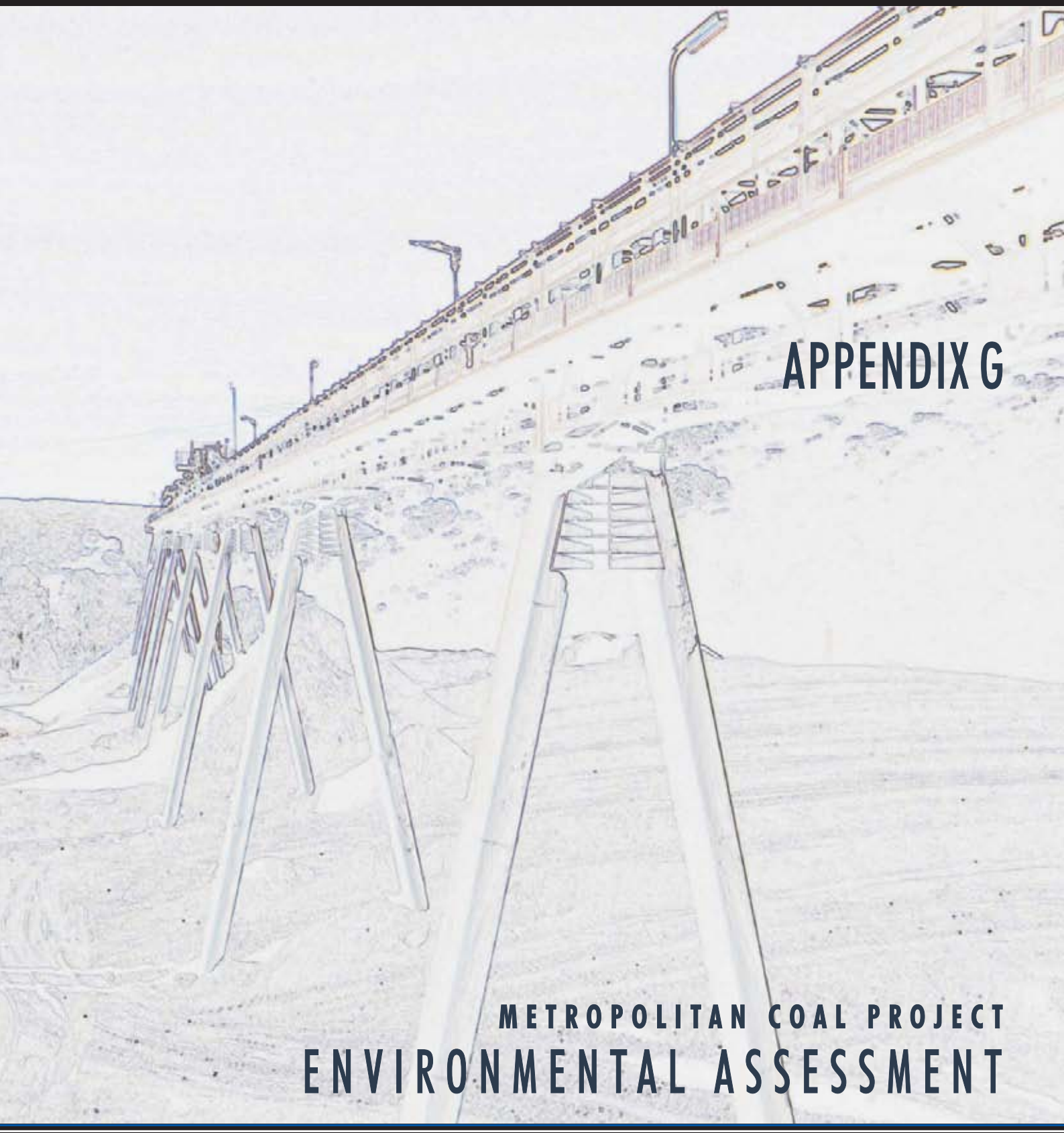

APPENDIX G

METROPOLITAN COAL PROJECT

ENVIRONMENTAL ASSESSMENT

METROPOLITAN COAL PROJECT

TERRESTRIAL FLORA AND FAUNA IMPACT ASSESSMENT

PREPARED BY

FLORASEARCH AND WESTERN RESEARCH INSTITUTE

JULY 2008

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1 INTRODUCTION

This Flora and Fauna Impact Assessment has been prepared for the Metropolitan Coal Project, which comprises the continuation, upgrade and extension of underground coal mining operations and surface facilities for the production of coal products at the existing Metropolitan Colliery. The Metropolitan Colliery is located approximately 30 kilometres (km) north of Wollongong in New South Wales (NSW) (Figure 1). The Colliery is owned and operated by Helensburgh Coal Pty Ltd (HCPL), a wholly owned subsidiary of Peabody Pacific Pty Limited (Peabody Pacific).

This Flora and Fauna Impact Assessment has been prepared for the Metropolitan Coal Project Environmental Assessment in accordance with Part 3A of the *Environmental Planning and Assessment Act, 1979* (EP&A Act) and Director-General's Environmental Assessment Requirements.

1.1 BACKGROUND

The Metropolitan Colliery is one of the earliest and longest running coal mining operations in Australia, with a history dating back to the 1880s. Completed and current underground mining areas are shown on Figure 2. Longwall mining at the Metropolitan Colliery commenced in 1995.

The underground mining operations are supported by the Metropolitan Colliery's surface facilities. The major surface facilities of the Metropolitan Colliery are situated off Parkes Street in Helensburgh (Figures 1 and 2). Coal extracted from the underground mining operations is transferred by conveyor to the Coal Handling and Preparation Plant (CHPP). Product coal is transported by train to the Port Kembla Coal Terminal and by truck to the Corrimal and Coalcliff Coke Works. CHPP coal reject material is transported by truck to the Glenlee Washery for emplacement.

1.2 PROJECT SUMMARY

The Metropolitan Coal Project would involve the continuation of underground mining operations at the Metropolitan Colliery. The main activities associated with the development of the Project are described in detail in Sections 1 and 2 of the Environmental Assessment main report. The Project would extend the underground mining area to the north of the completed and current underground mining areas (Figure 2). The Project would also include ongoing surface exploration activities, an increase in the rate of product coal and coal reject production, upgrade and extension of infrastructure, and environmental monitoring, management, rehabilitation and stream restoration activities.

2 REGIONAL SETTING

The Project is situated in the Central Coast Botanical Subdivision (Anderson, 1968; Harden, 2002), the Sydney Basin Interim Biogeographic Regionalisation for Australia bioregion (Thackway and Cresswell, 1995) and the Bassian zoogeographic region (Schodde, 1994).

A large portion of the Project is situated on the Woronora Plateau and within the Woronora Special Area. Much of the Woronora Plateau is dominated by underlying sandstone geologies, primarily derived from the Hawkesbury and Mittagong Formations (National Parks and Wildlife Service [NPWS], 2003a). The prevailing vegetation is a composite of dry sclerophyllous woodlands, forests and heaths. Quaternary Sand deposits are widespread across the catchments (NPWS, 2003a).

The Woronora Special Area is situated within the Woronora River catchment and drains to the Woronora Reservoir. A smaller portion of the Project (e.g. the north-eastern portion of the underground mining area and the Metropolitan Colliery's major surface facilities) are situated in the Hacking River catchment.

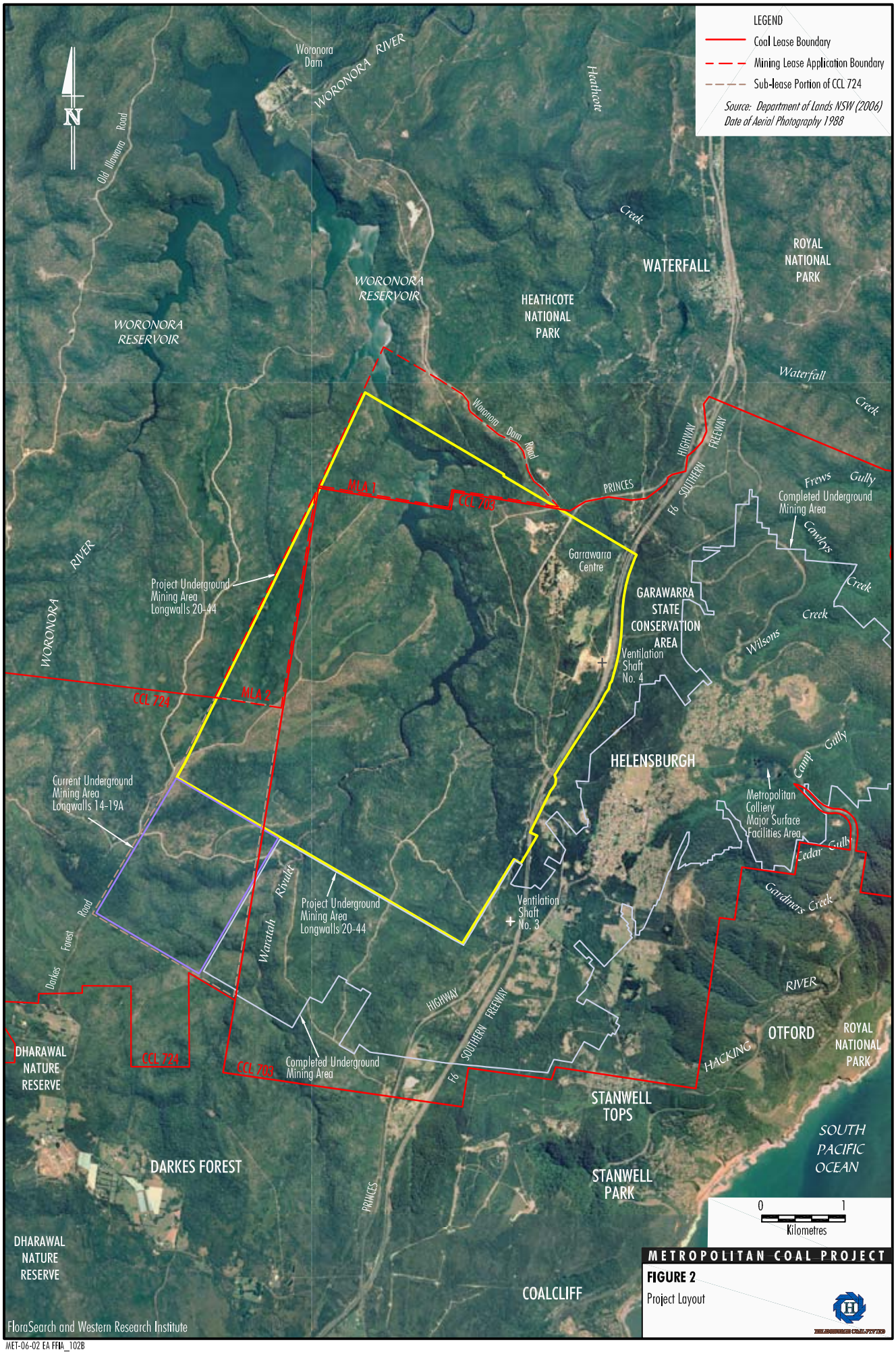
Source: Topographic Map Base - (Sydney Special, Wollongong Special) Geoscience Australia 2006, Reserve Boundaries - Department of Lands NSW 2003 and Sydney Catchment Authority Special Areas - Sydney Catchment Authority 2006

METROPOLITAN COAL PROJECT

FIGURE 1
Regional Location

HELENSBURGH COAL PTY LTD

MET-06-02 EA FFIA_001B



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A description of the study area (e.g. climate, geology and soils and fire history) is provided in Western Research Institute and Biosphere Environmental Consultants (2008) and Bangalay Botanical Surveys (2008).

3 BASELINE TERRESTRIAL FLORA AND FAUNA INFORMATION

3.1 BACKGROUND

Baseline flora surveys were conducted for the Project by Bangalay Botanical Surveys (2008) in spring 2006, summer 2006/2007, autumn 2007 and spring/summer 2007/2008. Previous surveys have also been conducted by Bangalay Botanical Surveys (2007) for the Longwalls 18-19A study area to the south in spring 2006, summer 2006 and autumn 2007. Field survey methods included random meanders, spot sampling, quadrat sampling, targeted searches for threatened flora (listed under the NSW *Threatened Species Conservation Act, 1995* [TSC Act] and Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* [EPBC Act]), targeted searches for flora of conservation significance and vegetation community mapping (including mapping of endangered ecological communities [EECs]). The baseline survey report by Bangalay Botanical Surveys (2008) is provided in Appendix E of the Metropolitan Coal Project Environmental Assessment.

Baseline terrestrial vertebrate fauna surveys were conducted for the Project in spring/early summer 2006 and autumn 2007 (Western Research Institute and Biosphere Environmental Consultants, 2008). Twenty fauna sampling sites were surveyed using a variety of methods including Elliott traps, cage traps, spotlighting, hair tubes, herpetofauna searches, bird surveys, call playback, platypus surveys, echolocation call detector systems, identification of faunal traces and opportunistic observations. Targeted surveys were conducted for threatened fauna species listed under the TSC Act and EPBC Act considered possible occurrences in the Project area and surrounds. Details of the survey methodologies utilised are provided in Western Research Institute and Biosphere Environmental Consultants (2008) in Appendix F of the Metropolitan Coal Project Environmental Assessment.

A number of reference sources containing the results of local or regional flora and fauna surveys, database records and other scientific studies and literature were also reviewed and where appropriate included in the baseline flora and fauna assessments (Bangalay Botanical Surveys, 2008; Western Research Institute and Biosphere Environmental Consultants, 2008).

An overview of the findings of the baseline flora and fauna surveys is provided in Sections 3.2 and 3.3, respectively.

Further to the conduct of the baseline flora and fauna surveys, an investigation of upland swamps and impacts of underground mining has been conducted by FloraSearch to inform the upland swamp assessment included in this Flora and Fauna Impact Assessment. The results of the investigation have been incorporated into Section 4.3 of this report.

3.2 FLORA

3.2.1 Vegetation Communities

Vegetation communities were mapped within the study area by Bangalay Botanical Surveys (2008) and include woodlands on sandstone or lateritic soils, heaths and mallee heaths, upland swamps, riparian scrub, tall open forests and sandstone forests. The vegetation map units are described in Table 1 and their distribution is mapped on Figure 3.

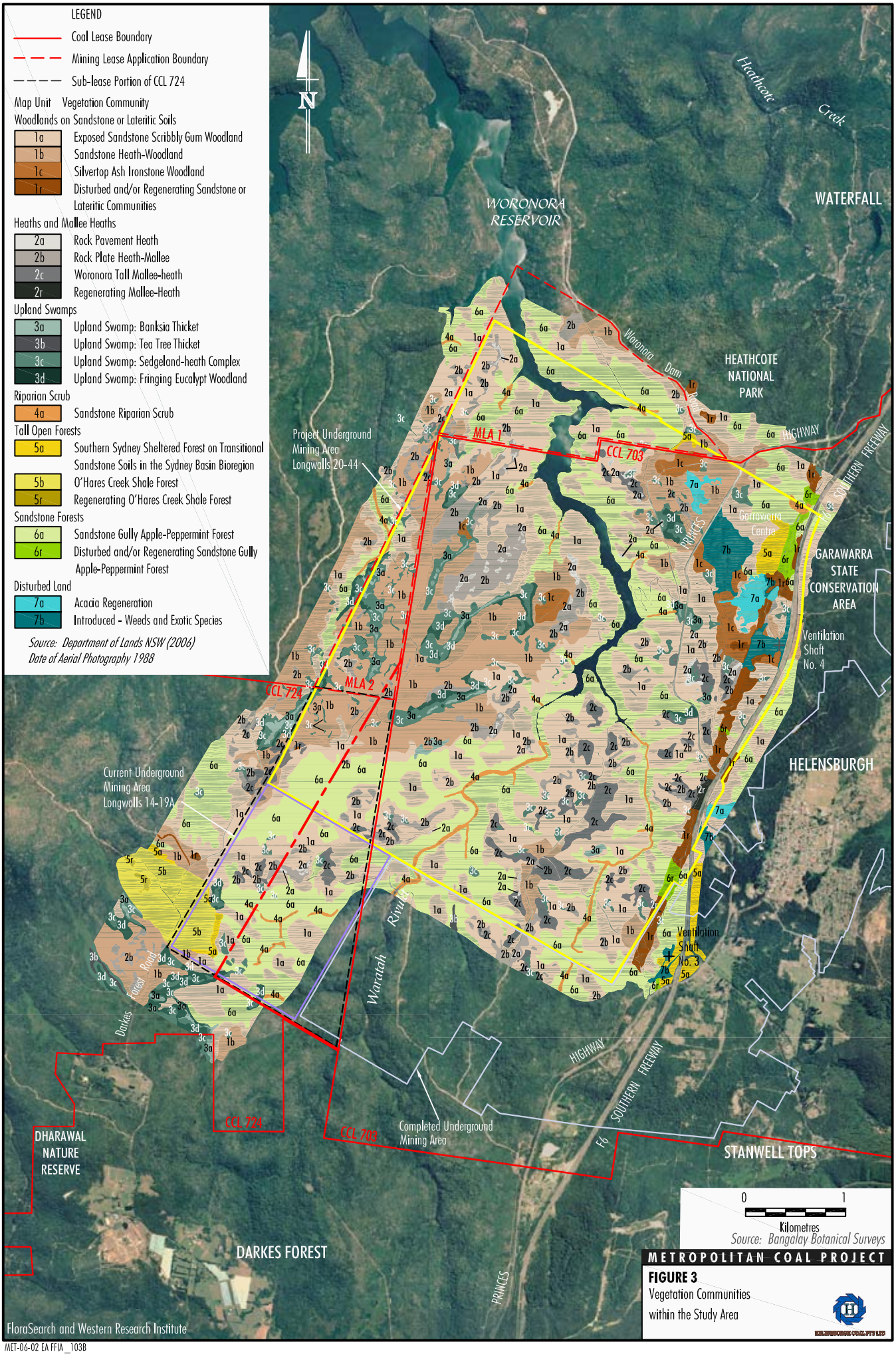
Table 1
Vegetation Communities Identified within the Study Area

Map Unit	Vegetation Community
Woodlands on Sandstone or Lateritic Soils	
1a	Exposed Sandstone Scribbly Gum Woodland
1b	Sandstone Heath-Woodland
1c	Silvertop Ash Ironstone Woodland
1r	Disturbed and/or Regenerating Sandstone or Lateritic Communities
Heaths and Mallee Heaths	
2a	Rock Pavement Heath
2b	Rock Plate Heath-Mallee
2c	Woronora Tall Mallee-heath
2r	Regenerating Mallee-heath
Upland Swamps	
3a	Upland Swamp: Banksia Thicket
3b	Upland Swamp: Tea Tree Thicket
3c	Upland Swamp: Sedgeland-heath Complex
3d	Upland Swamp: Fringing Eucalypt Woodland
Riparian Scrub	
4a	Sandstone Riparian Scrub
Tall Open Forests	
5a	Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion
5b	O'Hares Creek Shale Forest
5r	Regenerating O'Hares Creek Shale Forest
Sandstone Forests	
6a	Sandstone Gully Apple-Peppermint Forest
6r	Disturbed and/or Regenerating Sandstone Gully Apple-Peppermint Forest
Disturbed Land	
7a	*Acacia* Regeneration
7b	Introduced – Weeds and Exotics

Source: Bangalay Botanical Surveys (2008)

3.2.2 Flora Species Composition

The great majority of plant species occurring within the Woronora Special Area and the study area are native species (Bangalay Botanical Surveys, 2008). A total of 601 plant species were recorded during the baseline flora surveys, including 528 native and 73 introduced species (Bangalay Botanical Surveys, 2008). Plant families with the highest number of species were the Daisy family (Asteraceae), the Epacrids (Ericaceae subfamily Styphelioideae) the Pea Flowers (Fabaceae subfamily Faboideae), the Wattles (Fabaceae subfamily Mimosoideae), the Eucalypts and related genera (Myrtaceae), the Banksias, Grevilleas and related genera (Proteaceae), the Sedges (Cyperaceae) and the Grasses (Poaceae) (Bangalay Botanical Surveys, 2008).



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3.2.3 Introduced Flora Species and Noxious Weeds

Bangalay Botanical Surveys (2008) indicate that in general, introduced plant species were found to be limited to areas which have been subject to prior and/or current disturbance (i.e. Map Units marked "r" and track margins). Exotic species occurred infrequently along fire roads within the study area, and generally included widespread and common species in low densities. Bangalay Botanical Surveys (2008) also indicate that exotic species diversity and abundance increased within vegetation along major roads (the F6 Freeway and the Old Princes Highway) and larger areas of disturbed landscapes that occur in the north-eastern and eastern sections of the study area.

A number of weeds recorded in the baseline flora surveys are regarded as noxious in the Wollongong Local Government Area including Pampas Grass (*Cortaderia selloana*), African Love Grass (*Eragrostis curvula*), Lantana (*Lantana camara*), African Boxthorn (*Lycium ferocissimum*), Bridal Veil Creeper (*Myrsiphyllum asparagoides*), Prickly Pear (*Opuntia stricta*), Oxalis (*Oxalis* spp. [all spp. except natives]), Onion Grass (*Romulea rosea*) and Blackberry (*Rubus fruticosus* spp. aggregate) (Bangalay Botanical Surveys, 2008).

3.2.4 Threatened Flora

3.2.4.1 Threatened Flora Species

Three threatened flora species were recorded within the proposed underground mining area by Bangalay Botanical Surveys (2008), *viz*. Bynoe's Wattle (*Acacia bynoeana*), Thick-leaf Star-hair (*Astrotricha crassifolia*) and Prickly Bush-pea (*Pultenaea aristata*). Deane's Paperbark (*Melaleuca deanei*), Prickly Bush-pea (*P. aristata*) and Bynoe's Wattle (*A. bynoeana*) have also been recorded within the Longwalls 18-19A study area by Bangalay Botanical Surveys (2007). Possible occurrences of a further two threatened species, *viz*. *Leucopogon exolasius* and *Epacris purpurascens var. purpurascens* were recorded within the proposed underground mining area, although the identification of these species could not be confirmed due to the lack of fertile fruiting or flowering parts required for positive identifications (Bangalay Botanical Surveys, 2008). Threatened flora species recorded in the Project area or surrounds are summarised in Table 2 and shown on Figure 4.

Although potential habitat exists within the study area for a number of other threatened flora species, no other threatened flora species were detected within the study area or adjacent areas during the baseline surveys (Bangalay Botanical Surveys, 2008).

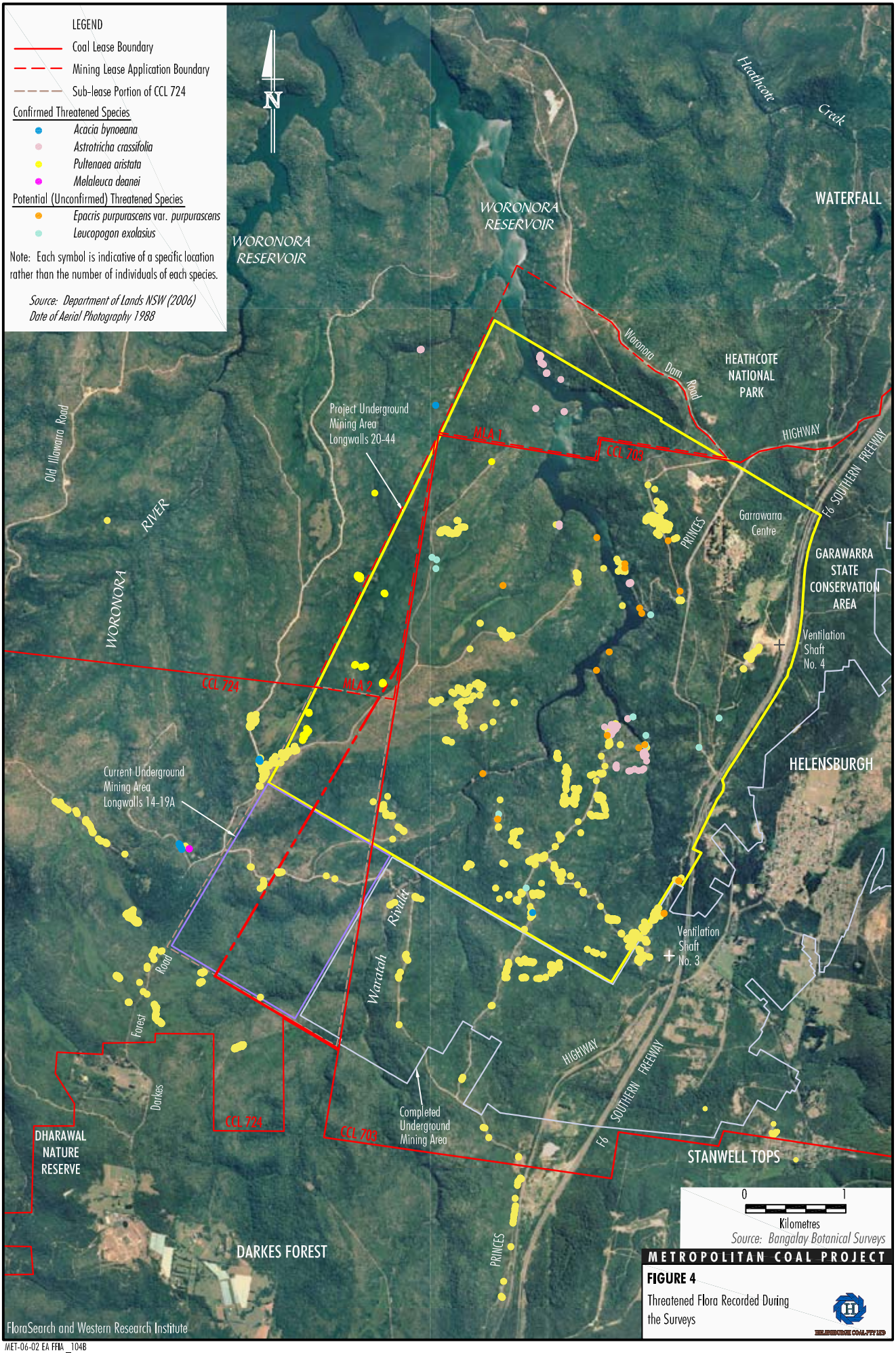
Table 2
Threatened Flora Species Recorded in the Project Area or Surrounds

Scientific Name	Common Name	Conservation Status[1]	
		TSC Act	EPBC Act
Confirmed			
Acacia bynoeana	Bynoe's Wattle	E	V
Astrotricha crassifolia	Thick-leaf Star-hair	V	V
Pultenaea aristata	Prickly Bush-pea	V	V
Melaleuca deanei	Deane's Paperbark	V	V
Unconfirmed			
Epacris purpurascens var. *purpurascens*	-	V	-
Leucopogon exolasius	Woronora Beard-heath	V	V

Source: Bangalay Botanical Surveys (2007; 2008)

[1] Threatened species status current as at 4 July 2008.

E - Endangered V – Vulnerable


LEGEND
Coal Lease Boundary
Mining Lease Application Boundary
Sub-lease Portion of CCL 724
Confirmed Threatened Species
Acacia bynoeana
Astrotricha crassifolia
Pultenaea aristata
Melaleuca deanei
Potential (Unconfirmed) Threatened Species
Epacris purpurascens var. purpurascens
Leucopogon exolasius
Note: Each symbol is indicative of a specific location rather than the number of individuals of each species.
Source: Department of Lands NSW (2006)
Date of Aerial Photography 1988
N
WORONORA RESERVOIR
WORONORA RESERVOIR
Heathcote Creek
WATERFALL
Woronora Dam Road
HEATHCOTE NATIONAL PARK
HIGHWAY
F6 SOUTHERN FREEWAY
Project Underground Mining Area Longwalls 20-44
MLA 1
CCL 703
Old Illawarra Road
RIVER
WORONORA
PRINCES
Garrawarra Centre
GARAWARRA STATE CONSERVATION AREA
Ventilation Shaft No. 4
CCL 724
MLA 2
HELENSBURGH
Current Underground Mining Area Longwalls 14-19A
Rivulet
Waratah
Road
Forest
Ventilation Shaft No. 3
HIGHWAY
SOUTHERN FREEWAY
F6
Darkes
CCL 724
CCL 703
Completed Underground Mining Area
DHARAWAL NATURE RESERVE
STANWELL TOPS
PRINCES
DARKES FOREST
0
1
Kilometres
Source: Bangalay Botanical Surveys
METROPOLITAN COAL PROJECT
FIGURE 4
Threatened Flora Recorded During the Surveys
FloraSearch and Western Research Institute
MET-06-02 EA FFIA _104B

3.2.4.2 Endangered Flora Populations

No endangered flora populations listed under the TSC Act are located in the Project area or are known to occur in the immediate surrounds (Bangalay Botanical Surveys, 2008; NPWS, 2003a).

3.2.4.3 Endangered Ecological Communities

One endangered ecological community (EEC) listed under the TSC Act was recorded in the Project baseline flora surveys, *viz*. Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC (Bangalay Botanical Surveys, 2008). In addition, the O'Hares Creek Shale Forest EEC occurs to the south of the proposed underground mining area in the vicinity of Longwalls 18-19A (*ibid*.).

No ecological communities listed under the EPBC Act have been recorded in the Project area or surrounds (Bangalay Botanical Surveys, 2008; NPWS, 2003a).

Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion

Southern Sydney sheltered forest on transitional sandstone soils is an open forest dominated by eucalypts with scattered subcanopy trees, a diverse shrub layer and well-developed groundcover of ferns, forbs, grasses and graminoids (NSW Scientific Committee, 2007). The dominant trees include *Angophora costata, Eucalyptus piperita* and occasionally *E. pilularis*, particularly around Helensburgh. Features that distinguish Southern Sydney sheltered forest on transitional sandstone soils from vegetation more typical of sandstone gullies in the eastern Sydney basin include the occurrence of *Eucalyptus pilularis, Acacia binervata, Elaeocarpus reticulatus, Pittosporum undulatum* and a relatively dense groundcover of ferns, grasses, rushes, lilies and forbs (*ibid*.). There is considerable variation in species composition, richness and structure within the community in response to local edaphic gradients and geographic gradients across the range (*ibid*.).

Southern Sydney sheltered forest on transitional sandstone soils is primarily associated with the heads and upper slopes of sandstone gullies, which are downslope from residual shale or ironstone caps. The associated shale caps may be weathered to varying degrees, and are sometimes represented only by outcropping ironstone on the adjacent ridges (indicating heavy weathering). In some cases, the transitional edaphic habitat may occur where sandstone overlies shale (e.g. Garrawarra Ridge). The community also occurs on sandstone sites associated with substrates other than shales and ironstones.

The occurrence of the southern Sydney sheltered forest on transitional sandstone soils within the study area was mapped by Bangalay Botanical Surveys (2008). The community occurs in the east of the study area in the vicinity of the F6 Southern Freeway and to the south of the proposed underground mining area, adjacent to the O'Hares Creek Shale Forest EEC (Figure 3).

O'Hares Creek Shale Forest

The O'Hares Creek Shale Forest EEC occurs on deep, well drained red loam on small outcrops of Hawkesbury shale in the Darkes Forest area on the Woronora Plateau within the Campbelltown, Wollondilly and Wollongong local government areas (NSW Scientific Committee, 1998a). The community occurs on flat ridgetops and adjacent slopes (NSW Scientific Committee, 1998a) and is dominated by Sydney Peppermint (*Eucalyptus piperita*), White Stringybark (*E. globoidea*) and Smooth-barked Apple (*Angophora costata*), with the latter species sometimes being the dominant canopy species (Department of Environment and Climate Change [DECC], 2008a). The shrub layer is variable in density and height but is characterised by *Acacia binervata*, *A. longifolia* ssp. *longifolia*, *Leucopogon lanceolatus* var. *lanceolatus*, and *Banksia spinulosa* var. *spinulosa* (*ibid*.).

The groundcover is often the distinguishing feature of the community with an impressive cushion of ferns, lilies, grasses and rushes that include species such as *Calochlaena dubia*, *Pteridium esculentum*, *Doryanthes excelsa*, *Dianella caerulea*, *Lomandra longifolia*, *Blechnum cartilagineum*, *Entolasia stricta*, and *Imperata cylindrica* var. *major* (*ibid*.).

The O'Hares Creek Shale Forest EEC occurs to the south in the vicinity of Longwalls 18-19A (Figure 3).

3.2.5 Rare or Threatened Australian Plants (ROTAP)

Ten species listed as rare in *Rare or Threatened Australian Plants* (RoTAP) (Briggs and Leigh, 1996) were recorded within the study area by Bangalay Botanical Surveys (2008), *viz*., *Hibbertia nitida, Lissanthe sapida, Darwinia diminuta, Monotoca ledifolia, Darwinia grandiflora, Eucalyptus apiculata, Eucalyptus luehmanniana, Grevillea longifolia, Boronia serrulata* and *Lomandra fluviatilis*.

3.3 FAUNA

3.3.1 Major Habitat Types

Five broad habitat types were identified in the study area by Western Research Institute and Biosphere Environmental Consultants (2008), namely, forest, woodland, heath and mallee, riparian (and associated watercourse) and upland swamp.

Forest habitat is generally confined to slopes of gullies, valley floors and upland areas where soil has accumulated and can support larger trees (Western Research Institute and Biosphere Environmental Consultants, 2008).

The woodland fauna habitat type varies from low to tall woodland and occurs mainly on elevated ridges and exposed parts of the plateau where there has been soil accumulation (usually associated with sandstone exposures or ledges) (*ibid*.).

Heath and mallee formations form a mosaic within this broad fauna habitat to a height of approximately 10 m. The heath areas generally form dense continuous canopies of a range of shrub and intermediate height trees. In mallee areas, clumps of Yellow-top Ash (*E. luehmanniana*) predominate along with less obvious mallees such as Mallee Ash (*E. stricta*) and Whipstick Mallee Ash (*E. multicaulis*) (Western Research Institute and Biosphere Environmental Consultants, 2008).

Riparian habitat occurs along streams which flow to the Woronora Reservoir and some of their tributaries (Western Research Institute and Biosphere Environmental Consultants, 2008). The Woronora Reservoir also provides habitat resources for terrestrial fauna. In the riparian zone, the immediate tree cover is often continuous and dense canopies form in the more sheltered areas. In upstream areas, the riparian vegetation gives way to upland swamp or gully forest vegetation (*ibid*.).

Upland swamps occur on ridge-tops where the drainage has been impeded by low floor slope, low permeability sandstone base and dense swamp vegetation. Tall sedges and rushes make up the majority of the vegetation. The swamp area is generally devoid of tall tree species but thickets of Banksia and Tea Tree occur together with a variety of shrubs and dry-swamp tolerant plants (Western Research Institute and Biosphere Environmental Consultants, 2008). Fringing eucalypt woodland (up to 15 m in height) is also present in some areas of upland swamp (*ibid*.).

The habitats in the study area are variable and of high quality although the majority of vegetation communities are in early to mid successional stage following the 2001 bushfire. Habitat connectivity within all habitat types is generally high (Western Research Institute and Biosphere Environmental Consultants, 2008).

Of the four priority fauna habitats mapped by the DECC (2007a), upland swamps are located in the Project area and surrounds. The Project area or surrounds do not contain Grassy Box Woodlands, Alluvial Forests and Woodland or Coastal Wetlands and Saltmarsh which are also considered to be priority fauna habitats in the Greater Southern Sydney Region (DECC, 2007a).

3.3.2 Fauna Species

Native Fauna Species

The number of native terrestrial fauna species identified during the surveys by Western Research Institute and Biosphere Environmental Consultants (2008) is provided per fauna type in Table 3. The species diversity recorded during the surveys is consistent with expected species diversity in a fire recovery mid-successional landscape, where populations are recovering gradually following the 2001 fire (*ibid*.).

Some 151 native terrestrial fauna species were identified in the wider Woronora Special Area by the DECC (2007a) including 22 amphibians, 30 reptile species, 72 bird species and 27 mammal species.

Table 3
Native Terrestrial Fauna Species

Fauna Type	Number of Native Species Identified
Amphibians	17
Reptiles	19
Birds	77
Mammals	27
Total	**140**

Source: Western Research Institute and Biosphere Environmental Consultants (2008)

Seven Myobatrachidae and 10 Hylidae amphibian species were recorded in the baseline fauna surveys. The Common Eastern Froglet (*Crinia signifera*) and Verreaux's Tree Frog (*Litoria verreaxii*) were the most widely distributed amphibian species across the study area during the surveys (Western Research Institute and Biosphere Environmental Consultants, 2008).

One Gekkonidae, eight Scincidae, three Agamidae, one Varanidae and six Elapidae reptile species were recorded during the baseline fauna surveys. Reptile species recorded at six or more of the systematic sampling sites included the Copper-tailed Skink (*Ctenotus taeniolatus*), Pale-flecked Garden Sunskink (*Lampropholis guichenoti*), Dark-flecked Garden Sunskink (*Lampropholis delicata*) and Lesueur's Velvet Gecko (*Oedura lesuerii*) (Western Research Institute and Biosphere Environmental Consultants, 2008).

One Ciconiidae, one Aedeidae, three Falconidae, three Accipitridae, one Charadriidae, four Columbidae, eight Psittacidae, three Cuculidae, one Tytonidae, one Strigidae, one Podargidae, one Caprimulgidae, one Aegothelidae, two Alcendinidae, one Menuridae, one Climacteridae, three Maluridae, two Pardalotidae, eight Acanthizidae, one Zosteropidae, twelve Meliphagidae, one Petroicidae, two Eupetidae, three Pachycephalidae, four Dicruridae, one Campephagidae, one Hirundinidae, four Artamidae, one Corvidae and one Sylviidae were recorded during the baseline fauna surveys (Western Research Institute and Biosphere Environmental Consultants, 2008).

Birds most widely distributed across the study area during the surveys included the Rainbow Lorikeet (*Trichoglossus haematodus*), White-throated Treecreeper (*Cormobates leucophaea*), Brown Thornbill (*Acanthiza pusilla*), Yellow-faced Honeyeater (*Lichenostomus chrysops*), White-eared Honeyeater (*Lichenostomus leucotis*), Little Wattlebird (*Anthochaera chrysoptera*), Red Wattlebird (*Anthochaera carunculata*), New Holland Honeyeater (*Phylidonyris novaehollandiae*), Eastern Spinebill (*Acanthorhynchus tenuirostris*), Grey Shrike-thrush (*Collurcincla harmonica*), Eastern Yellow Robin (*Eopsaltria australis*) and Rufous Whistler (*Pachycephala rufiventris*).

Native mammal species recorded during the baseline fauna surveys included one Ornithorhynchidae (Platypus), one Tachyglossidae (Short-beaked Echidna), three Dasyuridae (*Antechinus* spp. and the Common Dunnart), one Vombatidae (Common Wombat), one Burramyidae (Eastern Pygmy-possum), one Phalangeridae (Common Brushtail Possum), two Petauridae (Sugar Glider and Squirrel Glider), one Pseudocheiridae (Common Ringtail Possum), three Macropodidae (Eastern Grey Kangaroo, Euro and Swamp Wallaby), one Pteropidae (Grey-headed Flying Fox), seven Vespertiliomidae (microchiropteran bats) and four Muridae (*Rattus* spp. and the Eastern Water Rat) (Western Research Institute and Biosphere Environmental Consultants, 2008). In addition, diggings were recorded during the surveys that could potentially belong to the Peramelidae (Long-nosed Bandicoot or Southern Brown Bandicoot) or Potoroidae (Long-nosed Potoroo) (*ibid*.).

