlying sandstone. The swamps, however, contain sediment and organic material that may either seal or reduce water loss into the underlying fracture network. Drying, in conjunction with fire and substantial rainfall, can increase the susceptibility of swamps, particularly valley fill swamps, to erosion. However, it is often the case that no single factor can be directly implicated in enhanced erosion of upland swamps. The only swamp in the Russell Vale lease area that has undergone notable erosion is the valley fill swamp LCUS4 at Wonga West, which is outside the Study Area for this assessment.

Upland swamp water is stored within the shallow, perched, ephemeral groundwater system, whilst regional water is contained within the deeper Hawkesbury Sandstone aquifers. Empirical observation and field mapping (Biosis, 2013) indicates that past undermining of swamps in the Wollongong Coal lease area has not generated adverse ecological effects on swamps. It is therefore anticipated that observable reduction of swamp discharge to the Study Area catchments will not occur following subsidence across the subject catchment areas, although generation of potentially enhanced leakage from the base of the swamps may occur. Seepage from the swamp is currently highly ephemeral, with the volume and duration of baseflow being directly related to the degree of rainfall recharge and stream flow in the catchment.

Detailed risk assessment

Following assessment of a variety of risk factors, Table 21 provides an overall assessment of the potential for a significant impact to occur. This final risk assessment assesses the overall risk of a primary impact (based on the initial risk assessment) and the consequent risk of a secondary impact (based on factors such as groundwater data, reliance of vegetation communities on water availability, changes in flow accumulation and the position of water dependent communities within the upland swamp compared to areas of greatest tilt and strain).

The changes in storativity and permeability are estimated to have no observable impact above the water level variability due to climatic influences. Connective cracking to deeper strata is not predicted and, as such, it is not anticipated that the swamps could freely drain into the deeper sandstone strata. Based on observation of previously undermined swamps in the Wonga East area that have undergone similar strains to those predicted due to undermining by the previous Bulli and Balgownie workings, no observable adverse consequences are anticipated on the water holding capacity, water quality or ecosystem health of the majority of swamps, except possibly CCUS4. In addition to fracturing of the base of CCUS4, there is potential for impacts to the sandstone formation that forms a rockbar at the downstream extent of this upland swamp. Any rockfall that impacts on the integrity of this rockbar is likely to result in a significant impact to the water holding capacity of CCUS4.

Although the upper margins of upland swamps CCUS5 and CCUS10 overlie Longwalls 6 and 9 respectively, soil depths indicate that these upper margins are largely dry and unlikely to support significant groundwater resources. All other designated 'special significance' swamps are not anticipated to undergo sufficient compressional or extensional strains to generate cracks in the underlying or adjacent sandstone, and therefore are not anticipated to undergo any adverse effects or consequences from the proposed mining.

While there is some limited potential for redistribution of perched water levels and surface water run-off in some upland swamps, significant changes in water run-off are likely to be limited to small sections of upland swamps this is limited to smaller sections of upland swamps.

Although erosion of swamps is possible where elevated tilts occur due to subsidence, it is only generally valley fill swamps which have been directly undermined that are susceptible to erosion and scouring. No valley fill swamps are present at Wonga East.

It is not anticipated that the ephemeral water levels or baseflow seepage will be significantly adversely affected.

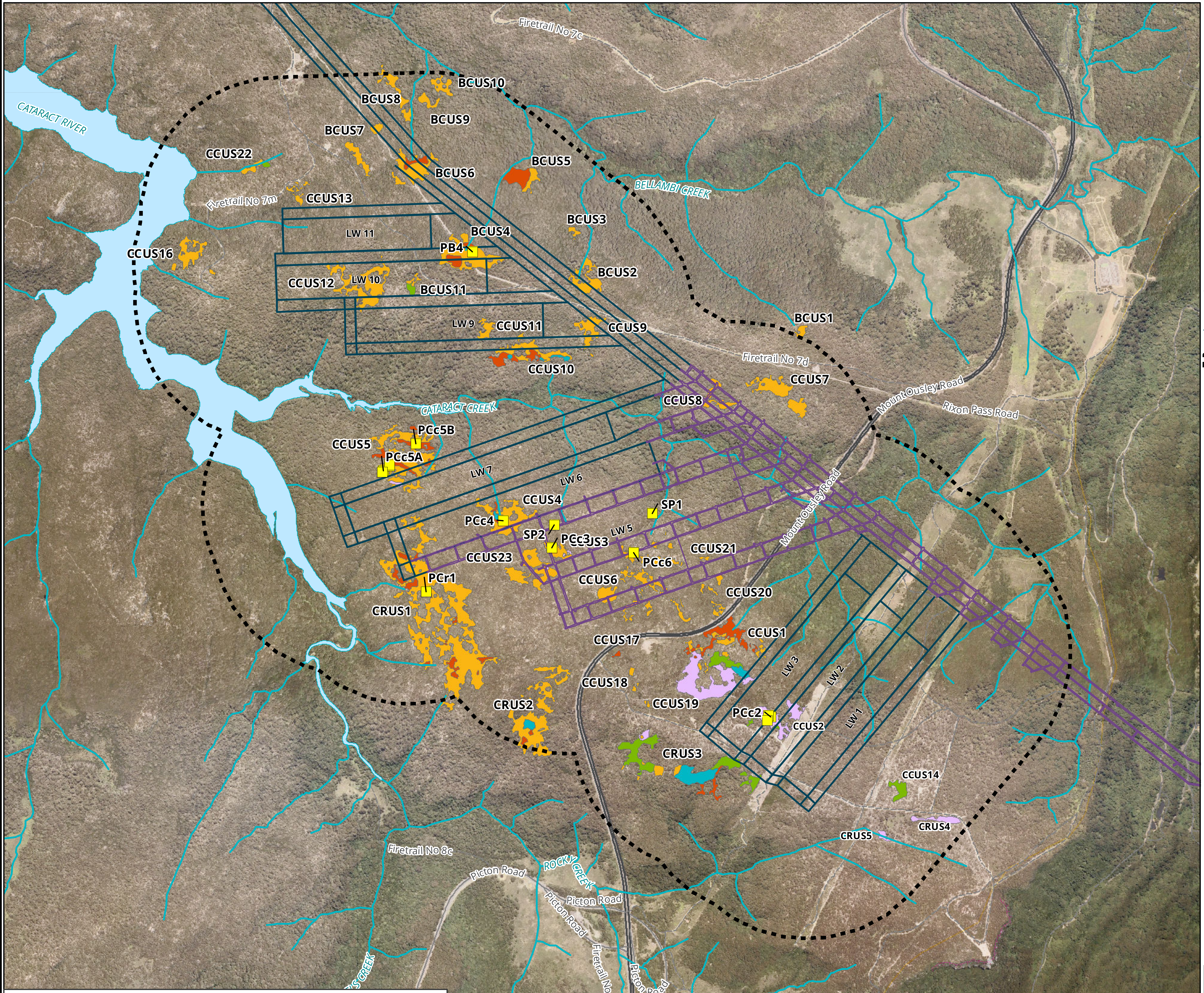
This final risk assessment indicates that there is a risk of a secondary impact to upland swamps BCUS4 and CCUS4 from the proposed extraction of coal in Wonga East. Only CCUS4 is considered to be of 'special significance'.