Introduced Fauna Species

Five introduced species were recorded during the baseline fauna surveys, including the House Mouse (*Mus musculus*), Dog (*Canis lupis familiaris*), Red Fox (*Vulpes vulpes*), Rusa Deer (*Cervus timorensis*) and Rabbit (*Oryctolagus cuniculus*) (Western Research Institute and Biosphere Environmental Consultants, 2008).

3.3.3 Threatened Fauna Species

Threatened fauna species recorded in the Project area or surrounds by Western Research Institute and Biosphere Environmental Consultants (2008) are listed in Table 4. Thirteen threatened species were recorded during the surveys. In addition, diggings were recorded that could potentially belong to the threatened Southern Brown Bandicoot or Long-nosed Potoroo, or the protected Long-nosed Bandicoot. Figure 5 illustrates the location of threatened species recorded during the Project surveys.

Although potential habitat exists within the study area for a number of other threatened fauna species, no other threatened fauna species were recorded within the study area during the surveys (Western Research Institute and Biosphere Environmental Consultants, 2008).

Table 4
Threatened Terrestrial Fauna Species Recorded in the Project Area or Surrounds

Common Name	Scientific Name	Conservation Status[1]	
		TSC Act	EPBC Act
Amphibians			
Giant Burrowing Frog	*Heleioporus australiacus*	V	V
Red-crowned Toadlet	*Pseudophryne australis*	V	-
Reptiles			
Broad-headed Snake	*Hoplocephalus bungaroides*	E	V
Birds			
Black-necked Stork	*Ephippiorhynchus asiaticus*	E	-
Square-tailed Kite	*Lophoictinia isura*	V	-
Grey Falcon	*Falco hypoleucos*	V	-
Eastern Ground Parrot	*Pezoporus wallicus wallicus*	V	-
Turquoise Parrot	*Neophema pulchella*	V	-
Mammals			
Eastern Pygmy-possum	*Cercartetus nanus*	V	-
Squirrel Glider	*Petaurus norfolcensis*	V	-
Grey-headed Flying Fox	*Pteropus poliocephalus*	V	V
Eastern Bentwing Bat	*Miniopterus schreibersii oceanensis*	V	-
Large-footed Myotis	*Myotis macropus*	V	-
Potential diggings of the:			
Southern Brown Bandicoot;	*Isoodon obesulus*	E	E
Long-nosed Bandicoot; or	*Perameles nasuta*	-	-
Long-nosed Potoroo	*Potorous tridactylus*	V	V

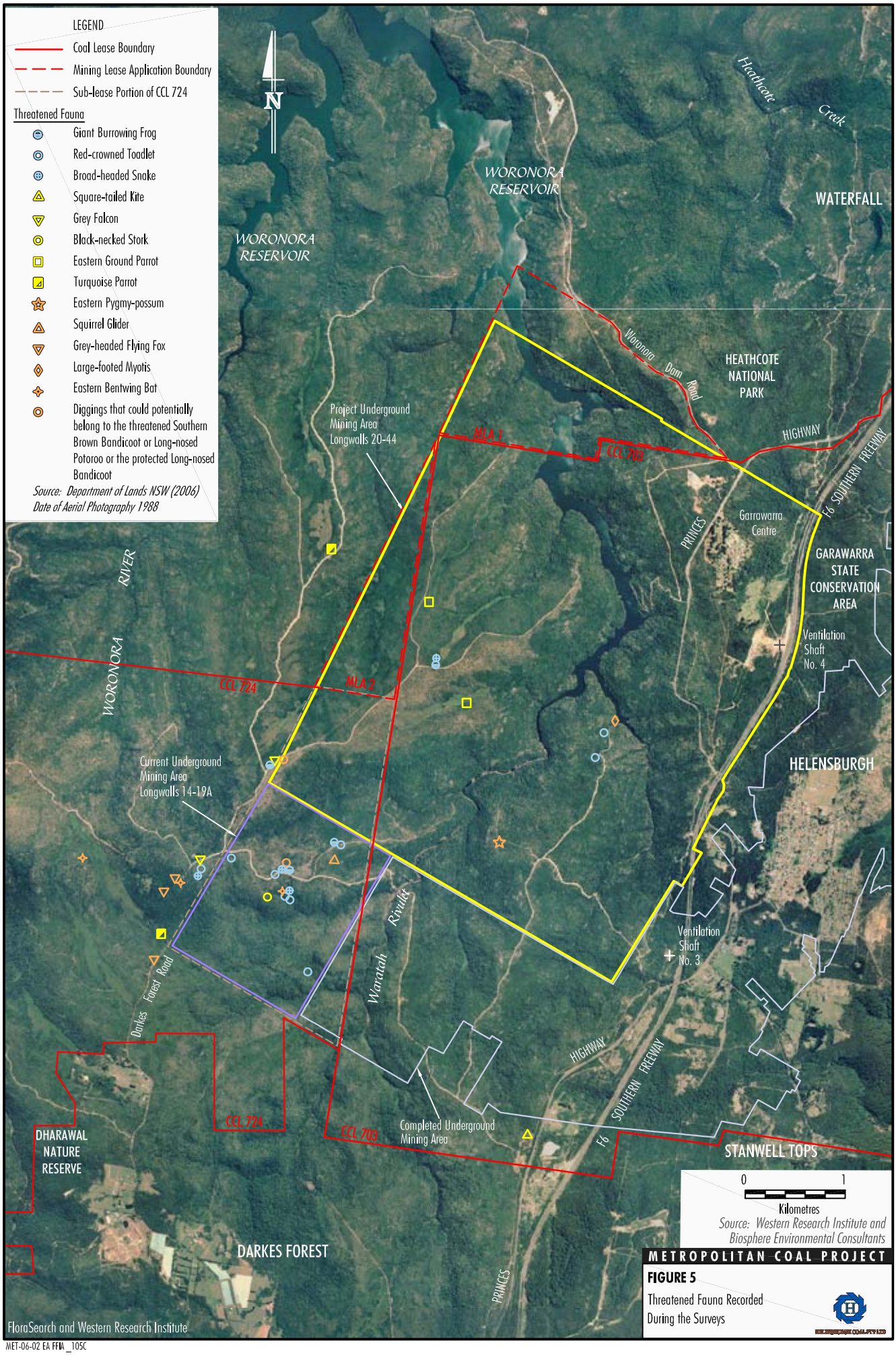
Source: Western Research Institute and Biosphere Environmental Consultants (2008)
[1] Threatened species status current as at 4 July 2008.
E - Endangered V – Vulnerable

3.3.4 Migratory Species

Western Research Institute and Biosphere Environmental Consultants (2008) provide a list of migratory species listed under the EPBC Act that have been recorded in the vicinity of the Project or in the wider surrounds by various sources including the Project surveys (Western Research Institute and Biosphere Environmental Consultants, 2008), Atlas of NSW Wildlife (DECC, 2007b), Australian Museum (2007), Birds Australia (2007) and fauna species recorded in the Woronora Special Area (DECC, 2007a).

One migratory bird species was recorded in the Woronora Special Area by DECC (2007a) and by the Project surveys (Western Research Institute and Biosphere Environmental Consultants, 2008), namely, the Rufous Fantail.

Some 63 migratory bird species have been recorded in the wider surrounds (DECC, 2007b; Australian Museum, 2007 and Birds Australia, 2007; in Western Research Institute and Biosphere Environmental Consultants, 2008).


LEGEND
Coal Lease Boundary
Mining Lease Application Boundary
Sub-lease Portion of CCL 724
Threatened Fauna
Giant Burrowing Frog
Red-crowned Toadlet
Broad-headed Snake
Square-tailed Kite
Grey Falcon
Black-necked Stork
Eastern Ground Parrot
Turquoise Parrot
Eastern Pygmy-possum
Squirrel Glider
Grey-headed Flying Fox
Large-footed Myotis
Eastern Bentwing Bat
Diggings that could potentially belong to the threatened Southern Brown Bandicoot or Long-nosed Potoroo or the protected Long-nosed Bandicoot
Source: Department of Lands NSW (2006)
Date of Aerial Photography 1988
N
Heathcote Creek
WORONORA RESERVOIR
WORONORA RESERVOIR
WATERFALL
Woronora Dam Road
HEATHCOTE NATIONAL PARK
HIGHWAY
Fb SOUTHERN FREEWAY
Project Underground Mining Area Longwalls 20-44
ML A 1
CCL 703
PRINCES
Garrawarra Centre
GARAWARRA STATE CONSERVATION AREA
Ventilation Shaft No. 4
WORONORA RIVER
CCL 724
ML A 2
Current Underground Mining Area Longwalls 14-19A
HELENSBURGH
Waratah Rivulet
Ventilation Shaft No. 3
Darkes Forest Road
HIGHWAY
SOUTHERN FREEWAY
Fb
CCL 724
CCL 703
Completed Underground Mining Area
DHARAWAL NATURE RESERVE
STANWELL TOPS
DARKES FOREST
PRINCES
0
1
Kilometres
Source: Western Research Institute and Biosphere Environmental Consultants
FloraSearch and Western Research Institute
METROPOLITAN COAL PROJECT
FIGURE 5
Threatened Fauna Recorded During the Surveys
MET-06-02 EA FFIA _105C

A large number of the migratory bird species recorded in the wider surrounds are associated with coastal habitats and would not normally be expected to utilise the Project area. This includes species from the Families:

- Diomedeidae (Albatrosses);
- Procellariidae and Hydrobatidae (Petrels, Shearwaters and Storm-Petrels);
- Phaethontidae, Fregatidae and Sulidae (White-tailed Tropicbird, Lesser Frigatebird and Brown Booby);
- Laridae (Terns); and
- Stercorariidae (Skuas).

A number of other migratory bird species could potentially occur in the Project area or surrounds. These species are assessed in Section 7.6.

3.3.5 Marine Protected Species

Western Research Institute and Biosphere Environmental Consultants (2008) provide a list of marine protected species listed under the EPBC Act that have been recorded in the vicinity of the Project or in the wider surrounds by various sources including the Project surveys (Western Research Institute and Biosphere Environmental Consultants, 2008), Atlas of NSW Wildlife (DECC, 2007b), Australian Museum (2007), Birds Australia (2007) and fauna species recorded in the Woronora Special Area (DECC, 2007a).

Thirteen marine protected bird species were recorded during the Project surveys, *viz*. the Nankeen Night Heron, Australian Kestrel, Brown Goshawk, Pallid Cuckoo, Fan-tailed Cuckoo, Channel-billed Cuckoo, Southern Boobook, White-throated Nightjar, Sacred Kingfisher, Rufous Fantail, Black-faced Cuckoo-Shrike, Welcome Swallow and Silvereye (Western Research Institute and Biosphere Environmental Consultants, 2008). DECC (2007a) has also recorded the Whistling Kite and White-bellied Cuckoo-shrike in the Woronora Special Area.

A larger number of marine protected bird species have been recorded in the wider surrounds (DECC, 2007b, Australian Museum, 2007 and Birds Australia, 2007; in Western Research Institute and Biosphere Environmental Consultants, 2008). Similarly to the migratory bird species, a number of the marine protected bird species recorded in the wider surrounds are associated with coastal habitats and would not be expected to utilise the Project area. This includes species from the Families:

- Spheniscidae (Little Penguin);
- Diomedeidae (Albatrosses);
- Procellariidae and Hydrobatidae (Petrels, Shearwaters and Storm-Petrels);
- Phaethontidae, Fregatidae, Pelecanidae and Sulidae (Tropicbirds, Frigatebirds, Pelicans, Gannets and Boobies);
- Burhinidae (Beach-stone Curlew);
- Laridae (Gulls and Terns); and
- Stercorariidae (Skuas).

A number of other marine protected bird species could potentially occur in the Project area or surrounds. These species are assessed in Section 7.7.

4 POTENTIAL IMPACTS OF THE PROJECT ON TERRESTRIAL FLORA AND THEIR HABITATS

In this section the potential adverse impacts of the Project on terrestrial flora and their habitats are evaluated. Potential impacts of the Project on terrestrial flora and their habitats include those associated with mine subsidence effects (e.g. surface cracking, buckling and/or dilating and changes to surface or groundwater hydrology). Subsidence effects on terrestrial flora and their habitats are described in Sections 4.1 to 4.3. The Project also has the potential to result in a number of other direct and indirect impacts as described in Section 4.4. An assessment of the potential impacts of the Project on threatened flora species, populations, ecological communities and their habitats is provided in Section 4.5. Cumulative impacts of the Project are described in Section 6.

While all available evidence has been considered, significant weight has been given to the findings of specific contemporary on-site studies. Hence this evaluation draws on the potential subsidence impacts as described by Mine Subsidence Engineering Consultants (MSEC) (2008), potential groundwater impacts as described by Heritage Computing (2008) and the potential surface water impacts as described by Gilbert and Associates (2008).

4.1 SUBSIDENCE EFFECTS AND RIPARIAN VEGETATION

Potential subsidence effects on streams and riparian zones include changes in stream gradients, increased scouring of stream banks, changes to stream alignments, cracking and/or changes in stream water levels (MSEC, 2008), as described below.

An increased potential for scouring of stream banks can occur when the predicted tilts considerably increase the natural pre-mining stream gradients (MSEC, 2008), particularly in stream sections with alluvial deposits. At Metropolitan Colliery, given the stream beds are predominantly Hawkesbury Sandstone and given the scale and nature of predicted subsidence, the potential for scouring is expected to be low (MSEC, 2008). The anticipated changes in channel gradients would cause localised increases and decreases in flow energy/velocities (Gilbert and Associates, 2008). Increases in flow energy in steeper sections may in turn result in bed, or more likely, bank erosion (Gilbert and Associates, 2008). The extent of any erosion effects will depend principally on the strength of bank materials and the integrity of the riparian vegetation (*ibid*.). Based on observation of similar streams that have been affected by subsidence, it is expected that bank erosion would be relatively minor and comprise a slow retreat of the bank until a new dynamic equilibrium is reached (Gilbert and Associates, 2008). MSEC (2008) also indicate that the potential for changes in stream alignments due to mine subsidence is low.

Mine subsidence is likely to result in cracking of surface rocks of streams, which could result in a portion of the total surface water flow being redirected into the dilated strata in some locations and/or a reduction in pool water levels (MSEC, 2008). There is also potential for cracking to occur in the riparian zone.

The subsidence effects described above have the potential to impact on riparian vegetation. For example, scouring of stream banks could directly impact on riparian vegetation, while changes in stream water levels may potentially alter the availability of water to riparian vegetation. The degradation of native riparian vegetation along NSW watercourses is listed as a key threatening process under the *Fisheries Management Act, 1994*. Changes in stream water levels may also potentially impact on aquatic macrophytes. Potential impacts of the Project on aquatic macrophytes are assessed in an aquatic ecology report prepared by Bio-Analysis Pty Ltd (2008).

Riparian vegetation along Waratah Rivulet has been monitored between its junction with Flat Rock Creek and Flat Rock Crossing since 2003 to identify impacts resulting from mine subsidence. The monitoring indicates that such impacts on riparian vegetation are localised and limited in extent (Gingra Ecological Surveys, 2007). Some of the observations include (Gingra Ecological Surveys, 2007):

- Limited dieback of streamside vegetation was first observed along the western bank of Waratah Rivulet, upstream from Flat Rock Crossing to the WRS3 rock bar, in autumn 2006. However, in spring 2007 following some relief from drought conditions, there was no evidence of dieback of the fringing riparian vegetation along the western bank owing to recovery of vegetation along this section.
- Dieback of fringing riparian vegetation has also been observed on the eastern bank of Waratah Rivulet, upstream from Flat Rock Crossing to the WRS3 rock bar, where reduced water levels had resulted in a strip of vegetation dieback along a 100 m long section of the rivulet. The dieback was restricted to a fringe approximately 10 cm wide, with no evidence of dieback beyond (upslope of) this strip.
- In the vicinity of the WRS3 rock bar, there has been limited dieback and an individual Water Gum (*Tristaniopsis laurina*) was observed to have died.
- Upstream of WRS3, *Lomatia myricoides* plants were observed to have been affected by variations in water level. However, signs of recovery were observed in spring 2007.
- A decrease in stream water levels has also exposed some aquatic macrophytes, resulting in desiccation. However, more recent surveys indicate that the aquatic macrophyte, Water Ribbons (*Triglochin procerum*) had re-established at this location.
- Black Wattle (*Callicoma serratifolia*) and Coachwood (*Ceratopetalum apetalum*) plants previously affected by changed water levels were also observed by the more recent surveys to be re-sprouting and in good condition.
- While surface cracking has been observed in the riparian zone at the Metropolitan Colliery, resulting in reductions in pool levels and surface flows, it has had minimal impact on riparian vegetation.

Mine subsidence impacts on riparian vegetation are expected to be similar to those experienced at the Metropolitan Colliery to date (i.e. localised and limited in their extent).

Gas emissions have been observed in the past in the bases of rivers and creeks as a result of longwall mining within the Southern Coalfield (MSEC, 2008) but not within the Metropolitan Colliery area. There is, however, only one known case where gas emissions have adversely affected vegetation, which occurred along the Cataract River at Tower Colliery (MSEC, 2005). However, there have been no reported cases of significant gas releases from mining within the Bulli Seam that have resulted in the death of vegetation (MSEC, 2008). While no gas emissions have previously been observed at the Metropolitan Colliery to date, gas emissions could potentially occur at the surface as a result of mine subsidence (MSEC, 2008). This has the potential to affect riparian vegetation in a localised area.

The potential subsidence effects on riparian vegetation are considered for threatened flora species in Section 4.5.3.

4.2 SUBSIDENCE EFFECTS AND SLOPE AND RIDGETOP VEGETATION

Slopes and ridgetops occur across the Project area and would be subject to mine subsidence. Mine subsidence has the potential to cause surface and sub-surface cracking. This includes the potential for surface tension cracking near the tops of slopes (MSEC, 2008). MSEC (2008) indicate that the most likely locations where surface cracking would occur is near the top edges of steep slopes and in the base of valleys. To date, the only surface tension crack reported at Metropolitan Colliery is adjacent to Fire Road 9C which is near the top of a steep slope (MSEC, 2008). MSEC (2008) indicate that the size and extent of surface cracking on slopes and ridgetops is expected to be minor, which is consistent with that observed during the extraction of previous longwalls at the Metropolitan Colliery. Further, it is unlikely that mine subsidence would result in any large-scale slope failure, since such failures have not been observed as the result of longwall mining in the Southern Coalfield (MSEC, 2008).

Surface and sub-surface cracking has the potential to alter, albeit at a small local scale, the movement of water in the plateau and hillslope areas (Gilbert and Associates, 2008). However, the magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes in these areas and is unlikely to have any biologically significant effect on the soil moisture regime that sustains the existing vegetation communities (Gilbert and Associates, 2008). There have been no reported observations of changes to ridgetop and slope vegetation that have been attributed to mine subsidence.

Mine subsidence also has the potential to cause rock fall (MSEC, 2008). Rock falls occur naturally, however subsidence movements have the potential to further reduce the stability of features (e.g. cliff lines and rock ledges). Nevertheless, given the predicted low incidence of rock falls (MSEC, 2008), the potential impacts on flora as a result of rock fall are likely to be minor.

In summary, any impacts on slope and ridgetop vegetation due to surface cracking or rock fall as a result of mine subsidence are likely to be minor. Slopes and ridgetops provide habitat opportunities for threatened flora and the potential subsidence effects on slopes and ridgetops are considered for threatened flora species in Section 4.5.3. The potential subsidence effects in areas which support EECs are discussed below and the potential impacts of the Project on them are assessed in Section 4.5.1.

Endangered Ecological Communities

As described in Section 3.2.4.3, one EEC listed under the TSC Act was recorded by the Project baseline flora surveys, *viz*. Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC (Bangalay Botanical Surveys, 2008). In addition, the O'Hares Creek Shale Forest EEC occurs to the south of the proposed underground mining area in the vicinity of Longwalls 18-19A (*ibid*.). The locations of the EECs are shown on Figure 3. MSEC (2008) has predicted the maximum potential subsidence effects within 20 m of the perimeter of the EECs, as described below.

Longwalls 20 to 44 would not result in any subsidence movements to the occurrences of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC (Map Unit 5a) or O'Hares Creek Shale Forest EEC (Map Units 5b and 5r) situated in the vicinity of Longwalls 18 to 19A (Figure 3) (MSEC, 2008).

In addition, subsidence movements at the occurrences of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC situated to the east of Longwalls 20 to 27 (Figure 3) as a result of Longwalls 20 to 44 would be negligible (MSEC, 2008).

Compressive strains greater than 2 mm/m may have the potential to result in cracking, buckling and/or dilating (MSEC, 2008). However, MSEC (2008) conservatively predict that the maximum total systematic tensile and compressive strains at the occurrence of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC in the far north-east of the Project area (Figure 3) are 0.7 mm/m and 0.6 mm/m, respectively. That is, cracking, buckling and/or dilating as a result of systematic compressive strains is not predicted to occur as a result of the extraction of Longwalls 20 to 44 (MSEC, 2008).

However, upsidence and closure movements also have the potential to result in cracking, buckling and/or dilating (MSEC, 2008). There is potential for cracking to occur due to closure strain, however it is expected to be isolated to the drainage lines that occur in the north and south of this community (MSEC, 2008). Away from these drainage lines, the vegetation community is not expected to be impacted by valley related movements (MSEC, 2008). Based on monitoring and observations to date at Metropolitan Colliery and the hydrological assessment presented by Gilbert and Associates (2008), the small portions of this community in proximity to the drainage line would not be expected to experience any significant change.

Tensile strains greater than 0.5 mm/m could be of sufficient magnitude to result in the cracking of the bedrock, which could result in minor surface cracking where the depths of bedrock are shallow. However, this occurrence of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC is located in an area where the depth of cover is approximately 450 m to 500 m (MSEC, 2008), such that the magnitudes of predicted strains are relatively low. Surface cracking as the result of systematic subsidence movements at these depths of cover is expected to be isolated and of a minor nature (MSEC, 2008).

The maximum total systematic tilt at the occurrence of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC in the far north-east of the Project area is conservatively predicted to be 5.6 mm/m (MSEC, 2008). The maximum predicted systematic tilt is small when compared to the existing natural surface gradients (MSEC, 2008).

Given the magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes in this area, it is unlikely that subsidence effects would have any biologically significant effect on the soil moisture regime that sustains the EEC in this area (Gilbert and Associates, 2008). As a result, it is unlikely that the EEC would be adversely affected by mine subsidence.

4.3 SUBSIDENCE EFFECTS AND UPLAND SWAMP VEGETATION

4.3.1 Upland Swamp Formation

Upland swamps on the Woronora Plateau occur in small headwater valleys that are characteristically sediment choked and swampy (Young, 1986). The presence of upland swamps is related to their topographic position, the lithology of the bedrock and the hydrological balance on the plateau (*ibid*.), as described below.

Topographically, upland swamps occur mainly on the eastern, higher parts of the Woronora Plateau. They generally occupy gently-sloping and trough-shaped valleys, but some extend from the valley-floor upwards onto quite steep slopes or occupy benches on the valley sides (*ibid*.). The swamps are most extensive and most numerous where the plateau is least dissected (Young, 1986). In the more dissected catchments (e.g. the Woronora River catchment), the swamps are confined largely to the headwater tributaries (*ibid*.).

Upland swamps are restricted to valleys cut in the massive Hawkesbury Sandstone comprising much of the surface of the Woronora Plateau (Young, 1986). Regional groundwater flow within the Hawkesbury Sandstone Formation is largely horizontal, as vertical permeability is low (Heritage Computing, 2008). The Hawkesbury Sandstone provides a low permeability base on which the swamp sediments and organic matter rest (*ibid*.). Swamps on the Woronora Plateau are not attributed to the presence of claystone underlying the sandstone, as is the case for the hanging swamps of the Blue Mountains (Young, 1986; Heritage Computing, 2008). The Hawkesbury Sandstone is also the predominant source of sediment for the upland swamps; erosion of the sandstone on the plateau surface supplies largely medium-coarse sand to the valleys in which the swamps lie (*ibid*.). Due to gentle gradients, only the largest upland swamps are able to maintain short open channels near the downstream end, sometimes with a series of discontinuous elongated pools in the valley axes further upstream (*ibid*.). The sandy sediment accumulation in the swamps traps rainfall infiltration, seepage and low-flow runoff.

The eastern part of the Woronora Plateau has a favourable climate for upland swamp formation. Average rainfall exceeds average evaporation in all months of the year (Young, 1986). Rainfall saturates the accumulating swamp material with drainage impeded by low floor slope, the low permeability sandstone base and the dense swamp vegetation (Heritage Computing, 2008). Partially decayed organic matter accumulates in the sediments, further increasing their water-holding capacity (Young, 1986). In most years the central axes of the swamps are saturated, though the margins may dry out periodically (Keith *et al*., 2006).

There is a spectrum of upland swamp types that differ according to the hydrological processes that are dominant. Broadly, upland swamps can be classified as headwater upland swamps or in-valley upland swamps, as described below by Heritage Computing (2008).

> *Headwater upland swamps (Figure 3a) occur in the headwaters or elevated sections of the topography on the plateau where the land surface is fairly flat. They are essentially rain-fed systems in which rainfall exceeds evaporation continuously. The water levels within the swamps fluctuate seasonally with climatic conditions, as rain adds to soil moisture and evapotranspiration slowly removes moisture from storage. Excess rainfall produces a permanent perched water table within the sediments that is independent of the natural regional water table in the underlying Hawkesbury Sandstone. During rain events, some stream flow and runoff along indistinct braided channels will infiltrate through the swamp sediments. The growth of dense vegetation and the low land gradient prevent the formation of an open channel that would otherwise transport water and sediments. In some headwater upland swamps, there could be minor groundwater seepage from the outcropping sandstone at the edges of the swamp.*
>
> *In-valley upland swamps (also called in-stream or valley floor swamps) occur along well defined drainage lines in the more deeply incised valleys, and are less common than headwater upland swamps on the eastern Woronora Plateau. They occupy relatively flat sections of streams within deeper valleys and are thought to be formed by deposition of sediments behind barriers such as piles of logs at choke points in the stream (Tomkins and Humphreys, 2006), or terminate at 'steps' in the underlying substrate where the gradient suddenly becomes steeper (Earth Tech, 2003). In-valley upland swamps (Figure 3b) have multiple sources of water. Primarily, they are sustained by stream flow along distinct channels, supplemented by rain infiltration. Given the incised nature of the axial stream, they are more likely to receive groundwater seepage from the sandstone walls at the edges of the swamp. In most cases the hydrology of the swamp is independent of the deeper regional water table in the underlying Hawkesbury Sandstone, but there might be occasions when the regional water table intersects the swamp sediments. In the latter case, depending on the relative elevations of the perched and regional water tables, groundwater could supplement swamp moisture or swamp moisture could drain towards the underlying aquifer.*

4.3.2 Upland Swamp Vegetation

Upland swamps support a high diversity of plant species (Keith and Myerscough, 1993; Keith, 1994) and are habitats of particular conservation significance for their biota. Most of the swamps are located within Special Areas jointly managed by the Sydney Catchment Authority (SCA) and DECC, or in conservation reserves. As a consequence, most are in near pristine condition.

The floristics and ecological relationships of swamp communities in the O'Hares and Stokes Creek catchments on the Woronora Plateau have been determined by Keith and Myerscough (1993) and are described by Keith (1994) and NPWS (2003a). Six swamp communities were identified. Their distinguishing features, ecological characteristics and landscape position are summarised in Table 5.

Table 5
Upland Swamp Communities of the Woronora Plateau

Community Name	Dominant/Characteristic Species	Ecological Characteristics	Landscape Position
I. Fringing Eucalypt Woodland	*Eucalyptus racemosa, Banksia ericifolia, Banksia oblongifolia, Hakea dactyloides, Hakea teretifolia, Leptocarpus tenax, Sprengelia incarnata, Mitrasacme polymorpha*	Damp soils on swamp/ woodland margins	Ecotone between treeless swamps and eucalypt woodlands
II. Banksia Thicket	*Banksia ericifolia, Hakea teretifolia*	Periodically damp shallow sandy loam soils	Upper slopes of upland swamps, swamp margins
III. Restioid Heath	*Banksia oblongifolia, Cryptandra ericoides, Lepyrodia scariosa, Leptocarpus tenax, Blandfordia nobilis, Haemadorum corymbosum*	Occasionally waterlogged shallow sandy loam soils	Damp upper slopes of large upland swamps or broad outer margins of swamps without major seepage zones
IV. Sedgeland	*Sprengelia incarnata, Bauera microphylla, Sympheonema paludosum, Baeckea imbricata, Lepidosperma filiforme, Schoenus paludosum*	Periodically wet sandy humic loam soils	Seepage slopes on sandstone benches or the sides of large upland swamps
V. Cyperoid Heath	*Banksia robur, Hakea teretifolia, Lepidosperma limicola, Gymnoschoenus sphaerocephalus*	Moderately deep gleyed organic sands and sandy loams	Wet seepage zones in upland swamps
VI. Tea Tree Thicket	*Leptospermum juniperinum, L. grandifolium, Banksia robur, Melaleuca aquarrosa, Viminaria juncea, Gleichenia* spp., *Gahnia sieberiana, Baumea teretifolia*	Deep, highly organic gleyed loams and clay loams	Waterlogged drainage lines in large upland swamps

Source: Keith and Myerscough (1993) and NPWS (2003a)

Communities II to IV are collectively referred to as the Sedgeland – Heath complex by Keith (1994) because they are structurally similar and cannot easily be mapped as separate units using air photo interpretation. Communities II to IV occupy similar positions in the landscape (upper margins of swamps) and share many species in common. Keith *et al.* (2006) show that differences in fire frequencies may drive short-term transitions between communities II to IV.

Communities I to VI represent progressively moister environments from the upper margins of swamps to the moist low drainage lines in the centre. Tea Tree thickets are usually wet except in drought years, but the margins may only be seasonally wet, sometimes drying out completely in summer. The soil conditions reflect the moisture gradient, with the wetter areas having generally higher organic and mineral contents. Species richness is however highest in the drier, nutrient poor restioid heaths and lowest in the Tea Tree thickets (Keith and Myerscough, 1993).

Communities I to IV are typically confined to headwater swamps, while Cyperoid Heath (Community V) and Tea Tree Thicket (Community VI) vegetation occur in both headwater swamps and in-valley swamps.

Upland swamps are not static features of the landscape, they wax and wane over time depending on medium term climatic cycles, and their floristic composition and structure may change rapidly in the short term in response to the frequency and intensity of fires (Keith *et al*., 2006).

4.3.3 Underground Mining in the Southern Coalfield and Upland Swamps – Literature Review

Alteration of habitat following subsidence due to longwall mining is listed as a key threatening process under the TSC Act (NSW Scientific Committee, 2005a). The Scientific Committee, government agencies and/or community concerns are that mine subsidence effects (e.g. cracking, buckling, dilating and/or tilting) may significantly affect the water balance of upland swamps, with subsequent desiccation of the swamp, increased susceptibility to fire, erosion and associated loss of specialised swamp biota. A literature review was conducted by FloraSearch in regard to underground mining and upland swamps in the Southern Coalfield. Key findings of the literature review are described below.

While there are relatively few peer reviewed and formally published scientific papers and theses, there is a more substantial 'grey' literature of technical reports and submissions relating to upland swamps and mine subsidence. A number of authors have considered the composition of the swamps from geomorphological (Young, 1986; Earth Tech, 2003; Gibbins, 2003; Tomkins and Humphreys, 2006), botanical (Keith and Myerscough, 1993; Keith 1994; Keith *et al.* 2006) and hydrological (Paterson, 2004) perspectives.

Upland swamps are subject to a range of natural disturbances including periodic wildfire, drought and storms. Evidence of charcoal within swamp sediments indicates that Woronora Plateau swamps have been disturbed by wildfires episodically over many thousands of years (Young, 1986; Tomkins and Humphreys, 2006). Within the last 40 years major wildfires have occurred in the O'Hares and Stokes Creek catchments in 1968, 1990 and 2001/2002 (Keith *et al.*, 2006). These and other fires also extended more widely across the plateau (NPWS, 2003a). Fire is generally considered to be the precursor to erosion events within upland swamps (Young, 1986; Earth Tech, 2003; Tomkins and Humphreys, 2006). Severe fires are likely to remove much of the swamp vegetation cover exposing the soil surface to the erosive forces of subsequent heavy rainfall and storms (Prosser and Slade, 1994). Analysis of aerial photographs taken over a 50 year period showed that not all wildfires lead to erosion of swamps, but that severe erosion, when it occurs, appears to follow a wildfire if some erosion is already present (Tomkins and Humphreys, 2006).

Tomkins and Humphreys (2006) found evidence of scour pools in aerial photographs of upland swamps over a period of 50 years. They considered that scour pools were '*a critical indicator of likely future gully erosion in the swamps*'. Air photo analysis by Earth Tech (2003) showed scour pools undergo cycles of development and in-filling over time without necessarily leading to severe erosion events. Pools are usually associated with topographical constrictions in swamps where increases in stream power during high flow events may remove vegetation creating a pool (Earth Tech, 2003). Such pools may subsequently increase in size in further storms or infill with lower energy flows.

Similarly, channels between pools may come and go. The dense swamp vegetation binding areas surrounding the pools appears to resist erosion under most circumstances. Tomkins and Humphreys (2006) found that severe erosion was not necessarily associated with severe storms, but could occur with moderately heavy rainfall (50 – 100 mm per day) after a fire. These observations suggest that other factors are important in determining whether or not severe erosion occurs, the most likely being the degree to which a swamp is effected by wildfire events, which in turn relates to the moisture condition of the swamp at the time of fire.

Tomkins and Humphreys (2006) suggest that small scale erosion due to the development of channeling between scour pools may result in changes to swamp soil moisture profile or drying to sections of the swamp, which in turn may lead to more complete vegetation removal in wildfires and greater susceptibility to major extensions of existing gullying. However, this view is not supported by the observations of Earth Tech (2003) that channeling is common in valley floor swamps and does not necessarily lead to erosion, even after wildfires. While it is unlikely that normal channeling can result in significant changes to swamp soil moisture profiles, drought and mine subsidence are potential mechanisms (Earth Tech, 2003; Paterson, 2004).

There is little discussion in the literature of the potential impacts of drought on upland swamps and their flora, or on other vegetation types on the Woronora Plateau. This is probably because drought is a relatively rare phenomenon in the area due to high precipitation, averaging 1550 mm per annum, around the Illawarra Escarpment. Precipitation on the eastern side of the plateau usually exceeds evaporation (ca. 900 mm per annum) by a large margin and is the main reason for the concentration of upland swamps in the area. Paterson (2004) showed that at least some swamps are recharged entirely by rainfall and are prone to drying out in droughts. However, other swamps are thought to be charged by seepage from horizontal aquifers within the Hawkesbury Sandstone beds (Young, 1982). In most dry periods the main axis of the swamps can be expected to remain moist and therefore be less damaged by fire than if it dried out completely. Nevertheless, there are likely to be occasions over many climate cycles when prolonged droughts completely desiccate the swamps. Such events may be the trigger for the long cycle episodic erosion events during the Holocene revealed by swamp stratigraphy (Young, 1986; Tomkins and Humphreys, 2006).

Studies undertaken by BHP Billiton Illawarra Coal indicate that approximately 546 swamps have been mined beneath on the Woronora Plateau, including 203 that have been undermined by multi-seam or longwall extraction. This literature review did not identify any documented evidence of adverse impacts from mine subsidence in the Southern Coalfield on the majority of upland swamps (e.g. erosion or changes in vegetation health, composition or abundance). Erosion has been observed in one upland swamp, namely, Drillhole Swamp as a result of physical surface disturbance (described below). Development of gully erosion and changes in vegetation composition have been reported in three upland swamps in the Southern Coalfield, namely, Swamp 18 and Swamp 19 (situated above the Elouera Colliery workings west of Dapto) and Flat Rock Swamp near the historic Darkes Forest and more recent Metropolitan Colliery workings near Helensburgh. No other swamps that had been subjected to mine subsidence have been identified with similar erosion or vegetation effects. This suggests that such effects are relatively uncommon.

Drillhole Swamp

Gully erosion in Drillhole Swamp (Flying Fox Creek, Avon Catchment) was observed subsequent to heavy rainfall (DECC, 2007c). The erosion has been attributed to physical surface disturbance of the swamp by mining investigations conducted in 1976 (including track construction, building of a small dam [which subsequently burst], removal of vegetation to bedrock and drilling operations), which created a knick-point resulting in erosion of the swamp during subsequent heavy rainfall in 1978 (Tomkins and Humphreys, 2006; DECC, 2007c).

Surface disturbance of this nature in any in-stream soil profile has the potential to trigger erosion processes, particularly if it involves the removal of stabilising vegetation. However, it is also recognised that periodic erosion of Drillhole Swamp is a naturally occurring process that pre-dates mining (Tomkins and Humphreys, 2006; DECC, 2007c).

Swamps 18 and 19

A major erosion event was identified in Swamp 18 following a series of storms after the 2001/02 wildfire severely burnt it and the nearby Swamp 19 (DECC, 2007c), causing extensive damage to the peat layer of both swamps.

Swamps 18 and 19 have been the subject of a series of studies aimed at determining the effects of mine subsidence on the swamps (e.g. Gibbins, 2003; Earth Tech, 2003; Earth Tech, 2005; Tomkins and Humphreys, 2006; BHP Billiton, 2006; BHP Billiton, 2007). Longwall mining beneath Swamp 18 (Native Dog Creek, Avon Catchment) occurred between 1995 and 1997 (DECC, 2007c). Swamp 19, also situated in Native Dog Creek has a similar longwall mining history to Swamp 18 (DECC, 2007c). Mine subsidence has been reported to have increased the gradient of the swamp (Earth Tech, 2003) and caused cracking of exposed bedrock (DECC, 2007c).

In a study of 35 swamps burnt in the 2001/02 wildfire, including 19 that had been subject to mine subsidence, Earth Tech (2003) found that Swamps 18 and 19 were more severely affected by fire than others. The very high fire intensity in Swamps 18 and 19 indicates the swamps were significantly drier than other swamps prior to the fire (Tomkins and Humphreys, 2006). The loss of surface vegetative cover and of the root mass binding the swamp sediments resulted in the severe erosion observed in Swamp 18. The 2001/02 wildfire coincided with the beginning of a six year dry period in south eastern Australia (BOM, 2007a), which may have been the primary cause of the drying of Swamps 18 and 19 (Earth Tech, 2003). However, it has been suggested that mine subsidence effects are likely to have made the swamps more susceptible to burning and erosion (DECC, 2007c). Bedrock cracking and rock falls due to subsidence are common in Native Dog Creek below Swamps 18 and 19. A sizeable surface crack has also been reported to occur on the eastern side of Swamp 18 (Earth Tech, 2003; Biosis Research, 2001 in Tomkins and Humphreys, 2006). This cracking resembled '*a fault with a downthrow of about 2m on the swamp side*' (Biosis Research, 2001). In addition, evidence of cracking and the presence of water in the normally impermeable bedrock below the swamp were demonstrated by seismic refraction results (Gibbins, 2003).

Tomkins and Humphreys (2006) analysed the sedimentary record of three swamps (Drillhole Swamp, Swamp 18 and Flat Rock Swamp) to determine the depositional and erosional chronology, develop an understanding of swamp dynamics and assess the causes or triggers of erosion including the current episode of erosion observed. In relation to potential effects of underground mining on these swamps, Tomkins and Humphreys (2006) state the following:

> *The impacts of mining on erosion of Swamp 18 and Flat Rock Swamp is less clear as both swamps were already in the process of erosion prior to the commencement of known mining and ground subsidence. It is possible that subsidence accelerated dewatering of Swamp 18 during the late 1990's which enhanced burning during the 2001-02 wildfires. Alternatively, the gully erosion through the lower part of the swamp prior to 1990 could have drained the swamp sufficiently to cause a similar effect. …….*
> ……
>
> *Wildfires can lead to further erosion in swamps where gully erosion is already underway. At least two of the swamps investigated showed knickpoint retreat following the 2001-02 fires despite very low magnitude rainfall events. The sensitivity of the swamps to erosion after fire suggests that the fire has a significant effect on surface roughness and runoff velocities. This is in contrast to the uneroded swamps where the vegetation is scorched but quickly recovers.*

Human disturbance in the catchment, particularly direct physical disturbance such as at Drillhole Swamp has been found to be an important trigger of erosion of swamps. The impact of mine subsidence, however is less clear. Both Swamp 18 and Flat Rock Swamp featured scour pools and gully erosion well before any direct effects of mining were observed. It may be likely that dewatering of swamps due to mining increases the sensitivity of swamps to other influences such as wildfires.

Further to the Tomkins and Humphreys (2006) study, the potential for mine subsidence to pre-dispose swamps to wildfire and subsequent gullying has been investigated by BHP Billiton. BHP Billiton (2006; 2007) has monitored soil moisture and mine subsidence in a number of swamps that overlie longwall mining operations. BHP Billiton (2006; 2007) report that the study has identified no significant difference between the overall soil moisture conditions observed in the swamps subject to mine subsidence and those that have not. BHP Billiton (2007) state that:

'*The overall soil surface moisture conditions of those swamps that have been mined under closely follow the conditions observed in the swamps that have not been mined under*.'

Earth Tech (2005) investigated the increase in longitudinal gradient increasing the hydraulic gradient of overland flows and thereby the potential for scour in a number of swamps including Swamp 18. Earth Tech (2005) concluded that:

'*…Scour would not have occurred as a result of mining in the absence of fire in reaches 3 and 6. We are of the opinion that any change in grade associated with subsidence had a minor to insignificant impact on scour in Swamp 18.*'

Of relevance to other upland swamps on the Woronora Plateau, the EarthTech (2005) investigation also considered that the systems at greatest risk due to increased scour have the following characteristics: high stream order (i.e. high flow and low gradient); poor vegetation condition; longwalls that lie perpendicular to swamp; and swamps that overly the mine subsidence perimeter.

Flat Rock Swamp

Flat Rock Swamp (Waratah Rivulet, Woronora Catchment) has undergone a similar post-fire erosion event to that in Swamp 18. Erosion in Flat Rock Swamp has occurred in the area between the historic Darkes Forest workings and the more recent Metropolitan Colliery longwalls. Similarly to Swamp 18, aerial photographs indicate that natural erosion in the swamp was occurring prior to mining, however the rate of erosion was enhanced following the bushfires (Tomkins and Humphreys, 2006).

The bushfire across Flat Rock Swamp in December 2001 occurred prior to any significant mining at the Metropolitan Colliery in the vicinity of Flat Rock Swamp (i.e. mining of Longwall 8 had only recently commenced [Figure 6]). Aerial photos, taken just after the fire, show some channeling in the swamp between scour pools, but no extensive erosion. Erosion gullying was identified in Flat Rock Swamp in February 2002 (DECC, 2007c). Significant rain (238 mm) fell 30 days after the 2001/02 fire and may have initiated the erosion. A further 163 mm fell seven weeks later. Subsequently, drier than normal conditions occurred in the region between September 2002 and January 2004 during which 212 mm fell in mid May 2003. This combination of dry conditions with a heavy rainfall event may have greatly exacerbated the erosion. Dry conditions returned in June 2004 and persisted until December of that year. These dry periods corresponded with predominantly El Nino weather patterns between mid 2002 and mid 2005.

METROPOLITAN COAL PROJECT

FIGURE 6
Location of Flat Rock Swamp in Relation to Mining

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MET-06-02 EA FFIA_006B

Gingra Ecological Surveys (2001) conducted a baseline vegetation survey in Flat Rock Swamp prior to the wildfire. However, the quadrats were situated above Longwalls 9 and 10 (i.e. downstream of the areas subsequently affected by erosion). No modification of swamp vegetation was observed in the quadrats monitored above Longwalls 9 and 10. Further discussion of the vegetation in Flat Rock Swamp based on site inspections is provided in Section 4.3.4 below.

Limitations of the Studies

There are a number of limitations associated with the studies referenced (e.g. a lack of controls or replication, one-off observations and study duration) which results in the outcomes of the studies being inconclusive. The degree to which natural disturbances (wildfire, drought and storms) and mine subsidence have contributed to the effects observed in upland swamps discussed above requires further data and research to be conclusive. It is noteworthy that none of the referenced papers have been published in scholarly reviewed scientific journals.

4.3.4 Underground Mining in the Southern Coalfield and Upland Swamps – Site Inspections

Site inspections of swamps that had experienced mine subsidence and those that had not on the Woronora Plateau were conducted by FloraSearch in January and February 2008. Twenty five upland swamps, or sections of swamps on the Woronora Plateau were examined by FloraSearch including 13 swamps subject to some degree of mine subsidence and 12 swamps that had not been subject to mine subsidence.

Rainfall data indicates that the Illawarra region experienced above average rainfall in the 12 months preceding the site inspections. In particular, above average precipitation was recorded in November and December 2007, and swamp water levels would have been high during the field inspections with no water stress on the vegetation. However, the preceding seven years had below average rainfall (2000 to 2002 and 2005 to 2006 were particularly dry years). Any effects of the dry conditions on the vegetation would be detectable during the field inspections.

Information recorded at each swamp location included swamp health (i.e. any signs of vegetation yellowing or browning, leaf/twig/branch dieback, evidence of new growth, evidence of reproduction), soil disturbance or erosion and the vegetation communities present.

These field inspections were informed by information provided by MSEC in relation to the occurrence of previous underground mining and mine subsidence potential.

A summary of the findings is provided below.

Plant Health

Evidence of dieback or death of swamp flora was only observed in one upland swamp. This swamp had not been subjected to mine subsidence (i.e. it was a natural event). Juvenile *Banksia ericifolia* were observed to have extensive foliage yellowing. It is likely that the plants had germinated and grown in the dry period experienced during 2000 to 2006 when the swamp was relatively dry. The return of high precipitation in 2007 is likely to have created unfavourably wet conditions for part of the population, being subject to waterlogging. *Banksia ericifolia* usually occurs on swamp margins where the soil is damp, but not wet.

Dieback or death of specialist hydrophilic swamp flora suggesting moisture stress was not observed in any of the swamps examined that had experienced mine subsidence. The vegetation was actively growing in all swamps without twig or branch dieback, or leaf browning. This is to be expected following wildfires (2001/02) after which active regenerative growth occurs.

In the absence of moisture stress, dieback is usually seen in senescing vegetation a decade or more post-fire. The vegetation observed in this survey was also actively reproducing in all swamps; most plants had flowered heavily in spring 2007, or were still flowering at the time of the survey.

There was no observable difference in plant health between swamps that had experienced mine subsidence and those that had not.

Soil Disturbance and Erosion

Except for three upland swamps (i.e. Drillhole Swamp, Swamp 18 and Flat Rock Swamp) with previously known gully erosion there was no sign of gully erosion in any of the swamps examined. A small amount of soil disturbance was observed in one upland swamp, involving removal of shallow soil over bedrock, possibly by wildlife. No evidence of active gully erosion was observed in any upland swamps, whether subject to mine subsidence or not, with the exception of those referred to above.

Erosion observed in Drillhole Swamp, Swamp 18 and Flat Rock Swamp is discussed in Section 4.3.3 above and Section 4.3.5 below.

Vegetation Communities

Examples of all six previously described vegetation communities (Table 5) were examined during the field inspections. Four of the six communities were typically confined to headwater swamps (namely Communities 1 to IV), while Cyperoid Heath (Community V) and Tea Tree Thicket (Community VI) vegetation occurred in both headwater swamps and in-valley swamps. In headwater swamps, Cyperoid Heath and Tea Tree Thicket vegetation usually occur in the wetter areas of the larger swamps.

No observable differences in vegetation communities were found between the majority of upland swamps that had experienced mine subsidence and those that had not. However, patches of Acacia Thicket, which is not currently recognised in the literature on Woronora Plateau flora, were found in three upland swamps (Swamp 18, Swamp 19 and Flat Rock Swamp), as described below.

The Acacia Thickets were dominated by species of wattles, *Acacia myrtifolia* in Swamps 18 and 19, and *Acacia longifolia* in Flat Rock Swamp. The community comprises dense thickets of tall (to 10 m high) single stemmed Acacia plants with little or no understorey. The understorey comprises remnants of the Tea Tree Thicket vegetation community that generally dominates wetter sections of upland swamps, including *Gahnia sieberiana, Gleichenia* species, *Leptospermum juniperinum*, *Banksia robur* and *Empodisma minus.* In Flat Rock Swamp, Acacia Thicket also commonly includes *Callicoma serratifolia.*

In Flat Rock Swamp, the acacia is growing on two swamp soil types: grey sand over peat and peat without sand. The sand and peat layers were quite dry at the time of the inspection (31 January 2008) and water was confined to the erosion channel within the rivulet. R. Lembit (pers. comm.) observed the presence of acacias upstream of his quadrat sites prior to the 2001/02 fire, indicating the vegetation change preceded the fire. However, the extent to which Tea Tree Thicket was present with the acacias pre 2002 is not clear. Currently, only isolated remnants of Tea Tree Thicket are present in the sections of the swamp experiencing erosion and the occurrence of Tea Tree Thicket vegetation appears to have been reduced by the 2001/02 wildfire. Evidence of burnt and killed *Gahnia* clumps indicates *Gahnia* was much more common prior to the fire. *G. sieberiana* is reported to resprout after fire (Benson and McDougall, 2002), but the 2001/02 fire in Flat Rock Swamp appears to have severely reduced the population indicating it was a very hot fire. This suggests that the areas subject to erosion were substantially dry well before the 2001/02 fire, making the *Gahnia* highly susceptible to fire-induced mortality.

Under dry conditions, fires may consume peat, resulting in the complete death of surface vegetation and seed banks, and exposure of the remaining substrate to further erosion (NSW Scientific Committee, 2004a). Keith *et al*., (2002) also note that the habitat structure of certain wet heathlands is profoundly affected by fires that consume not only standing biomass, but also peaty substrates (Young, 1982; Kirkpartick and Dickinson, 1984) and the subterranean vegetative recovery organs and seed banks that they contain (Gill, 1996). The destruction of peat, loss of its capacity for moisture retention and cation exchange, and subsequent exposure of mobile gravels and sands is likely to influence the number and species of seedlings that are able to establish and grow in the post-fire environment (Keith *et al*., 2002). Long-lasting open space and unstable substrates seem likely to favour widely dispersed opportunists over species in which population persistence is predicated on the longevity of individuals and *in situ* recovery mechanisms (*ibid*.). Many *Acacia* species, including *Acacia longifolia* and *Acacia myrtifolia* have large, hard-coated seeds which persist in the soil for many years, and may be stimulated to germinate by the pulse of heat associated with a hot fire.

The knickpoint for erosion in Flat Rock Swamp is in a band of peat situated over 400 m to the south of Metropolitan Colliery Longwall 9. At this point the Waratah Rivulet flows over the peat bed for at least a further 30 m upstream. This observation indicates that Flat Rock Swamp previously extended further upstream than now evident. The vegetation on each side of the creek at this point is more typical of Sandstone Gully Forest than Upland Swamp, indicating that forest vegetation has colonised a former swamp. Evidence for this transition from earlier air photos is presented by Tomkins and Humphreys (2006). This suggests that drying of the upper parts of Flat Rock Swamp may have occurred many years ago and that changes to the swamp flora were well advanced.

In summary, there were no observable differences in the plant community composition in the majority of upland swamps due to mine subsidence. In three upland swamps there has been a change in plant community composition from Tea Tree Thicket to Acacia Thicket following fire. The current dominance of acacias in sections of these swamps is likely to be a result of high intensity fire, associated disturbance to surface vegetation and loss of swamp peat layers and the presence of Acacia seed banks in the soil. The high fire intensity suggests the swamp peat layers were very dry due to drought, possibly exacerbated by swamp dewatering related to mine subsidence. However, the observation that Flat Rock Swamp formerly extended further upstream suggests that drying of the upper parts of Flat Rock Swamp may have occurred many years ago.

The degree to which previous fires, dry periods and mine subsidence from the historic Darkes Forest workings have influenced the occurrence of Acacias in these locations is unknown. However, the dry conditions experienced prior to the wildfires would have increased fire intensity and its subsequent effects on the swamp.

In-Valley Swamp at the Metropolitan Colliery Overlying Completed Longwalls

The field inspection included the examination of an in-valley swamp at the Metropolitan Colliery overlying completed Longwalls 7 and 8. The swamp is characterised by dense Tea Tree Thicket vegetation and no discernable channel for the majority of its length. At the downstream section of the swamp, a small, narrow flow of water was observed over a length of 5 m beneath the dense vegetation. One pool surrounded by healthy intact vegetation was observed in the upper reaches and on the edge of the swamp. In wetter sections of the swamp, iron staining and iron-oxidising bacteria were present in free water, observed when the vegetation was trodden under foot. Iron staining and iron-oxidising bacteria were also observed in the abovementioned pool and were considered likely to be due to previous mining activities (i.e. while iron-staining is known to be a natural phenomenon, greater amounts were observed than would be expected to naturally occur). The vegetation in these areas appeared healthy. There was no observable effect from mine subsidence on vegetation health, erosion or vegetation community composition or abundance in the swamp.

The downstream section of this swamp is situated outside of the proposed underground mining area (Longwalls 20 to 44), but within the potential extent of mine subsidence effects (i.e. angle of draw). The potential impacts of the Project on the swamp are described in Section 4.3.5.3.

4.3.5 Potential Impacts on Upland Swamps

4.3.5.1 Upland Swamps in the Project Area and Surrounds

A number of upland swamps are situated within the proposed underground mining area (Longwalls 20-44) and within the potential extent of mine subsidence effects as shown on Figure 3 (upland swamp vegetation is mapped as vegetation communities 3a, 3b, 3c and 3d).

With the exception of one swamp, the upland swamps shown on Figure 3 are headwater upland swamps, occurring on or near headwater tributaries. The vegetation of the headwater swamps has been mapped by Bangalay Botanical Surveys (2008) as Banksia Thicket (Map Unit 3a), Sedgeland-Heath Complex (Map Unit 3c) and Fringing Eucalypt Woodland (Map Unit 3d).

One in-valley swamp (referred to as Swamp S21 by MSEC [2008]) is situated on a tributary (a third order watercourse) of Waratah Rivulet to the south of Longwall 20. This swamp is situated outside of the proposed underground mining area (Longwalls 20-44), but within the potential extent of mine subsidence effects (i.e. angle of draw). This swamp overlies completed Longwalls 7 and 8 and consequently has already experienced mine upsidence from Metropolitan Colliery's existing operations. This in-valley swamp comprises Tea Tree Thicket vegetation (Map Unit 3b) (Bangalay Botanical Surveys, 2008), although note the swamp extends to the south of the Bangalay Botanical Surveys (2008) mapping boundary.

MSEC (2008) has predicted the maximum potential subsidence effects within 20 m of the perimeter of the upland swamps. MSEC (2008) explains the conservative nature of these predictions as they are based on a conservative empirical methodology that takes into account a comprehensive data set of previously recorded subsidence magnitudes. Therefore, it is likely that subsidence effects will be less than the maximum predicted (MSEC, 2008). The predictions include subsidence resulting from the extraction of Longwalls 20 to 44, as well as the cumulative subsidence effect resulting from the previously extracted or approved longwalls (i.e. Longwalls 1 to 19A). Potential effects on upland swamps are described below.

The upland swamps within the Project area and surrounds are not situated in the four key clusters of swamps identified by DECC (2007a) as being of particular significance in the Southern Coalfield (Maddens Plains [O'Hares and Cataract catchments], Wallandoola Creek [Cataract catchment], North Pole [southern Avon catchment] and Stockyard [southern Avon catchment]). However, it is recognised that upland swamps are of particular ecological significance.

4.3.5.2 Headwater Upland Swamps

Surface Cracking

At Metropolitan Colliery, tensile strains greater than 0.5 mm/m may have the potential to result in cracking in the bedrock (MSEC, 2008). Compressive strains greater than 2 mm/m may have the potential to result in cracking, buckling and/or dilating (*ibid*.). MSEC (2008) conservatively predict that the maximum total systematic tensile and compressive strains in headwater upland swamps within the proposed underground mining area (Longwalls 20-44) and within the potential extent of mine subsidence effects are 1.4 mm/m and 1.7 mm/m, respectively.

This means that cracking, buckling and/or dilating as a result of systematic compressive strains is not predicted to occur as a result of the cumulative subsidence from the extraction of Longwalls 1 to 44 (i.e. compressive strains less than the 2 mm/m threshold are predicted) (MSEC, 2008).

Upsidence and closure movements also have the potential to result in cracking, buckling and/or dilating (MSEC, 2008). However, as headwater upland swamps are generally located higher in the catchment topography in areas with relatively shallow relief (Heritage Computing, 2008), headwater swamps would generally be subject to minimal valley related upsidence and closure movements (MSEC, 2008). Predictions of valley related upsidence and closure movements were made for a number of headwater swamps located in drainage lines with the steepest valley profiles. A maximum total closure strain of 8.9 mm/m is predicted. The soils in the swamps comprise mainly unconsolidated alluvial sediments and in most cases, the cracking that might occur at the rock surface may not appear at the surface of the swamps. The most likely locations where cracking may occur would be where the swamps are located over the edges of the mining area. However, given the depth of cover which is generally over 420 m, even on the edges of the mining area, MSEC (2008) indicate that they would not expect much cracking. As indicated above, the headwater swamps would generally be subject to minimal valley related upsidence and closure movements.

A maximum total systematic tensile strain at headwater swamps of 1.4 mm/m is conservatively predicted to occur and therefore there is some potential for minor cracking (MSEC, 2008). Any cracking of the bedrock is expected to be isolated and of a minor nature, due to the relatively low magnitudes of the predicted strains and the relatively high depths of cover (MSEC, 2008). Further, the minor cracking within the swamp areas would generally not be expected to propagate through swamp soil profiles (*ibid*.). The only locations where such cracking is expected to be observed, based on previous monitoring over the previous longwalls at the Metropolitan Colliery, are located along the higher ridge top rock outcrops (MSEC, 2008).

Given the minor nature of potential tensile cracking and the hydrogeological characteristics of headwater swamps, there is very little potential for any measurable change in swamp moisture conditions (Heritage Computing, 2008). Drainage of water from the perched water table in a headwater swamp to the regional water table in the underlying sandstone is not expected as the sandstone bedrock is massive in structure and permeability decreases with depth (Heritage Computing, 2008). It is expected that any surface cracking that may occur would be superficial in nature (i.e. would be relatively shallow) and would terminate within the unsaturated part of the low permeability sandstone (Heritage Computing, 2008). In addition, due to the low hydraulic gradient of the water table within a swamp, lateral movement of water through the swamp towards a crack would be very small and very slow (Heritage Computing, 2008). Any changes in swamp moisture as a result of cracking are expected to be immeasurable when compared to the scale of seasonal and even individual rainfall event based changes in swamp groundwater levels (Heritage Computing, 2008).

Available data from studies undertaken by the SCA for the Kangaloon borefield supports the overall assessment that the regional aquifer is hydraulically disconnected from perched water in upland swamps (Heritage Computing, 2008). The subsidence assessment indicates that the free-draining fractured zone expected to develop at depth above the extracted coal seam is at a maximum height of approximately 155 m (i.e. approximately 265 m below the ground surface) (MSEC, 2008). Hence, the perched water in the upland swamps is not expected to be affected directly by the depressurisation of the deeper aquifer systems (Heritage Computing, 2008). To satisfy the requirements of the Dams Safety Committee and to validate the predictive assessment undertaken in the Metropolitan Coal Project Environmental Assessment, HCPL would undertake a program of geological investigation to identify geological anomalies and to inform mine planning decisions throughout the mine life. These are described in principle in the Environmental Assessment main text and would be detailed in the Subsidence Management Plan and Dams Safety Committee approval documentation.

In summary, surface cracking of this nature is not expected to result in an increase in the vertical movement of water from the perched water table into the regional aquifer (Heritage Computing, 2008). Given the above, no change to the fundamental surface hydrological processes (Gilbert and Associates, 2008) and upland swamp vegetation are expected within headwater swamps situated within the proposed underground mining area (Longwalls 20-44) and within the potential extent of mine subsidence effects. This assessment is supported by the literature on underground mining and headwater upland swamps (described in Section 4.3.3), as well as site inspections conducted by FloraSearch in headwater upland swamps that had experienced subsidence and those that had not (described in Section 4.3.4).

Tilting and Alterations to Natural Gradients

Trough-shaped subsidence profiles associated with longwall mining develop tilt between adjacent points that have subsided different amounts (NSW Scientific Committee, 2005a). Maximum ground tilts are developed above longwalls and adjacent to the edges of the area of extraction (MSEC, 2008).

The maximum predicted total systematic tilt in any of the headwater swamps within the proposed underground mining area (Longwalls 20-44) and within the potential extent of mine subsidence effects is conservatively predicted to be 7.2 mm/m (MSEC, 2008). Thirty-seven headwater swamps are predicted to have maximum total systematic tilts of less than 2 mm/m, forty-three swamps are predicted to have maximum total systematic tilts in the range 2.1 to 4 mm/m, thirty-eight swamps in the range 4.1 to 6 mm/m and three swamps are predicted to have a maximum total systematic tilt in the range 6.1 to 7.2 mm/m. The predicted tilts are expected to be comparable to what has been experienced by other headwater swamps in the Southern Coalfield and that are predicted to be experienced by swamps situated in the Longwalls 18 to 19A area at the Metropolitan Colliery (maximum predicted total systematic tilts up to 8.2 mm/m) (MSEC, 2008).

Swamp grades vary naturally and the predicted maximum mining-induced tilts are generally orders of magnitude lower than the existing natural grades within the swamps (e.g. estimated maximum natural grades of approximately 30 mm/m to 100 mm/m) (MSEC, 2008). Significant changes in grade within the swamps as a result of mining-induced tilt are not anticipated (MSEC, 2008). The predicted tilts would not have any significant affect on the localised or overall gradient of the swamp or the flow of water (Gilbert and Associates, 2008). The dominant hydrological process affecting moisture in the swamps are infiltration of incident rainfall resulting in retention of a shallow perched groundwater system in the swamp sediments, and losses to evapotranspiration. Any minor mining-induced tilting of the scale and nature predicted is not expected to significantly increase lateral surface water movements which are small in relation to the other components in the swamp water balance (Gilbert and Associates, 2008).

Given the above, no change to the surface hydrological processes (Gilbert and Associates, 2008) and therefore upland swamp vegetation are expected within headwater swamps situated within the proposed underground mining area (Longwalls 20-44) and within the potential extent of mine subsidence effects. This assessment is supported by the literature on underground mining and headwater upland swamps (described in Section 4.3.3), as well as site inspections conducted by FloraSearch in headwater upland swamps that had experienced subsidence and those that had not (described in Section 4.3.4).

4.3.5.3 In-Valley Upland Swamps

Surface Cracking

As described in Section 4.3.5.1, one in-valley upland swamp is situated outside of the proposed underground mining area (Longwalls 20-44), but within the potential extent of mine subsidence effects. The in-valley swamp (referred to as Swamp S21 by MSEC [2008]) is situated on a tributary (a third order watercourse) of Waratah Rivulet to the south of Longwall 20. This in-valley swamp overlies completed Longwalls 7 and 8 and consequently has already experienced mine subsidence from Metropolitan Colliery's existing operations.

Compressive strains greater than 2 mm/m at Metropolitan Colliery may have the potential to result in cracking, buckling and/or dilating (*ibid*.). MSEC (2008) conservatively predict that the maximum predicted systematic total compressive strains at the in-valley swamp overlying completed Longwalls 7 and 8, after the extraction of Longwalls 1 to 44 is 1.0 mm/m. This means that cracking, buckling and/or dilating as a result of systematic compressive strains is not predicted to occur as a result of the cumulative subsidence from the extraction of Longwalls 1 to 44 (i.e. systematic compressive strains less than the 2 mm/m threshold are predicted) (MSEC, 2008).

At Metropolitan Colliery, tensile strains greater than 0.5 mm/m may have the potential to result in cracking in the bedrock (MSEC, 2008). A maximum total systematic tensile strain of 1.4 mm/m at the in-valley swamp is conservatively predicted to occur and therefore there is some potential for minor cracking (MSEC, 2008). It is estimated that longwall mining to date has resulted in maximum predicted total systematic tensile strains of 1.3 mm/m at the in-valley swamp overlying completed Longwalls 7 and 8 (MSEC, 2008). As a result, the extraction of Longwalls 20 to 44 is expected to result in only a negligible change in the predicted existing systematic tensile strains (i.e. less than 1 mm/m). Any cracking of the bedrock is expected to be isolated and of a minor nature, due to the relatively low magnitudes of the predicted strains and the relatively high depth of cover (MSEC, 2008). Further, the minor cracking within the swamp areas would generally not be expected to propagate through swamp soil profiles (*ibid*.). The only locations where such cracking is expected to be observed, based on previous monitoring over the previous longwalls at the Metropolitan Colliery, are located along the higher ridge top rock outcrops (MSEC, 2008).

Similar to the nature of surface cracking in headwater swamps in the Project area, surface cracking in this in-valley swamp is not expected to result in an increase in the vertical movement of water from the perched water table into the regional aquifer (Heritage Computing, 2008). Given the above, no change to the fundamental surface hydrological processes (Gilbert and Associates, 2008) and upland swamp vegetation are expected within this in-valley swamp.

Upsidence and closure movements also have the potential to result in cracking, buckling and/or dilating (MSEC, 2008). A maximum total closure strain of 10.6 mm/m is predicted for the in-valley swamp overlying completed Longwalls 7 and 8 after the extraction of Longwalls 1 to 44 (MSEC, 2008). However, it is estimated that longwall mining to date has already resulted in a maximum total closure strain of 10.6 mm/m at this swamp (MSEC, 2008). Site inspections of this swamp indicate that there was no observable effect of previous mine subsidence on vegetation health, erosion or vegetation community composition or abundance in the swamp. However, the presence of iron staining and iron-oxidising bacteria was noted.

Tilting and Alterations to Natural Gradients

Tilting as a result of mine subsidence has the potential to change natural grades and trigger or exacerbate surface erosion events.

The maximum predicted total systematic tilt at the in-valley swamp overlying completed Longwalls 7 and 8, after the extraction of Longwalls 1 to 44, is conservatively predicted to be 8.0 mm/m (MSEC, 2008). It is estimated that longwall mining to date at this in-valley swamp has resulted in a maximum predicted total systematic tilt of 8.1 mm/m (MSEC, 2008). As a result, the extraction of Longwalls 20 to 44 is not expected to result in any effect or change which is different or goes beyond that which has already occurred.

Swamp grades vary naturally and the predicted maximum mining-induced tilts are generally one or more orders of magnitude lower than the existing natural grades within the swamps (e.g. the in-valley swamp overlying Longwalls 7 and 8 has an estimated maximum natural grade of approximately 75 mm/m) (Gilbert and Associates, 2008). Significant changes in grade within the swamps as a result of mining-induced tilt are not anticipated (MSEC, 2008). As with the headwater swamps, the predicted tilts would not have any significant affect on the localised or overall gradient of the swamp or the flow of water (Gilbert and Associates, 2008).

Site inspections indicate there is no observable effect of existing tilts from the previously completed longwall panels on vegetation health, erosion or vegetation community composition or abundance in the swamp overlying completed Longwalls 7 and 8.

Given the above, no change to the hydrological or hydrogeological processes (Gilbert and Associates, 2008; Heritage Computing, 2008) and therefore to upland swamp vegetation are expected within this in-valley swamp.

4.4 OTHER DIRECT OR INDIRECT POTENTIAL IMPACTS ON VEGETATION

Vegetation Clearance

The Project would include some vegetation clearance. Clearing of native vegetation is listed as a key threatening process under the TSC Act and land clearance is listed as a key threatening process under the EPBC Act.

Vegetation clearance activities would primarily be associated with ongoing surface exploration activities, the upgrade and extension of surface infrastructure, access tracks, environmental monitoring and management activities (e.g. installation of monitoring equipment), stream restoration activities and other minor Project-related surface activities. A ventilation shaft would be constructed in the north-east of the Project area. The approximate location of the ventilation shaft (Ventilation Shaft No. 4) is shown on Figure 2. The specific location of the ventilation shaft would be determined during the detailed design of the Project ventilation system. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required.

The Project area is greater than 2,000 hectares in size. The proposed surface disturbance would occupy only very small areas of the surface. It is estimated that the Project would involve less than 10 hectares of proposed vegetation clearance. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some small areas are likely to be disturbed (in the order of two hectares), while previously disturbed areas would be in various stages of rehabilitation. To minimise impacts on terrestrial vegetation, vegetation clearance would generally be restricted to the slashing of vegetation (i.e. leaving the lower stem and roots *in-situ* to maximise the potential for natural regrowth) and lopping of branches, where practicable, rather than the removal of soils or trees.

Vegetation clearance (associated with Project works such as stream restoration activities, the establishment of monitoring stations and other surface facilities) would be managed through the development and implementation of a Flora and Fauna Management Plan (FFMP) under the Part 3A Approval which would require locality surveys for threatened flora species prior to disturbance and relocation of works, where feasible, to avoid or minimise impacts on any threatened species population. In the event field inspections identify individuals of a threatened species within a proposed disturbance area that are not practicable to avoid, the potential impacts of the proposed works on the population of the threatened species would be assessed. In the event the proposed surface activities are considered likely to have a significant impact on a population of the threatened species listed under the TSC Act or EPBC Act, the proposed works would be modified to avoid such an outcome. However, given the nature of the proposed activities requiring vegetation clearance, it is anticipated that the majority of activities would be able to avoid disturbance to individuals of a threatened species. Access to these sites would typically be by helicopter or on foot from existing SCA roads/tracks. The FFMP would be developed in consultation with the DECC, SCA and to the satisfaction of the DoP. Given the localised nature of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils EEC, Project infrastructure (including surface works such as surface exploration activities, access tracks, and environmental monitoring equipment) would be located to avoid vegetation clearance in the EEC.

Weeds

Many weed species are effective competitors for resources and have the potential to reduce the floristic structure and diversity of native plant communities. Introduced plant species in the Project area are largely confined to disturbed sites (Bangalay Botanical Surveys, 2008), including fire roads, cleared areas in the north east of the Project area and along the verges of the F6 Freeway and Princes Highway. Bangalay Botanical Surveys (2008) noted that the incidence of introduced species along fire roads in the Woronora Special Area involved infrequent occurrences of widespread, common species in low numbers. In general, introduced species are absent from all areas of undisturbed natural habitat in the Woronora Special Area. There is potential for introduced species to invade areas of disturbed soils in the Project area. However, it is unlikely that introduced species would invade intact natural habitats in the absence of soil disturbance. Soil and weed management measures for surface activities in the Woronora Special Area would be developed in consultation with the SCA and included in the FFMP.

Introduced Plant Pathogen, Phytophthora cinnamomi

Infection of native plants by *Phytophthora cinnamomi* is listed as a key threatening process under the TSC Act and dieback caused by the root-rot fungus (*Phytophthora cinnamomi*) is listed as a key threatening process under the EPBC Act. *Phytophthora cinnamomi* is a soil borne pathogen and infection of native plants by *P. cinnamomi* can result in the death of plants and reduction in habitat complexity (NSW Scientific Committee, 2002a). The reproductive structures that spread *P. cinnamomi* (sporangia and clamydospores) form on vegetative mycelia in soil and plant roots in warm, moist conditions (*ibid*.). The spread of *P. cinnamomi* occurs through movement of spores which may swim to new hosts or be dispersed over large distances in flowing water, such as storm runoff (NSW Scientific Committee, 2002a). Some spread within a site may be by mycelial growth from infected roots to roots of healthy plants. Propagules of *P. cinnamomi* may also be dispersed by vehicles (e.g. cars and earth moving equipment) used in a range of activities (e.g. transport, road making and maintenance), animals (e.g. feral pigs) and walkers. In all these cases, movement of *P. cinnamomi* involves infected soil and/or root material. Project-related activities have the potential to introduce or spread the infection of native plants by *P. cinnamomi.* A FFMP would be prepared for the Project and would include measures for the management of *P. cinnamomi* within the Project area, consistent with the Department of the Environment and Heritage (DEH) (2006a) *Management of Phytophthora cinnamomi for Biodiversity Conservation in Australia.*

Dust and Vegetation

Studies have shown that excessive dust generation can impact on the health and viability of surrounding vegetation (e.g. Farmer, 1993; Eller, 1977). Surface activities associated with the Project (e.g. the operation of the CHPP [including conveying, stockpiling and crushing activities], construction and development activities, windblown emissions from exposed stockpiles, product coal and coal reject handling and surface operation of mine mobile fleet) have the potential to result in the generation and dispersion of atmospheric dust. The potential effect of dust caused by the Project on the health and viability of surrounding vegetation would be localised. It is relevant to note the Project is situated in a relatively high rainfall area with a mean annual rainfall of 1,419 mm recorded at Darkes Forest which is more or less spread evenly throughout the year (Bureau of Meteorology, 2007b). Notwithstanding, a range of dust control measures would be employed at the major surface facilities area including the watering of potential dust generating surfaces. The potential for dust generation in the proposed underground mining area and surrounds is expected to be low. Vehicle access in the Woronora Special Area would be via existing fire trails and HCPL personnel and contractors would be required to observe speed limits (current speed limit of 40 km/hr) when using the fire trails.

Fire

Human access to the Woronora Special Area as a result of the Project has the potential to result in an increase in the frequency of bushfire. High frequency fire is listed as a key threatening process in the TSC Act (NSW Scientific Committee, 2000a). A range of management measures would be implemented for the Project to minimise the potential for bushfire.

Greenhouse Gas Emissions and Climate Change Effects

There is increased scientific certainty that there has been significant growth in greenhouse gases from human activity and that this is having a detrimental effect on the environment. Increased greenhouse gas levels have altered the interaction amongst climate variables such as cloud cover, rainfall, wind patterns, ocean currents, sea levels and the distribution of plant and animal species. The distribution of most species, populations and communities is influenced by climate (NSW Scientific Committee, 2000b). Human-caused Climate Change is listed as a key threatening process under the TSC Act and Loss of Climatic Habitat Caused by Anthropogenic Emissions of Greenhouse Gases is listed as a key threatening process under the EPBC Act.

Greenhouse gas emissions associated with direct emission sources (e.g. the use of fixed and mobile plant and fugitive coal seam gas emissions), indirect emission sources (e.g. the use of electricity) and other indirect emissions (e.g. the transport of coal and rejects, emissions associated with the burning of coal in domestic and international power stations and the use of coal for off-site coke and subsequent steel and iron production) have been assessed for the Project by Holmes Air Sciences (2008). Holmes Air Sciences (2008) estimate that on average over the 23 years of mining, Metropolitan Colliery would directly release 0.26 Mt per year of CO_2-equivalent emissions and 0.15 Mt per year of CO_2-equivalent emissions would be released indirectly due to on-site use of fuel and electricity. It is estimated that 8.08 Mt per year would be released by other parties through the export and end use of the coal. Measures to minimise greenhouse gas emissions are described in Section 4 of the Environmental Assessment main report (e.g. improvements to maximise efficiency of the use of fuels and minimise electricity consumption).

The *Climate Change - An Australian Guide to the Science and Potential Impacts* (Pittock, 2003) describes climate change projections for Australia. In eastern Australia, the El Niño-Southern Oscillation leads to alternations between floods and prolonged droughts and there is a possibility that climate change will result in a more El Niño-like state (*ibid*.). Annual average temperatures in Australia are expected to increase by 0.4 to 2.0°C by 2030, and 1.0 to 6.0°C by 2070 (relative to 1990) and evaporation and heatwaves are expected to increase and frosts to decrease (*ibid*.).

In parts of south-eastern Australia annual rainfall is expected to change by -10% to +5% by 2030 and -35% to +10% by 2070 (Pittock, 2003). Based on the expected changes in rainfall and evaporation, soil moisture is likely to decrease and droughts are likely to become more severe (*ibid*.). An increase in the intensity of heavy rain events is also expected (*ibid*.). Sea level would also continue to rise (Pittock, 2003). Further to this, the *Carbon Pollution Reduction Scheme Green Paper* (Department of Climate Change, 2008) released in July 2008 updates the climate change predictions for Australia. A rise in average temperatures of up to 5^{o}C by 2070 across Australia is predicted under a scenario of high emissions (Department of Climate Change, 2008).

The potential effects of climate change on the nature and extent of the Project potential impacts has been considered including those relating to groundwater (Heritage Computing, 2008) and surface water (Gilbert and Associates, 2008). Heritage Computing (2008) indicates the Project is likely to have a negligible incremental effect on baseflow and that the anticipated climate change effects on baseflow in the Woronora Special Area are far greater than any changes in baseflow induced by mining (i.e. by more than two orders of magnitude). Gilbert and Associates (2008) indicate that climate change would produce more pronounced seasonal patterns of runoff in the region with increasing amounts of runoff occurring in the summer and less in the autumn, winter and spring. Relative to the current streamflows, which are more winter dominated, this might lead to a more uniform pattern of flows through the year (*ibid*.). Overall there would also be a tendency for reduced overall streamflow but with an increase in larger flow events in summer. These effects would occur irrespective of any effects of longwall mining in the catchment (Gilbert and Associates, 2008). Longwall mining is predicted to have localised effects on pools and the frequency of interconnected flows between pools. A climate change induced decrease in annual average rainfall and rainfall frequency has the potential to result in a reduction in low flow persistence, an increase in the frequency of low pool water levels and a reduction in inter-pool connection (*ibid*.). The predicted small increase in summer rain and rainfall intensity might increase low flow persistence in summer which is likely to be the currently dominant time for low pool water levels and loss of inter-pool connection (Gilbert and Associates, 2008). Climate change induced reductions in winter and spring rainfall would be expected to result in a significant change to the flow regime irrespective of any mining impacts (*ibid*.). As a result, the potential direct effects of the Project on riparian vegetation, which are expected to be minor and limited in extent, are unlikely to significantly exacerbate the expected effects of climate change.

Threatened Flora

Evaluations have been conducted to assess potential impacts of the Project, including direct, indirect and cumulative potential impacts, on threatened flora species, populations, ecological communities, and their habitats. The evaluations were conducted in accordance with the Draft *Guidelines for Threatened Species Assessment* (DEC and DPI, 2005), which identify important factors that must be considered when assessing potential impacts on threatened species, populations, or ecological communities, or their habitats for development applications assessed under Part 3A of the EP&A Act (Department of Environment and Conservation [DEC] and Department of Primary Industries [DPI], 2005). These evaluations are provided in Section 4.5.

Matters of National Environmental Significance

Evaluations have been conducted to assess potential impacts of the Project, including direct, indirect and cumulative potential impacts, on matters of national environmental significance. The evaluations are based on the *Significant Impact Guidelines – Matters of National Environmental Significance* (DEH, 2006b). These evaluations are provided in Section 7.

Flora Management

A FFMP would be developed for the Project. The management plan would include the following in relation to other Project direct and indirect impacts on vegetation:

- measures to minimise impacts on vegetation;
- measures to avoid or minimise impacts to threatened flora;
- environmental management of sites where vegetation removal is necessary;
- *P. cinnamomi* management measures;
- soil and weed management measures;
- bushfire management measures; and
- natural regeneration and rehabilitation measures.

The FFMP would be developed in consultation with the SCA for activities conducted in the Woronora Special Area.