The revision of the mine plan for Wonga East has resulted in a reduction in risk to upland swamps of 'special significance' CRUS2 and CRUS3 due to these upland swamps now being situated outside of the predicted subsidence impact zone. Revision of the longwall layout has also resulted in a reduction in risk for CCUS5, as only the upper reaches of this upland swamp are now within the predicted subsidence impact zone.

The changes in subsidence predictions and higher tilts and strains have resulted in an increase in risk level for CCUS4.

Table 21: Final risk assessment for upland swamp sin the Wonga East area (swamps of 'special significance' are shown in italics)

Swamp	Initial risk assessment (risk of negative environmental consequences?)	Groundwater	Flow accumulation	Compressive tilts and strains	Final risk assessment
BCUS4	No	Low	Moderate	Low	Moderate
BCUS11	Yes	N/A	Negligible	Low	Low
CCUS1	Yes	N/A	Low	Moderate	Low
CCUS2	Yes	Low	Low	Low	Low
CCUS3	Yes	Low	Low	Moderate	Low
CCUS4	Yes	Moderate	Low	High	High
CCUS5	Yes	Low	Moderate	Low	Low
CCUS6	Yes	Low	Low	Low	Low
CCUS10	Yes	N/A	Low	Low	Low
CCUS11	Yes	N/A	Moderate	Low	Low
CCUS12	Yes	N/A	Negligible	Low	Low
CCUS23	Yes	N/A	Negligible	Low	Low
CRUS1	Yes	Low	Low	Low	Low



Acknowledgements: Topo (c) NSW Land and Planning Information(2011); Overivew (c) State of NSW (c.2003)

Legend

- Peizo Locations

Vegetation Sub-Communities

- MU42, Upland Swamps: Banksia Thicket
- MU43, Upland Swamps: Tea-Tree Thicket
- MU44a, Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Longwall Layout

- Approved Longwalls (Preliminary works project)
- Proposed Longwalls (Underground Expansion)
- 600m Study Area

Figure 8: Upland swamps in the study area

0 150 300 450 600 750

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

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Date: 28 May 2014,
Checked by: NMG, Drawn by: ANP, Last edited by: apritchard
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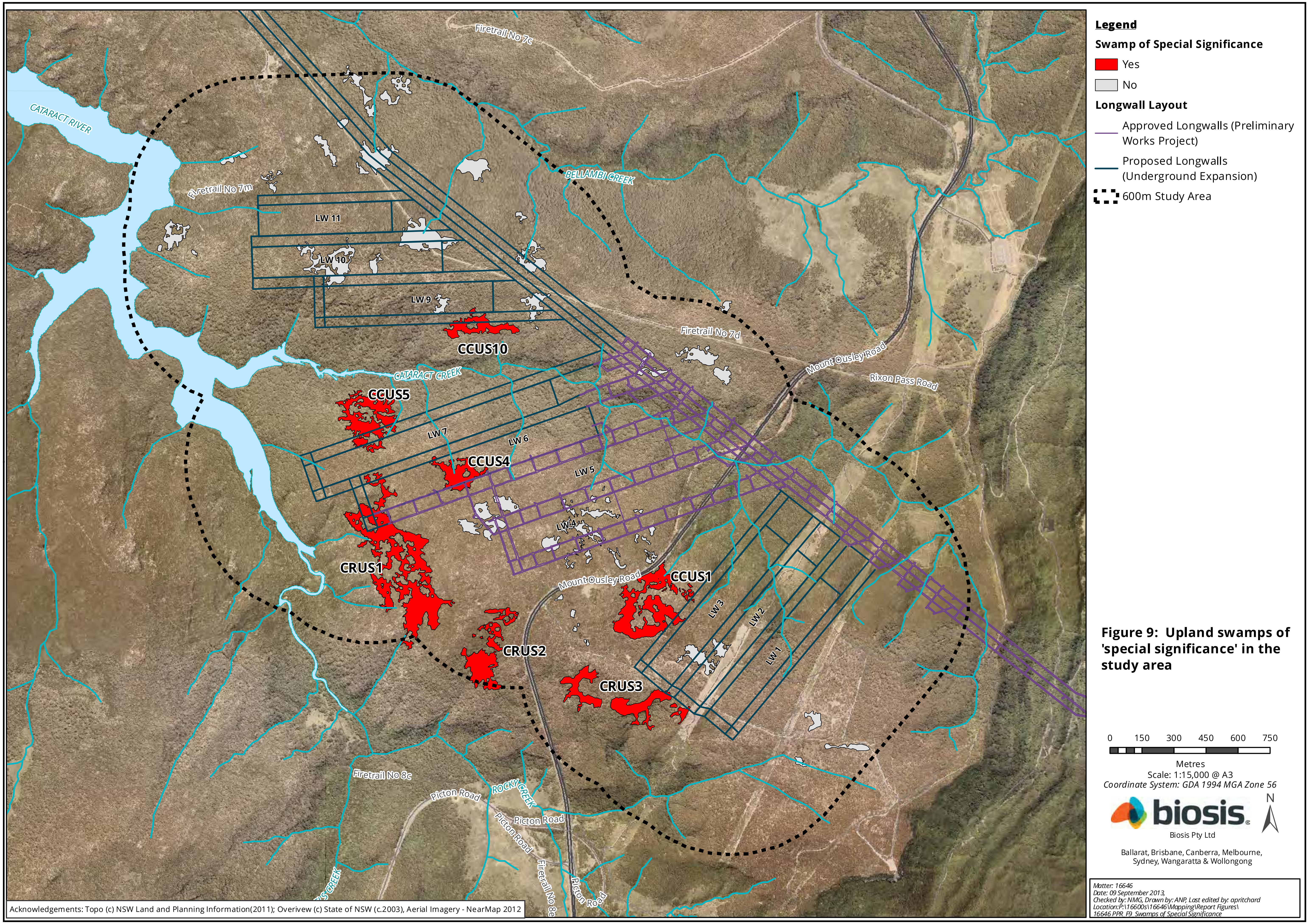