4.5 THREATENED FLORA

This flora and fauna impact assessment has been prepared in accordance with the Draft *Guidelines for Threatened Species Assessment* (DEC and DPI, 2005), which identify important factors that must be considered when assessing potential impacts on threatened species, populations, or ecological communities, or their habitats for development applications assessed under Part 3A of the EP&A Act (DEC and DPI, 2005).

To assist in identifying whether the potential impacts of the Project are likely to have a significant effect on threatened flora, evaluations were conducted. These evaluations were based on the Draft *Guidelines for Threatened Species Assessment* (DEC and DPI, 2005) and included consideration of the following items:

- How is the proposal likely to affect the lifecycle of a threatened species and/or population?
- How is the proposal likely to affect the habitat of a threatened species, population or ecological community?
- Does the proposal affect any threatened species or populations that are at the limit of its known distribution?
- How is the proposal likely to affect current disturbance regimes?
- How is the proposal likely to affect habitat connectivity?
- How is the proposal likely to affect critical habitat?

Evaluations were conducted for threatened flora recorded in the proposed underground mining area or surrounds as well as for other threatened flora for which potential habitat occurs.

The evaluations for EECs are provided in Section 4.5.1, for endangered populations in Section 4.5.2 and for threatened flora species in Section 4.5.3.

4.5.1 Endangered Ecological Communities

4.5.1.1 *Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion*

Southern Sydney sheltered forest on transitional sandstone soils EEC is dominated by Sydney Red Gum, *Angophora costata*, Sydney Peppermint, *Eucalyptus piperita* and to a lesser extent Blackbutt, *Eucalyptus pilularis* (DECC, 2008b). The community has some subcanopy trees characteristic of moist, fertile environments including *Acacia binervata*, *Elaeocarpus reticulatus* and *Pittosporum undulatum*. The shrub layer is diverse and the ground layer comprises a mid-dense cover of ferns, forbs, herbs, grasses, lilies and rushes.

The community is associated with transitional sandstone soils with a strong upslope shale or ironstone influence and typically occurs on upper slopes and sheltered gully heads near eroding shale or ironstone caps (DECC, 2008b).

Threats relevant to the Southern Sydney sheltered forest on transitional sandstone soils EEC include small scale clearing and fragmentation (transport and utility corridors), weed invasion, frequent fires and grazing by the Rusa Deer (DECC, 2008b).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Not applicable. Refer to Question 2 below.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Southern Sydney sheltered forest on transitional sandstone soils EEC occurs in a limited area in the east of the study area in the vicinity of the F6 Southern Freeway and to the south of the proposed underground mining area adjacent to the O'Hares Creek Shale Forest EEC (Figure 3) (Bangalay Botanical Surveys, 2008). Only one patch occurs in the proposed underground mining area (in the north-east of the Project area), adjacent to Exposed Sandstone Scribbly Gum Woodland on a sandstone plateau and Sandstone Gully Apple-Peppermint Forest.

Potential impacts of the Project on the Southern Sydney sheltered forest on transitional sandstone soils EEC are summarised in Sections 4.2 and 4.4. The north-east occurrence of the Southern Sydney sheltered forest on transitional sandstone soils EEC is located in an area where the longwall depth of cover is approximately 420 m. Surface cracking as the result of systematic subsidence movements at these depths of cover is expected to be isolated and of a minor nature due to the relatively low magnitudes of the predicted strains and the relatively high depths of cover. Further, the maximum predicted systematic tilt is small when compared to the existing natural surface gradients (Section 4.2). The magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes in this area, therefore it is unlikely that subsidence effects would have any biologically significant effect on the soil moisture regime that sustains the EEC in this area (Section 4.2). As a result, it is unlikely that the EEC would be adversely affected by mine subsidence. Given the localised nature of the EEC, Project infrastructure would be located to avoid it. In accordance with the FFMP, all proposed infrastructure sites would be surveyed for threatened flora species, populations and communities prior to disturbance and works relocated as described in Section 4.4. In addition, the FFMP would contain protocols for minimising the risk of spread of *Phytophthora cinnamomi* and weeds in the Project area. The FFMP would also address the proposed management of pest fauna species (e.g. Rusa Deer). The management measures would be developed in consultation with the SCA for activities in the Woronora Special Area.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Southern Sydney sheltered forest on transitional sandstone soils EEC occurs in a limited area bounded by Hurstville, Carrs Park, Bundeena, Otford, Stanwell Tops, Darkes Forest, Punchbowl Creek and Menai (DECC, 2008b). The Project lies within the known distribution of the community.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most relevant to the Project area is fire. High frequency fire is listed as a key threatening process under the TSC Act (NSW Scientific Committee, 2000a). Given the range of management protocols, including bushfire management measures, proposed to be in place to manage the behaviour of people in the Project area, it is unlikely there would be an increase in fire frequency resulting from the Project.

Introduced plant species in the Project area are largely confined to disturbed sites (Bangalay Botanical Surveys, 2008), including fire roads, cleared areas in the north east of the Project area and along the verges of the F6 Freeway and Princes Highway. Bangalay Botanical Surveys (2008) noted that the incidence of introduced species along fire roads in the Woronora Special Area involved infrequent occurrences of widespread, common species in low numbers. In general, introduced species are absent from all areas of undisturbed natural habitat in the Woronora Special Area. There is low potential for introduced species to invade areas of the Southern Sydney sheltered forest on transitional sandstone soils EEC as a result of the Project as the EEC would be avoided for the siting of Project infrastructure.

Disease in natural ecosystems of Australia, caused by the introduced plant pathogen *Phytophthora cinnamomi*, is listed as a key threatening process under the TSC Act and EPBC Act. *P. cinnamomi* has been known to cause the decline of plant populations and habitat quality over wide areas of Australia where the rainfall exceeds 600 mm per annum (O'Gara *et al.*, 2005). However, it should be noted that *P. cinnamomi* has not often been reported as a serious problem in NSW by contrast with more southern areas in Western Australia, Victoria and Tasmania (O'Gara *et al*., 2005). In view of the potential threat of *P. cinnamomi*, the FFMP for the Project would include a range of measures to minimise the potential for the introduction or spread of *P. cinnamomi* in the Project area. The most likely means of spreading *P. cinnamomi* is in mud on vehicles, mainly 4WDs and equipment that have recently been in infected areas, and on similarly infected soiled footwear and tools. Measures for the management of *P. cinnamomi* within the Project area would be consistent with the DEH (2006a) *Management of Phytophthora cinnamomi for Biodiversity Conservation in Australia.*

Disturbance relating to mine subsidence is described in Question 2 above.

5. How is the proposal likely to affect habitat connectivity?

The occurrence of the Southern Sydney sheltered forest on transitional sandstone soils EEC in the Project area is naturally isolated from other occurrences of the same community by other vegetation types. Accordingly, the species that uniquely define this community are also restricted to the existing occurrence. Given the localised nature of the EEC, Project infrastructure would be located to avoid it. In accordance with the FFMP, all proposed infrastructure sites would be surveyed for threatened flora species, populations and communities prior to disturbance and relocation of works as described in Section 4.4. The Project would not result in loss of connectivity for the Southern Sydney sheltered forest on transitional sandstone soils EEC.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Southern Sydney sheltered forest on transitional sandstone soils EEC. There is no critical habitat as listed on the NPWS Critical Habitat Register (NPWS, 2008) or the DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

4.5.2 Endangered Populations

Twenty three endangered flora populations are currently (June 2008) listed under the TSC Act. None occur in the Project area.

4.5.3 Threatened Flora Species

The baseline flora survey conducted by Bangalay Botanical Surveys (2008) targeted a comprehensive list of 28 threatened flora species for field searches. The targeted species included all threatened flora for which it was considered potential habitat may occur in the study area. Many of the targeted species have not previously been recorded on the Woronora Plateau or in close proximity to it, but occur in similar habitats to the north or south. Other species occur naturally close to the Woronora Plateau, but in somewhat different habitats to those on the study area. The assessment in this section is confined to threatened flora species either known to occur on the Woronora Plateau, or whose distributions include similar habitats both to the north and south giving a reasonable expectation that potential habitat is likely to occur in the study area. Table 6 lists 16 targeted species excluded from this assessment, with reasons for their exclusion, and Table 7 lists the 12 assessed species with reasons for their inclusion.

Table 6
Threatened Flora Species Excluded from Further Assessment

Scientific Name	Common Name	Reasons for Exclusion
Acacia pubescens	Downy Wattle	Confined to the Cumberland Plain, particularly to shale/sandstone transition soils.
Boronia deanei	Deane's Boronia	Tableland species only.
Caladenia tessellata	Tesselated Spider Orchid	Mainly near coastal, not on sandstone plateaux areas.
Callistemon linearifolius	Netted Bottle Brush	Confined to shale and Permian clay soils. Occurs on margins of Woronora Plateau, but not on it.
Cryptostylis hunteriana	Leafless Tongue Orchid	Coastal lowland species in southern NSW.
Grammitis stenophylla	Narrow-leaf Finger Fern	No records in surrounding area. Mainly north of Parramatta River. Habitat of mossy boulders unlikely to be present.
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	Occurs on shale/sandstone transition soils on Cumberland Plain and western edge of the Woronora Plateau.
Haloragis exalata var. *exalata*	Square Raspwort	Mainly coastal lowlands on rainforest margins and moist creeks.
Hibbertia puberula	-	Few records, all coastal or Cumberland Plain, absent from sandstone plateaux.
Lasiopetalum joyceae	-	Restricted distribution north of Parramatta River.
Persoonia mollis subsp. *maxima*	-	A narrow range endemic confined to a small area north of Sydney.
Prasophyllum affine	Jervis Bay Leek Orchid	Confined to Jervis Bay area on coastal sedgeland-heath.
Prostanthera densa	Villous Mintbush	Confined to coastal clifftops and headlands.
Pterostylis saxicola	Sydney Plains Greenhood	Confined to Cumberland Plain, mainly shale/sandstone transitional soils on the margins.
Tetratheca glandulosa	-	Only occurs north of the Parramatta River.
Thesium australe	Austral Toadflax	Occurs in grassy woodland, especially that dominated by Kangaroo Grass, *Themeda australis*. Habitat unlikely in Project area.

The potential impacts of the Project on four threatened species positively identified, and two that were tentatively identified, on or near the Project area during the baseline flora survey (Bangalay Botanical Surveys, 2008) are considered below in individual assessments. These are *Pultenaea aristata*, *Astrotricha crassifolia, Acacia bynoeana*, *Melaleuca deanei*, *Epacris purpurascens* var. *purpurascens* and *Leucopogon exolasius*. The remaining six species in Table 7 are considered in two groups of three for assessment since each group occurs in similar habitats on sandstone plateaux, namely sandstone rock plates or sandstone plateau woodlands.

Table 7
Threatened Flora Species Considered in this Assessment

Scientific Name	Common Name	Reasons for Inclusion	Broad Habitat Class
Acacia baueri subsp. *aspera*	-	Known on Woronora Plateau	Sandstone rock plates
Acacia bynoeana	Bynoe's Wattle	Known on Woronora Plateau	Sandstone plateau heath/ woodland
Astrotricha crassifolia	Thick-leaf Star-hair	Known on Woronora Plateau	Sandstone gully/riparian
Darwinia biflora	-	Known on Woronora Plateau	Sandstone plateau heath/ woodland
Darwinia peduncularis	-	Widespread on rock plates, may occur on Woronora Plateau	Sandstone rock plates
Epacris purpurascens var. *purpurascens*		Known on Woronora Plateau	Swamp margins, gullies, riparian
Eucalyptus camfieldii	Camfield's Stringybark	Known on Woronora Plateau	Sandstone plateau heath/ woodland
Genoplesium baueri	Bauer's Midge Orchid	Known on Woronora Plateau	Sandstone rock plates
Leucopogon exolasius	Woronora Beard-heath	Known on Woronora Plateau	Sandstone gully/riparian
Melaleuca deanei	Deane's Paperbark	Known on Woronora Plateau	Sandstone plateau heath/woodland
Persoonia hirsuta subsp. *hirsuta*	-	Known on Woronora Plateau	Sandstone plateau heath/woodland
Pultenaea aristata	Prickly Bush-pea	Known on Woronora Plateau	Swamp margins, sandstone plateau heath/woodland, gullies

4.5.3.1 Prickly Bush-pea (Pultenaea aristata)

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The Prickly Bush-pea is a small erect shrub, usually less than 40 cm tall, with leaves 8–22 mm long and 1-2 mm wide (DECC, 2008c; Benson and McDougall, 1996a; Sydney Royal Botanic Gardens, 2008). The species has linear leaves with a distinctive long bristle tapering to a sharp point. Flowers of the Prickly Bush-pea appear in yellow to light orange terminal heads between September and October (Benson and McDougall, 1996a; Fairley and Moore, 2000).

During recent targeted surveys within the Project area and surrounds, the Prickly Bush-pea was recorded by Bangalay Botanical Surveys (2008) in vegetation map units 1a, 1b, 1r, 2a, 2b, 2c, 2r, 3c, 3d, 4a, 6a, 6r and 7b (Figures 3 and 4). However, while this species was recorded in a range of vegetation communities, within the study area it is more commonly found in damp sites in heath, and along the fringes of upland swamps (Bangalay Botanical Surveys, 2008).

The main threats to the Prickly Bush-pea include inappropriate fire regimes, understorey clearing, road widening and easement maintenance practices (DECC, 2008c). Habitat alteration by longwall mining is also considered a threat to this species (NSW Scientific Committee, 2005a).

Potential impacts of the Project on flora are summarised in Sections 4.1 to 4.4. Prickly Bush-pea occurs very widely within the Project area and surrounds (Bangalay Botanical Surveys, 2008) (Figure 4) with additional populations located by FloraSearch. The species is locally common within the study area. Given this, it is considered highly unlikely that the Project would impact significantly on the species. Sections 4.1 to 4.4 indicate that the effects of ridgetop tension cracks and rock falls on ridgetops and slopes are likely to be minor.

The magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes on ridgetops/slopes and in upland swamps and is unlikely to have any biologically significant effect on the soil moisture regime that sustains vegetation in these areas. Mine subsidence has the potential to affect moisture availability to plants in the riparian zone which may result in dieback or death of some plants close to the stream channel. The studies summarised in Section 4.1 indicate that the occurrence of plant dieback or death in the riparian zone of Waratah Rivulet in previously mined areas has been localised and limited in extent (e.g. dieback has been observed in some areas of the stream bank on Waratah Rivulet to be restricted to a fringe approximately 10 cm wide), with most plants recovering upon the return of stream flows. Further, only very small proportions of the *Pultenaea aristata* populations occur in the riparian zone. Most of the populations of the species occur on the adjoining slopes and in upland swamps. As a result, there are no potential mechanisms for disrupting the lifecycle, apart from small amounts of vegetation clearance for surface infrastructure (e.g. ventilation shaft, exploration and monitoring boreholes, monitoring equipment and access tracks). Vegetation clearance would be managed through the development and implementation of a FFMP for the Project. This would require surveys for threatened flora species prior to disturbance and relocation of works to avoid disruption to Prickly Bush-pea populations as described in Section 4.4. Prickly Bush-pea is often present along tracks and in disturbed areas such as powerline easements (Bangalay Botanical Surveys, 2008). It is possible that increased track maintenance due to additional mine related traffic may impact on individuals of the species. However, this is unlikely to lead to the loss of local populations.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Prickly Bush-pea grows in low nutrient sandstone soils in both moist and dry areas (Threatened Species Scientific Committee, 2008a). The Prickly Bush-pea is often associated with the upland swamp vegetation complex (NPWS, 2003a) and has been recorded from several locations within the sub-communities of Banksia Thicket and Restioid Heath (Threatened Species Scientific Committee, 2008a). The species is also known to occur in association with areas of impeded drainage and creek lines within sandstone woodland and gully forest plant communities (NPWS, 2003a). As indicated above it is highly unlikely that the upland swamp habitats of Prickly Bush-pea would be modified by subsidence and the effects of mine subsidence on riparian vegetation would be localised and limited in extent. As described in Section 4.4, Project infrastructure would occupy only very small areas of the surface. Vegetation clearance would be managed through the development and implementation of a FFMP which would require surveys for threatened flora species prior to disturbance and relocation of works to avoid disruption to any threatened species population (refer Section 4.4). The Project is therefore unlikely to significantly reduce the quality or availability of habitat for the Prickly Bush-pea.

Introduced plant species in the Project area are largely confined to disturbed sites (Bangalay Botanical Surveys, 2008), including fire roads, cleared areas in the north east of the Project area and along the verges of the F6 Freeway and Princes Highway. Bangalay Botanical Surveys (2008) noted that the incidence of introduced species along fire roads in the Woronora Special Area involved infrequent occurrences of widespread, common species in low numbers.

In general, introduced species are absent from all areas of undisturbed natural habitat in the Woronora Special Area. There is potential for introduced species to invade areas of disturbed soils in the Project area. However, it is unlikely that introduced species would invade intact natural habitats in the absence of soil disturbance. The FFMP would describe measures to be implemented to minimise soil disturbance and the spread of weeds.

Disease in natural ecosystems of Australia, caused by the introduced plant pathogen *Phytophthora cinnamomi*, is listed as a key threatening process under the TSC Act and EPBC Act. *P. cinnamomi* has been known to cause the decline of plant populations and habitat quality over wide areas of Australia where the rainfall exceeds 600 mm per annum (O'Gara *et al.*, 2005). However, it should be noted that *P. cinnamomi* has not often been reported as a serious problem in NSW by contrast with more southern areas in Western Australia, Victoria and Tasmania (O'Gara *et al*., 2005). In view of the potential threat of *P. cinnamomi*, the FFMP for the Project would include a range of measures to minimise the potential for the introduction or spread of *P. cinnamomi* in the Project area. The most likely means of spreading *P. cinnamomi* is in mud on vehicles, mainly 4WDs and equipment that have recently been in infected areas, and on similarly infected soiled footwear and tools. Measures for the management of *P. cinnamomi* within the Project area would be consistent with the DEH (2006a) *Management of Phytophthora cinnamomi for Biodiversity Conservation in Australia.*

The Project may increase the frequency of fire trail maintenance measures due to the increase in vehicular traffic in the Woronora Special Area. However, road/track maintenance measures would continue to maintain the existing easement and would not require additional clearance.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Prickly Bush-pea is endemic to the Woronora Plateau in NSW, between Helensburgh and Mount Keira (Threatened Species Scientific Committee, 2008a).

The Project is located within the known distribution of the Prickly Bush-pea and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

Current natural disturbance regimes relevant to the Prickly Bush-pea are fire and drought, which are also related to each other. It has been suggested that mine subsidence may potentially increase the intensity of fire in upland swamps by making the swamp vegetation more flammable (NSW Scientific Committee, 2005a). High frequency fire is listed as a key threatening process under the TSC Act (NSW Scientific Committee, 2000a). However, changes to swamp hydrology as a result of mine subsidence are highly unlikely (Section 4.3.5). Further, given the range of management protocols, including bushfire management measures, proposed to be in place to manage the behaviour of people in the Project area, it is unlikely there would be an increase in fire frequency resulting from the Project.

Issues related to human-related disturbance are discussed in Question 2.

5. How is the proposal likely to affect habitat connectivity?

No Project related factors are likely to alter habitat connectivity for the Prickly Bush-pea. Only small isolated areas of vegetation clearance would be required for surface infrastructure including ventilation shafts and monitoring boreholes. There is already a network of firetrails managed by the SCA and no further roads would be required, apart from possible short temporary access tracks from the main trails to infrastructure. Such access tracks would involve minimal disturbance to vegetation, and would be closed when no longer needed and allowed to regenerate from the soil seed bank, such that habitat connectivity would not be significantly affected.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for *Pultenaea aristata*. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or the DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

4.5.3.2 Bynoe's Wattle (Acacia bynoeana)

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Bynoe's Wattle is an erect or spreading shrub, 0.2 – 1 m high (Morrison and Davies, 1991) and a low prostrate shrub to 50 cm across (Morrison and Davies, 1991; Benson and McDougal, 1996b; Tame, 1992). The leaves are covered in coarse hairs (NPWS, 1999a).

Bynoe's Wattle flowers from September until March and the fruit matures from November to January with the peak fruit maturation occurring in November (NPWS, 1999a). Seeds are shed at maturity (Benson and McDougal, 1996b). Seed production is considered to be minimal, seedlings are rare (S. Douglas pers. comm. in NPWS, 1999a) and there is thought to be little local dispersal of seed (Benson and McDougal, 1996b). The species is considered likely to resprout from rootstock after fire, and maintains a long-term soil-stored seedbank (Benson and McDougal, 1996b). Plants may not always be apparent and appear periodically, perhaps in response to local disturbance (NPWS, 1999a).

During recent targeted surveys within the Project area and surrounds, the Bynoe's Wattle was recorded by Bangalay Botanical Surveys (2008) in sandstone heath-woodland (Figure 4).

The main threats to Bynoe's Wattle include habitat disturbance (including road, trail and powerline maintenance and recreational vehicle use), clearing, weed invasion and frequent fire. Due to the fragmented nature of populations, their small size, fire mitigation activities and the proximity of urbanisation, the species is considered to be susceptible to catastrophic events and localised extinction (NSW Scientific Committee, 1998b). It is considered important that *A. bynoeana* populations, which seem to preferentially inhabit trail margins, be protected from excessive habitat disturbance such as road works, clearing or high frequency fires (NPWS, 1999a).

Because local populations of Bynoe's Wattle are often very small, even quite restricted disturbance events can potentially eliminate a local population. Such events may include vegetation clearance for the installation of surface infrastructure (e.g. ventilation shaft, exploration and monitoring boreholes, monitoring equipment and access tracks). Disruption of local populations of Bynoe's Wattle would be avoided by implementing a FFMP requiring, among other things, surveys for threatened flora species prior to disturbance, and relocation of works as necessary.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

Bynoe's Wattle occurs mainly in heath and dry sclerophyll forest (Morrison and Davies, 1991). The substrate is typically sand and sandy clay, often with ironstone gravels and is usually very infertile and well-drained (NPWS, 1999a). The species seems to prefer open, sometimes slightly disturbed sites such as trail margins, edges of roadside spoil mounds (from grading) and recently burnt open patches (S. Douglas pers. comm. in NPWS, 1999a; Benson and McDougall, 1996b). Associated overstorey species often include *Corymbia gummifera, Eucalyptus haemastoma, E. parramattensis, E. sclerophylla, Banksia serrata* and *Angophora bakeri*. Shrubs often associated with Bynoe's Wattle include *B. spinulosa, B. serrata, A. oxycedrus, A. myrtifolia* and *Kunzea* spp. (Winning, 1992; James, 1997).

The Project area and surrounds offers known and potential habitat resources for Bynoe's Wattle. Habitat for this species occurs on broad ridges and plateaux, where subsidence effects are highly unlikely to significantly disturb habitat for this species (refer to discussion in Sections 4.1 to 4.4). Reduction of potential habitat for Bynoe's Wattle due to surface infrastructure would be very small in comparison with the amount of habitat available. It is considered that the Project would not have a significant impact on the locally available habitat for the Bynoe's Wattle.

The Project may increase the frequency of fire trail maintenance measures due to the increase in vehicular traffic in the Woronora Special Area and this has the potential to disturb trackside populations of Bynoe's Wattle. However, road/track maintenance measures would continue to maintain the existing easement and would not require additional clearance.

Introduced plant species in the Project area are largely confined to disturbed sites (Bangalay Botanical Surveys, 2008), including fire roads, cleared areas in the north east of the Project area and along the verges of the F6 Freeway and Princes Highway. In general, introduced species are absent from all areas of undisturbed natural habitat in the Woronora Special Area. The FFMP to be developed for the Project would include measures to minimise soil disturbance and the spread of weeds.

In view of the potential threat of *P. cinnamomi*, the FFMP for the Project would include a range of measures to minimise the potential for the introduction or spread of *P. cinnamomi* in the Project area. The most likely means of spreading *P. cinnamomi* is in mud on vehicles, mainly 4WDs and equipment that have recently been in infected areas, and on similarly infected soiled footwear and tools. Measures for the management of *P. cinnamomi* within the Project area would be consistent with the DEH (2006a) *Management of Phytophthora cinnamomi for Biodiversity Conservation in Australia.*

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Bynoe's Wattle is endemic to central eastern NSW and occurs in an area from the Hunter district on the Central Coast south to the Southern Highlands (Morrison and Davies, 1991). The stronghold of the species' distribution is in the Blue Mountains area (Winning, 1992). The species was known from 34 locations and the number of individuals within each of these locations is typically only 1-5 plants. Only a few sites exist with 30-50 individuals. The total population was estimated to consist of only a few hundred plants (NSW Scientific Committee, 1998b). The species has recently been found in the Colymea and Parma Creek areas west of Nowra (DECC, 2008d).

The Project is located within the known distribution of the Bynoe's Wattle and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The Project would have a limited affect on current disturbance regimes. High frequency fire is listed as a key threatening process under the TSC Act (NSW Scientific Committee, 2000a) and is relevant to the Bynoe's Wattle. Given the range of management protocols, including bushfire management measures, proposed to be in place to manage the behaviour of people in the Project area, it is unlikely there would be an increase in fire frequency resulting from the Project.

Issues related to human-related disturbance are discussed in Question 2.

5. How is the proposal likely to affect habitat connectivity?

Bynoe's Wattle occurs in heath and woodland, which is mainly on the plateaux and ridgetops of the Project area, where connectivity of potential habitat for the species is high. Roads and tracks may potentially reduce habitat connectivity. A network of SCA roads and tracks currently exists. The Project would result only in a small increase in access tracks to localised surface infrastructure. Disruption of local populations of Bynoe's Wattle would be avoided by implementing a FFMP requiring, among other things, surveys for threatened flora species prior to disturbance and relocation of works as necessary (refer Section 4.4). Damage to vegetation would be minimised and tracks would be closed and vegetation allowed to regenerate once they are no longer needed.

There is unlikely to be any significant change in habitat connectivity for Bynoe's Wattle due to the Project.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for *Acacia bynoeana*. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or the DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

4.5.3.3 Thick-leaf Star-hair (Astrotricha crassifolia)

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The Thick-leaf Star-hair is an erect shrub growing to 2.4 m high (Carolin and Tindale, 1993; Henwood and Makinson, 2007) and can grow from suckers (Carolin and Tindale, 1993) which are reported to be produced in response to fire (Benson and McDougall, 1993). The Thick-leaf Star-hair flowers in spring (Harden, 1992; Carolin and Tindale, 1993), from September to December, with fruit maturing between November and December (Benson and McDougall, 1993). The flowers are small, five-petalled, white or cream with mauve anthers (DECC, 2008e).

During recent targeted surveys within the Project area and surrounds, the Thick-leaf Star-hair was recorded by Bangalay Botanical Surveys (2008) on benches and slopes in deeper gullies, occasionally extending further upslope where conditions are favourable (Figure 4). Within the proposed underground mining area, this species was recorded in vegetation map units 1a, 2c, 4a and 6a (Figures 3 and 4).

The main threats to the Thick-leaf Star-hair include inappropriate fire regimes, habitat loss and fragmentation, and roadside management activities including weed control (DECC, 2008e).

Vegetation clearance for surface infrastructure would be managed through the development and implementation of a FFMP for the Project. This would require surveys for threatened flora species prior to disturbance and relocation of works as necessary to avoid disruption to Thick-leaf Star-hair populations. The Project may increase the frequency of fire trail maintenance measures due to the increase in vehicular traffic in the Woronora Special Area. These measures are unlikely to impact on most of the population which occurs away from roads/tracks on steep slopes in the Project area. The Project would not require road/track maintenance beyond the existing easement. Roadside weed control is generally unnecessary in the Woronora Special Area, owing to a lack of weeds requiring control, which in turn relates to low soil fertility and disturbance levels.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Thick-leaf Star-hair grows on dry ridgetops to 300 m altitude (Benson and McDougall, 1993) and is associated with very rich heath, or dry sclerophyll woodland (Harden, 1992). Vegetation associations include typical sandstone genera such as *Hakea*, *Banksia* and *Xylomelum* (Benson and McDougall, 1993). However, the species occurs in a wider variety of habitats on the Project area (Bangalay Botanical Surveys, 2008) (see above).

Potential effects of underground mining on the Thick-leaf Star-hair habitat mainly relate to subsidence–related rock fall on steep slopes. However, experience in the Southern Coalfield indicates these phenomena are usually localised and small and unlikely to significantly affect habitat of the Thick-leaf Star-hair. However, Thick-leaf Star-hair was also observed by Bangalay Botanical Surveys (2008) in Sandstone Riparian Scrub. Mine subsidence has the potential to affect moisture availability to plants in the riparian zone which may result in dieback or death of some plants close to the stream channel. The studies summarised in Section 4.1 indicate that the occurrence of plant dieback or death in the riparian zone of Waratah Rivulet in previously mined areas has been localised and limited in their extent (e.g. dieback has been observed in some areas of the stream bank on Waratah Rivulet to be restricted to a fringe approximately 10 cm wide), with most plants recovering upon the return of stream flows. Further, only very small proportions of the Thick-leaf Star-hair populations occur in the riparian zone. Most of the populations of the species occur on the adjoining slopes. These effects are likely to be very localised and affect only a very small portion of habitat for this species. Further, the reduction of potential habitat for the Thick-leaf Star-hair due to surface infrastructure would be very small in comparison with the amount of habitat available.

The Project may increase the frequency of fire trail maintenance measures due to the increase in vehicular traffic in the Woronora Special Area. These measures are unlikely to impact on most of the population which occurs away from roads/tracks on steep slopes in the Project area. The Project would not require road/track maintenance beyond the existing easement. Roadside weed control is generally unnecessary in the Woronora Special Area, owing to a lack of weeds requiring control, which in turn relates to low soil fertility and disturbance levels. Measures to minimise soil disturbance and the spread of weeds would be included in a FFMP to be developed for the Project. The FFMP would also include measures to minimise the potential for the introduction or spread of *P. cinnamomi* in the Project area.

It is considered that the Project would not have a significant impact on the locally available habitat for the Thick-leaf Star-hair.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Thick-leaf Star-hair is considered a local endemic in NSW (Benson and McDougall, 1993). It is found in the Brisbane Water National Park, near Patonga (Gosford Local Government Area), and on the Woronora Plateau including the Royal National Park (Fairley and Moore, 1989; Harden, 1992; DECC, 2008e). Other select locations include Warrah, Mt Wondabyne (Brisbane Water National Park), Woronora Dam and Hacking River (Benson and McDougall, 1993). There is also a record from near Glen Davis (Lithgow Local Government Area) (DECC, 2008e). Although the Thick-leaf Star-hair is reported also to occur in Victoria, it is considered to be a different, undescribed species (Threatened Species Scientific Committee, 2008b).

The Project is located at the southern known distribution limit of the Thick-leaf Star-hair. However, the distribution of the species is so small that it is unlikely the population in the Project area represents a geographically isolated or morphologically distinct form of the species.

4. How is the proposal likely to affect current disturbance regimes?

High frequency fire is listed as a key threatening process under the TSC Act (NSW Scientific Committee, 2000a) and is relevant to the Thick-leaf Star-hair. Given the range of management protocols, including bushfire management measures, proposed to be in place to manage the behaviour of people in the Project area, it is unlikely there would be an increase in fire frequency resulting from the Project.

Issues related to human-related disturbance are discussed in Question 2.

5. How is the proposal likely to affect habitat connectivity?

Most surface infrastructure for the Project would be placed in easily accessible locations on the plateaux and would not impact on habitat connectivity for the Thick-leaf Star-hair. However, some surface infrastructure may be installed in potential habitat for this species. Access to surface infrastructure may traverse Thick-leaf Star-hair habitat and some disturbance resulting in a minor loss of connectivity is possible. However, under the FFMP, proposed disturbance areas would be surveyed for the presence of Thick-leaf Star-hair, and harm minimisation strategies would be implemented, including seeking alternative routes.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for *Astrotricha crassifolia*. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or the DEWHA Register of Critical Habitat (2008a) located in the Project area or surrounds.

4.5.3.4 Deane's Paperbark (Melaleuca deanei)

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Deane's Paperbark is a shrub to 3 m high with fibrous, flaky bark (NSW Scientific Committee, 1999a; DECC, 2008f). New stems are furry and white, though the mature stems are hairless. The smooth leaves are narrow, to 25 mm long and 6 mm wide, with pointed tips (*ibid*.). The many white flowers form spikes to 6 cm long, on a furry stem. The woody fruits are barrel-shaped, to 7 mm in diameter (*ibid*.). Flowers appear in summer and seed production appears to be small (DECC, 2008f).

Deane's Paperbark was recorded by Bangalay Botanical Surveys (2008) at one location within the LW18-19A study area within Sandstone Heath-Woodland (vegetation map unit 1b) (Figures 3 and 4).

The main threats to Deane's Paperbark include inappropriate fire regimes, urban development, fire trail maintenance and widening, low population numbers and limited capacity to regenerate, with many sites having little or no seeds set (NSW Scientific Committee, 1999a; DECC, 2008f). Habitat alteration by longwall mining is also considered a threat to this species (NSW Scientific Committee, 2005a).

Potential impacts of the Project on flora are summarised in Sections 4.1 to 4.4. Sections 4.1 to 4.4 indicate that the effects of ridgetop tension cracks and rock falls are likely to be minor. Further, the magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes on ridgetops/slopes and is unlikely to have any biologically significant effect on the soil moisture regime that sustains vegetation in these areas (Gilbert and Associates, 2008). As a result, there are no potential mechanisms for disrupting the lifecycle of this species, apart from small amounts of vegetation clearance for surface infrastructure (e.g. ventilation shaft, exploration and monitoring boreholes, monitoring equipment and access tracks).

Vegetation clearance would be managed through the development and implementation of a FFMP for the Project. This would require surveys for threatened flora species prior to disturbance and relocation of works to avoid disruption to the Deane's Paperbark as described in Section 4.4. Trail maintenance and widening also has the potential to impact on this species. It is possible that increased track maintenance due to additional mine related traffic may impact on individuals of the species. However, this is unlikely to lead to the loss of local populations.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

Deane's Paperbark grows in heath on sandstone ridges and plateaux (NSW Scientific Committee, 1999a; DECC, 2008f). The Project area and surrounds offers known and potential habitat resources for Deane's Paperbark. Habitat for this species occurs on broad ridges and plateaux, where subsidence effects are highly unlikely to significantly disturb habitat for this species (refer to discussion in Sections 4.1 to 4.4) Reduction of potential habitat for Deane's Paperbark due to surface infrastructure would be very small in comparison with the amount of habitat available.

The Project may increase the frequency of fire trail maintenance measures due to the increase in vehicular traffic in the Woronora Special Area and this has the potential to disturb trackside populations of Deane's Paperbark. However, road/track maintenance measures would continue to maintain the existing easement and would not require additional clearance.

Introduced plant species in the Project area are largely confined to disturbed sites (Bangalay Botanical Surveys, 2008), including fire roads, cleared areas in the north east of the Project area and along the verges of the F6 Freeway and Princes Highway. In general, introduced species are absent from all areas of undisturbed natural habitat in the Woronora Special Area. The FFMP to be developed for the Project would include measures to minimise soil disturbance and the spread of weeds.

In view of the potential threat of *P. cinnamomi*, the FFMP for the Project would include a range of measures to minimise the potential for the introduction or spread of *P. cinnamomi* in the Project area. The most likely means of spreading *P. cinnamomi* is in mud on vehicles, mainly 4WDs and equipment that have recently been in infected areas, and on similarly infected soiled footwear and tools. Measures for the management of *P. cinnamomi* within the Project area would be developed consistent with the DEH (2006a) *Management of Phytophthora cinnamomi for Biodiversity Conservation in Australia.*

It is considered that the Project would not have a significant impact on the locally available habitat for the Deane's Paperbark.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Deane's Paperbark occurs in two distinct areas, namely, in the Ku-ring-gai/Berowra area in the north and in the Holsworthy/Wedderburn area in the south of Sydney (NSW Scientific Committee, 1999a; DECC, 2008f). More isolated occurrences of this species have been recorded in the Blue Mountains, Wollemi National Park, Yalwal (west of Nowra) and Central Coast (Hawkesbury River) areas (DECC, 2008f).

The Project is located within the known distribution of the Deane's Paperbark and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The Project would have a limited affect on current disturbance regimes. High frequency fire is listed as a key threatening process under the TSC Act (NSW Scientific Committee, 2000a) and is relevant to Deane's Paperbark. Given the range of management protocols, including bushfire management measures, proposed to be in place to manage the behaviour of people in the Project area, it is unlikely there would be an increase in fire frequency resulting from the Project.

Issues related to human-related disturbance are discussed in Question 2.

5. How is the proposal likely to affect habitat connectivity?

Deane's Paperbark is known from only one isolated population in the Project area in Sandstone Heath Woodland (Bangalay Botanical Surveys, 2008). Sandstone Heath-Woodland is one variant of the Sandstone Woodlands that dominate the interconnected ridgetops and plateaux in the study area. Project activities would not result in any clearance of Sandstone Woodlands likely to reduce habitat connectivity. Any clearance would be for small localised surface infrastructure including ventilation shafts, exploration bores and monitoring equipment.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for *Melaleuca deanei*. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or the DEWHA Register of Critical Habitat (2008a) located in the Project area or surrounds.

4.5.3.5 Woronora Beard-heath (Leucopogon exolasius)

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The Woronora Beard-heath is an erect shrub that grows to 1 m (DECC, 2008g). It has sharp-pointed leaves that grow to about 15 mm long by 2.5 mm wide (*ibid*.). Up to three drooping, white, tubular flowers grow in the angles where the leaves meet the stems, on stalks to 5 mm long (*ibid*). Flowering occurs in August and September (DECC, 2008g). The habitat for this species is reported to be steep rocky lower slopes and sandy alluvium along rivers and creeks (Fairley, 2004). It has been recorded from the upper Georges River, O'Hares Creek, Stokes Creek and the Avon, Cataract and Woronora catchments. There is one old record from the Grose River in the Blue Mountains (Fairley, 2004).

During recent targeted surveys within the Project area and surrounds, several specimens of *Leucopogon* species were identified potentially as *Leucopogon exolasius*, though fertile material, required for their confirmation was not available during the surveys (Bangalay Botanical Surveys, 2008). Within the proposed underground mining area, this species was tentatively recorded in vegetation map units 1a, 1b, 2c and 6a (Figures 3 and 4).

The Woronora Beard-heath is considered to be secure from habitat loss, but the small range and population size makes this species vulnerable to local extinction (DECC, 2008g). Habitat alteration by longwall mining is also considered a threat to this species (NSW Scientific Committee, 2005a).

Potential impacts of the Project on flora are summarised in Sections 4.1 to 4.4. Potential effects on individual plants relate to possible rock falls on steep slopes and mine subsidence effects (including valley closure and upsidence) along watercourses. Subsidence-induced rock falls are rare and localised occurrences in the Southern Coalfield. While individuals or small groups of plants may be dislodged, rock falls are unlikely to eliminate whole local populations, or to affect multiple populations within an area.

Upsidence in the riparian zone has the potential to affect moisture availability to plants which may result in dieback or death of some plants. However, such effects are likely to be very limited and restricted, so that the majority of local populations of the Woronora Beard-heath are unlikely to be affected. Vegetation clearance would be managed through the development and implementation of a FFMP for the Project. This would require surveys for threatened flora species prior to disturbance and relocation of works as necessary to avoid disruption to the Woronora Beard-heath.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Woronora Beard-heath occurs along rivers and creeks on rocky lower slopes and in the riparian zone on alluvial sands (Fairley, 2004). Suggestions that habitats may be altered by subsidence-related hydrological changes have not been supported by recent studies (Sections 4.1 and 4.2), which by contrast, indicate that changes to hydrology are very unlikely in all potential Woronora Beard-heath habitats, except in riparian zones, where there may be minor localised effects. Further, the reduction of potential habitat for Woronora Beard-heath due to surface infrastructure would be very small in comparison with the amount of habitat available. It is considered that the Project would not have a significant impact on the locally available habitat for Woronora Beard-heath (refer Section 4.4).