Figure 9: Upland swamps of 'special significance' in the study area

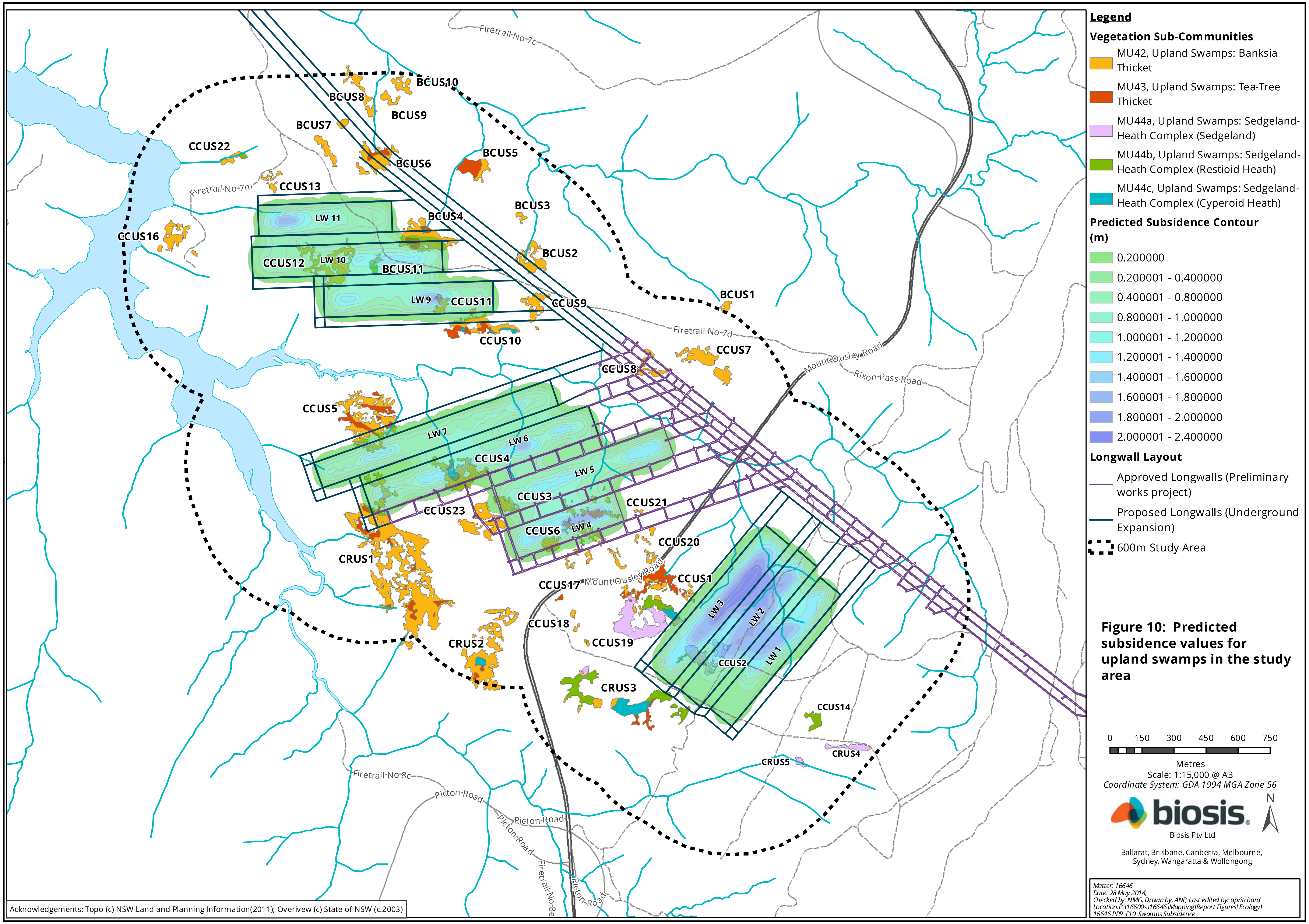
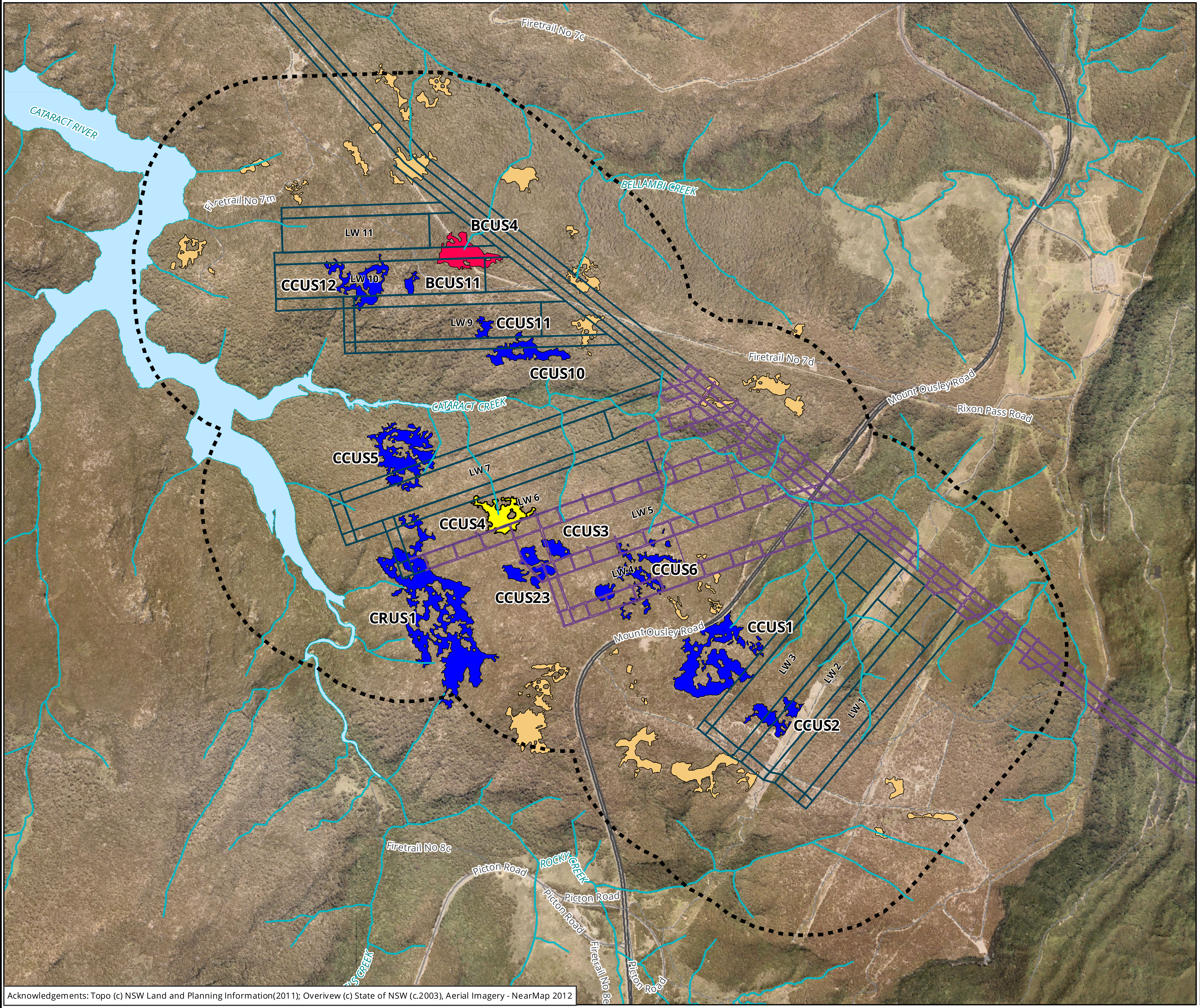


Figure 10: Predicted subsidence values for upland swamps in the study area



Legend

Risk Assessment

- High
- Moderate
- Low
- Negligible

Longwall Layout

- Approved Longwalls (Preliminary Works Project)
- Proposed Longwalls (Underground Expansion)
- 600m Study Area

Figure 11: Final risk assessment for upland swamps in Wonga East

0 150 300 450 600 750

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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Location:\\10.3.0.4\Matters\16600s\16646\Mapping\Report Figures\Ecology\16646 PPR_F11_Swamps Final Risk

4. Impact Management

The following impact management strategies are reiterated from the Preferred Project Report (NRE 2013).

4.1 Terrestrial Ecology

The majority of potential impacts to terrestrial biodiversity have been avoided as a result of the Preferred Project mine layout. Impact management will be broadly undertaken as outlined in Section 24.6of the EA, (ERM 2013b) as far as it pertains to the Preferred Project.

The existing Biodiversity Management Plan (BMP) for Longwalls 4 and 5 (Biosis 2012a) will be updated for the preferred Project. A monitoring plan consistent with the monitoring plan outlined in the existing BMP for Longwalls 4 and 5 (Biosis 2012a) will be adopted and expanded for the Preferred Project and included in the revised BMP. The current monitoring focuses on natural features at risk of subsidence effects in particular upland swamps and streams in particular, Coastal Upland Swamp EEC, Giant Burrowing Frog, Heath Frog, Red-crowned Toadlet, Stuttering Barred Frog and Broad-headed Snake. The BMP includes:

- Monitoring of vegetation in upland swamps according to the Before-After Control-Impact (BACI) design where data is collected before (baseline) and after impact at control and impact sites. Data collected during baseline monitoring will be used for comparison of data collected during and after mining and data collected at impact sites will be compared to data collected at control sites (control-impact).
- Monitoring of frog habitat according to the BACI design.
- Monitoring of upland swamps using shallow piezometers to gauge any changes in standing water levels and swamp groundwater quality (see Geoterra 2012d).
- Monitoring of water levels in Cataract Creek and tributaries (see Geoterra 2012d).

The BMP will be updated to include Longwalls 1 – 3 and 6 – 11. Monitoring for threatened species identified as having a moderate to high likelihood of occurring in the Study Area, and as vulnerable to the impacts of subsidence will be undertaken. Monitoring will be undertaken at annual intervals in appropriate seasonal timeframes for the detection of each individual species.

An adaptive management plan will be developed to use the monitoring program to detect the need for adjustment to the mining operations so that the subsidence predictions are not exceeded and subsidence impacts creating a risk of negative environmental consequences do not occur in upland swamps, streams and rocky habitats associated with cliffs and steep slopes.

Further measures to mitigate potential small scale affects of subsidence can be utilised as follows:

- If rock fracturing does occur and is confirmed to be a result of mining, remediation will be implemented as soon as possible, via a method to be determined in consultation with relevant stakeholders. All remediation works undertaken will be controlled and implemented in accordance with a BMP.
- If rock fracturing occurs leading to loss of surface water these areas will be prioritised for remediation, and extraction will be ceased in areas with similar fracture risks.