Measures to minimise soil disturbance and the spread of weeds would be included in a FFMP to be developed for the Project. The FFMP would also include measures to minimise the potential for the introduction or spread of *P. cinnamomi*.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Woronora Beard-heath is found along the upper Georges River, O'Hares Creek, Stokes Creek and in the Avon, Cataract and Woronora catchments. There is one old record from the Grose River in the Blue Mountains (Fairley, 2004). It also occurs in Heathcote National Park (DECC, 2008g).

The Project is located within the known distribution of the Woronora Beard-heath and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the life cycles and survival of plants on the study area is fire (Keith *et al*., 2006). However, given the range of management protocols, including bushfire management measures, proposed to be in place to manage the behaviour of people in the Project area, it is unlikely there would be an increase in fire frequency resulting from the Project.

Issues related to human-related disturbance are discussed in Question 2.

5. How is the proposal likely to affect habitat connectivity?

The lower slope and riparian habitats of Woronora Beard-heath populations would not be disturbed by most of the surface infrastructure for the Project, which would be primarily located in plateau situations. However, some monitoring equipment may be installed in or near lower slope habitats and riparian zones. Access to surface infrastructure may traverse Woronora Beard-heath habitat and some disturbance resulting in a minor loss of connectivity is possible. However, small access tracks are unlikely to significantly fragment the population since they would not significantly affect movement by pollinators or seed dispersal.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for *Leucopogon exolasius*. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or the DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

4.5.3.6 Epacris purpurascens var. purpurascens

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Epacris purpurascens var*. purpurascens* is an erect shrub, 50 - 180 cm high (DECC, 2008h). Leaves are spreading and recurved above, ovate to heart-shaped, 7 - 21 mm long, 4.4 - 9 mm wide, with sharply pointed tips (*ibid.*). Flowers of this species are white or sometimes pinkish, 7 - 10 mm in diameter, covering much of the branchlets (*ibid*.). *E. purpurascens* var*. purpurascens* grows in poorly drained clay soils over sandstone, on shales among rocks in eucalypt forest or along creek banks (Benson and McDougall, 1995; Fairley, 2004). The species is confined to the Sydney region, where it has been recorded from Gosford in the north to Avon Dam in the south and the Nattai area in the west. Near the Project area it has been recorded at Wilton, Avon Dam and Waterfall (DECC, 2008h; Fairley, 2004).

During recent targeted surveys within the Project area and surrounds, several specimens of Epacris species were identified potentially as *E. purpurascens* var*. purpurascens*, though fertile material, required for their confirmation was not available during the surveys (Bangalay Botanical Surveys, 2008). Within the proposed underground mining area, this species was tentatively recorded in vegetation map units 1a, 1b, 1c, 2c, 4a and 6a (Figures 3 and 4).

The main threats to *E. purpurascens* var*. purpurascens* (particularly in areas north of Sydney) are considered to be clearing and too frequent fire (NSW Scientific Committee, 1999b). Other threats to this species include habitat loss/modification particularly on ridge-tops, urban run-off (leading to flooding, erosion, nitrification of soil substrate, altered pH, weed invasion and introduction of plant pathogens), uncontrolled vehicular or pedestrian access, soil compaction, slashing (e.g. powerline easements) and fill and rubbish dumping (DECC, 2008h). Habitat alteration by longwall mining is also considered a threat to this species (NSW Scientific Committee, 2005a).

The known habitats of *E. purpurascens* var*. purpurascens* indicate it may potentially occur on the Project area in a variety of habitats including the drier parts of upland swamps, moist rocky areas and along creek banks, particularly where there is a strong shale influence (DECC, 2008h; Fairley, 2004). Potential impacts of the Project on flora are summarised in Sections 4.1 to 4.4, which indicate that the effects of ridgetop tension cracks and rock falls are likely to be minor. Further, the magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes on ridgetops/slopes and in upland swamps and is unlikely to have any biologically significant effect on the soil moisture regime that sustains vegetation in these areas. Mine subsidence has the potential to affect moisture availability to plants in the riparian zone which may result in dieback or death of some plants. The studies summarised in Section 4.1 indicate that the occurrence of plant dieback or death in the riparian zone of Waratah Rivulet in previously mined areas has been localised and limited in extent, with most plants recovering upon the return of stream flows. In accordance with the FFMP that would be prepared for the Project, surveys for threatened flora species would be conducted prior to disturbance and relocation of works to avoid disruption to *E. purpurascens* var*. purpurascens* populations as described in Section 4.4. Therefore, it is unlikely that clearing for infrastructure would result in the loss of any local populations of *E. purpurascens* var*. purpurascens*.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

E. purpurascens var. *purpurascens* is found in a range of habitat types, most of which have a strong shale soil influence (DECC, 2008h), including poorly drained clay soils over sandstone, shales among rocks in eucalypt forest or creek banks (Benson and McDougall, 1995; Fairley, 2004). The Project is not considered likely to affect habitat conditions. Suggestions that habitats may alter due to subsidence-related hydrological changes have not been supported by recent studies (Sections 4.1 and 4.2), which by contrast, indicate that changes to hydrology are very unlikely in all potential *E. purpurascens* var. *purpurascens* habitats, except in riparian zones, where there may be minor localised effects. Further, the reduction of potential habitat for *E. purpurascens* var. *purpurascens* due to surface infrastructure would be very small in comparison with the amount of habitat available.

Measures to minimise soil disturbance and the spread of weeds would be included in a FFMP to be developed for the Project. The FFMP would also include measures to minimise the potential for the introduction or spread of *P. cinnamomi*.

It is considered that the Project would not have a significant impact on the locally available habitat for *E. purpurascens* var. *purpurascens*.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

E. purpurascens var. *purpurascens* has been recorded from Gosford in the north, to Narrabeen in the east, Silverdale in the west and in the vicinity of Avon Dam in the south (DECC, 2008h).

The Project is located within the known distribution of *E. purpurascens* var. *purpurascens* and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the life cycles and survival of plants on the study area is fire (Keith *et al*., 2006). However, given the range of management protocols, including bushfire management measures, proposed to be in place to manage the behaviour of people in the Project area, it is unlikely there would be an increase in fire frequency resulting from the Project.

Issues related to human-related disturbance are discussed in Question 2.

5. How is the proposal likely to affect habitat connectivity?

Potential habitats for *E. purpurascens* var. *purpurascens* populations would not be disturbed by most of the surface infrastructure for the Project, which would primarily be located in dryland plateau situations. However, some equipment (e.g. exploration boreholes or monitoring equipment) may be installed in or near riparian zones. Access to the site may traverse *E. purpurascens* var. *purpurascens* habitat and some disturbance resulting in a minor loss of connectivity is possible. However, small access tracks are unlikely to significantly fragment the population since it would not affect movement by pollinators or seed dispersal.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for *Epacris purpurascens* var. *purpurascens*. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or the DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

4.5.3.7 Group 1. Threatened flora species known to occur on the Woronora Plateau that are primarily associated with rock plate heaths: *Acacia baueri* subsp. *aspera, Darwinia peduncularis* and *Genoplesium baueri*

Acacia baueri subsp. *aspera*

Acacia baueri subsp. *aspera* is a low growing, well-branched shrub mostly 0.1 - 1 m high (DECC, 2008i). The leaves are crowded, scattered or in irregular whorls, cylindrical and warty (*ibid*.). *Acacia baueri* subsp. *baueri* has flowerheads consisting of 10 - 20 golden yellow flowers (*ibid*.). Peak flowering occurs from December to March and pods have been observed to remain on plants for several months, maturing October to December (DECC, 2008i).

The main threats to *Acacia baueri* subsp. *aspera* include habitat loss due to clearing, habitat modification (e.g. roadside maintenance and weed invasion) and inappropriate fire regimes (DECC, 2008i). Habitat alteration by longwall mining is also considered a threat to this species (NSW Scientific Committee, 2005a).

Darwinia peduncularis

D. peduncularis is a divaricate shrub that grows to approximately 1.5 m in height (Harden, 1991; Benson and McDougall, 1998). Flowers occur usually in pairs, during winter to early spring (Harden, 1991), are white while open, turning pink in the upper part and closing at maturity (Benson and McDougall, 1998). The flowers mature successively for pollination by honeyeaters (*ibid.*).

Populations of *D. peduncularis* are vulnerable due to the small numbers present in each sub-population. Threats relevant to *D. peduncularis* include inappropriate fire regimes, weed invasion and habitat disturbance (NSW Scientific Committee, 1999c).

Genoplesium baueri

Bauer's Midge Orchid is a terrestrial orchid approximately 6-15 cm high, fleshy, brittle, yellowish-green or reddish (NSW Scientific Committee, 2004b; DECC, 2008j). The green and red or wholly reddish flowers open from December to March (*ibid*.).

The main threats to the Bauer's Midge Orchid include loss of habitat and inappropriate fire regimes (DECC, 2008j).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Group 1 species mainly occur in very shallow soil in low open heaths on sandstone rock pavements. These habitats are restricted to elevated plateaux in the study area. Impacts to these species could potentially result from clearing of habitat for surface infrastructure (Section 4.4). However, vegetation clearance for surface infrastructure would be managed through the development and implementation of a FFMP for the Project (Section 4.4), which would include surveys for threatened flora species prior to disturbance and relocation of works to avoid disruption to threatened flora populations.

Some increases to road maintenance activities may become necessary due to increased traffic in the Woronora Special Area associated with the Project. However, this is not expected to significantly increase risks to the threatened species in this group, since the existing SCA road network avoids areas of rock plate which is unsuitable as a road surface. In addition, weeds that may be inadvertently introduced on vehicles are unlikely to threaten this habitat, which is weed free, and has harsh conditions unfavourable to introduced species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Project area and surrounds offer potential habitat for *Acacia baueri* subsp*. aspera, Darwinia peduncularis* and *Genoplesium baueri*. Longwall mining is regarded as a threat to species in this group (NSW Scientific Committee, 2005a). Habitat for these species occurs on broad plateaux and ridgetops, where subsidence effects are highly unlikely to significantly disturb habitat for these species (refer to discussion in Section 4.2). Observations and measurements of subsidence in the Southern Coalfield indicate that the effects of cracking (e.g. ridgetop tension cracks) would be localised and small (Section 4.2). The magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes on ridgetops/slopes and is unlikely to have any biologically significant effect on soil moisture availability for plants on sandstone rock plates (Section 4.2). Reduction of potential habitat for *Acacia baueri* subsp*. aspera, Darwinia peduncularis* and *Genoplesium baueri* due to surface infrastructure would be very small in comparison with the amount of habitat available.

The Project may increase the frequency of fire trail maintenance measures due to the increase in vehicular traffic in the Woronora Special Area and this has the potential to disturb trackside populations of these species. However, road/track maintenance measures would continue to maintain the existing easement and would not require additional clearance. Measures to minimise soil disturbance and the spread of weeds would be included in a FFMP to be developed for the Project. The FFMP would also include measures to minimise the potential for the introduction or spread of *P. cinnamomi*.

It is considered that the Project would not have a significant impact on the locally available habitat for these species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Acacia baueri subsp. *aspera* is restricted to the Sydney region, occurring on the Kings Tableland in the central Blue Mountains and with sporadic occurrences on the Woronora Plateau in the Royal National Park, Mt. Keira district and at Wedderburn (DECC, 2008i). The species may also occur on the escarpment/Woronora Plateau in the Flat Rock Junction and Stanwell Tops area of the Illawarra (*ibid*.).

D. peduncularis occurs as local disjunct populations in coastal NSW with a few isolated populations located in the Blue Mountains (NSW Scientific Committee, 1999c). This species has been recorded at Layburys Creek, Brooklyn, Berowra, Mount Ku-ring-gai, Galston Gorge, Hornsby, Bargo River, Glen Davis in the Central Coast Botanical Division and Mount Boonbourwa and Kings Tableland in the Central Tablelands Botanical Division (NSW Scientific Committee, 1999c; Benson and McDougall, 1998).

The Bauer's Midge Orchid has been recorded from locations between Nowra and Pittwater and may occur as far north as Port Stephens (NSW Scientific Committee, 2004b; DECC, 2008j). About half the records were made before 1960 with most of the older records being from Sydney suburbs including Asquith, Cowan, Gladesville, Longueville and Wahroonga (*ibid*.). The Bauer's Midge Orchid has been recorded at locations now likely to be within the following conservation reserves: Berowra Valley Regional Park, Royal National Park and Lane Cove National Park and may occur in the Woronora, O'Hares, Metropolitan and Warragamba Catchments (*ibid*.).

The Project is located within the known distributions of the three species and does not represent a distributional limit for them.

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the life cycles and survival of plants on the study area is fire (Keith *et al*., 2006). High frequency fire is listed as a key threatening process under the TSC Act (NSW Scientific Committee, 2000a) and is relevant to these species. Given the range of management protocols, including bushfire management measures, proposed to be in place to manage the behaviour of people in the Project area, it is unlikely there would be an increase in fire frequency resulting from the Project.

Issues related to human-related disturbance are discussed in Question 2.

5. How is the proposal likely to affect habitat connectivity?

Group 1 species occur in sandstone heath on rock platforms on the plateaux and ridgetops of the Project area. The occurrences of this habitat are patchy and naturally fragmented within the complex of heaths and woodlands on the sandstone plateaux. Roads and tracks may potentially reduce habitat connectivity. A network of SCA roads and tracks currently exists. The Project would result only in a small increase in access tracks to localised surface infrastructure. These would be established only after prior surveys for threatened flora species in accordance with the FFMP and relocation of works to avoid disruption to threatened flora species populations. Damage to vegetation would be minimised and tracks would be closed and vegetation allowed to regenerate once they are no longer needed.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for *Acacia baueri* subsp. *aspera*, *Darwinia peduncularis* or *Genoplesium baueri*. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or the DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

4.5.3.8 Group 2. Threatened flora species known to occur on the Woronora Plateau that are primarily associated with sandstone plateau woodlands: *Eucalyptus camfieldii*, *Darwinia biflora* and *Persoonia hirsuta* subsp*. hirsuta*

<u>*Eucalyptus camfieldii*</u>

Camfield's Stringybark is usually a mallee to 4 m tall (DECC, 2008k). Its bark is rough, fibrous and stringy and red or dark grey-brown in colour (*ibid*.). The juvenile leaves are round to heart shaped and roughly hairy, while the adult leaves are broadly lance-shaped (*ibid*.). Flowers of Camfield's Stringybark are creamy-white (DECC, 2008k) and may appear at any time of year (*ibid*.).

The main threats to Camfield's Stringybark include loss of habitat due to clearing, inappropriate fire regimes, weed invasion and possible in-breeding due to too small and isolated populations (DECC, 2008k).

<u>*Darwinia biflora*</u>

Darwinia biflora is an erect to spreading shrub which grows to approximately 80 cm high (Harden, 1991) and may flower throughout the year, however, flowering is concentrated in autumn with mature fruits being produced from May to August (Auld *et al.*, 1993). The seed is stored in the seedbank which is stimulated by fire (*ibid.*), however, the seedbank is predicted to be short-lived due to early seed decay (Auld *et al.*, 2000). Plants are thought to live for 15-20 years (NPWS, 1999b).

Threats relevant to *D. biflora* include the loss and degradation of habitat, inappropriate fire regimes and weed invasion (NPWS, 1999c).

Persoonia hirsuta subsp*. hirsuta*

Persoonia hirsuta subsp*. hirsuta* is a low spreading shrub to 1 m high with hairy young branchlets and densely hairy juvenile foliage (Weston, 2002; Fairley, 2004). The leaves are linear to narrow-oblong (0.75-1.5 mm wide) with revolute margins. The ovaries of the flowers and the fruit are also very hairy (*ibid.*). Flowering is from November to January (Fairley, 2004). Populations are often very small, usually 1 to 3 plants, with a maximum known size of 20 plants (Fairley, 2004).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Group 2 species mainly occur in shallow loamy sand soil in low open heathy woodlands on sandstone plateaux, except for *Darwinia biflora*, which occurs on laterite or at shale/sandstone transitions. These habitats are restricted to elevated plateaux in the study area. Impacts to these species could potentially result from clearing of habitat for surface infrastructure (Section 4.4). For *Eucalyptus camfieldii* and *Persoonia hirsuta* subsp. *hirsuta*, reductions in the size of already small populations may have important genetic consequences for inbreeding. However, vegetation clearance for surface infrastructure would be managed through the development and implementation of a FFMP for the Project (Section 4.4), which would include surveys for threatened flora species prior to disturbance and relocation of works to avoid disruption to threatened flora populations.

Some increases to road maintenance activities may become necessary due to increased traffic in the Woronora Special Area associated with the Project. The existing SCA road network is largely located within the heathy woodlands on the plateau. However, these roads are well maintained with slashed verges and some increase in vehicle use is not likely to significantly increase risks to the threatened species in this group. In addition, weeds that may be inadvertently introduced on vehicles are unlikely to threaten this habitat, which is generally weed free, and has harsh conditions unfavourable to introduced species. Nevertheless, it is recognised that extensive disturbance can encourage weed establishment. Measures would be implemented through the FFMP to minimise disturbance to natural habitat and weed invasion.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Project area and surrounds offers potential habitat for *Eucalyptus camfieldii, Darwinia biflora* and *Persoonia hirsuta subsp. hirsuta.* Alteration of habitat by mine subsidence is regarded as a threat to threatened flora in NSW coalfields (NSW Scientific Committee, 2005a). Observations and measurements of subsidence in the Southern Coalfield indicate that the effects of cracking (e.g. ridgetop tension cracks) would be localised and small (Section 4.2). The magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes on ridgetops/slopes and is unlikely to have any biologically significant effect on soil moisture availability for plants on sandstone plateaux (Section 4.2). Reduction of potential habitat for *Eucalyptus camfieldii, Darwinia biflora* and *Persoonia hirsuta subsp. hirsuta* due to surface infrastructure would be very small in comparison with the amount of habitat available.

The Project may increase the frequency of fire trail maintenance measures due to the increase in vehicular traffic in the Woronora Special Area and this has the potential to disturb trackside populations of these species. However, road/track maintenance measures would continue to maintain the existing easement and would not require additional clearance.

Introduced plant species in the Project area are largely confined to disturbed sites (Bangalay Botanical Surveys, 2008), including fire roads, cleared areas in the north east of the Project area and along the verges of the F6 Freeway and Princes Highway. In general, introduced species are absent from all areas of undisturbed natural habitat in the Woronora Special Area.

The FFMP to be developed for the Project would include measures to minimise soil disturbance and the spread of weeds. The FFMP would also include measures to minimise the potential for the introduction or spread of *P. cinnamomi*.

It is considered that the Project would not have a significant impact on the locally available habitat for these species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

D. biflora mainly occurs in the northern and north-western suburbs of Sydney, in the Ryde, Baulkham Hills, Hornsby and Ku-ring-gai local government areas (NPWS, 1999b).

Camfield's Stringybark has a restricted distribution, occurring in a narrow band with the most northerly records in the Raymond Terrace Area south to Waterfall (DECC, 2008k). Camfield's Stringybark has a localised and scattered distribution which includes sites at Norah Head (Tuggerah Lakes), Peats Ridge, Mt Colah, Elvina Bay Trail (West Head), Terrey Hills, Killara, North Head, Menai, Wattamolla and a few other sites in Royal National Park (*ibid*.).

Persoonia hirsuta subsp. *hirsuta* is known to occur in a coastal zone between Gosford to the north of Sydney and the Royal National Park at the northern end of the Woronora Plateau (Fairley, 2004).

The Project is located south of the known distributions of all three group 2 species, and therefore would represent a distributional limit for these species, if they occurred in the Project area. However, none was found during the baseline flora surveys (Bangalay Botanical Surveys, 2008).

4. How is the proposal likely to affect current disturbance regimes?

The disturbance regime most critical to the life cycles and survival of plants on the study area is fire (Keith *et al*., 2006). High frequency fire is listed as a key threatening process under the TSC Act (NSW Scientific Committee, 2000a) and is relevant to these species. Given the range of management protocols, including bushfire management measures, proposed to be in place to manage the behaviour of people in the Project area, it is unlikely there would be an increase in fire frequency resulting from the Project.

Issues related to human-related disturbance are discussed in Question 2.

5. How is the proposal likely to affect habitat connectivity?

Group 2 species occur in sandstone heathy woodlands on plateaux and ridgetops. This habitat is widely distributed and extensively connected on the plateau, although there are some isolated patches (Bangalay Botanical Surveys, 2008). Roads and tracks may potentially reduce habitat connectivity. A network of SCA roads and tracks currently exists. The Project would result only in a small increase in access tracks to localised surface infrastructure. Damage to vegetation would be minimised under the FFMP and tracks would be closed and vegetation allowed to regenerate once they are no longer needed. It is unlikely that the Project would significantly decrease connectivity in the habitat for group 2 species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for *Eucalyptus camfieldii, Darwinia biflora* and *Persoonia hirsuta* subsp. *hirsuta*. There is no critical habitat as listed on the NPWS Critical Habitat Register (NPWS, 2008) or the DEWHA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5 POTENTIAL IMPACTS OF THE PROJECT ON TERRESTRIAL VERTEBRATE FAUNA AND THEIR HABITATS

In this section the potential adverse impacts of the Project on terrestrial vertebrate fauna and their habitats are evaluated. Potential impacts of the Project on terrestrial vertebrate fauna and their habitats include those associated with mine subsidence effects (e.g. surface cracking, buckling and or dilating, rock fall, and changes to surface or groundwater hydrology). The potential subsidence related impacts of the Project on terrestrial vertebrate fauna and their habitats (woodland-forest, heath and mallee, riparian [and associated watercourse], and upland swamps) are described in Sections 5.1 to 5.4 below. Other potential direct or indirect impacts of the Project are described in Section 5.5 below. An assessment of the potential impacts of the Project on species-specific threatened fauna is found in Section 5.6 below. Cumulative impacts of the Project are described in Section 6.

Subsidence effects and other direct, indirect and cumulative impacts have the potential to result in short or long term changes in fauna habitats and fauna populations. The assessment of whether or not a significant adverse impact on vertebrate fauna or specific species is likely to occur is determined by predicting how various potential physical changes and their interaction with fauna habitats may or may not initiate adverse changes to vertebrate species distribution and/or abundance, as well as impact on species-specific population viability. These assessments are based on:

- current baseline knowledge of fauna from surveys described in this report and elsewhere;
- ecological theory including current understanding of population dynamics;
- current studies on mine subsidence-related impacts, hydrogeological and hydrological assessments, and flora surveys;
- knowledge of fire history in this location and the known impacts of fire on vertebrate distribution and abundance; and
- consideration of relevant legislation including the TSC Act.

While available evidence has been considered, significant weight has been given to the findings of specific contemporary on-site studies. Hence this evaluation draws on the potential subsidence impacts as described by MSEC (2008), potential groundwater impacts as described by Heritage Computing (2008), the potential surface water impacts as described by Gilbert and Associates (2008) and the potential flora impacts as described in this report.

5.1 SUBSIDENCE EFFECTS AND WOODLAND/FOREST HABITAT

The dominant lithographic unit in the study area is the surface layer of Hawkesbury Sandstone, which is nutrient-poor and generates sandy, highly porous soils. Because of the relatively high rainfall of the local area and the runoff features of the Hawkesbury sandstone, soils generally do not readily accumulate on the upper ridges or slopes and erosion quickly strips sand and clay particles away leaving bare rock ledges or skeletal soil pockets. As a result, woodland and forest habitat in the Project area comprises variable rock formations including rock platforms, beehive formations, and free standing or groups of smaller rocks and mid–sized to large boulders with numerous crevices, cracks and hiding places (Western Research Institute and Biosphere Environmental Consultants, 2008). Many sites offering potential roosting or resting locations for a range of vertebrate species are located throughout the Project area. Some on ground logs are also present in this habitat type.

Vegetation communities representative of the woodland and forest habitats in the Project area include Exposed Sandstone Scribbly Gum Woodland (Map Unit 1a), Sandstone Heath-Woodland (Map Unit 1b), Silvertop Ash Ironstone Woodland (Map Unit 1c), Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion (Map Unit 5a) and Sandstone Gully Apple-Peppermint Forest (Map Unit 6a) (Figure 3).

The variety of canopy, mid-storey and understory flora species provides vertebrate fauna with foraging, breeding, nesting and shelter resources (e.g. insects, acacia gum and nectar and tree hollows) and facilitates the movement of fauna between areas.

The woodland/forest habitats may also contain drainage lines or ephemeral streams that contain water during and for a period following rain.

Surface Cracking

Mine subsidence has the potential to cause surface and sub-surface cracking. Surface cracking (e.g. tension cracks) has the potential to form areas capable of 'trapping' some ground dwelling fauna (e.g. frogs and reptiles) in the same way that pitfall traps operate. The woodland/forest habitats generally occur on slopes and ridgetops. As described in Section 4.2, the only surface tension crack reported at Metropolitan Colliery to date is adjacent to Fire Road 9C which is near the top of a steep slope (MSEC, 2008). MSEC (2008) indicate that the size and extent of surface cracking on slopes and ridgetops is expected to be minor, which is consistent with that observed during the extraction of previous longwalls at the Metropolitan Colliery. Any impacts on vertebrate fauna due to surface cracking are likely to be relatively minor and very unlikely to result in an impact that would threaten the viability of any vertebrate species population.

As described in Section 4.2, the magnitude of surface cracking is considered too small to influence the hydrological processes in the slope and ridgetop areas and is unlikely to have any biologically significant effect on the soil moisture regime that sustains the existing vegetation (Gilbert and Associates, 2008).

Rock Falls

Rock falls occur naturally, however subsidence has the potential to further reduce the stability of features (e.g. cliffs and overhangs) and increase the incidence of rock fall. Rock falls have the potential to reduce terrestrial fauna habitat resources (e.g. roost sites for bats, nest sites for birds, and shelter for reptiles) or result in the loss of individuals in a few cases, either by entrapment or direct fatal rock fall.

Cliffs and overhangs in the Project area are generally located along the alignment of the Waratah Rivulet (MSEC, 2008). MSEC (2008) indicate that the incidence of rock falls in the Project area are likely to be isolated and the lengths of potential instabilities along cliffs and overhangs resulting from the extraction of Longwalls 20 to 44 are expected to be less than 3% of the lengths of these cliffs/overhangs. Most of the mining induced cliff falls have been observed where the depth of cover to mining was shallow, as in the Western Coalfield, and few cliff falls or rock falls have been observed where the depth of cover is more than 400 m, as generally occurs in the Southern Coalfield (MSEC, 2008). Given the predicted low incidence of rock falls (MSEC, 2008), it is considered unlikely that mine subsidence would result in a significant impact on any fauna species.

Availability of Water

As described above, mine subsidence has the potential to cause cracking and alter the availability of water. Non-persistent sources of water (e.g. surface seeps, ponded water adjacent to fire trails, drainage lines and ephemeral streams) occur naturally and are generally available to terrestrial vertebrate fauna during and for a period following rain. As described above, the magnitude of surface cracking is considered too small to influence the hydrological processes in these areas and is unlikely to have any biologically significant effect on the availability of water (Gilbert and Associates, 2008). The potential impacts of mine subsidence on more persistent sources of water are described in Section 5.3 below.

5.2 SUBSIDENCE EFFECTS AND HEATH AND MALLEE HABITAT

Heath and mallee formations form a mosaic within this broad fauna habitat to a height of approximately 10 m. Vegetation communities representative of the heath and mallee habitats in the Project area include Rock Pavement Heath (Map Unit 2a), Rock Plate Heath-Mallee (Map Unit 2b) and Woronora Tall Mallee-heath (Map Unit 2c) (Figure 3).

Heath areas generally form dense continuous canopies of a range of shrub and intermediate height trees (Western Research Institute and Biosphere Environmental Consultants, 2008). Heath areas are dominated by shrubs such as Heath-leaved Banksia (*B. ericifolia*), Conesticks (*Petrophile pulchella*) and various narrow-leaved peas and wattles (*ibid*.). The ground cover is often sparse with native grasses and isolated sedges are found in areas not dominated by shrubs. Soils are very shallow or skeletal.

In mallee areas, clumps of Yellow-top Ash (*E. luehmanniana*) predominate along with less obvious mallees such as Mallee Ash (*E. stricta*) and Whipstick Mallee Ash (*E. multicaulis*). The tall shrubs found in mallee areas include the Flaky-barked Tea-tree (*Leptospermum trinervium*) and Heath-leaved Banksia (*B. ericifolia*). Grasses and isolated sedges appear as a sparse ground cover (*ibid*.).

The mallee and heath fauna habitats are characterised by a low abundance of tree hollows and dominant mallee Eucalypt species, in mid successional formations. Bare sandy soils and/or rocky platforms can be located between vegetation units.

No permanent water is located in this broad fauna habitat, however free water can occur during and for a period following rain.

Surface Cracking

Mine subsidence has the potential to cause cracking in heath and mallee habitats similar to the potential for cracking in woodland and forest habitats. As described in Section 5.1, the size and extent of surface cracking is expected to be minor, which is consistent with that observed during the extraction of previous longwalls at the Metropolitan Colliery (MSEC, 2008). Any impacts on vertebrate fauna due to surface cracking in heath and mallee habitats are likely to be relatively minor and very unlikely to result in an impact that would threaten the viability of any vertebrate species population.

Rock Falls

The heath and mallee habitats typically occur on ridges, upper slope and plateau areas. There is limited potential for rock falls in the heath and mallee habitats given the dominant rock forms are pavement platforms, with scattered stable formations of boulder formations and limited minor cliff faces and overhangs. Given the predicted low incidence of rock falls (MSEC, 2008), it is considered unlikely that mine subsidence would result in a significant impact on any fauna species utilising this habitat type.

Availability of Water

As described in Section 5.1, mine subsidence has the potential to cause cracking and alter the availability of water. Non-persistent sources of water (e.g. surface seeps, ponded water adjacent to fire trails, drainage lines and ephemeral streams) occur naturally and are generally available to terrestrial vertebrate fauna during and for a period following rain. The magnitude of surface cracking is considered too small to influence the hydrological processes in these areas and is unlikely to have any biologically significant effect on the availability of water (Gilbert and Associates, 2008).

5.3 SUBSIDENCE EFFECTS AND RIPARIAN (AND ASSOCIATED WATERCOURSE) HABITAT

Riparian habitat occurs along streams which flow to the Woronora Reservoir and some of their tributaries. Riparian habitat occurs as narrow, sinuous zones following the watercourses along the floors of the deeper gullies and valleys. In the upstream areas, the riparian vegetation gives way to swamps or gully forest vegetation (Western Research Institute and Biosphere Environmental Consultants, 2008). The Woronora Reservoir also provides habitat resources for terrestrial fauna.

Subsidence Effects and Riparian Vegetation

Section 4.1 describes the potential subsidence effects on streams and riparian zones (including changes in stream gradients, increased scouring of stream banks, changes to stream alignments, cracking and changes in stream water levels and gas emissions) and the associated potential impacts on riparian vegetation. These subsidence effects may result in localised and limited impacts on riparian vegetation, which may reduce the habitat resources available to terrestrial fauna in the riparian zone. However, the nature of the impacts on riparian habitat is unlikely to significantly impact this habitat type or any terrestrial fauna species.

Alteration of Natural Flow Regimes

The alteration of natural flow regimes of rivers and streams is recognised as a key threatening process under the TSC Act and *Fisheries Management Act, 1994.*

Some terrestrial vertebrate fauna species utilise watercourses as a source of drinking water or for other components of their lifecycle. For example, the Eastern Water Dragon (*Physignathus lesuerii*), a semi-aquatic arboreal lizard feeds on a variety of insects and aquatic organisms including frogs, as well as other small terrestrial vertebrates, while the Common Eastern Froglet (*Crinia signifiera*) is known to breed in slow-flowing creeks after rain, calling from within shallow water or fringing grass or leaf-litter (Cogger, 2000).

Mine subsidence (including upsidence and valley closure) would result in fracturing of the rock strata in watercourses which may result in conveyance of a portion of low flows via the fracture network, and a reduction in water level in pools as they become hydraulically connected with the fracture network. There is also likely to be reduced continuity of flow between affected pools during dry weather.

Gilbert and Associates (2008) estimate that in Waratah Rivulet, typical underflow via the fracture network is expected to increase the average frequency of no flow days from 2% to 15% and increase the average frequency of low flows (less than 2 ML/day) from 36% to 40% of days. Gilbert and Associates (2008) also indicate that mine subsidence associated with the Project would have a negligible effect (less than 0.5%) on moderate (approximately 10 ML/day) and larger (10-40 ML/day) flows. During prolonged dry periods when flows recede to low levels, a greater proportion of the lower flows would be conveyed via the fracture network (Gilbert and Associates, 2008). Such abnormally persistent low flows have been observed in the Waratah Rivulet in recent times (*ibid*.). Pool water levels would fluctuate in response to stream flow variability (i.e. increasing during periods of increasing flow and reducing with flow recession). Gilbert and Associates (2008) indicate that during periods of significant rainfall and runoff in Waratah Rivulet, the water level in subsidence impacted pools would be similar to pools unaffected by subsidence. Under these flow conditions pools and their downstream rock bars would become “drowned out”. During dry periods when flows in the rivulet are in a low, recessionary regime the water level in pools affected by subsidence would recede much faster than is the case in unaffected pools (*ibid*.). Despite prolonged dry periods, pools (albeit smaller, with reduced connectivity) have been observed to be present in Waratah Rivulet. That is, a number of micro-pools remain which hold water (Gilbert and Associates, 2008).

Tributaries of Waratah Rivulet also contain numerous in-stream pools, which are however relatively much smaller, both in plan area, depth and volume relative to runoff flow rates than those on the rivulet (Gilbert and Associates, 2008). The effects of subsidence on typical tributary pools can be seen as lower pool levels during the longer recessionary periods with little observable effect during periods of normal creek flow (*ibid*.). In longer recessionary periods pool water levels can decline below the 'cease to flow' level at a rate faster than it did prior to being undermined (Gilbert and Associates, 2008). This response is consistent with the capture and underflow of small flows (*ibid*.).

Observations of the subsidence affected upper reaches of the Eastern Tributary at the Metropolitan Colliery provide an indication of mine subsidence effects on pools in tributaries (Gilbert and Associates, 2008). Inspections of subsidence affected reaches of the Eastern Tributary in the completed underground mining area were carried out in March 2006, February 2007 and July 2007 (*ibid*.). The Eastern Tributary was undermined by Longwall 2 in 1996 and has potentially been affected by Longwalls 2 and 3. The stream has not been affected by longwall mining over the last 10 years and provides an opportunity to assess the effects of longwall mining on tributary pools and natural remediation in the medium term. The observations in March 2006 corresponded with a significant dry period (Gilbert and Associates, 2008). The observations in February 2007 were preceded by five dry days which followed significant rainfall (93.6, 60.6 and 83.4 mm in the three days prior). The observations in July 2007 corresponded with a relatively dry period (an average of 2.2 mm of rainfall was recorded over the previous 26 days and no rainfall over the 13 days leading up to the inspection) (*ibid*.).

In March 2006, a number of pools were observed upstream of the completed underground mining area. Within the completed underground mining area, one dry pool and several non-flowing pools were observed (Gilbert and Associates, 2008). In February 2007, no dry pools were observed, although some pools had no observable overflow (Gilbert and Associates, 2008). Ten significant pools were observed and most contained clear water with sand deposits visible in the bottom of some pools (*ibid*.). In July 2007, no dry pools were observed and most pools were full or near full. The observations of pools in the Eastern Tributary and in tributaries of Waratah Rivulet indicate that although mine subsidence has the potential to increase the rate of leakage (and consequently pool level recession) of pools, it is likely that a portion of the pools subject to mine subsidence effects will hold some water during prolonged dry periods (Gilbert and Associates, 2008). These latter pools would remain full during most typical wetting and drying cycles (*ibid*.).

Mine subsidence also has the potential to result in changes in stream water quality. The effects of subsidence on water quality have been most noticeable as localised and transient changes (spikes or pulses) in iron, manganese and to a lesser extent aluminium and minor associated increases in electrical conductivity (Gilbert and Associates, 2008). The most likely mechanism for this appears to be flushing of minerals from freshly exposed fractures created by upsidence and valley closure (*ibid*.). By nature, these pulses are isolated and non-persistent (Gilbert and Associates, 2008). It is also apparent that the pulses have not had any measurable effect on water quality in the Woronora Reservoir downstream (*ibid*.).

Terrestrial vertebrate fauna species recorded in riparian (and associated watercourse) habitat during the recent surveys include a number of amphibians (e.g. Common Eastern Froglet, Brown-striped Frog, Bleating Tree Frog, Freycinet's Frog, Broad-palmed Frog and Peron's Tree Frog), reptiles (e.g. Copper-tailed Skink, Eastern Water-skink, Dark-flecked Garden Sunskink, Pale-flecked Garden Sunskink, Water Dragon and Red-bellied Black Snake), birds (e.g. Common Bronzewing Pigeon, Sacred Kingfisher, Nankeen Night Heron, Spotted Pardalote, Rockwarbler, White-browed Scrub wren, Yellow-faced Honeyeater and Spotted Quail-thrush) and mammals (e.g. Brown Antechinus, Gould's Wattled Bat, Little Forest Bat and Bush Rat) (Western Research Institute and Biosphere Environmental Consultants, 2008). A range of fauna species are likely to utilise stream pools for drinking (e.g. the Eastern Grey Kangaroo), feeding (e.g. many lizards, small mammals and microchiropteran bats), bathing (e.g. small birds) or breeding (e.g. Hylid frogs such as Lesueur's Frog, Blue Mountains Tree Frog and Leaf Green River Tree Frog).

In consideration of the nature of the potential impacts described above and the lifecycle components of terrestrial vertebrate fauna that may utilise the riparian (and watercourse) habitat, it is unlikely that any vertebrate population would be put at risk by the potential subsidence-related impacts. Many of the terrestrial vertebrate fauna species are known to utilise a range of habitats, or are mobile allowing them to move to alternative habitat in response to changes in stream flows or water levels. For species that are likely to utilise small pools in Waratah Rivulet rather than the large body of water in Woronora Reservoir (e.g. frogs), a number of micro-pools remain which hold water even during times of abnormally persistent low flows. Pool water levels would fluctuate in response to stream flow variability (i.e. increasing during periods of increasing flow and reducing with flow recession). During periods of moderate to high flow, the pool water level behaviour in areas subject to subsidence is expected to be similar to pre-subsidence behaviour (i.e. pool levels persist, rockbars experience overflow and significant surface flows occur) (Gilbert and Associates, 2008). The observations of pools in the Eastern Tributary and in tributaries of Waratah Rivulet indicate that although mine subsidence has the potential to increase the rate of leakage (and consequently pool level recession) of pools, it is likely that a portion of the pools subject to mine subsidence effects will hold some water during prolonged dry periods (Gilbert and Associates, 2008). These latter pools would remain full during most typical wetting and drying cycles (*ibid*.).