- If significant rock cracking occurs in vegetated areas and is confirmed to be a result of mining, then measures such as temporary fencing will be implemented. This will ensure that fauna (including humans) are not injured or trapped.
- Prior to any remediation works, advice will be sought from an ecologist regarding the potential impacts of such remediation works to plant and animal populations within the area.

A Biodiversity Offset Strategy would be developed if triggers, outlined in the Conditions of Approval and detailed in the Biodiversity Management Plan, are exceeded.

4.2 Aquatic Ecology

The potential impacts of longwall mining on the aquatic ecology of the Study Area have largely been mitigated through the design of the proposed longwall layout and will be further managed through an adaptive mine plan, ongoing monitoring of subsidence, water quality, aquatic habitat, macro invertebrates and fish.

A monitoring plan consistent with the monitoring plan outlined in the BMP for Longwalls 4 and 5 (Biosis 2012a) will be adopted and expanded for the Preferred Project. Monitoring of water quality, aquatic habitat, macro invertebrates and fish during the same seasons as used for the baseline study will continue. There will be additional surveys of aquatic habitats and biota if fractures of the stream bed and associated loss of water from pools occur, fish or yabby kills are noted during routine surface monitoring or if significant changes in pH, dissolved oxygen, turbidity or metal concentrations are detected during routine surface monitoring.

If significant effects on aquatic habitats and/or biota are detected during subsidence monitoring it may be necessary to reduce further impacts and environmental consequences by adopting one of the following strategies:

- Modifying mine layout to further reduce potential subsidence impacts.
- Increasing the setback of the longwall being extracted and future longwalls from the affected watercourse.

A Biodiversity Offset Strategy would be developed if triggers, outlined in the Conditions of Approval and detailed in the Biodiversity Management Plan, are exceeded.

4.3 Upland Swamps

The BMP will include an upland swamp monitoring plan to determine, as far as possible, the historic impacts on swamps and establish a comprehensive monitoring regime for water, ecology and geotechnical elements of swamp communities. Key elements of the monitoring plan will include:

- 3D subsidence surveys to gather detailed data on subsidence levels.
- Shallow piezometers to monitor changes in water levels and quality in upland swamps.
- A network of weirs to monitor base flow from upland swamps and inflows into Cataract Creek.
- Monitoring to get detailed data on climatic conditions.
- Detailed vegetation monitoring, as outlined above.

The aim of the upland swamp monitoring plan will be to determine whether subsidence associated with longwall mining results in impacts to the ecological functioning of upland swamps. The plan will be developed in consultation with relevant stakeholders.

The existing shallow piezometers installed within the upland swamps in the Study Area will be monitored to gauge any changes in standing water levels and swamp groundwater quality over the active mining area and all key water quality parameters on a regular basis for the duration and an appropriate time following mining.

A monitoring program will be designed and implemented to:

- Assess the swamp hydrology;
- Provide advance warning of potential breaches of subsidence predictions;
- Detection of adverse impacts on a swamp and underlying strata hydrology; and
- Characterise the relationship between swamp/s and their role in recharging the regional groundwater systems.

Water levels will be measured from a network of shallow piezometers in potentially impacted swamps and reference sites, before and after mining. Evaporation and rainfall data will also be collected. Should the standing water level or groundwater quality be unacceptably affected due to subsidence, WCL will investigate methods in liaison with the OEH and SCA and ameliorate as required.

At least one appropriately purged and collected, stored and transported groundwater sample will be collected from each swamp piezometer pre and post undermining to enable ongoing assessment of any subsidence related changes in groundwater quality.

Any visual observation of surface impacts such as cracking of rock outcrops, erosion, slumping or changes in flow patters within the swamp that are detected during regular monitoring will be reported and a plan to remediate or repair the impact will be determined in liaison with OEH and SCA.

Adaptive management measures will be utilised in the context of ongoing mining in the Wonga East area. Adaptive management based on groundwater levels is not rapid enough to prevent potential impacts to swamps as groundwater is a trailing indicator. If a swamp is impacted Wollongong Coal will review the mine plan in liaison with relevant stakeholders to determine options to prevent recurrence of impacts to future swamps affected by subsidence.

A Biodiversity Offset Strategy would be developed if triggers, outlined in the Conditions of Approval and detailed in the Biodiversity Management Plan, are exceeded.

5. Response to Submissions

This section provides a response to submissions received on the Underground Expansion Project (UEP) Preferred Project Report (PPR).

A total of six submissions related to biodiversity were received from:

- Department of Primary Industries (Fisheries NSW)
- Office of Environment and Heritage (OEH)
- Sydney Catchment Authority (SCA)
- Wollongong City Council (WCC)
- Bruce Hebblewhite (on behalf of the Department of Planning and Infrastructure (DP&I))
- Evans & Peck (on behalf of DP&I)

The submissions indicate that a number of issues raised in the initial response to submissions on the Environmental Assessment (EA) have been addressed, including:

- Underestimation of subsidence impacts and consequent level of impact to upland swamps.
- Monitoring of upland swamps.
- Impacts to upland swamps of special significance CCUS1, CCUS5, CCUS10, CRUS2, CRUS3 and BCUS.
- Undermining of Cataract Creek and consequent impacts to threatened species.
- Impact to threatened fish species, including survey techniques and effort.
- Potential impacts to threatened frog species.

Table 22 provides a summary of submissions received in relation to the PPR along with who raised them, and provides responses to these submissions.

Table 22: Summary of submissions and responses to these submissions

Submission	Response
Upland Swamps	
Mining under swamps of special significance (WCC, DP&I, Evans & Peck, OEH, SCA)	The PPR proposes to mine beneath upland swamps of 'special significance' CCUS4 (wholly) and CCUS5, CCUS10 and CRUS1 (partially). Of these, CCUS5, CCUS10 and CRUS1 are considered to be at negligible risk of impact. CCUS4 is considered to be at a high risk of impact. Evans & Peck in its analysis of risk of impact to upland swamps has concluded that the risk of impact to all upland swamps is low to minor, and has downgraded the risk of impact for BCUS4 and CCUS4 to Minor while upgrading the risk of impact to CCUS21 from Low to Minor.

Submission	Response
	It has been noted that monitoring by BHP Billiton Illawarra Coal (BHPBIC) and OEH has demonstrated that mining has resulted in fracturing of bedrock beneath upland swamps and consequent loss of the perched aquifer, loss of water flow at the base of the swamp and loss of soil moisture. Such impacts have been posited to *'alter the ecological function of the upland swamp and a high likelihood of eventual loss of vegetation communities and habitat that characterize upland swamps'* (OEH submission on the PPR). Section 3.3.3 provides an assessment of the historic impacts to upland swamps in the Wonga East area from mining of the Bulli and Balgownie seams. The data from this assessment indicates that at least some of the upland swamps in the Wonga East area have experienced levels of subsidence considered likely to have resulted in fracturing of bedrock and a risk of negative environmental outcome. A previous report by Biosis (2013) concluded that data from piezometers located in some of these upland swamps show regression of groundwater consistent with a 'fractured' swamp (e.g. CCUS3, CCUS6 and CRUS1), whilst others do not (e.g. CCUS2, CCUS4 and CCUS5). A subsequent review undertaken by Evans & Peck, on behalf of DP&I, concluded that the water retention characteristics of upland swamps had not been affected by past mining and that the majority of upland swamps in this area have maintained a perched groundwater system and do not show any evidence of cracking (see below for further information). It is the professional opinion of Biosis that there is currently insufficient data available to draw the conclusion that fracturing of bedrock beneath an upland swamp leads to a high likelihood of eventual loss of the vegetation communities and habitat that characterise upland swamps. The paucity of suitable monitoring data from past mining illustrates the difficulty in determining the nature and extent of past impacts. Previous conditions of approval for longwall mining projects

Submission	Response
	in the Southern Coalfield have set a performance measure of *"negligible impacts"* to upland swamps of special significance. Biosis (2013) concludes that CCUS4 is the only upland swamp of 'special significance' at risk of a more than negligible impact. A detailed upland swamp network monitoring program is currently being developed. This monitoring program will assist WCL in determining whether impacts are negligible, as well as providing information on primary and secondary effects of longwall mining on upland swamps. The Biodiversity Management Plan, currently being developed, will outline how Wollongong Coal proposes to achieve these aims and what corrective actions will be undertaken should greater than negligible impacts to CCUS4 occur.
Subsidence predictions exceed those that are predicted to result in fracturing of bedrock beneath upland swamps **(DP&I, Evans & Peck, OEH, SCA)**	The subsidence criteria adopted in the Bulli Seam Operations Planning and Assessment Commission (PAC) report (DoP 2010) and by OEH in their Draft Upland Swamp Environmental Impact Assessment Guidelines (2012) are a '*threshold for investigation – not a conclusion that the swamp will be impacted or suffer consequences*' (DoP 2010, p. 120). The PPR report for Biodiversity (Biosis 2013) sets out how this further investigation has been undertaken, and provides a comprehensive assessment of upland swamps. Based on the historical analysis of upland swamps it is clear that fracturing of bedrock beneath upland swamps does not necessarily result in the loss of the swamp. This is supported by the review undertaken by Evans & Peck, which concluded that the water retention characteristics of upland swamps had not been affected by past mining, except, potentially, for CCUS3 and CCUS6. Evans & Peck conclude that the majority of upland swamps in this area have maintained a perched groundwater system and do not show any evidence of cracking, despite past mining (with the possible exception of CCUS3 and CCUS6). With regard to CCUS3 and CCUS6, Geoterra, in their response to submissions on the PPR, notes that other factors, such as higher soil porosity, lower humic content, location of the piezometer in the

Submission	Response
	swamp, lower catchment area, discontinuous swamp soil extent and a greater proportion of outcropping / subcropping sandstone lead to more rapid water level lowering in these two swamps. The scale of impacts from past mining is currently unknown due to a paucity of monitoring data from past mining activities. However, large scale loss of upland swamps in the study area has not resulted from past mining, and some upland swamps, such as CCUS4, show healthy vegetation communities and significant baseflow. The proposed upland swamp network monitoring program currently being developed will provide additional information on the scale of primary and secondary impacts. Any impacts above those outlined in the Conditions of Approval will be offset under the biodiversity offset strategy to be developed.
Loss of base flow from upland swamps and consequent impacts to Cataract Creek and Cataract River **(OEH, DP&I, Evans & Peck, SCA)**	See Geoterra and GES (2014). Predictions arising from this report are included in Sections 3.1.4, 3.2.3 and 3.3.4. It is worth noting that Evans & Peck concluded that only one out of six upland swamps with piezometer data "*exhibits behaviour consistent with the hypothesized significant contribution to baseflow from upland swamps in general*". Evans & Peck conclude that upland swamps CCUS3 and CCUS6 would not be classified as upland swamps from a hydrological perspective. Biosis and Geoterra agree with this assessment due to the absence of a significant perched groundwater table and significant contribution to baseflow. However, as these two upland swamps meet the floristic characteristics of the Coastal Upland Swamps EEC they have been included in this assessment. There is currently minimal robust data on impacts to baseflow resulting from fracturing of bedrock beneath upland swamps. To date, the only study the authors are aware of looking at this issue is being undertaken by OEH, with baseflow measured at the exit point of an upland swamp in the Dendrobium