The Platypus was recorded during the Project surveys in the Woronora River and Waratah Rivulet (Western Research Institute and Biosphere Environmental Consultants, 2008). The Platypus is uncommon in the Waratah Rivulet. Mainly nocturnal, the Platypus forages on stream biota such as insect larvae, freshwater shrimp or adult insects on the surface of the water (DECC, 2008l). Out of the water, the Platypus spends most of its time in burrows which have been dug into the river bank, with their entrances usually above water level (*ibid*.). The Platypus uses a number of short resting burrows (three to five metres long) as protection from predators and temperature extremes. As described above, mine subsidence has the potential to alter stream flows, including those in Waratah Rivulet, and result in a reduction in pool water levels and reduced continuity of flow between affected pools during dry weather or in some cases to result in the drying of a pools in response to water flow being redirected into the dilated strata (Gilbert and Associates, 2008). However, there is no net loss of water within the system as it resurfaces further downstream (Gilbert and Associates, 2008). The Platypus is also likely to utilise the upper reaches of the Woronora Reservoir. The Platypus is a species that is able to rapidly relocate downstream or upstream as stream or pools dry in response to adverse weather conditions, or to move upbank in response to episodic flow events. It is conceivable, given the relatively small size of pools along the Rivulet that a single breeding female Platypus could be potentially adversely impacted and recruitment possibly terminated. However such an impact would be very unlikely to impact adversely on the viability of the Platypus population within the Waratah Rivulet. Dispersing juvenile Platypus could occasionally make use of tributary streams until such times as they dry in response to seasonal changes in rainfall. It is very unlikely that Platypus breed in these tributaries given their nature. Hence it is very unlikely that cracking or subsidence in tributary streams would impact the Platypus population.

Some threatened fauna species are also known to utilise riparian (and associated watercourse) habitat. For example, the Large-footed Myotis was recorded by Anabat detection flying above water in the eastern arm of the Woronora Reservoir (Western Research Institute and Biosphere Environmental Consultants, 2008). The threatened fauna species evaluations provided in Section 5.6 consider the potential impacts of the Project's alteration of natural flow regimes on threatened fauna species.

5.4 SUBSIDENCE EFFECTS AND UPLAND SWAMP HABITAT

Upland swamps on the Woronora Plateau occur in small headwater valleys that are characteristically sediment choked and swampy. Vegetation communities representative of upland swamp habitats in the Project area include Banksia Thicket (Map Unit 3a), Tea Tree Thicket (Map Unit 3b), Sedgeland-Heath Complex (Map Unit 3c) and Fringing Eucalypt Woodland (Map Unit 3d) (Figure 3).

The upland swamp habitat contains tall sedges and rushes and, with the exception of the fringing Eucalypt woodland, is devoid of tall tree species. Thickets of Banksia (*Banksia oblongifolia*) and Tea Tree (*Leptospermum juniperinum*) occur together with a variety of shrubs and dry-swamp tolerant plants (Western Research Institute and Biosphere Environmental Consultants, 2008). Vegetation height typically varies from 1-5 m and the vegetation is very dense.

Within this habitat type, there are generally no hollows, rocky areas or ground log (Western Research Institute and Biosphere Environmental Consultants, 2008). However, large amounts of leaf litter can occur scattered throughout the swamp (*ibid*.). Many vertebrate species are known to utilise upland swamps, however many species are not dependent on this habitat type. However, a few species are dependent on upland swamp habitats (e.g. the Eastern Ground Parrot).

Alteration of habitat following subsidence due to longwall mining is listed as a key threatening process under the TSC Act (NSW Scientific Committee, 2005a). The Scientific Committee, government agencies and/or community concerns are that mine subsidence effects (e.g. cracking, buckling, dilating and/or tilting) may significantly affect the water balance of upland swamps, with subsequent desiccation of the swamp, increased susceptibility to fire, erosion and associated loss of specialised swamp biota. The potential impacts of Project mine subsidence on upland swamps is described below.

Surface Cracking

As described in Section 4.3.5, MSEC (2008) has predicted the maximum potential subsidence effects within 20 m of the perimeter of upland swamps situated within the proposed underground mining area (Longwalls 20-44) and within the potential extent of mine subsidence effects. All of the upland swamps are headwater upland swamps, with the exception of one in-valley swamp that overlies completed Longwalls 7 and 8. The in-valley swamp has already experienced mine upsidence from Metropolitan Colliery's existing operations.

Heritage Computing (2008) indicates that there is very little potential for any measurable change in swamp moisture conditions given the minor nature of potential cracking and the hydrogeological characteristics of the swamps (Heritage Computing, 2008). Drainage of water from the perched water table to the regional water table in the underlying sandstone is not expected as the sandstone bedrock is massive in structure and permeability decreases with depth (Heritage Computing, 2008). It is expected that any surface cracking that may occur would be superficial in nature (i.e. would be relatively shallow) and would terminate within the unsaturated part of the low permeability sandstone (Heritage Computing, 2008). In addition, due to the low hydraulic gradient of the water table within a swamp, lateral movement of water through the swamp towards a crack would be very small and very slow (Heritage Computing, 2008). Any changes in swamp moisture as a result of cracking are expected to be immeasurable when compared to the scale of seasonal and even individual rainfall event based changes in upland swamp groundwater levels (Heritage Computing, 2008).

Available data from studies undertaken by the SCA for the Kangaloon borefield supports the overall assessment that the regional aquifer is hydraulically disconnected from perched water in upland swamps (Heritage Computing, 2008). The subsidence assessment indicates that the free-draining fractured zone expected to develop at depth above the extracted coal seam is at a maximum height of approximately 155 m (i.e. approximately 265 m below the ground surface) (MSEC, 2008). Hence, the perched water in the upland swamps is not expected to be affected directly by the depressurisation of the deeper aquifer systems (Heritage Computing, 2008).

In summary, surface cracking of this nature is not expected to result in an increase in the vertical movement of water from the perched water table into the regional aquifer (Heritage Computing, 2008). No change to the fundamental surface hydrological processes (Gilbert and Associates, 2008) and upland swamp vegetation are expected within upland swamps. Given the above, it is unlikely that vertebrate fauna species or their habitats would be impacted and that any vertebrate population would be put at risk.

Tilting and Alterations to Natural Gradients

Trough-shaped subsidence profiles associated with longwall mining develop tilt between adjacent points that have subsided different amounts (NSW Scientific Committee, 2005a). This has the potential to alter natural gradients.

Potential impacts of predicted total systematic tilts on upland swamps are described in detail in Section 4.3.5. In summary, swamp grades vary naturally and the predicted maximum mining-induced tilts are generally orders of magnitude lower than the existing natural grades within the swamps (Gilbert and Associates, 2008). Significant changes in grade within the swamps as a result of mining-induced tilt are not anticipated (MSEC, 2008). The predicted tilts would not have any significant affect on the localised or overall gradient of the swamps or the flow of water (Gilbert and Associates, 2008). Any minor mining-induced tilting of the scale and nature predicted is not expected to significantly increase lateral surface water movements which are small in relation to the other components in the swamps' water balance (Gilbert and Associates, 2008).

No change to the surface hydrological processes (Gilbert and Associates, 2008) and therefore upland swamp vegetation are expected within upland swamps situated within the proposed underground mining area (Longwalls 20-44) and within the potential extent of mine subsidence effects. Given the above, it is unlikely that vertebrate fauna species or their habitats would be impacted and that any vertebrate population would be put at risk.

5.5 OTHER DIRECT OR INDIRECT POTENTIAL IMPACTS ON TERRESTRIAL FAUNA

Habitat Disturbance

As described in Section 4.4, the Project would include some clearance of vegetation. Vegetation within the Project area provides terrestrial fauna with opportunities (to varying degrees) for foraging, breeding, nesting, shelter and movement between areas. These opportunities could potentially be reduced by Project-related habitat disturbance.

Vegetation clearance associated with the Project would primarily be associated with ongoing surface exploration activities, the upgrade and extension of surface infrastructure (e.g. Ventilation Shaft), access tracks, environmental monitoring and management activities (e.g. installation of monitoring equipment), stream restoration activities and other minor Project-related surface activities. Where practicable, the required works would be sited to minimise the amount of vegetation clearance required. The proposed vegetation clearance would be progressive over the life of the mine. As a result, at any one time some small areas are likely to be disturbed (in the order of two hectares), while previously disturbed areas would be in various stages of rehabilitation. To minimise impacts on terrestrial vegetation, vegetation clearance would generally be restricted to the slashing of vegetation (i.e. leaving the lower stem and roots *in-situ* to maximise the potential for natural regrowth) and lopping of branches, where practicable, rather than the removal of soils or trees. Natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. Management measures to be implemented in regard to vegetation clearance activities would be included in a FFMP to be developed for the Project.

Fire

Human access to the Woronora Special Area as a result of the Project has the potential to result in an increase in the frequency of bushfire. High frequency fire is listed as a key threatening process in the TSC Act (NSW Scientific Committee, 2000a). A range of management measures would be implemented for the Project to minimise the potential for bushfire.

Fauna Traps

There is potential for native fauna to become trapped in excavated holes in the ground (e.g. drill holes associated with groundwater monitoring bores, remediation activities or exploration activities). To minimise the potential for native fauna to become trapped, the holes would be filled, capped and/or covered.

Fauna and Road Traffic

The movement of vehicles has the potential to increase the incidence of fauna mortality via vehicular strike. Speed limits would be imposed on fire trails to reduce the potential for vehicle strike on native fauna in the Woronora Special Area.

Fauna and Noise

Numerous studies have been undertaken on the effects of noise on wildlife (e.g. Algers *et al.*, 1978, Allaire, 1978; Ames, 1978; Busnel, 1978; Lynch and Speake, 1978; Shaw, 1978; Streeter *et al.*, 1979; Poole, 1982). The studies indicate that many species are well adapted to human activities and noise. The Project would not increase the existing level of noise at the major surface facilities, however, noise associated with the major surface facilities has the potential to disrupt the routine activities of vertebrate fauna. Noise mitigation and management measures would be implemented at the Project major surface facilities in accordance with the NSW Industrial Noise Policy (Environment Protection Authority [EPA], 2000). Potential sources of noise in the proposed underground mining area and surrounds include the ventilation shafts, vehicle movements and the operation of equipment (e.g. drill rig, compressors and other drilling-related equipment). The potential for noise generation in the proposed underground mining area and surrounds is expected to be low. Construction-related noise-generating activities in this area would typically be localised and of short duration.

Fauna and Artificial Lighting

Project lighting has the potential to affect behavioural patterns of some species. Some bird and bat species, for example, are attracted to insects around lights. As a consequence of this, they could become prey for larger predators (e.g. owls). However, it is relevant to note that changes to Project lighting at the major surface facilities area would be minimal compared to the existing lighting at the Metropolitan Colliery.

Introduced Terrestrial Fauna Species

The provision of refuge or scavenging areas (e.g. discarded food scraps and other rubbish) has the potential to increase populations of introduced fauna species in or around the Project area. A clean, rubbish-free environment would be maintained in order to discourage scavenging and reduce the potential for colonisation of these areas by non-endemic fauna. Employees and contractors would not be allowed to take domestic pets into the Woronora Special Area. The FFMP would describe management measures to be implemented to reduce the potential for introduced pest fauna species and would be developed in consultation with the SCA for activities in the Woronora Special Area.

Amphibian Chytrid Fungus

Infection of frogs by amphibian chytrid causing the disease Chytridiomycosis is listed as a key threatening process under the TSC Act and infection of amphibians with chytrid fungus resulting in Chytridiomycosis is listed as a key threatening process under the EPBC Act.

A water-borne fungal pathogen *Batrachochytrium dendrobatidis*, commonly known as the amphibian or frog chytrid fungus, is responsible for the disease Chytridiomycosis (Berger *et al.*, 1999). Infection occurs through water-borne zoospores released from an infected amphibian in water (NPWS, 2001a). Collection and handling of frogs and inadvertent transport of infected material between frog habitats may also promote the disease's spread (NSW Scientific Committee, 2003a).

To reduce the likelihood of spreading infection, personnel conducting amphibian surveys or surface water sampling for the Metropolitan Colliery would observe appropriate hygiene protocols in accordance with the NPWS (2001a) *Hygiene Protocols for the Control of Disease in Frogs*.

SEPP 44 – Koala Habitat Protection

In response to a state-wide decline of Koala populations, the Department of Urban Affairs and Planning (now DoP) gazetted the State Environmental Planning Policy No. 44 – Koala Habitat Protection (SEPP 44) in January 2005. Western Research Institute and Biosphere Environmental Consultants (2008) assessed whether SEPP 44 applied in consideration of the potential Koala habitat available and the presence of core Koala habitat. Core Koala habitat is an area of land with a resident population of Koala's, evidenced by attributes such as breeding females (i.e. females with young) and recent sightings of and historical records of, a population. While potential Koala habitat occurs in the Project area and surrounds, the Project area does not fall within the definition of core Koala habitat. There was no evidence of the presence of Koalas within the study area during the surveys. No characteristic scratches or faecal pellets were observed, despite searching smooth-barked trees and the base of trees. Based on the above, it is concluded that the provisions of SEPP 44 do not apply (Western Research Institute and Biosphere Environmental Consultants, 2008).

Greenhouse Gas Emissions and Climate Change Effects

As described in Section 4.4, there has been significant growth in greenhouse gases from human activity which in turn affects climate variables such as cloud cover, rainfall, wind patterns, ocean currents, sea levels and the distribution of plant and animal species. Human-caused Climate Change is listed as a key threatening process under the TSC Act and Loss of Climatic Habitat Caused by Anthropogenic Emissions of Greenhouse Gases is listed as a key threatening process under the EPBC Act.

The distribution of most species, populations and communities is influenced by climate (NSW Scientific Committee, 2000b). Many species would be adversely affected unless populations were able to move across the landscape (DECC, 2008m). Species with long generations, poor mobility, narrow ranges, specific host relationships, isolate and specialised species and those with large home ranges are considered to be particularly at risk (Hughes and Westoby, 1994). Examples of fauna species potentially at risk in NSW include the Mountain Pygmy-possum, Long-footed Potoroo, Broad-toothed Rat, Smoky Mouse, Malleefowl, Plains-wanderer, Sooty Owl, Red-tailed Black-Cockatoo, Regent Parrot, Pink Robin, Red-lored Whistler, Striped Legless Lizard, Spotted Frog, Southern Bell Frog, Northern Corroboree Frog and Southern Corroboree Frog (NSW Scientific Committee, 2000b).

Greenhouse gas emissions associated with direct emission sources (e.g. the use of fixed and mobile plant and fugitive coal seam gas emissions), indirect emission sources (e.g. the use of electricity) and other indirect emissions (e.g. the transport of coal and rejects, emissions associated with the burning of coal in domestic and international power stations and the use of coal for off-site coke and subsequent steel and iron production) have been assessed for the Project by Holmes Air Sciences (2008). Holmes Air Sciences (2008) estimate that on average over the 23 years of mining, Metropolitan Colliery would directly release 0.26 Mt per year of CO_2-equivalent emissions and 0.15 Mt per year of CO_2-equivalent emissions would be released indirectly due to on-site use of fuel and electricity. It is estimated that 8.08 Mt per year would be released by other parties through the export and end use of the coal. Measures to minimise greenhouse gas emissions are described in Section 4 of the Environmental Assessment main report (e.g. improvements to maximise efficiency of the use of fuels and minimise electricity consumption).

The *Climate Change - An Australian Guide to the Science and Potential Impacts* (Pittock, 2003) describes climate change projections for Australia. In eastern Australia, the El Niño-Southern Oscillation leads to alternations between floods and prolonged droughts and there is a possibility that climate change will result in a more El Niño-like state (*ibid*.). Annual average temperatures in Australia are expected to increase by 0.4 to 2.0°C by 2030, and 1.0 to 6.0°C by 2070 (relative to 1990) and evaporation and heatwaves are expected to increase and frosts to decrease (*ibid*.). In parts of south-eastern Australia annual rainfall is expected to change by -10% to +5% by 2030 and -35% to +10% by 2070 (Pittock, 2003). Based on the expected changes in rainfall and evaporation, soil moisture is likely to decrease and droughts are likely to become more severe (*ibid*.). An increase in the intensity of heavy rain events is also expected (*ibid*.). Sea level would also continue to rise (Pittock, 2003). Further to this, the *Carbon Pollution Reduction Scheme Green Paper* (Department of Climate Change, 2008) released in July 2008 updates the climate change predictions for Australia. A rise in average temperatures of up to 5^{o}C by 2070 across Australia is predicted under a scenario of high emissions (Department of Climate Change, 2008).

The potential effects of climate change on the nature and extent of the Project potential impacts has been considered including those relating to groundwater (Heritage Computing, 2008), surface water (Gilbert and Associates, 2008) and terrestrial flora (Section 4.4). Heritage Computing (2008) indicates the Project is likely to have a negligible incremental effect on baseflow and that the anticipated climate change effects on baseflow in the Woronora Special Area are far greater than any changes in baseflow induced by mining (i.e. by more than two orders of magnitude). Gilbert and Associates (2008) indicate that climate change would produce more pronounced seasonal patterns of runoff in the region with increasing amounts of runoff occurring in summer and less in the autumn, winter and spring. Relative to the current streamflows, which are more winter dominated, this might lead to a more uniform pattern of flows through the year (*ibid.*). Overall there would also be a tendency for reduced overall streamflow but with an increase in larger flow events in summer. These effects would occur irrespective of any effects of longwall mining in the catchment (Gilbert and Associates, 2008). Longwall mining is predicted to have localised effects on pools and the frequency of interconnected flows between pools. A climate change induced decrease in annual average rainfall and rainfall frequency has the potential to result in a reduction in low flow persistence, an increase in the frequency of low pool water levels and a reduction in inter-pool connection (*ibid.*). The predicted small increase in summer rain and rainfall intensity might increase low flow persistence in summer which is likely to be the currently dominant time for low pool water levels and loss of inter-pool connection (Gilbert and Associates, 2008). Climate change induced reductions in winter and spring rainfall would be expected to result in a significant change to the flow regime irrespective of any mining impacts (*ibid.*). As described in Section 4.4, the potential direct effects of the Project on riparian vegetation, which are expected to be minor and limited in extent, are unlikely to significantly exacerbate the expected effects of climate change.

The likely impacts of climate change on vertebrate species are difficult to predict. Currently a team of DECC scientists along with other fauna specialists is seeking to determine likely impacts of climate change on protected and threatened vertebrate fauna in NSW in particular (M. Pennay, DECC, pers. comm.).

However the project is ongoing. It becomes even more difficult to make precise predictions in specific locations such as what might possibly occur in respect to the Project area. The important local changes within the Project area appear likely to be:

- increasing temperatures;
- increasing evaporation rates;
- increased frequency of heat wave conditions;
- increased runoff in summer;
- decreased runoff in autumn, winter and spring;
- the possibility of more uniform flows throughout the year;
- an increase in the frequency of low pool levels and loss of inter-pool connectivity; and
- an increase in the intensity of storm events.

All vertebrate species operate within given tolerances being physiologically adapted to for example a particular temperature range. If tolerances are exceeded then fauna will seek to re-locate, possibly cease reproduction, and in some cases likely respond adversely with a resulting increase in mortality in various age groups. More vagile species may be able to move to more suitable locations and others could respond by changing their behaviour, for example spending longer periods sheltering in shady habitats that also help to minimise moisture loss.

It is likely that frogs might be adversely impacted, as might riparian species such as the Water Dragon, Water Rat and the Platypus. Birds can be susceptible to increasing heat wave conditions as can a number of terrestrial mammalian species. The climate change scenarios predicted are likely to lead to an increase in fire frequency with a corresponding loss in habitat quality that in the long term could lead to some species becoming local extinct as plant succession dynamics are impacted and/or habitat homogenisation occurs.

The elevation differences in the Project area are not great enough to be able to offer any mitigating effects for increasing temperatures.

What appears to be reasonably certain is that it is likely that a significant number of species could be physiologically stressed with variable adverse outcomes that are likely to be highly species specific and likely to be much greater than the predicted impacts of the Project.

Threatened Fauna

Evaluations have been conducted to assess potential impacts of the Project, including direct, indirect and cumulative potential impacts, on threatened fauna species and their habitats. The evaluations were conducted in accordance with the Draft *Guidelines for Threatened Species Assessment* (DEC and DPI, 2005), which identify important factors that must be considered when assessing potential impacts on threatened species, populations, or ecological communities, or their habitats for development applications assessed under Part 3A of the EP&A Act (DEC and DPI, 2005). These evaluations are provided in Section 5.6.

Matters of National Environmental Significance

Evaluations have been conducted to assess potential impacts of the Project, including direct, indirect and cumulative potential impacts, on matters of national environmental significance. The evaluations are based on the *Significant Impact Guidelines – Matters of National Environmental Significance* (DEH, 2006b). These evaluations are provided in Section 7.

Fauna Management

A FFMP would be developed for the Project. The management plan would include the following in relation to other Project direct and indirect impacts on terrestrial fauna:

- measures to minimise impacts on terrestrial fauna habitats;
- measures to avoid or minimise impacts to threatened terrestrial fauna;
- environmental management of sites where vegetation clearance is necessary;
- measures to minimise impacts on terrestrial fauna including those relating to fauna traps, vehicle strike and introduced pest species;
- Chytridiomycosis management measures;
- bushfire management measures; and
- natural regeneration and habitat rehabilitation measures.

The FFMP would be developed in consultation with the SCA for activities conducted in the Woronora Special Area.

5.6 THREATENED TERRESTRIAL FAUNA

This flora and fauna impact assessment has been prepared in accordance with the Draft *Guidelines for Threatened Species Assessment* (DEC and DPI, 2005), which identify important factors that must be considered when assessing potential impacts on threatened species, populations, or ecological communities, or their habitats for development applications assessed under Part 3A of the EP&A Act (DEC and DPI, 2005).

To assist in identifying whether the potential impacts of the Project are likely to have a significant effect on threatened fauna, evaluations were conducted. These evaluations were based on the Draft *Guidelines for Threatened Species Assessment* (DEC and DPI, 2005) and included consideration of the following items:

- How is the proposal likely to affect the lifecycle of a threatened species and/or population?
- How is the proposal likely to affect the habitat of a threatened species, population or ecological community?
- Does the proposal affect any threatened species or populations that are at the limit of its known distribution?
- How is the proposal likely to affect current disturbance regimes?
- How is the proposal likely to affect habitat connectivity?
- How is the proposal likely to affect critical habitat?

Evaluations were conducted for threatened fauna recorded in the proposed underground mining area or surrounds as well as for other threatened fauna for which potential habitat occurs.

5.6.1 Invertebrates

The Giant Dragonfly has not been recorded in the Woronora Special Area, however potential habitat for this species (i.e. upland swamps) occurs in the Project area and surrounds.

An evaluation for this threatened species is provided below.

5.6.1.1 Giant Dragonfly

The Giant Dragonfly lives in permanent swamps and bogs, which typically comprise some free water and open vegetation (DECC, 2008n). Largely terrestrial throughout its lifecycle, the larvae of the Giant Dragonfly are distinguished from other species of dragonfly by an inability to swim and are thought to avoid open water (NSW Scientific Committee, 1998c). Larvae of the Giant Dragonfly dig long chambered burrows under a swamp, emerging to feed at night and in wet weather on insects and other invertebrates (DECC, 2008n; NSW Scientific Committee, 1998c). The larval stage is long, lasting from at least 10 to 30 years (*ibid*.). Adults of the Giant Dragonfly emerge in October and fly over the swamp and along its margins hunting for flying insects until late January (*ibid*.)

Threats relevant to this species include the loss or degradation of wetland habitats, as well as the declining population size (NSW Scientific Committee, 1998c).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on upland swamp habitats are summarised in Sections 4.3.5 and 5.4. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; changed surface hydrological conditions leading to a reduced availability of habitat and resources; and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing activities would impact this species. Vegetation clearance for surface infrastructure would not take place in upland swamps except for monitoring purposes. Establishment of monitoring sites would involve minimal vegetation clearance for equipment and access. The magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes in upland swamps and is unlikely to have any biologically significant effect on the soil moisture regime that sustains vegetation/habitats in these areas. As a result, mine subsidence is unlikely to result in a reduction in availability of habitat and resources that would impact on the lifecycle of the Giant Dragonfly. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Further, the Project would not involve the conduct of any prescribed burns in native remnant vegetation including upland swamps. Hence it is very unlikely that the Project would adversely impact the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Giant Dragonfly inhabits both coastal and upland permanent wetlands (NSW Scientific Committee, 1998c). Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat of this species. Further, the Project would not involve the conduct of any prescribed burns in native remnant vegetation including upland swamps. Since very limited clearing would occur within the Project area, it is unlikely that clearing activities would have a significant impact on the habitat of this species. Vegetation clearance for surface infrastructure would not take place in upland swamps except for monitoring purposes.

Establishment of monitoring sites would involve minimal vegetation clearance for equipment and access. The Project is unlikely to significantly reduce the quality or availability of habitat for the Giant Dragonfly.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Giant Dragonfly is distributed along the east coast of NSW from the Victorian border to northern NSW, however is not found west of the Great Dividing Range (DECC, 2008n). Known occurrences have been recorded in the Blue Mountains and Southern Highlands, in the Clarence River catchment, and on a few coastal swamps from north of Grafton to Nadgee in the south (*ibid*.).

The Project is generally located within the known distribution of the Giant Dragonfly and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance*;* limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Giant Dragonfly.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was clearing of the species habitats, a significant increase in fire frequency or if changes in surface hydrology impacted adversely on upland swamp habitats. Vegetation clearance for surface infrastructure would not take place in upland swamps except for monitoring purposes. Establishment of monitoring sites would involve minimal vegetation clearance for equipment and access. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Gilbert and Associates (2008) have demonstrated that mine subsidence effects would not result in changes to surface hydrology that would adversely impact on upland swamp habitats. Hence the Project is very unlikely to adversely impact habitat connectivity for the Giant Dragonfly.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Giant Dragonfly. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEWHA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.2 Amphibians

The Giant Burrowing Frog and Red-crowned Toadlet were recorded by Western Research Institute and Biosphere Environmental Consultants (2008) in the Project area or surrounds.

Other threatened amphibian species recorded in the Woronora Special Area or wider surrounds which could potentially occur in the Project area or surrounds include the Stuttering Frog, Littlejohn's Tree Frog and Green and Golden Bell Frog.

Evaluations for these threatened amphibian species are provided below.

5.6.2.1 Giant Burrowing Frog

Much of the Giant Burrowing Frog's existence is spent burrowed underground sometimes beneath deep leaf-litter or in earth-filled rock crevices interspersed with brief periods of activity throughout the year during rainy weather (NPWS, 2001b). Burrows are excavated into the earth around, or associated with rocks fissures or boulders (NPWS, 2001b). It has also been reported that yabbie holes are utilised along the beds and banks of drying creeks (NPWS, 2001b). The Giant Burrowing Frog mainly breeds between mid summer and autumn (Cogger, 2000). Males call from within or adjacent to the breeding burrows or amongst accumulated vegetation debris (NPWS, 2001b). Tadpoles develop in three to six months (NPWS, 2001b). The diet of the Giant Burrowing Frog mainly consists of invertebrates including ants, beetles, cockroaches, spiders, centipedes and scorpions (NPWS, 2001b). The Giant Burrowing Frog is thought to have a large home range; having been recorded at considerable distances from suitable moist habitat (Hoser, 1989; Gillespie, 1990). Individuals have been recorded to move up to 200-300 m in a night (NPWS, 2001b).

Threats relevant to this species include vegetation clearance, habitat disturbance, erosion and sedimentation of headwater creek lines, high nutrient flows, predation by feral animals, fire and road mortality (NPWS, 2001b). Habitat alteration by longwall mining is also considered a threat to this species (NSW Scientific Committee, 2005a).

The Giant Burrowing Frog has been located within the Project area (Figure 5) and it is likely that a viable population (s) of the species is/are present.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. Mine subsidence has the potential to impact marginally on populations through limited rock fall and surface tension cracks impacting on particular individuals but not at a level likely to have a negative impact on population dynamics. Changes in surface hydrology have the potential to impact on the habitats of the Giant Burrowing Frog (Sections 5.1 to 5.4) including potential impacts on habitats likely important in the species' breeding. However, the magnitude of surface cracking is too small to influence the hydrological processes and vegetation on slopes/ridgetops and in upland swamps and is unlikely to have any biologically significant effect on the availability of water (see Sections 5.1 to 5.5). There is the potential for mine subsidence to alter the availability of water in streams, particularly during times of low flow. Gilbert and Associates (2008) indicate that mine subsidence associated with the Project would have a negligible effect on moderate and larger flows in streams. While mine subsidence has the potential to increase the rate of leakage (and consequently pool level recession) of pools, it is likely that a portion of the pools subject to mine subsidence effects will hold some water during prolonged dry periods (Gilbert and Associates, 2008). As described above, much of the Giant Burrowing Frog's existence is spent burrowed underground interspersed with brief periods of activity throughout the year during rainy weather (NPWS, 2001b). An increase in fire frequency also has the potential to impact on the lifecycle of this species.

Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency resulting from the Project. Further, the Project would involve minimal vegetation clearance. It is very unlikely that the Project would adversely impact on the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The northern populations of the Giant Burrowing Frog are largely confined to sandstone ridgetop habitat and broader upland valleys, where the species is associated with small headwater creek lines and slow flowing to intermittent creek lines in undisturbed areas (NPWS, 2001b). The vegetation in these areas is typically woodland, open woodland and heath, with riparian components in and along the sides of early order streams. The species may also utilise upland swamps as a component of the range of habitats it is able to exploit. The Project area and/or surrounds is considered to contain high quality habitat for the Giant Burrowing Frog (DECC, 2007a).

There is the potential for relatively small components of each of the broad habitat types identified as being part of the Giant Burrowing Frog's 'habitat' to be impacted by the Project via cliff face and rock-fall, changes in stream gradients, increased scouring of stream banks, changes to stream alignments and sub surface and surface tension cracking (Sections 5.1 to 5.4). However the likely impacts of the potential changes in habitat described has been demonstrated to be relatively minor and localised.

Mine subsidence also has the potential to cause cracking and alter the availability of water. The Giant Burrowing Frog is typically associated with small headwater creek lines and slow flowing to intermittent creek lines (NPWS, 2001b). Non-persistent sources of water (e.g. surface seeps, ponded water adjacent to fire trails, drainage lines and ephemeral streams) occur naturally and are generally available to terrestrial vertebrate fauna including the Giant Burrowing Frog during and for a period following rain. However, the magnitude of surface cracking is too small to influence the hydrological processes on slopes/ridgetops and in upland swamps. For more persistent sources of water, there is the potential for mine subsidence to convey a portion of low stream surface flows via fracture networks and reduce the water level in pools as they become hydraulically connected with the fracture network. There is also likely to be reduced continuity of flow between affected pools during dry weather. Gilbert and Associates (2008) estimate that in Waratah Rivulet, typical underflow via the fracture network is expected to increase the average frequency of no flow days from 2% to 15%, with the average frequency of low flows (less than 2 ML/day) increasing from 36% to 40% of days. Gilbert and Associates (2008) also indicate that mine subsidence associated with the Project would have a negligible effect on moderate and larger flows. During prolonged dry periods when flows recede to low levels, a greater proportion of the lower flows would be conveyed via the fracture network. Such abnormally persistent low flows have been observed in the Waratah Rivulet in recent times. Despite prolonged dry periods, pools (albeit smaller, with reduced connectivity) have been observed to be present in Waratah Rivulet. That is, a number of micro-pools remain which hold water. Tributaries of Waratah Rivulet also contain numerous in-stream pools, which are however relatively much smaller, both in plan area, depth and volume relative to runoff flow rates than those on the rivulet. The effects of subsidence on typical tributary pools can be seen as lower pool levels during the longer recessionary periods with little observable effect during periods of normal creek flow. In longer recessionary periods pool water levels can decline below the 'cease to flow' level at a rate faster than it did prior to being undermined (Gilbert and Associates, 2008). Mine subsidence also has the potential to result in changes in stream water quality. The effects of subsidence on water quality have been most noticeable as localised and transient changes (spikes or pulses) in iron and manganese and minor associated increases in electrical conductivity. Potential impacts on riparian vegetation would be localised and limited in extent.

As described in Section 5.5, the Project would include some minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Vegetation clearance would be managed through the development and implementation of a FFMP which would include measures to minimise habitat disturbance.

Given the nature of the hydrological changes and other potential Project impacts, the Project is unlikely to significantly reduce the quality or availability of habitat for the Giant Burrowing Frog.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Giant Burrowing Frog occurs in southeastern NSW and Victoria (NPWS, 2001b). In the north of its distribution, this species is largely confined to the sandstone geology of the Sydney Basin extending as far south as Jervis Bay (Daly, 1996). In the south, this species occurs in disjunct 'pockets' from Narooma in NSW, south into eastern Victoria.

During recent targeted surveys within the Project area and surrounds, Western Research Institute and Biosphere Environmental Consultants (2008) recorded the Giant Burrowing Frog in areas where weeping joint in the upper sandstone areas had created damp sand banks and shallow ditches; sedges and plants typically associated with wet heath were prevalent at these sites (Figure 5).

The Project is located within the known distribution of the Giant Burrowing Frog and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Further, the FFMP would contain protocols for minimising the risk of introduction or spread of the Chytrid fungus, vertebrate pests, weeds and *Phytophthora cinnamomi*. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Giant Burrowing Frog.

5. How is the proposal likely to affect habitat connectivity?

The Giant Burrowing Frog has been located within the Project area and it is likely that a viable population(s) of the species is/are present. It is also likely that the existing populations are undergoing recovery following the 2001 bushfires.

Disruption of existing habitat connectivity for existing populations would be possible following events such as significant habitat clearing, extensive rock falls or major surface cracking that created a barrier to movement, or the complete and permanent drying of streams that separated existing meta-populations. However only minimal clearing would result from the Project and rock fall and surface cracking are predicted to be relatively minor (Sections 5.1 to 5.5). Potential impacts along streams where the Giant Burrowing Frog occurs, is very unlikely to fragment existing populations. It is very unlikely that habitat connectivity for the Giant Burrowing Frog would be significantly affected by the Project.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Giant Burrowing Frog. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEWHA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.2.2 Red-crowned Toadlet

The Red-crowned Toadlet is a relatively long-lived species (8-10 years) (NSW Scientific Committee, 2002b) and is able to withstand prolonged periods of drought through its nocturnal, semi-fossorial lifestyle and use of moist microhabitat refugia (NPWS, 2001c).

The Red-crowned Toadlet has a unique terrestrial reproductive strategy: small nests are formed within decomposing accumulated leaf matter and clutch sizes are small, consisting of around 20-24 large eggs (NPWS, 2001c). The nests retain the eggs through the early stages of tadpole development; then rainfall events flush the embryos from the nest, and tadpoles complete development within transient pools (NPWS, 2001c). The timing of follow up rain events and duration of temporary pools is critical to reproductive success. Many clutches are lost to desiccation through evaporation of the shallow pools and therefore recruitment is usually in low numbers (NPWS, 2001c). To offset this loss, females can lay multiple clutches and breed opportunistically when appropriate conditions prevail (*ibid*.). The Red-crowned Toadlet has been recorded calling in all months of the year, including winter, and eggs have been found in all months (NPWS, 2001c). Midwinter breeding is infrequent and likely to occur during milder weather conditions that may prevail in the coastal part of its range in some years (*ibid*.). The Red-crowned Toadlet can also be found breeding along eroded gutters or the verges of unsealed fire trails (NPWS, 2001c). In these locations, accumulations of leaf-litter in association with temporary pools mimics natural feeder creek breeding habitat (*ibid*.).

When not breeding, Red-crowned Toadlets are thought to disperse over wider areas of its sandstone habitat and many individuals have been observed sheltering under cover that would be unsuitable for egg-laying (NPWS, 2001c). However, it is likely that such ‘dispersion’ is only in the order of a few tens of metres from suitable breeding areas (*ibid*.). Red-crowned Toadlets forage on ants, termites, mites, pseudo-scorpions, collembolans and small cockroaches (Rose, 1974; Webb, 1983).

Threats relevant to this species include habitat loss or degradation, high frequency fire, bush rock removal, Chytrid fungus disease, water pollution and changed hydrological regimes (NPWS, 2001c; NSW Scientific Committee, 2002b). Habitat alteration by longwall mining is also considered a threat to this species (NSW Scientific Committee, 2005a).

The Red-crowned Toadlet has been located within the Project area and it is likely that a viable population(s) of the species is/are present.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. Mine subsidence has the potential to impact marginally on populations through limited rock fall and surface tension cracks impacting on particular individuals but not at a level likely to have a negative impact on population dynamics. Changes in surface hydrology are likely to impact marginally, if at all, on the habitats, and as a result the lifecycle of the Red-crowned Toadlet (Sections 5.1 to 5.4). There is low potential for disruption to the Red-crowned Toadlet given its use of streams that are typically ephemeral in nature, as well eroded gutters or the verges of unsealed fire trails. These sources of water, which are generally available during and for a period following rain, would not be impacted by the Project. The effects of subsidence on typical tributary pools can be seen as lower pool levels during the longer recessionary periods with little observable effect during periods of normal creek flow. An increase in fire frequency also has the potential to impact on the lifecycle of this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency resulting from the Project. Further, the Project would involve minimal vegetation clearance. It is very unlikely that the Project would adversely impact on the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Red-crowned Toadlet is known only from Triassic sandstones of the Sydney Basin, being found in steep escarpment areas and plateaus, as well as low undulating ranges with benched outcroppings (NPWS, 2001c). Within these geological formations, this species mainly occupies the upper parts of ridges, usually being restricted to within about 100 m of the ridgetop (*ibid*.). The Red-crowned Toadlet may also occur on plateaus or more level rock platforms along the ridgetop, however this area is usually less preferred than the first talus slope areas below the upper escarpment or just below benched rock platforms (NPWS, 2001c).

Favoured microhabitats for shelter sites are under flat sandstone rocks ('bush-rock') either resting on bare rock or damp loamy soils (NPWS, 2001c). Red-crowned Toadlet's have also been found under logs on soil, beneath thick ground litter, particularly near large trees and in horizontal rock crevices near the ground (*ibid*.). Red-crowned Toadlets do not usually live along permanent flowing water courses occurring in gullies, instead preferring permanently moist soaks or areas of dense ground vegetation or litter along or near headwater stream beds (NPWS, 2001c). These are the non-perennial first or second order drainage systems that are adjacent to ridges, are ephemeral in nature, and commonly called 'feeder-creeks' (*ibid*.). These drainage systems channel water from the ridges, benches, cliffs and talus slopes to the perennial streams in the gullies below. Such watercourses are dry or reduced to scattered shallow pools or ponds for much of the year, and have sustained flow for only a few weeks following thunderstorms (NPWS, 2001c). Under natural conditions these feeder creeks have high water quality and low nutrient loads. The main vegetation communities found in association with this species are open woodland and heath communities that are typical for Hawkesbury and Narabeen geology (NPWS, 2001c). Tree cover, when present, is usually open and low (10 – 20 m) and with a xeromorphic understorey (*ibid*.).

The Project area and/or surrounds is considered to contain high quality habitat for the Red-crowned Toadlet (DECC, 2007a).

There is the potential for relatively small components of the Red-crowned Toadlet's 'habitat' to be impacted by the Project via cliff face and rock-fall, changes in stream gradients, increased scouring of stream banks, changes to stream alignments and sub surface and surface tension cracking (Sections 5.1 to 5.4). However the likely impacts of the potential changes in habitat described has been demonstrated to be relatively minor and localised. Changes in surface hydrology are likely to impact marginally, if at all, on the habitats of the Red-crowned Toadlet (Sections 5.1 to 5.4).