Submission	Response
	area. WCL is proposing an upland swamp network monitoring program that will assess changes in baseflow from upland swamps as well as a holistic view of catchment process to look at inflows from upland swamps into Cataract Creek.
Lack of analysis of subsidence effects from past mining on upland swamps, particularly CCUS4. (OEH, DP&I, Evans & Peck)	Section 3.3.3 provides a summary of historic impacts to upland swamps from previous mining activity. Mining of the Balgownie seam has resulted in compressive and tensile strains and tilts that exceed criteria used to determine risk of negative environmental consequences to upland swamps (DoP 2010, OEH 2012). CCUS4 contains patches of MU43 Tea-tree Thicket and MU44c Cyperoid Heath, both of which are reliant on permanent and semi-permanent water logging. Further, piezometer data from CCUS4 shows significant groundwater contact for prolonged periods following rainfall. This data appears to illustrate that CCUS4 has undergone negligible levels of impact from past mining activities. However, other swamps that have previously been mined beneath in this area show rapid regression of groundwater levels following rainfall, which may indicate fracturing of bedrock beneath these swamps (see previous comments on other factors that may influence piezometer regression rates). Despite this, the vegetation in these areas is consistent with upland swamps, albeit often drier representation of swamp communities. In the absence of historic monitoring data it is difficult to make any conclusions on what impacts if any, have occurred.
Over reliance on flow accumulation in risk assessment for upland swamps. (OEH)	Comments from OEH on over reliance on flow accumulation to assess risk to upland swamps is noted. However, the assessment of historic impacts to upland swamps in Wonga East from past mining see Section 3.3.3 of Biosis 2013) indicates that the fracturing of bedrock beneath swamps alone does not result in catastrophic loss of upland swamps. We are of the view that the upland swamp impact assessment includes additional geomorphic,

Submission	Response
	hydrologic and pedological criteria that facilitate a more robust assessment of potential impacts. However, we would welcome the opportunity to work with OEH to refine these criteria if they feel the assessments are still weighted towards flow accumulation impacts.
Threatened Species	
Potential impacts to threatened frogs. (WCC, OEH)	Impacts to threatened frogs are discussed in Section 3.1.4. Biosis has now completed two years of targeted surveys for the Giant Burrowing Frog, Littlejohn's Tree Frog and Stuttering Frog as a part of the ecological monitoring program for Wonga East. These species have not been recorded within the subsidence impact zone during these targeted surveys. These species are now considered unlikely to be present within the Wonga East area and are therefore unlikely to be impacted by the proposed extraction of coal in this area. Upland swamps do not provide suitable habitat for the Stuttering Frog.
Impacts to Cataract Creek, including loss of inflow and increase in iron seepage. Cataract Creek provides habitat Macquarie Perch and Trout Cod, particularly spawning habitat and refugia for juveniles . (OEH)	See Geoterra and GES (2014). Predictions arising from this report are included in Sections 3.1.4, 3.2.3 and 3.3.4. The groundwater model indicates that the average daily stream flow from Cataract Creek to Cataract Reservoir is 11.2 ML/d, of which 3.5 ML/d is baseflow. The model predicts a 0.013 ML/d (0.12%) loss of stream baseflow following mining. This level of change is unlikely to be detectable and unlikely to result in observable changes to flow regimes in Cataract Creek. There are currently significant levels of iron flocculent in Cataract Creek due to the hematitic / sideritic nature of the Bald Hill Claystone and potentially past mining of the Bulli and Balgownie seams. It is anticipated that there will be no discernible change in iron levels in Cataract Creek. Additional surveys have been undertaken for threatened fish species (Biosis 2013c). Fisheries NSW in their submission on the PPR stated that the

Submission	Response
	issues they previously raised have been addressed.
Impacts to habitat for the Giant Dragonfly. (OEH)	Additional surveys for the Giant Dragonfly have been undertaken and are discussed in Section 3.1.4 and below. The PPR incorrectly stated that areas of Tea-tree Thicket, particularly in upland swamp CRUS1, provide likely habitat for this species. Preferred habitat identified by OEH (2013c) includes open vegetation with free-standing water. In the PPR report for biodiversity (Biosis 2013c), CCUS4 was identified as suitable habitat for this species. Potential breeding habitat for the Giant Dragonfly can be identified based on the hydrogeomorphology, rainfall range and soils (Baird 2012). Breeding habitat is presumed to be associated with groundwater dependent habitat with some associated development of organic-rich or peaty soils. Swamp types with a negative water balance and prolonged periods of surface drying, or characterised by permanent or prolonged seasonal inundation, are not considered to provide potential breeding habitat for this species. Based on this information, Biosis has undertaken a review of potential habitat within the Wonga East area and identified upland swamps CCUS1, CCUS4, CCUS5, CCUS10, CRUS1 and BCUS4 as potential habitat for this species based on presence of communities reliant on presence of groundwater and potential for organic-rich soils. Additional surveys of these areas were undertaken in December 2013 to February 2014. These additional surveys focused on identifying significant breeding habitat through surveys for exuviae of the Giant Dragonfly, as it is breeding habitat for this species that is likely to be susceptible to impacts from subsidence and consequent changes in soil moisture. Exuviae were located in upland swamps CCUS4, CRUS1 and BCUS4. In all upland swamps exuviae were located in areas with deep, organic soils. In CCUS4 and BCUS4 this was at the downstream

Submission	Response
	extent of these swamps, where there was an accumulation of groundwater and open vegetation. In CRUS1 this was in pockets of groundwater dependent Tea-tree Thicket with an open overstorey, created by underlying geology. Of the locations where exuviae were observed only CCUS4 will be directly mined beneath. The potential for other locations listed above to support breeding habitat for this species cannot be discounted; however other locations will not be directly undermined.

6. Conclusions

Changes to the project, as outlined in Section 2 have resulted in a significant reduction in predicted impacts to terrestrial and aquatic biodiversity and upland swamps. A summary of the reduced impact predictions is provided below:

- Removal of Wonga West from the program has resulted in reduced impacts to cliffs, providing habitat for threatened bats, rocky outcrops, providing habitat for threatened flora species and the Broad-headed Snake, and habitat for threatened frogs. The risk assessment for each of these groups of species now indicates a low risk of potential impact.
- The revision of the mine plan to avoid undermining of Cataract Creek has resulted in a reduced risk of impact to Macquarie Perch, Murray Cod and Silver Perch, as well as habitat for the threatened Adam's Emerald Dragonfly.
- The revision of the mine plan has resulted in a reduction in risk for several upland swamps, including CRUS2, CRUS3 and CCUS5, and will result in low risk of impact for all upland swamps except BCUS4 and CCUS4.

Impacts to the biodiversity values in the Wonga East area overall is considered to be low. Whilst there remains a high risk of localised impact to habitat for the Giant Dragonfly in upland swamp CCUS4, as well as a moderate to high risk of impact to two upland swamps (BCUS4 and CCUS4) including one upland swamps of 'special significance' (CCUS4), these impacts are not considered likely to result in a significant effect on these threatened species or communities such that the long term viability of a local population of any threatened species or community will be reduced.

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Appendix H

UNDERGROUND EXPANSION PROJECT: RESPONSE TO SUBMISSIONS ON THE PREFERRED PROJECT REPORT – HERITAGE

27 March 2014

David Clarkson
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FAIRY MEADOW NSW 2519

Dear David

Underground Expansion Project: Response to Submissions on the Preferred Project Report - Heritage

Our Ref: Matter 16646

The purpose of this letter is to provide a response to submissions received on the Preferred Project Report (PPR) for Wollongong Coal Ltd's (WCL) Underground Expansion Project (UEP).

A total of two submissions related to heritage were received from:

- Wollongong City Council (WCC); and,
- Heritage Council of NSW.

WCC identified that previous Aboriginal heritage issues had been addressed and did not raise any new heritage issues.

The Heritage Council has queried a WCL statement, made in the PPR, in regards to commitments to heritage made in the Statement of Commitments (SoC). In the PPR, WCL has stated that the SoC contained in the EA has been "*eclipsed by activities for the Preliminary Works Project Part 3A approval (MP 10-0046)*" and provide a summary of activities undertaken according to the Conditions of Approval for the Preliminary Works Project against these SoC.

WCL is not concluding that the Statement of Commitments is unnecessary; rather that the activities associated with these SoC are either completed or on-going. Table 1 below provides an update on activities associated with the SoC, including whether they are complete or ongoing.

Table 1: Status of activities associated with the Statement of Commitments

Statement of Commitment	Status	Notes
A Conservation Management Plan will be prepared for the Project. The plan will reflect the future need of the site as a continuing mine and include procedures to follow for the discovery of unanticipated 'Relics'.	Completed	The final versions of the Heritage Management Plan (HMP; Biosis 2012b) and Conservation Management Plan (CMP; Biosis 2013a) were submitted to DP&I in October 2012 and February 2013 respectively. Procedures for the discovery of unanticipated 'Relics" have been detailed in the CMP and HMP.

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Statement of Commitment	Status	Notes
No items identified as having heritage value or contributing to the heritage value of the site will be demolished as part of this project.	Ongoing	The CMP (Biosis 2013a) and HMP (Biosis 2012b) identify those items within the Russell Vale Colliery that have heritage value or contribute to heritage value. Heritage items need to be managed in accordance with the CMP (Biosis 2013a) and HMP (Biosis 2012b) requirements. This will be an ongoing task managed by Wollongong Coal.
A photographic recording of the 1887 portal and the site will be undertaken and copies will be lodged with the appropriate local and state repositories.	Completed	An archival recording of the Russell Vale Colliery (Biosis 2013b) was undertaken between 2011 and 2013, including photographic recordings of the 1887 portal and other site features to Heritage Archival Recording standards. Copies of the Archival Recording were lodged with NSW State Library and Wollongong City Library in August 2013.
A photographic recording of the site should be undertaken to Heritage Archival Recording standards, prior to commencement of construction for the Project, to provide a lasting record for the site prior to the new development. Copies of the recording should be lodged with the appropriate local and state repositories.	Completed	See above
Items of moveable heritage, including historical photos, plans, maps, records and the like will be documented, collated and catalogued. Items of moveable heritage will be retained at their current location on site and documented including historical photos, plans, maps and records to Heritage Archival Recording Standards. A conservator will provide advice regarding the long term storage of items to maximise their survival. When the item has been appropriately catalogued it will be donated to a suitable repository. Appropriate repositories will be identified prior to project works commencing.	Ongoing	A catalogue of heritage items has been be prepared; including historical documents as well as physical heritage elements, and has been included in the archival recording (Biosis 2013b). Historical documents are currently retained in Wollongong Coal archives on-site. If required, the Wollongong Library Local Studies Section has indicated it is prepared to be a repository for historical documents; however it is intended to keep documents on-site as a first preference. Conservator advice for other items of moveable heritage has been provided to Wollongong Coal and conservation actions are ongoing.
No secondary extraction will occur beneath or within 1 km of the Cataract Dam Wall.	Completed	There is 1.5 km exclusion zone for secondary extraction around the dam wall.

As can be seen, the vast majority of activities arising from the SoC have been completed. Only those activities associated with the conservation and management of heritage items are ongoing.

The Heritage Council also identified that it was unclear if issues previously raised by the OEH Heritage Branch with the previous version of the HMP (Biosis 2012a) had been addressed. Comments on the HMP were received from OEH Heritage Branch on 4 September 2012 and were addressed in Section 3.1 of the revised HMP (Biosis 2012b). The revised HMP was re-submitted to DP&I in October 2012.

Yours sincerely

Nathan Garvey
Resource Group Manager

References

Biosis 2012a. *NRE No. 1 Colliery Heritage Management Plan. NREN EMSMP 008. Revision number 2.* Report prepared for Gujarat NRE Coking Coal Ltd.

Biosis 2012b. *NRE No. 1 Colliery Heritage Management Plan. NREN EMSMP 008. Revision number 4.* Report prepared for Gujarat NRE Coking Coal Ltd.

Biosis 2013a. *NRE No. 1 Colliery, Russell Vale: Conservation Management Plan.* Report prepared for Gujarat NRE Coking Coal Ltd.

Biosis 2013b. *NRE No. 1 Mine Preliminary Works Project: Archival Recording Report.* Report prepared for Gujarat NRE Coking Coal Ltd.