Non-persistent sources of water (e.g. surface seeps, ponded water adjacent to fire trails, drainage lines and ephemeral streams) occur naturally and are generally available to terrestrial vertebrate fauna including the Red-crowned Toadlet during and for a period following rain. However, the magnitude of surface cracking is too small to influence the hydrological processes on slopes/ridgetops and in upland swamps. For more persistent sources of water, there is the potential for mine subsidence to convey a portion of low stream surface flows via fracture networks and reduce the water level in pools as they become hydraulically connected with the fracture network. The effects of subsidence on typical tributary pools can be seen as lower pool levels during the longer recessionary periods with little observable effect during periods of normal creek flow. There is also likely to be reduced continuity of flow between affected pools during dry weather. Mine subsidence also has the potential to result in changes in stream water quality. Potential impacts on riparian vegetation would be localised and limited in extent. As described in Section 5.5, the Project would include some minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Vegetation clearance would be managed through the development and implementation of a FFMP which would include measures to minimise habitat disturbance.

Given the nature of the hydrological changes and other potential Project impacts, the Project is unlikely to significantly reduce the quality or availability of habitat for the Red-crowned Toadlet.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Red-crowned Toadlet has a restricted distribution, known from a relatively small area of mid-eastern NSW (NPWS, 2001c). It is known from isolated portions of the Sydney Basin, from Pokolbin State Forest in the north to the Nowra district in the South, and Mt Victoria in the west.

During recent targeted surveys within the Project area and surrounds, the Red-crowned Toadlet was recorded at several locations in eucalypt woodland and heath, typically below sandstone ridges (Western Research Institute and Biosphere Environmental Consultants, 2008).

The Project is located within the known distribution of the Red-crowned Toadlet and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Further, the FFMP would contain protocols for minimising the risk of introduction or spread of the Chytrid fungus, vertebrate pests, weeds and *Phytophthora cinnamomi*. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Red-crowned Toadlet.

5. How is the proposal likely to affect habitat connectivity?

The Red-crowned Toadlet has been located within the Project area and it is likely that a viable population(s) of the species is/are present. It is also likely that the existing populations are undergoing recovery following the 2001 bushfires. Disruption of existing habitat connectivity for existing populations would be possible following events such as significant habitat clearing, extensive rock falls or major surface cracking that created a barrier to movement, or the complete and permanent drying of tributary creeks that separated existing meta-populations. However only minimal clearing would result from the Project and rock fall and surface cracking are predicted to be relatively minor (Sections 5.1 to 5.5). Potential impacts along upland streams where the Red-crowned Toadlet occurs, is very unlikely to fragment existing populations. It is very unlikely that habitat connectivity for the Red-crowned Toadlet would be significantly affected by the Project.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Red-crowned Toadlet. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.2.3 Stuttering Frog, Littlejohn's Tree Frog and Green and Golden Bell Frog

The Stuttering Frog inhabits rainforest and wet, tall open forest and breeds in streams during summer after heavy rain (DECC, 2008o). Eggs are laid on rock shelves or shallow riffles in small, flowing streams (*ibid*.). As the tadpoles grow they move to deep permanent pools and take approximately 12 months to metamorphose (DECC, 2008o). Outside the breeding season adults live in deep leaf litter and thick understorey vegetation on the forest floor. The Stuttering Frog feeds on insects and smaller frogs.

The Littlejohn's Tree Frog occurs along permanent rocky streams with thick fringing vegetation associated with eucalypt woodlands and heaths among sandstone outcrops (DECC, 2008p). The Littlejohn's Tree Frog breeds mostly in autumn, but the species will also breed after heavy rainfall in spring and summer (NSW Scientific Committee, 2000c). Males have been found to call from elevated positions beside ponds and creeks with breeding habitat not restricted to any particular type of water body having been found in streams, temporary pools and dams (Anstis, 2002; Lemckert, 2005). The Littlejohn's Tree Frog hunts either in shrubs or on the ground.

The Green and Golden Bell Frog is generally active from about September to April, when they leave their "over winter" shelter sites to forage and breed. Males call in spring and summer, while floating partly-submerged in open water, or while perched on low mats of emergent vegetation, the ground, or vegetation near water (Pyke and White, 2001). Although active during the night and day, the Green and Golden Bell Frog generally limits daytime movements to emerging from a shelter site and moving to a basking site where it is often found sitting in the sun (*ibid*.). The home range of an individual Green and Golden Bell Frog may range from less than 100 m^2 to an area at least 700 m away. Individuals have been observed sheltering in residential gardens located 200–300 m from their breeding site (*ibid*.). The Green and Golden Bell Frog feeds on a wide variety of prey including frogs, lizards, crickets, cockroaches, dragonflies, grasshoppers, caterpillars, slugs, earth-worms, molluscs, isopods, flies and tadpoles (Pyke and White, 2001).

Threats relevant to the Stuttering Frog include habitat loss or modification, changes to natural water flows and water quality, predation of eggs and tadpoles by the introduced Mosquito Fish and the Chytrid fungus disease (DECC, 2008o), while threats relevant to the Littlejohn's Tree Frog include limited dispersal from small populations which increases the risk of local extinction; clearing of native vegetation and reduced habitat availability; and inappropriate fire practices (including pre- and post-logging burns and control burning) that disturb breeding habitat (NSW Scientific Committee, 2000a).

Threats relevant to the Green and Golden Bell Frog include loss of habitat, drainage of wetlands and ponds, predation of eggs and tadpoles by the Mosquito Fish, predation of adults by Foxes and Cats, the use of herbicides, insecticides and other chemicals near wetland areas and the Chytrid fungus disease (NPWS, 2000a). Habitat alteration by longwall mining is also considered a threat to the Stuttering Frog and Littlejohn's Tree Frog (NSW Scientific Committee, 2005a).

The Stuttering Frog, Littlejohn's Tree Frog and the Green and Golden Bell Frog have not been located within the Project area and it is unlikely viable populations of these species are present.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. Mine subsidence has the potential to impact marginally on populations through limited rock fall and surface tension cracks impacting on particular individuals but not at a level likely to have a negative impact on population dynamics. Changes in surface hydrology have the potential to impact on potential habitat of the Stuttering Frog, Littlejohn's Tree Frog and the Green and Golden Bell Frog (Sections 5.1 to 5.4). There is the potential for mine subsidence to alter the availability of water in streams, particularly during times of low flow. However, Gilbert and Associates (2008) indicate that mine subsidence associated with the Project would have a negligible effect on moderate and larger flows in streams. While mine subsidence has the potential to increase the rate of leakage (and consequently pool level recession) of pools, it is likely that a portion of the pools subject to mine subsidence effects will hold some water during prolonged dry periods (Gilbert and Associates, 2008). An increase in fire frequency also has the potential to impact on the lifecycle of these species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency due to the Project. Further, the Project would involve minimal vegetation clearance. It is very unlikely that the Project would adversely impact on the lifecycle of these three species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Stuttering Frog inhabits rainforest and wet, tall open forest in the foothills and escarpment on the eastern side of the Great Dividing Range (DECC, 2008o), while the Littlejohn's Tree Frog appears to be restricted to sandstone woodland and heath communities at mid to high altitude (NSW Scientific Committee, 2000c). The Green and Golden Bell Frog has been recorded in a wide variety of habitats including wetlands, marshes, swamps, ponds, dams, ditches, creeks, rivers and watering troughs (Pyke and White, 2001) and is also known to inhabit disturbed sites such as landfill areas and disused industrial sites (NPWS, 1999d). The Project area and/or surrounds is considered to contain high quality habitat for the Stuttering Frog and low quality habitat for the Green and Golden Bell Frog (DECC, 2007a). The habitat quality of the Project area and surrounds has not been mapped by DECC (2007a) for the Littlejohn's Tree Frog.

There is the potential for relatively small components of each of the broad habitat types identified as being part of these three species 'habitat' to be impacted by the Project via cliff face and rock-fall, changes in stream gradients, increased scouring of stream banks, changes to stream alignments, and sub surface and surface tension cracking (Sections 5.1 to 5.4). However the likely impacts of the potential changes in habitat described has been demonstrated to be relatively minor and localised. Mine subsidence also has the potential to cause cracking and alter the availability of water. There is the potential for mine subsidence to convey a portion of low stream surface flows via fracture networks and reduce the water level in pools as they become hydraulically connected with the fracture network. There is also likely to be reduced continuity of flow between affected pools during dry weather.

Gilbert and Associates (2008) estimate that in Waratah Rivulet, typical underflow via the fracture network is expected to increase the average frequency of no flow days from 2% to 15%, with the average frequency of low flows (less than 2 ML/day) increasing from 36% to 40% of days. Gilbert and Associates (2008) also indicate that mine subsidence associated with the Project would have a negligible effect on moderate and larger flows. During prolonged dry periods when flows recede to low levels, a greater proportion of the lower flows would be conveyed via the fracture network. Such abnormally persistent low flows have been observed in the Waratah Rivulet in recent times. Despite prolonged dry periods, pools (albeit smaller, with reduced connectivity) have been observed to be present in Waratah Rivulet. That is, a number of micro-pools remain which hold water. Tributaries of Waratah Rivulet also contain numerous in-stream pools, which are however relatively much smaller, both in plan area, depth and volume relative to runoff flow rates than those on the rivulet. The effects of subsidence on typical tributary pools can be seen as lower pool levels during the longer recessionary periods with little observable effect during periods of normal creek flow. In longer recessionary periods pool water levels can decline below the 'cease to flow' level at a rate faster than it did prior to being undermined (Gilbert and Associates, 2008). Mine subsidence also has the potential to result in changes in stream water quality. The effects of subsidence on water quality have been most noticeable as localised and transient changes (spikes or pulses) in iron and manganese and minor associated increases in electrical conductivity. Potential impacts on riparian vegetation would be localised and limited in extent.

As described in Section 5.5, the Project would include some minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required.

Given the nature of the hydrological changes and other potential Project impacts, the Project is unlikely to significantly reduce the quality or availability of habitat for these three species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Stuttering Frog occurs along the east coast of Australia from southern Queensland to the northeastern Victoria. The species has declined in distribution and abundance, particularly in south-east NSW (DECC, 2008o). It was once not uncommon through the wetter forests and rainforests of the Blue Mountains and the Illawarra Escarpment (DECC, 2007a). There is a record for this species from the last fifteen years from near Helensburgh and an unconfirmed record from the Illawarra Escarpment from 2001 (NPWS, 2003b).

Littlejohn's Tree Frog is distributed along the eastern slopes of the Great Dividing Range from Watagan State Forest near Wyong, south to Buchan in northeastern Victoria (NSW Scientific Committee, 2000c). Within the Greater Southern Sydney Bioregion, the Woronora Plateau and the higher rainfall areas of the Blue Mountains are considered two key areas that are important to this species (DECC, 2007a). In the past, Littlejohn's Tree Frog has been reported to be common at Darkes Forest (A. White pers. comm. in DECC, 2007a).

The Green and Golden Bell Frog are distributed in a series of isolated coastal populations within its former known range. Since 1990 there have been approximately 50-recorded locations in NSW, most of which are small, coastal, or near coastal populations (DECC, 2008q). Within the Sydney Basin, most of the remaining populations occur within a few kilometres of the coast (DECC, 2007a).

The Project is generally located within the known distribution of the Stuttering Frog, Littlejohn's Tree Frog and Green and Golden Bell Frog and does not represent a distributional limit for these species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Further, the FFMP would contain protocols for minimising the risk of introduction or spread of the Chytrid fungus, vertebrate pests, weeds and *Phytophthora cinnamomi*. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on these three frogs.

5. How is the proposal likely to affect habitat connectivity?

The Stuttering Frog, Littlejohn's Tree Frog and the Green and Golden Bell Frog have not been located within the Project area and it is unlikely viable populations of these species are present. Disruption of existing habitat connectivity for existing populations were they found to exist, would be possible following events such as significant habitat clearing, extensive rock falls or major surface cracking that created a barrier to movement, or the complete and permanent drying of streams that separated populations. However only minimal clearing would result from the Project and rock fall and surface cracking are predicted to be relatively minor (Sections 5.1 to 5.5). Potential impacts along streams, is very unlikely to fragment existing populations, were they found to exist. It is very unlikely that the Project would degrade or lessen existing habitat connectivity for these three species if they were to be found within the Project area.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Stuttering Frog, Littlejohn's Tree Frog or Green and Golden Bell Frog. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.3 Reptiles

The Broad-headed Snake was recorded by Western Research Institute and Biosphere Environmental Consultants (2008) during recent surveys for the Project. Rosenberg's Goanna has also been recorded in the Woronora Special Area and wider surrounds.

Evaluations for these threatened reptile species are provided below.

5.6.3.1 Broad-headed Snake

The Broad-headed Snake is found in rocky outcrops and adjacent sclerophyll forest and woodland (Cogger *et al*., 1993; NPWS, 2001d). Most suitable sites occur in sandstone ridgetops (Cogger *et al*., 1993). Suitable habitat is patchily distributed throughout the species range (Cogger *et al*., 1993). Adult snakes show a seasonal, temperature induced, shift in habitat use (Webb and Shine, 1998a). Adults use rocks and crevices as shelter sites in rocky outcrops in autumn, winter and early spring (Webb and Shine, 1994). Juvenile snakes remain in rocky habitat year round (Downes, 1999). Snakes shelter under thin (<20 cm) rocks on exposed sites, which fit closely with a rocky substrate (Webb and Shine, 1994; Webb and Shine, 1998b). Occupied crevices have a sunny aspect (Webb and Shine, 1998b) and rocks used by snakes are those that receive the most warmth from the sun (Pringle *et al.*, 2003). The majority of occupied retreat sites occur on exposed cliff edges (Webb and Shine, 1994). Thermally suitable microhabitat may be a limiting resource for the species (Pringle *et al.*, 2003). Snakes often spend long periods of inactivity in a retreat site.

The Broad-headed Snake is nocturnal to crepuscular (active at dusk) and ambushes its prey (NPWS, 1999e). This species forages predominately on lizards (particularly Lesueur's Velvet Gecko) and frogs during winter, while the feeding preference shifts to mammals during the warmer months (Cogger, 2000; Webb and Shine, 1998c). Young are almost totally dependant on geckos as a source of food (Webb and Shine, 1998c). Individual Broad-headed Snakes have been recorded moving distances of up to 600 m (Ayers *et al*., 1996). This species is ovoviviparous giving birth to eight to 20 young (Cogger, 2000). Juveniles take four to six years to reach maturity (NPWS, 1999e).

Threats relevant to the Broad-headed Snake include the removal of bush rock (loss of shelter for this species and for its prey), bushfire, fire suppression, forestry activities, impacts of feral animals such as Feral Goats, as well as illegal collection of the species (Green, 1997; Wilson and Swan, 2003; Pringle *et al.*, 2003; Webb *et al*., 2005; NPWS, 1999e). Habitat alteration by longwall mining and removal of dead wood and dead trees are other threats relevant to this species (NSW Scientific Committee, 2003b; NSW Scientific Committee, 2005a).

During the surveys, the Broad-headed Snake was found to be relatively common in appropriate habitat and it is very likely that viable populations of the Broad-headed Snake are located within the Project area.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in the frequency of bushfire; an increase in exotic predator species; an increase in the rate of rock fall; and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact this species. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact on this species, or an increase in feral exotic species. MSEC (2008) have predicted only minor increases in rock fall and cliff face collapse, with likely only small impacts, if any, on potential shelter or retreat sites for the Broad-headed Snake. Hence it is very unlikely that the Project would adversely impact the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Broad-headed Snake favours habitat centred on the communities occurring on the Triassic sandstone of the Sydney Basin including exposed sandstone outcrops and benching in woodland, open woodland and/or heath (NPWS, 1999e). The Broad-headed Snake seasonally occupies distinctive microhabitats within these broader habitat types - rock crevices and exfoliating sheets of weathered sandstone during the cooler months and tree hollows during summer (Webb and Shine, 1998b). The rock crevice refuges commonly have a west to northwesterly aspect in order to maximise temperatures (Webb and Shine, 1998b). The Project area and/or surrounds are considered to contain high quality habitat for the Broad-headed Snake (DECC, 2007a).

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. To minimise impacts on terrestrial vegetation, vegetation clearance would be restricted to the slashing of vegetation (i.e. leaving the lower stem and roots *in-situ* to maximise the potential for natural regrowth) and lopping of branches, where practicable, rather than the removal of trees. Reduction of habitat for the Broad-headed Snake due to surface infrastructure would be very small in comparison with the amount of habitat available. Further, given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or an increase in feral exotic species that could adversely impact habitat. A significant loss of shelter/retreat sites for the Broad-headed Snake due to mine subsidence associated with the Project is unlikely based on the relatively small increase in rock fall and cliff face collapse predicted to occur by MSEC (2008). The Project is unlikely to significantly reduce the quality or availability of habitat for this species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Broad-headed Snake is restricted to within a 200 km radius of Sydney, from Wollemi National Park in the north, south to the Clyde River Catchment, south-west of Nowra, west to the upper Blue Mountains and east to the Royal National Park (NPWS, 1999e). The current distribution of this species is focused in four key locations: the Blue Mountains, southern Sydney, an area north-west of the Cumberland Plains and the Nowra hinterland. Its eastern most distribution is within Royal National Park and the escarpment areas above the northern end of the Illawarra (NPWS, 1999e).

During recent targeted surveys within the Project area and surrounds, the Broad-headed Snake was recorded at several locations in sandstone escarpment areas where tall trees were present (Figure 5). The Broad-headed Snake has also been recorded in the Metropolitan, O'Hares and Woronora Special Areas and is considered to be a species of high regional priority (DECC, 2007a).

The Project is located within the known distribution of the Broad-headed Snake and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Further, a FFMP to be developed for the Project would include measures to minimise the occurrence of pest fauna species. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Broad-headed Snake.

5. How is the proposal likely to affect habitat connectivity?

Disruption of existing habitat connectivity for an existing population, would be possible following events such as significant habitat clearing, extensive rock falls or major surface cracking that created a barrier to movement. However only minimal clearing would result from the Project, and rock fall and surface cracking are predicted to be relatively minor (Sections 5.1 to 5.5). Hence it is very unlikely that the Project would adversely impact habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Broad-headed Snake. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.3.2 Rosenberg's Goanna

Rosenberg's Goanna is mostly terrestrial and shelters in burrows (which it digs for itself), hollow logs and rock crevices (Wilson and Swan, 2003; Cogger, 2000). This species lays clutches of eggs in termite mounds (Wilson and Swan, 2003). Rosenberg's Goanna forages on insects, small mammals, birds and other reptiles. The species is found in heath, open forest and woodland, is associated with termites, the mounds of which this species nests in. Individuals require large areas of habitat.

Threats to Rosenberg's Goanna include habitat loss and fragmentation, removal of habitat elements such as termite mounds and fallen timber, vehicle strike and predation by Cats and Dogs (DECC, 2008r). Dog and Fox control programs may also impact on this species (DECC, 2007a). Habitat alteration by longwall mining and removal of dead wood and dead trees are other threats relevant to this species (NSW Scientific Committee, 2003b; NSW Scientific Committee, 2005a).

During the surveys by Western Research Institute and Biosphere Environmental Consultants (2008), Rosenberg's Goanna was not located. However given the known range of the species, its habitat requirements and previous sightings in the southern Sydney catchment it is likely that the species could be located within the Project area. However it could not be determined whether or not a viable population of this species exists within the Project area.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in the frequency of bushfire; an increase in exotic predator species; an increase in the rate of rock fall; and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact this species. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact on this species, or an increase in feral exotic species. MSEC (2008) have predicted only minor increases in rock fall, with likely only small impacts, if any, on potential habitat for the Rosenberg's Goanna. Hence it is very unlikely that the Project would adversely impact the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

Rosenberg's Goanna is known to associate with sandstone environments, occurring in open woodlands, heaths on sandy soil and in both wet and dry sclerophyll forests, where it shelters in burrows, hollow logs and rock crevices (Wilson and Swan, 2003; Cogger, 2000; DECC, 2007a). The Project area and/or surrounds is considered to contain high quality habitat for the Rosenberg's Goanna (DECC, 2007a).

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Reduction of habitat for the Rosenberg's Goanna due to surface infrastructure would be very small in comparison with the amount of habitat available. Further, given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or an increase in feral exotic species that could adversely impact habitat. Loss of habitat due to increased rock fall associated with predicted mine subsidence is likely to be minimal (MSEC, 2008). The Project is unlikely to significantly reduce the quality or availability of habitat for this species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Rosenberg's Goanna occurs on the Sydney Sandstone in Wollemi National Park to the north-west of Sydney, in the Goulburn and Australian Capital Territory (ACT) regions and near Cooma in the south (DECC, 2008r). There are also records for this species from the South West Slopes near Khancoban and Tooma River (*ibid*.).

Rosenberg's Goanna has been recorded in the Metropolitan, O'Hares and Woronora Special Areas and the Woronora Plateau is considered to be one of the most important population centres in NSW for this species (DECC, 2007a).

The Project is located within the known distribution of the Rosenberg's Goanna and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Further, a FFMP to be developed for the Project would include measures to minimise the occurrence of pest fauna species. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Rosenberg's Goanna.

5. How is the proposal likely to affect habitat connectivity?

Disruption of existing habitat connectivity for an existing population, would be possible following events such as significant habitat clearing, extensive rock falls or major surface cracking that created a barrier to movement. However only minimal clearing would result from the Project, and rock fall and surface cracking are predicted to be relatively minor (Sections 5.1 to 5.5). Hence it is very unlikely that the Project would adversely impact habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Rosenberg's Goanna. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.4 Birds

The Square-tailed Kite, Eastern Ground Parrot and Turquoise Parrot were recorded by Western Research Institute and Biosphere Environmental Consultants (2008) in the Project area or surrounds during recent targeted surveys for the Project.

Other threatened bird species recorded in the Woronora Special Area or wider surrounds which could potentially occur in the Project area or surrounds include the Gang-gang Cockatoo, Glossy Black Cockatoo, Powerful Owl, Sooty Owl, Masked Owl, Barking Owl, Swift Parrot, Superb Parrot, Regent Honeyeater, Brown Treecreeper, Speckled Warbler, Diamond Firetail, Hooded Robin, Black-chinned Honeyeater, Pink Robin, Olive Whistler, Bush Stone-curlew and Eastern Bristlebird.

Evaluations for the abovementioned threatened bird species are provided below.

The Black-necked Stork and Grey Falcon were also recorded flying over-head during the Project surveys (Western Research Institute and Biosphere Environmental Consultants, 2008), however these species are known only as vagrants in the area (DECC, 2007a; Pizzey and Knight, 1999) and are not considered further.

5.6.4.1 Square-tailed Kite

The Square-tailed Kite breeds from July to December (Lindsey, 1992; Pizzey and Knight, 1999) and while little is known of its requirements for breeding in terms of habitat, it appears to need a large wooded area in the order of hundreds of hectares (Marchant and Higgins, 1993a). Nests are constructed in a mature tree near an assured food supply and often within 100 m of a watercourse (Marchant and Higgins, 1993a; Schodde and Tidemann, 1997). The nests of this species consist of large platforms made from sticks, which are lined with Eucalypt leaves. Square-tailed Kites may re-use nests in successive years (Lindsey, 1992; Schodde and Tidemann, 1997).

The Square-tailed Kite specialises in taking small prey from the tree canopy, such as birds (including nestlings), reptiles and insects (Schodde and Tidemann, 1997; Ayers *et al.,* 1996), and rarely, if ever, visits the ground (NPWS, 2000b). It hunts primarily over open forest, woodlands and mallee communities that are rich in passerines, as well as over adjacent heaths and other low scrubby habitats and in wooded towns (Storr, 1980; Debus and Czechura, 1989). Resident pairs have a large hunting range of at least 100 km^2 (NPWS, 2000b). Records suggest that this species moves north to tropical areas in winter (Blakers *et al*., 1984; Brouwer and Garnett, 1990), and Marchant and Higgins (1993a) describe the species as migratory across much of its distribution.

The Square-tailed Kite is threatened by the removal, degradation and fragmentation of habitat, particularly of mature Eucalypts along watercourses (Ayers *et al*., 1996; NPWS, 1999f; NPWS, 2000b). Other threats relevant to this species include inappropriate fire regimes, illegal shooting, and collection of eggs (Ayers *et al*., 1996; NPWS, 1999f; NPWS, 2000b).

An opportunistic sighting of the Square-tailed Kite was made during the surveys carried out by Western Research Institute and Biosphere Environmental Consultants (2008). It is unlikely that a viable population of the species exists within the Project area.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The Square-tailed Kite was located opportunistically during surveys within the Project area. However it is unlikely that a viable population of the species exists. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur: an increase in fire frequency or clearing of habitat that results in a decline in prey species. Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. Since very limited vegetation clearing would occur within the Project area, it is unlikely that clearing activities would impact on the availability of prey for this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency. Hence it is very unlikely that the Project would adversely impact on the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Square-tailed Kite inhabits dry woodland and open forest, while vegetation along major rivers and belts of trees in urban or semi-urban areas are favoured for hunting (NPWS, 2000b). The Project area and/or surrounds are considered to contain high quality habitat for the Square-tailed Kite (DECC, 2007a). Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact this species habitat. As described in Section 5.5, the Project would involve some minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. The Project is unlikely to significantly reduce the quality or availability of habitat for the Square-tailed Kite.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Square-tailed Kite is uncommon, yet widespread, occurring across most parts of NSW (Marchant and Higgins, 1993a; NPWS, 2000b). In NSW, scattered records of the species throughout the state indicate that the species is a regular resident in the north, north-east and along the major west-flowing river systems (DECC, 2008s). It is a summer breeding migrant to the south-east, including the NSW south coast, arriving in September and leaving by March (DECC, 2008s).

During recent targeted surveys within the Project area and surrounds, the Square-tailed Kite was recorded flying over woodland/forest (Figure 5). The Square-tailed Kite has also been recorded in the Metropolitan, O'Hares and Woronora Special Areas, however is considered to be a rare summer migrant to the Greater Southern Sydney Region (DECC, 2007a).

The Project is located within the known distribution of the Square-tailed Kite and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Square-tailed Kite.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of the species habitats or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for a vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to impact on habitat connectivity for the Square-tailed Kite.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Square-tailed Kite. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.4.2 Eastern Ground Parrot

The Eastern Ground Parrot lives in low heathland and sedgeland (Meredith, 1984; Meredith *et al.*, 1984, McFarland, 1989). Nests are made on the ground beneath dense vegetation and the clutch size averages 3-4 (McFarland, 1991a). The Eastern Ground Parrot eats seeds from a wide range of herbs, graminoids and heath, the diet generally reflecting the range of available plants, but excludes seeds that need processing to remove woody husks (McFarland, 1991b).

Threats relevant to this species include habitat loss and fragmentation (Higgins, 1999), however inappropriate fire regimes are considered to be the main threat (DECC, 2007a). The principal management action for this species on the Woronora Plateau is the maintenance of a mosaic of burn ages within suitable habitat (*ibid*.).

During recent targeted surveys within the Project area, the Eastern Ground Parrot was recorded in upland swamp habitat. It could not be determined whether or not a viable population of the species exists within the Project area.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; changed surface hydrological conditions leading to a reduced availability of habitat and resources; and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing activities would impact this species. The magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes on ridgetops/slopes and in upland swamps and is unlikely to have any biologically significant effect on the soil moisture regime that sustains vegetation/habitats in these areas. As a result, mine subsidence is unlikely to result in a reduction in availability of habitat and resources that would impact on the lifecycle of the Eastern Ground Parrot. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Further, the Project would not involve the conduct of any prescribed burns in native remnant vegetation. Hence it is very unlikely that the Project would adversely impact the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Eastern Ground Parrot lives in low heathland and sedgeland. Heathland becomes unsuitable immediately after fire (Meredith *et al.*, 1984, McFarland, 1993), in some cases, for a further four years (Jordan, 1987; Baker and Whelan, 1994), but suitability may decline if left unburnt for more than 15 years (McFarland, 1989). In sedgeland and graminoid heathlands, Ground Parrots persist for many more years after fire (Meredith *et al.*, 1984; Baker and Whelan, 1994). A mosaic of burning that allows movement between patches of different post-fire recovery is considered likely to be important to ensure rapid recolonisation of recently burnt areas. An imposed fire regime is required to maintain the integrity of habitat with a mosaic of fire ages being used to ensure refugia in time of fire, rapid recolonisation of habitat that has recovered after fire, and recovery of habitat that has become unsuitable through being unburnt for too long (Meredith, 1984; McFarland, 1993).

Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat of this species. Further, the Project would not involve the conduct of any prescribed burns in native remnant vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing activities would have a significant impact on the habitat of this species.

Vegetation clearance for surface infrastructure would not take place in upland swamps except for monitoring purposes. Establishment of monitoring sites would involve minimal vegetation clearance for the equipment and access. The Project is unlikely to significantly reduce the quality or availability of habitat for the Eastern Ground Parrot.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The eastern subspecies of the Eastern Ground Parrot (*Pezoporus wallicus wallicus*) inhabits southeastern Australia from southern Queensland through NSW to western Victoria (DECC, 2008t). The upland swamps of the Woronora Plateau once supported many populations of this parrot, however they were thought to have disappeared following a period of frequent burning after the extensive 1968 bushfires (C. Chafer pers. comm. in DECC, 2007a).

During recent targeted surveys within the Project area and surrounds, the Eastern Ground Parrot was recorded by Western Research Institute and Biosphere Environmental Consultants (2008) in upland swamp habitat (Figure 5).

The Project is located within the known distribution of the Eastern Ground Parrot and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance*;* limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of the Eastern Ground Parrot on the study area is fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Eastern Ground Parrot.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of the species habitats, a significant increase in fire frequency or if changes in surface hydrology impacted adversely and at landscape scale on upland swamp and heathland habitats. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for a vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Gilbert and Associates (2008) have demonstrated that mine subsidence effects would not result in changes to surface hydrology that would adversely impact on upland swamp or heathland habitats or habitat connectivity. Hence the Project is very unlikely to adversely impact habitat connectivity for the Eastern Ground Parrot.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Eastern Ground Parrot. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.4.3 Turquoise Parrot

The Turquoise Parrot lives on the edged of eucalypt woodlands adjoining clearings, timbered ridges and creeks in farmland. The Turquoise Parrot breeds between August and December, often-producing two broods (Schodde and Tidemann, 1997). Nests are built in hollows and cavities, which occur in stumps, fence posts and live trees close (usually <2 m) to the ground (Forshaw, 1981; Lindsey, 1992; Ayers *et al.,* 1996). Logs on the ground are also used for nesting (Quinn and Baker-Gabb, 1993). Females are responsible for incubation, which lasts approximately 18 days. Birds fledge at four weeks, after which young birds are dependent on the parents for a few months (Schodde and Tidemann, 1997). Foraging is almost entirely on the ground (Higgins, 1999) on introduced and native grasses and herbs (Ayers *et al.,* 1996) such as the Parrot Pea (*Dillwynia* sp.), Barley Grass (*Hordeum murinum*), Mustard (*Sisymbrium* sp.), Wallaby Grass (*Danthonia* sp.), Stinging Nettle (*Urtica urens*) and Saffron Thistle (*Carthamus lanatus*) (Crome and Shields, 1992). In addition, a reliable water source is an essential component of the habitat requirements of this species (Higgins, 1999). The Turquoise Parrot is partly nomadic (Ayers *et al.*, 1996).

Threats to this species include habitat loss and fragmentation, timber cutting, inappropriate fire regimes removing understorey vegetation, grazing, and predation by Cats and Foxes (NPWS, 1999g; Garnett and Crowley, 2000).

During recent targeted surveys within the Project area and surrounds, the Turquoise Parrot was observed on the ground in a grassy clearing near tall forest close to Darkes Forest Road and north of Site 19 near Fire Trail 9 (Figure 5) (Western Research Institute and Biosphere Environmental Consultants, 2008). However it could not be determined whether or not a viable population of the species exists within the Project area.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency or clearing of vegetation impacting the species habitat. Since very limited clearing would occur within the Project area, it is unlikely that clearing activities would impact this species. Further, given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Hence it is very unlikely that the Project would adversely impact the lifecycle of the Turquoise Parrot.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Turquoise Parrot favours eucalypt woodlands and open forests that have a ground cover of grasses (DECC, 2007a). The Project area and/or surrounds are considered to contain high quality habitat for the Turquoise Parrot (DECC, 2007a). Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Vegetation clearance would be managed through the development and implementation of a FFMP which would include measures to minimise habitat disturbance. Mine subsidence also has the potential to cause cracking and alter the availability of water (e.g. in Waratah Rivulet), however the changes described would not be of an extent that would significantly affect the availability of habitat resources for this species. The Project is unlikely to significantly reduce the quality or availability of habitat for the Turquoise Parrot.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Turquoise Parrot occurs along the eastern and western scarps of the Great Dividing Range, south to Nowra and Benalla (NSW), north to Maryborough and Taroom (Queensland), and west to Griffith (Schodde and Tidemann, 1997).

During recent targeted surveys within the Project area and surrounds, the Turquoise Parrot was observed on the ground in a grassy clearing near tall forest close to Darkes Forest Road and north of Site 19 near Fire Trail 9 (Figure 5) (Western Research Institute and Biosphere Environmental Consultants, 2008).

The Project is located within the known distribution of the Turquoise Parrot and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycle of the Turquoise Parrot is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Turquoise Parrot.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of the species habitats or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for a vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for the Turquoise Parrot.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Turquoise Parrot. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.4.4 Swift Parrot, Superb Parrot and Regent Honeyeater

These three species have been grouped together because they were not observed during recent fauna surveys and are unlikely to be represented by viable populations within the Project area. However both the Swift Parrot and the Regent Honeyeater have been reported at numerous locations within the Sydney catchment and the immediate surrounds. Furthermore the Swift Parrot has been reported immediately west of the Project area and just south of Darkes Forest, whereas the Regent Honeyeater has been reported from areas adjacent to the Project area in the north, west and south. The Superb Parrot has also been located within the Sydney catchment and immediate surrounds near Port Hacking and near the northern boundary of the catchment. Their core breeding area is on the south-western slopes where their habitat consists of Box Woodland-Cypress Pine formations, and River Red Gum Forest. There may be small pockets of suitable woodland and forest habitat available in the Project area but marginal rather than prime habitat.

The Swift Parrot only breeds in Tasmania, always within 8 km of the coast (Brereton, 1998) and nests in tree cavities or hollows, usually high in a Eucalypt (Lindsey, 1992; Pizzey and Knight, 1999). The Swift Parrot migrates to mainland Australia from May to August (Swift Parrot Recovery Team, 2001; NSW Scientific Committee, 2000d). Non-breeding birds are highly mobile and their movements vary between years (Hindwood and Sharland, 1964; Brown, 1989). Generally a canopy feeder, the Swift Parrot congregates where there is profuse flowering of Eucalypts (Blakers *et al.*, 1984; Brouwer and Garnett, 1990). *Eucalyptus robusta*, *Corymbia maculata* and Red Bloodwood (*C. gummifera*) are utilised by this species on the coast of NSW (Swift Parrot Recovery Team, 2001). If sufficient food is available this species will remain in an area and return to the same tree to roost (Pizzey and Doyle, 1980).

The Superb Parrot is associated with eucalypt forest, open woodland and near watercourses, particularly where River Red Gum, White Box and Yellow Box occur (Schodde and Tidemann, 1997; Pizzey and Knight, 1998). Two main breeding centres are known *viz.* Murray-Riverina district and the south-west slopes (bounded by Cowra, Rye Park, Yass, Grenfell, Young, Cootamundra and Coolac) (Weber and Ahern, 1992). The Superb Parrot nests in hollows or holes in tall trees such as the River Red Gum and Box woodland species (Ayers *et al.*, 1996; Schodde and Tidemann, 1997; Pizzey and Knight, 1998). The Superb Parrot exhibits high nest site fidelity, while non-breeding flocks are nomadic and partly migratory (Ayers *et al.*, 1996). This species diet ranges from grass seed to nectar (Lindsey, 1992; Garnett, 1993) and the flowers, fruits and young buds of Box species (Ayers *et. al*, 1996; Garnett, 1993).

The Regent Honeyeater usually nests in isolated pairs, although they sometimes breed in loose colonies (NPWS, 1999h). The nest is a thick walled cup of bark strips bound with cobwebs and lined with dry grass and bark shreds (Geering and French, 1998). There are only a small number of known breeding sites in NSW, the most important being in the Capertee Valley (DEC, 2004) although other important breeding areas are situated in Warrumbungle National Park, Pilliga Nature Reserve, Barraba district, the central coast around Gosford, and the Hunter Valley (Ayers *et al.,* 1996; NPWS, 1999h). Although nectar is their main food source, Regent Honeyeaters also eat insects, lerps and fruit (Ayers *et al.,* 1996). The Regent Honeyeater has demonstrated a preference for larger trees to forage and the preference for particular species may be related to the timing of flowering (DEC, 2004). The Regent Honeyeater is regarded as a single population (DEC, 2004). The birds are partly migratory, shifting generally northwards in autumn and winter and returning south to breed in spring (Schodde and Tidemann, 1997). Individuals have been found to travel over 350 km between the Capertee Valley and Canberra (David Geering pers. comm., 2004). The movements of the Regent Honeyeater are related to the regional patterns of flowering of the key forage species (DEC, 2004).

Threats to the Swift Parrot, Superb Parrot and/or Regent Honeyeater include the removal of foraging habitat (NSW Scientific Committee, 2000d; Ayers *et al*., 1996; Garnett and Crowley, 2000; DEC, 2004), firewood collection (Garnett and Crowley, 2000) and lack of water and degradation of riparian habitat through over-utilised or diverted stream flows (DEC, 2004).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of these three species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency or clearing of vegetation impacting the species' habitat. Since very limited clearing would occur within the Project area, it is unlikely that clearing activities would impact these species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Hence it is very unlikely that the Project would adversely impact the lifecycle of the Swift and Superb Parrots and the Regent Honeyeater.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

In NSW the Swift Parrot inhabits Box-Ironbark forests and woodlands (Swift Parrot Recovery Team, 2001), while the Superb Parrot is primarily associated with eucalypt forest and open woodland throughout inland NSW. The Regent Honeyeater occurs in a wide variety of habitats including Swamp Mahogany forest, Spotted Gum, riverine She-oak woodlands, remnant stands of timber, roadside reserves and travelling stock routes (DEC, 2004), however it is most commonly found in Box-Ironbark woodlands (DEC, 2004; NPWS, 1999h).

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Reduction of habitat for the Swift and Superb Parrots or the Regent Honeyeater due to surface infrastructure would be very small in comparison with the amount of habitat available. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat.

Mine subsidence also has the potential to cause cracking and alter the availability of water (e.g. in Waratah Rivulet), however the changes described would not be of an extent that would significantly affect the availability of habitat resources for these species. The Project is unlikely to significantly reduce the quality or availability of habitat for the Swift and Superb Parrots or the Regent Honeyeater.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Swift Parrot breeds in Tasmania and typically migrates to mainland Australia to over-winter on the inland slopes of the Great Dividing Range in Victoria and central and eastern NSW, with smaller numbers reaching south-east Queensland and south-east South Australia (Swift Parrot Recovery Team, 2001; Garnett and Crowley, 2000).

The Superb Parrot occurs in the woodlands of the western watershed of the Great Dividing Range, west to the eastern edge of Hay Plains, south to the Murray-Murrumbidgee Rivers, and north to the Barwon catchment (Ayers *et al*., 1996; Schodde and Tidemann, 1997).

The Regent Honeyeater is distributed from the Great Dividing Range, north to Brisbane in Queensland and south to Bendigo in Victoria, with outliers in the Mount Lofty Ranges and Kangaroo Island in South Australia (Schodde and Tidemann, 1997). On the western-edge of its range in NSW, this species occurs as far inland as Narrabri, Warrumbungle National Park, Dubbo, Parkes and Finley (DEC, 2004).

The Project is located within the known distribution of the Swift Parrot and Regent Honeyeater and near the eastern limit of the known distribution of the Superb Parrot.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance*;* limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Swift and Superb Parrots and the Regent Honeyeater.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for these three species within the Project area would only be likely if there was widespread clearing of their habitats or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for these three vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for the Swift and Superb Parrots and the Regent Honeyeater.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Swift Parrot, Superb Parrot or Regent Honeyeater. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEWHA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.4.5 Gang-gang Cockatoo and Glossy Black Cockatoo

These two species have been grouped together because they were not observed during recent fauna surveys and are unlikely to be represented by viable populations within the Project area.

The Gang-gang Cockatoo breeds in hollows in the trunks or large limbs of large trees (Gibbons, 1999; Gibbons and Lindenmayer, 2000). Breeding usually occurs in tall mature sclerophyll forests that have a dense understorey, and occasionally in coastal forests (NSW Scientific Committee, 2005b). Nests are most commonly recorded in eucalypt hollows in live trees close to water (Beruldsen, 1980). The species undertakes nomadic as well as seasonal movements and may occur at apparently random points within its range (NSW Scientific Committee, 2005b).

The Glossy Black Cockatoo roosts communally in groves of trees in close proximity to stands of She-oaks (Pizzey and Knight, 1999). The species nests in hollow limbs or trunks of old or dead trees lined with woodchips, usually 15-30 m off the ground (Pizzey and Knight, 1999). The Glossy Black Cockatoo forages for long hours each day to gain sufficient food, particularly during the breeding season and its diet is primarily restricted to the seeds of She-oaks (*Allocasuarina* sp. and *Casuarina* sp.), although Acacia, angophora and Eucalypt seeds, angophora fruit, sunflower seeds and grubs found in some *Allocasuarina* and *Acacia* species have occasionally been recorded (Higgins, 1999; Schodde and Tidemann, 1997; Barker and Vestjens, undated; Blakers *et al.*, 1984). Populations of the Glossy Black Cockatoo are often sedentary so long as the requirement of an adequate supply of seed exists, however they are nomadic when supplies fail for any reason (Schodde and Tidemann, 1997).

Threats to the Gang-gang Cockatoo and/or the Glossy Black Cockatoo include the removal or degradation of nesting or foraging habitat, Psittacine cirovirus disease, competition for hollows and grazing of She-oak seedlings by Rabbits, Sheep and Goats (NSW Scientific Committee, 2005b; NSW Scientific Committee, 1999d; NPWS, 1999i; Garnett and Crowley, 2000).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of these two species has the potential to be adversely impacted if the Project resulted in impacts on the species habitat through an increase in fire frequency or vegetation clearing. Since very limited clearing would occur within the Project area, it is unlikely that clearing activities would impact these species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Hence it is very unlikely that the Project would adversely impact the lifecycle of either the Gang-gang Cockatoo or the Glossy Black Cockatoo.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

In summer, the Gang-gang Cockatoo is generally found in tall montane forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests (NSW Scientific Committee, 2005d). The species may also occur in sub-alpine Snow Gum *Eucalyptus pauciflora* woodland and occasionally in temperate rainforests (Forshaw, 1989).

In winter, the Gang-gang Cockatoo occurs at lower altitudes in drier, more open eucalypt forests and woodlands, particularly in box-ironbark assemblages, or in dry forest in coastal areas (Shields and Crome, 1992). At this time the species may be observed in urban areas including parks and gardens (Morcombe, 1986). The Glossy Black Cockatoo inhabits coastal forests, open woodland, timbered watercourses or wherever Casuarinas are common (Schodde and Tidemann, 1997; Pizzey and Knight, 1999). However, not all apparently suitable habitats provide adequate food value to support the cockatoos (Crowley and Garnett, in press; Crowley *et al*., 1999; Clout, 1989). The Project area and/or surrounds are considered to contain moderate quality habitat for the Gang-gang Cockatoo and Glossy Black Cockatoo (DECC, 2007a).

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. To minimise impacts on terrestrial vegetation, vegetation clearance would be restricted to the slashing of vegetation (i.e. leaving the lower stem and roots *in-situ* to maximise the potential for natural regrowth) and lopping of branches, where practicable, rather than the removal of trees. Any reduction of habitat for the Gang-gang Cockatoo and Glossy Black Cockatoo due to surface infrastructure would be very small in comparison with the amount of habitat available, if it was to occur at all. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project would not have a significant impact on the locally available habitat of either the Gang-gang Cockatoo or the Glossy Black Cockatoo.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

In NSW, the Gang-gang Cockatoo is distributed from the south-east coast to the Hunter region, and inland to the Central Tablelands and south-west slopes (NSW Scientific Committee, 2005b). The Glossy Black Cockatoo is sparsely distributed along the east coast and immediate inland districts from western Victoria to Rockhampton in Queensland (Crome and Shields, 1992). In NSW the Glossy Black Cockatoo is found as far west as Cobar and Griffith in isolated mountain ranges (NPWS, 1999i).

The Project is located within the known distribution of the Gang-gang Cockatoo and Glossy Black Cockatoo and does not represent a distributional limit for these species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance*;* limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on these two species.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for these two species within the Project area would only be likely if there was widespread clearing of their habitats or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to these species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for these two vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for the Gang-gang Cockatoo and Glossy Black Cockatoo.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Gang-gang Cockatoo or Glossy Black Cockatoo. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEWHA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.4.6 Powerful Owl, Masked Owl, Barking Owl and Sooty Owl

These four owl species were not located during recent terrestrial fauna surveys of the Project area. However it could not be determined whether or not viable populations of these species exist within the Project area.

Nests of the Powerful Owl are located in large hollow tree limbs or trunks (Schodde and Tidemann, 1997). The Powerful Owl roosts by day on the branches of relatively open trees, usually within dense foliage along streams amid Eucalypt forest (Ayers *et al.*, 1999). Each pair has a number of roosting trees (Schodde and Tidemann, 1997). The Powerful Owl is a sedentary species that lives singly or in pairs within permanent territories (300 to 1,000 ha depending on habitat productivity) (Schodde and Tidemann, 1997; Ayers *et al.*, 1999). The Powerful Owl hunts nocturnally for primary prey items such as arboreal and semi-arboreal mammals, birds, insects and terrestrial mammals (*ibid.*).

The Masked Owl roosts communally within a diverse range of wooded habitats that provide large hollow-bearing trees, often in riparian forests (Garnett and Crowley, 2000). The species nests on decayed debris in hollow Eucalypts 12-20 m high, bare sand or earth of cave (Pizzey and Knight, 1999). The Masked Owl forages in nearby open areas (Kavanagh and Murray, 1996; Higgins, 1999) and its diet mainly consists of possums, rabbits, currawongs, gliders, bats, birds and lizards (Pizzey and Knight, 1999; Garnett and Crowley, 2000). This species keeps to the same territory all year round (Schodde and Tidemann, 1997).

The Barking Owl roosts by day in dense streamside galleries and thickets of Acacia, Casuarina and Eucalypts, and forages in adjacent woodland (Ayers *et al.,* 1996). Breeding takes place in traditional territories, in large hollows in old Eucalypts (Ayers *et al.,* 1996), which may be used year after year. Nest entrances are typically 2-35 m above the ground (Higgins, 1998). The Barking Owl hunts nocturnally for a variety of small to medium-sized mammals, birds and large insects within woodland and forest habitats (Higgins, 1998). The species is assumed to be sedentary, living singly, in pairs, or in family groups of 3-5 in permanent territories containing several roost sites (Ayers *et al.*, 1996).

The Sooty Owl inhabits dimly lit rainforests and rainforest gullies overtopped by eucalypts (Schodde and Tidemann, 1997). Nests are typically a 40 – 500 cm deep hollow in a tall eucalypt in or on the edge of rainforest. The Sooty Owl is thought to pair permanently and hold the same territory (approximately 200 to 800 ha) each year.

The Sooty Owl roosts by day in one of a number of set perches (e.g. a deep hollow, on the stems of a giant fig or a crevice under a bank or cliff) and hunts through the forest and along its edge for prey items such as possums, glider, rats, bandicoots and birds.

Threats relevant to the Powerful Owl, Masked Owl, Barking Owl and/or Sooty Owl include clearing of vegetation and consequently foraging and breeding habitat (Debus and Chafer, 1994; Garnett and Crowley, 2000; NPWS, 2003c; NPWS, 2000a), as well as timber harvesting, inappropriate fire regimes and predation by foxes on fledgling owls (McNabb, 1996; Debus and Chafer, 1994; Debus, 1997; NPWS, 2003c).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of these four owl species has the potential to be adversely impacted if the Project resulted in impacts on the species' habitat through an increase in fire frequency or vegetation clearing. Since very limited clearing would occur within the Project area, it is unlikely that clearing activities would impact these species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Hence it is very unlikely that the Project would adversely impact the lifecycle of these four species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Powerful Owl occurs in open forest and tall open forest, particularly in wet and dry sclerophyll forest, as well as in gully rainforest and in woodland (NPWS, undated a). The Masked Owl inhabits forests, woodlands and nearby clearings (Flegg, 2002), while the Barking Owl primarily inhabits open forest and woodland in warm lowland areas on gentle terrain (Ayers *et al.*, 1996), avoiding high altitudes and dense, wet escarpment forests (Debus, 1997). The Sooty Owl is associated with rainforests and eucalypt rainforest gullies (Schodde and Tidemann, 1997).

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. To minimise impacts on terrestrial vegetation, vegetation clearance would be restricted to the slashing of vegetation (i.e. leaving the lower stem and roots *in-situ* to maximise the potential for natural regrowth) and lopping of branches, where practicable, rather than the removal of trees. Clearing of vegetation and consequently foraging and breeding habitat for these four species due to surface infrastructure would be very small in comparison with the amount of habitat available, if it was to occur at all. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project is unlikely to reduce the quality or availability of habitat for the Powerful Owl, Masked Owl, Barking Owl or Sooty Owl.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Powerful Owl is primarily distributed from the Clarke Range in Queensland to the Mount Burr region of southeastern South Australia, primarily on the coastal side of the Great Dividing Range (Ayers *et al.*, 1999).

The main distribution of the Masked Owl is located along the coast (NPWS, undated b), however this species is also sparsely distributed through sub-coastal mainland Australia from Fraser Island to Carnarvon (Western Australia) including the Nullarbor Plain and inland of the Great Dividing Range (Schodde and Mason, 1980; Smith *et al.*, 1995; Higgins, 1999).

The Barking Owl is found throughout most of NSW, with the main part of the distribution being west of the Great Dividing Range (Debus, 1997).

The Sooty Owl is distributed in southeastern Australia, along the eastern scarp of the Great Dividing Range, north to the Conondale-Blackall Ranges in Queensland, and south to the Dandenong Ranges in Victoria (Schodde and Tidemann, 1997).

The Project is located within the known distribution of the Powerful Owl, Masked Owl, Barking Owl and Sooty Owl and does not represent a distributional limit for these species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on these four owl species.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for these four owl species within the Project area would only be likely if there was widespread clearing of their habitats or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to these species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for these four vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for these four owl species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Powerful Owl, Masked Owl, Barking Owl or Sooty Owl. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.4.7 Bush Stone-curlew

Limited habitat exists for this species within the Project area. The species was not located during recent terrestrial fauna surveys and it is unlikely that a viable population of this species is extant within the Project area.

In NSW, Bush Stone-curlews occur in lowland grassy woodland and open forest, much of which has been cleared for agriculture and urban development (Johnson and Baker-Gabb, 1994). Bush Stone-curlew habitat is described by broad ground and understorey structural features and is not necessarily associated with any particular vegetation communities. In general, habitat occurs in open woodlands with few, if any, shrubs, and short, sparse grasses of less than 15 cm in height, with scattered fallen timber, leaf litter and bare ground present. In coastal areas, structurally similar elements of tidal and estuarine communities provide suitable habitat, for example Bush Stone-curlews are recorded within Casuarina woodlands, salt marsh and mangroves (Price, 2004). In general, Bush Stone-curlews are not found on the escarpments but in lower elevation grassy woodlands of the coast or west of the divide throughout the sheep-wheat belt (DECC, 2006).

Bush Stone-curlew nests consist of a slight depression in the ground usually near dead timber where they roost during the day relying on camouflage to hide them from predators (NPWS, 1999j; Pizzey and Knight, 1999; DECC, 2006). Breeding occurs in spring with both parents caring for and actively defending their young (Marchant and Higgins, 1993b). Bush Stone-curlews are nocturnal and forage on invertebrates (molluscs, centipedes, crustaceans, spiders, grasshoppers, moths, etc.), small vertebrates (frogs, lizards, snakes, small rodents) and some vegetation (NPWS, 1999j; DECC, 2006). This species is mainly sedentary although is known to be locally dispersive outside breeding periods, occurring singly or in pairs (NPWS, 1999j).

Threats relevant to the Bush Stone-curlew include removal of dead timber, cultivation, grazing, predation by Foxes, Pigs, Dogs and Cats, and disturbance by human activities (especially during nesting) (NPWS, 2003d; NPWS, 1999j).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency, an increase in exotic predator species or clearing of vegetation impacting the species habitat. Since very limited clearing would occur within the Project area, it is unlikely that clearing activities would impact this species. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact on this species, or an increase in feral exotic species. Hence it is very unlikely that the Project would adversely impact the lifecycle of the Bush Stone-curlew.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

In NSW, Bush Stone-curlews occur in lowland grassy woodland and open forest, much of which has been cleared for agriculture and urban development (Johnson and Baker-Gabb, 1994). Bush Stone-curlew habitat is described by broad ground and understorey structural features and is not necessarily associated with any particular vegetation communities. In general, habitat occurs in open woodlands with few, if any, shrubs, and short, sparse grasses of less than 15 cm in height, with scattered fallen timber, leaf litter and bare ground present. In general, Bush Stone-curlews are not found on the escarpments but in lower elevation grassy woodlands of the coast or west of the divide throughout the sheep-wheat belt (DECC, 2006).

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Clearing of vegetation and consequently foraging and breeding habitat for this species due to surface infrastructure would be very small. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or an increase in feral exotic species that could adversely impact habitat. The Project is unlikely to reduce the quality or availability of habitat for the Bush Stone-curlew.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Bush Stone-curlew is distributed throughout mainland Australia, except in the most arid areas and offshore islands (Garnett and Crowley, 2000). Once widespread along the east coast of NSW, recent records indicate that the distribution of the Bush Stone-curlew is now limited to areas of the NSW central and north coast (NPWS, 1999j; DECC, 2006).

The Project is located within the known distribution of the Bush Stone-curlew and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. The FFMP would also include measures to minimise the potential for the introduction or spread of weeds and feral pests. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Bush Stone-curlew.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of their habitats or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for the Bush Stone-curlew.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Bush Stone-curlew. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.4.8 Eastern Bristlebird

The Eastern Bristlebird was not located during the recent terrestrial fauna surveys and it is very unlikely that a viable population of this species exists within the Project area.

The Eastern Bristlebird inhabits a wide range of vegetation communities including rainforest, eucalypt forest, woodland, mallee, shrubland, swamp, heathland and sedgeland where there is low dense cover (Baker, in press). The Eastern Bristlebird is considered to be a cover-dependent and fire-sensitive species (NPWS, 1999k).

Eastern Bristlebirds have low fecundity; generally laying a clutch of two eggs and raising only one fledgling (NPWS, 1999k). Eastern Bristlebird nests are elliptical domes constructed in low dense vegetation, usually in tufted plants (NPWS, 1999k). The diet of the Eastern Bristlebird includes ants, beetles and weevils (Baker, 1998). Individuals have a home range of more than 10 ha and are presumed to be sedentary (Baker, 1998).

Potential threats to this species are thought to include loss of habitat (including indirect loss due to too frequent fires), predation by native and introduced predators, road-kills (known to occur in the Jervis Bay area), grazing by livestock and trampling of habitat (northern populations), off-road vehicle damage to habitat and invasion of habitat by weeds (NPWS, 1999k). Fragmentation and isolation characteristic of the Eastern Bristlebird populations may also be adversely affecting the species (*ibid*.).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; an increase in exotic predator species, changed surface hydrological conditions leading to a reduced availability of habitat and resources; and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing activities would impact this species. Vegetation clearance for surface infrastructure would not take place in upland swamps except for monitoring purposes. Establishment of monitoring sites would involve minimal vegetation clearance for the equipment and access. The magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes on ridgetops/slopes and in upland swamps and is unlikely to have any biologically significant effect on the soil moisture regime that sustains vegetation/habitats in these areas. As a result, mine subsidence is unlikely to result in a reduction in availability of habitat and resources that would impact on the lifecycle of the Eastern Bristlebird. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or feral exotic species that could adversely impact on this species. Further, the Project would not involve the conduct of any prescribed burns in native remnant vegetation. Hence it is very unlikely that the Project would adversely impact the lifecycle of the Eastern Bristlebird.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Eastern Bristlebird inhabits a wide range of vegetation communities including rainforest, eucalypt forest, woodland, mallee, shrubland, swamp, heathland and sedgeland where there is low dense cover (Baker, in press). The Eastern Bristlebird is considered to be a cover-dependent and fire-sensitive species (NPWS, 1999k).

Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Further, the Project would not involve the conduct of any prescribed burns in native remnant vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing activities would have a significant impact on the habitat of this species. Vegetation clearance for surface infrastructure would not take place in upland swamps except for monitoring purposes. The magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes on ridgetops/slopes and in upland swamps and is unlikely to have any biologically significant effect on the soil moisture regime that sustains vegetation/habitats in these areas. The FFMP to be developed for the Project would also include measures to minimise the potential for the introduction or spread of weeds and feral pests. The Project is unlikely to significantly reduce the quality or availability of habitat for the Eastern Bristlebird.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Eastern Bristlebird is a rare species that is restricted to coastal eastern Australia, ranging from the Conondale Ranges in south-eastern Queensland, south along the NSW coast, to north-eastern Victoria (Chaffer 1954; Blakers *et al.*, 1984). Eastern Bristlebirds are currently confined to three disjoint areas of southeastern Australia: the NSW/Queensland border region, the Illawarra region and in the vicinity of the NSW/Victorian border (NSW Scientific Committee, 1997; DECC, 2008u). The estimated population size is less than 2,000 individuals occupying a total area of about 120 sq km (DECC, 2008u). Within NSW, populations of Eastern Bristlebirds are isolated, fragmented and small (NPWS, 1999k). The Illawarra population comprises an estimated 1,600 birds, mainly from Barren Grounds Nature Reserve, Budderoo National Park and the Jervis Bay area (DECC, 2008u).

The Project is located within the known distribution of the Eastern Bristlebird.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of the Eastern Bristlebird on the study area is probably fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project.

In general, introduced plant species are absent from areas of undisturbed natural habitat in the Woronora Special Area. The FFMP to be developed for the Project would include measures to minimise the spread of weeds and feral pests. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Eastern Bristlebird.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of their habitats, a significant increase in fire frequency or if changes in surface hydrology impacted adversely and at landscape scale on forest, woodland, heathland or upland swamp habitats. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Gilbert and Associates (2008) have demonstrated that mine subsidence effects would not result in changes to surface hydrology that would impact on forest, woodland, heathland or upland swamp habitats or habitat connectivity. Hence the Project is very unlikely to adversely impact habitat connectivity for the Eastern Bristlebird.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Eastern Bristlebird. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEWHA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.4.9 Brown Treecreeper, Speckled Warbler, Diamond Firetail, Hooded Robin and Black-chinned Honeyeater

These five species were not located during the recent terrestrial fauna surveys of the Project area. It is unlikely that viable populations of these species are extant within the Project area.

The Brown Treecreeper, Speckled Warbler, Diamond Firetail and Hooded Robin inhabit a range of Eucalypt dominated vegetation communities, as well as drier open forests (Brown Treecreeper and Hooded Robin), Cypress dominated vegetation (Speckled Warbler) and Acacia scrubland (Hooded Robin); typically with a grassy understorey. In NSW, the Black-chinned Honeyeater is mainly found in woodlands containing Box-Ironbark woodland associations and River Red Gum.

The Brown Treecreeper, Speckled Warbler, Diamond Firetail and Black-chinned Honeyeater occur predominantly on the western side of the Great Dividing Range, although scattered populations also exist on the east of the Divide in drier areas. The Hooded Robin is distributed throughout southeastern Australia, from central Queensland to the Spencer Gulf in South Australia.

The Brown Treecreeper builds cup nests, which are made from dried grass, bark and dung; usually lined with fur, feathers or plant down (Schodde and Tidemann, 1997). Nests are often built in the hollows of trees, on branches or fence posts, 1-3 m above the ground (NSW Scientific Committee, 2001a). This species is insectivorous, and forages on tree trunks and the ground for ants, beetles and larvae (Garnett and Crowley, 2000) and is sedentary, often occurring in pairs or small groups (NSW Scientific Committee, 2001a). Pairs or groups of three to six hold to the same large territory of about 5-10 ha year round (Schodde and Tidemann, 1997).

Domed nests of the Speckled Warbler are made from grass and bark shreds and are lined with fur and feathers (Schodde and Tidemann, 1997). The nest is usually hidden in a slight hollow predominantly on the ground (Gardner, 2002), however it can also be placed in a low shrub or tree trunk (Schodde and Tidemann, 1997; Pizzey and Knight, 1998).

The Speckled Warbler forages on the ground for arthropods and seeds (Blakers *et al*., 1984; Ford *et al*., 1986). Preferred foraging habitat of the Speckled Warbler includes areas with a combination of open grassy patches, leaf litter and shrub cover (NSW Scientific Committee, 2001b). The Speckled Warbler is sedentary, living in pairs or trios and the home range of this species can vary from 6 to 12 ha (NSW Scientific Committee, 2001b).

Nests of the Diamond Firetail are placed in the thick foliage of mistletoe clumps, Eucalypt tree or shrub, up to 10 m above the ground (Schodde and Tidemann, 1997). The nests are bulky and bottle-shaped and are made from grass (Pizzey and Knight, 1998). After fledging, young birds spend about a week in the breeding area before joining a larger flock to forage wherever food sources are abundant (Schodde and Tidemann, 1997). Diamond Firetails drink frequently throughout the day. The main food source of this species is seed, mostly from grasses (Read, 1994), however their diet can also include insects (Blakers *et al*., 1984, Read, 1994). At dusk, feeding flocks disperse to dense shrubbery or to specifically build nests to roost (Schodde and Tidemann, 1997). Roosting nests are made of coarse green and dry grasses and are smaller and built lower to the ground than breeding nests (*ibid.*).

The nest of the Hooded Robin is an open cup made from bark-strips, rootlets, grass and/or spiders web. The nest is built in a tree fork, crevice or hollow on or near dead wood, approximately 1-6 m above the ground (Pizzey and Knight, 1999; Schodde and Tidemann, 1997). The Hooded Robin feeds on the ground on insects and small lizards in areas with a mix of bare ground, ground cover and leaf litter (Garnett and Crowley, 2000; NSW Scientific Committee, 2001c). This species is often observed in small family groups and sometimes in isolated pairs (NSW Scientific Committee, 2001c). The species is typically territorial and has a home range of approximately 10-20 ha (Schodde and Tidemann, 1997). Juveniles of this species are dispersive (Pizzey and Knight, 1999).

Nests of the Black-chinned Honeyeater are a fragile cup made of bark-shreds, grass, wool and/or spiders web (Pizzey and Knight, 1997). This species typically nests high (approximately 3-15 m) in outer foliage (Schodde and Tidemann, 1997). Breeding can be communal, with additional members of the colony helping the senior parental pair feed their young (*ibid.*). The Black-chinned Honeyeater feeds on insects, nectar and lerp (Blakers *et al*., 1984). The Black-chinned Honeyeater has a large feeding territory and as a result, often appears locally and is seasonally nomadic (Pizzey and Knight, 1997; Schodde and Tidemann, 1997).

Threats relevant to the Brown Treecreeper, Speckled Warbler, Diamond Firetail, Hooded Robin and/or Black-chinned Honeyeater include the clearance and fragmentation of woodland habitat, removal of dead timber, loss of hollow bearing trees, grazing by stock in woodland areas and predation (NSW Scientific Committee, 2001a; NSW Scientific Committee, 2001b; NSW Scientific Committee, 2001c; NSW Scientific Committee, 2001d; NSW Scientific Committee, 2001e; Gardner, 2002).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of these species has the potential to be be adversely impacted if the Project resulted in impact on the species' habitat through an increase in fire frequency or vegetation clearing. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact these species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Hence it is very unlikely that the Project would adversely impact the lifecycle of these five species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Brown Treecreeper, Speckled Warbler, Diamond Firetail and Hooded Robin inhabit a range of Eucalypt dominated vegetation communities, as well as drier open forests (Brown Treecreeper and Hooded Robin), Cypress dominated vegetation (Speckled Warbler) and Acacia scrubland (Hooded Robin); typically with a grassy understorey. In NSW, the Black-chinned Honeyeater is mainly found in woodlands containing Box-Ironbark woodland associations and River Red Gum.

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Clearing of vegetation and consequently foraging and breeding habitat for these five species due to surface infrastructure would be very small. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project would not have a significant impact on the locally available habitat of these five species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Brown Treecreeper, Speckled Warbler, Diamond Firetail and Black-chinned Honeyeater occur predominantly on the western side of the Great Dividing Range, although scattered populations also exist on the east of the Divide in drier areas. The Hooded Robin is distributed throughout southeastern Australia, from central Queensland to the Spencer Gulf in South Australia.

The Project is located within the known distribution of the Brown Treecreeper, Speckled Warbler, Diamond Firetail, Hooded Robin and Black-chinned Honeyeater and does not represent a distributional limit for these species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance*;* limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on these five species.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of their habitats or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for these five vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for these five species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Brown Treecreeper, Speckled Warbler, Diamond Firetail, Hooded Robin or Black-chinned Honeyeater. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.4.10 Pink Robin and Olive Whistler

These two species were not located during the recent terrestrial fauna surveys of the Project area. It is unlikely that there are viable populations of these two species present within the Project area.

The Pink Robin inhabits rainforest and tall, open eucalypt forest, particularly in densely vegetated gullies (DECC, 2008v). The Olive Whistler inhabits mostly wet forests above 500 m, however, may move to lower altitudes during the winter months (DECC, 2008w).

The Pink Robin is found in Tasmania and the uplands of eastern Victoria and far southeastern NSW, almost as far north as Bombala. On the mainland, the species disperses north and west and into more open habitats in winter, regularly as far north as the ACT area, and sometimes being found as far north as the central coast of NSW (DECC, 2008v).

The Olive Whistler inhabits the wet forests on the ranges of the east coast (DECC, 2008w). The Olive Whistler has a disjunct distribution in NSW chiefly occupying the beech forests around Barrington Tops and the MacPherson Ranges in the north and wet forests from Illawarra south to Victoria (*ibid*.). In the south it is found inland to the Snowy Mountains and the Brindabella Range.

The nest of the Pink Robin is a deep, spherical cup made of green moss bound with cobweb and adorned with camouflaging lichen, lined with fur and plant down (DECC, 2008v). The nest is placed in an upright or oblique fork, from 30 cm to 6 m above the ground, in deep undergrowth (*ibid*.). Females do most or all of the nest building and incubate unaided, however both adults feed the nestlings (DECC, 2008v). Insects and spiders are the main dietary items of the Pink Robin.

The nest of the Olive Whistler is made from twigs and grass and is placed in low forks of shrubs. The Olive Whistler forages in trees and shrubs and on the ground, feeding on berries and insects (DECC, 2008w).

Threats relevant to the Pink Robin and Olive Whistler include the clearing of rainforest and tall, wet forest habitat, particularly near gullies.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of these two species has the potential to be adversely impacted if the Project resulted in impact on the species' habitat through an increase in fire frequency or vegetation clearing. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact these species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Hence it is very unlikely that the Project would adversely impact the lifecycle of these two species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Pink Robin inhabits rainforest and tall, open eucalypt forest, particularly in densely vegetated gullies (DECC, 2008v). The Olive Whistler inhabits mostly wet forests above 500 m, however, may move to lower altitudes during the winter months (DECC, 2008w).

Limited habitat for these species exists within the Project area. As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Clearing of vegetation and consequently foraging and breeding habitat for these two species due to surface infrastructure would be very small. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project is unlikely to significantly reduce the quality or availability of habitat for the Pink Robin or Olive Whistler.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Pink Robin is found in Tasmania and the uplands of eastern Victoria and far southeastern NSW, almost as far north as Bombala. On the mainland, the species disperses north and west and into more open habitats in winter, regularly as far north as the ACT area, and sometimes being found as far north as the central coast of NSW (DECC, 2008v).

The Olive Whistler inhabits the wet forests on the ranges of the east coast (DECC, 2008w). The Olive Whistler has a disjunct distribution in NSW chiefly occupying the beech forests around Barrington Tops and the MacPherson Ranges in the north and wet forests from Illawarra south to Victoria (*ibid*.). In the south it is found inland to the Snowy Mountains and the Brindabella Range.

The Project is considered to be located within the known distribution of the Pink Robin and Olive Whistler.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Pink Robin and the Olive Whistler.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of their habitats or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for these two vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for these two species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Pink Robin or Olive Whistler. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.5 Mammals

The Squirrel Glider, Eastern Pygmy-possum, Grey-headed Flying Fox, Eastern Bentwing Bat and Large-footed Myotis were recorded by Western Research Institute and Biosphere Environmental Consultants (2008) during recent targeted surveys in the Project area or surrounds. In addition, diggings that could potentially belong to the threatened Southern Brown Bandicoot or Long-nosed Potoroo, or the protected Long-nosed Bandicoot were recorded during the surveys.

Other threatened mammal species recorded in the Woronora Special Area or wider surrounds include the Brush-tailed Rock Wallaby, Spotted-tailed Quoll, Yellow-bellied Glider, Koala, Yellow-bellied Sheathtail Bat, Eastern Freetail Bat, Eastern False Pipistrelle, Greater Broad-nosed Bat and Large-eared Pied Bat. The Brush-tailed Rock Wallaby is believed to be extinct within the Woronora Plateau and has not been considered further.

Evaluations for the remaining threatened mammal species are provided below.

5.6.5.1 Southern Brown Bandicoot

The Southern Brown Bandicoot occurs in a variety of habitats including heathland, shrubland, dry sclerophyll forest with heathy understorey, sedgeland and woodland (Hocking, 1990; Kemper, 1990; Menkhorst and Seebeck, 1990; Rounsevell *et al.*, 1991) however, prefers sandy soil with scrubby vegetation in areas with low ground cover that are burnt out from time to time (Strahan, 1998). Many of the habitats occupied by the Southern Brown Bandicoot are prone to fire and some authors have suggested that the species prefers to occupy early seral stages following disturbance (NPWS, 2001e).

The Southern Brown Bandicoot is nocturnal and prefers to stay close to cover when in search of food on the surface of the ground and in the shallow, conical holes that it digs with its foreclaws. It is omnivorous, feeding on earthworms, other invertebrates, insects (both adult and larval), fungi and other subterranean plant material (NPWS, 2001e; Strahan, 1998). The Southern Brown Bandicoot usually nests during the day in shallow depressions in the ground covered by leaf litter, grass or other plant material (NPWS, 2001e; DECC, 2008x). Breeding begins in winter and usually last six to eight months; under favourable conditions reproduction is high producing up to 6 young per litter (Strahan, 1998; Braithwaite, 1983).

Threats to this species include predation by feral carnivores, habitat loss, inappropriate fire regimes leading to degradation of habitat and road-kill from vehicular traffic (NPWS, 2001e). Habitat alteration by longwall mining is also considered a threat to this species (NSW Scientific Committee, 2005a).

Diggings were recorded in the recent surveys within the Project area that could potentially belong to the Southern Brown Bandicoot.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; an increase in exotic predator species; and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact this species. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or an increase in feral exotic species that could adversely impact on this species. Further, speed limits would be imposed on fire trails to reduce the potential for vehicle strike on native fauna. Hence it is very unlikely that the Project would adversely impact the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Southern Brown Bandicoot occurs in a variety of habitats including heathland, shrubland, dry sclerophyll forest with heathy understorey, sedgeland and woodland (Hocking, 1990; Kemper, 1990; Menkhorst and Seebeck, 1990; Rounsevell *et al.*, 1991) however, prefers sandy soil with scrubby vegetation in areas with low ground cover that are burnt out from time to time (Strahan, 1998). Many of the habitats occupied by the Southern Brown Bandicoot are prone to fire and some authors have suggested that the species prefers to occupy early seral stages following disturbance (NPWS, 2001e).

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required.

Reduction of habitat for the Southern Brown Bandicoot due to surface infrastructure would be very small in comparison with the amount of habitat available. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or exotic pest species that could adversely impact habitat. The Project is unlikely to significantly reduce the quality or availability of habitat for the Southern Brown Bandicoot.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Southern Brown Bandicoot is found in the south-east and south-west of mainland Australia, Tasmania, Cape York Peninsula and a few islands off the coast of South Australia (NPWS, 2001e). In NSW, this species is thought to be restricted to the coastal fringe, from the southern side of the Hawkesbury River in the north to the Victorian border.

During recent targeted surveys within the Project area and surrounds, Western Research Institute and Biosphere Environmental Consultants (2008) noted diggings that could potentially belong to the Southern Brown Bandicoot (or alternatively the Long-nosed Bandicoot or Long-nosed Potoroo) in deep gully sites where dense ground cover was present (Figure 5).

The Project is located within the known distribution of the Southern Brown Bandicoot.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Further, a FFMP to be developed for the Project would include measures to minimise the occurrence of pest fauna species. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Southern Brown Bandicoot.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of habitat or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Southern Brown Bandicoot. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.5.2 Other Ground Mammals - Long-nosed Potoroo and Spotted-tailed Quoll

The Long-nosed Potoroo inhabits coastal heaths and dry and wet sclerophyll forests. Dense understorey with occasional open areas is an essential part of habitat, and may consist of grass-trees, sedges, ferns or heath, or of low shrubs of tea-trees or melaleucas. A sandy loam soil is also a common feature (DECC, 2008y).

The Spotted-tailed Quoll occurs in a range of habitats that include sclerophyll forests and woodlands, rainforests and coastal heathlands (NPWS, 1999l). This species has also been observed in treeless areas including grazing lands, open country and rocky outcrops but they do require large areas of relatively intact vegetation for foraging as well as hollow logs, tree hollows, rock outcrops and caves to use as den sites.

The Long-nosed Potoroo is mainly nocturnal and hides by day in dense vegetation, however during the winter months animals may forage during daylight hours (DECC, 2008y). The Long-nosed Potoroo often digs small holes in the ground in a similar way to bandicoots and the fruit-bodies of hypogeous (underground-fruiting) fungi are a large component of their diet. The Long-nosed Potoroo also eats roots, tubers, insects and their larvae and other soft-bodied animals in the soil. Breeding peaks typically occur in late winter to early summer and adults are capable of two reproductive bouts per year. Individuals of the Long-nosed Potoroo are mainly solitary, non-territorial and have home range sizes ranging between 2 to 5 hectares (DECC, 2008y).

The Spotted-tailed Quoll utilises numerous dens (such as hollow logs, tree hollows, rock outcrops or caves) within its home range (NPWS, 1999l). Both sexes of the Spotted-tailed Quoll become sexually mature when they reach about one year old (Edgar and Belcher, 1998). The Spotted-tailed Quoll requires an abundance of food (such as birds and small mammals) and large areas of relatively intact vegetation through which to forage (Ayers *et al*., 1996; NPWS, 1999l). This species is primarily solitary and nocturnal, although it may forage during the day (NPWS, 1999l). Prey items of this carnivore include birds, reptiles, small mammals (e.g. gliders, possums, rats and small macropods), arthropods and carrion (Edgar and Belcher, 1998; Ayers *et al.*, 1996; NPWS, 1999l). This species is thought to occupy large home ranges (between 800 ha and 2,000 ha) and has been known to move several kilometres overnight (NPWS, 1999l).

Threats relevant to the Long-nosed Potoroo include habitat loss and fragmentation, predation from Foxes, Dogs and Cats and too frequent fires or grazing by stock that reduce the density and floristic diversity of understorey vegetation (DECC, 2008y). Threats relevant to the Spotted-tailed Quoll include loss of habitat through clearing, logging and frequent fire, loss of potential den sites including hollow logs (NPWS, 1999l), as well as competition for food and predation by Foxes and Cats, and shooting as agricultural pests (NPWS, 1999l).

Habitat alteration by longwall mining is also considered a threat to the Long-nosed Potoroo (NSW Scientific Committee, 2005a). Diggings were recorded in the recent surveys within the Project area that could potentially belong to the Long-nosed Potoroo.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of these two species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; an increase in exotic predator species; in the case of the Spotted-tailed Quoll increased rock fall due to subsidence, and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact these species. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or an increase in feral exotic species that could adversely impact on this species. MSEC (2008) has predicted that subsidence is likely to lead to a relatively small increase in rock fall. Hence it is very unlikely that the Project would adversely impact the lifecycle of the Spotted-tailed Quoll or the Long-nosed Potoroo.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Long-nosed Potoroo inhabits coastal heaths and dry and wet sclerophyll forests. Dense understorey with occasional open areas is an essential part of habitat, and may consist of grass-trees, sedges, ferns or heath, or of low shrubs of tea-trees or melaleucas. A sandy loam soil is also a common feature (DECC, 2008y).

The Spotted-tailed Quoll occurs in a range of habitats that include sclerophyll forests and woodlands, rainforests and coastal heathlands (NPWS, 1999l). This species has also been observed in treeless areas including grazing lands, open country and rocky outcrops but they do require large areas of relatively intact vegetation for foraging as well as hollow logs, tree hollows, rock outcrops and caves to use as den sites.

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Reduction of habitat for the Long-nosed Potoroo and Spotted-tailed Quoll due to surface infrastructure would be very small in comparison with the amount of habitat available. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or exotic pest species that could adversely impact habitat. In the case of the Spotted-tailed Quoll loss of potential habitat due to increased rock fall associated with predicted mine subsidence is likely to be minimal (MSEC, 2008). The Project is unlikely to significantly reduce the quality or availability of habitat for the Long-nosed Potoroo and Spotted-tailed Quoll were they to occur in the Project area.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

In NSW, the Long-nosed Potoroo is generally restricted to coastal heaths and forests east of the Great Dividing Range, with an annual rainfall exceeding 760 mm (DECC, 2008y).

During recent targeted surveys within the Project area and surrounds, Western Research Institute and Biosphere Environmental Consultants (2008) noted diggings that could potentially belong to the Long-nosed Potoroo (or alternatively the Long-nosed Bandicoot or Southern Brown Bandicoot) in deep gully sites where dense ground cover was present (Figure 5).

In NSW, the Spotted-tailed Quoll occurs on both sides of the Great Dividing Range (NPWS, 1999l). The Spotted-tailed Quoll is mainly distributed towards the coast in the NSW Sydney Basin Bioregion (*ibid*.).

The Project is located within the known distribution of the Long-nosed Potoroo and Spotted-tailed Quoll and does not represent a distributional limit for these species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance*;* limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Further, a FFMP to be developed for the Project would include measures to minimise the occurrence of pest fauna species. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Spotted-tailed Quoll and the Long-nosed Potoroo.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for these two species within the Project area would only be likely if there was widespread clearing of their habitats or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to these species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for these species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for these two species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Long-nosed Potoroo or the Spotted-tailed Quoll. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.5.3 Squirrel Glider

The Squirrel Glider is distributed widely in eastern Australia, from northern Queensland, through eastern NSW to Victoria (NPWS, 2000c).

During recent targeted surveys within the Project area and surrounds, Western Research Institute and Biosphere Environmental Consultants (2008) recorded the call of a Squirrel Glider in woodland habitat (Figure 5) and it is likely that a viable population(s) of the species is/are present.

The Squirrel Glider inhabits dry sclerophyll forests and woodland where it lives in family groups of up to ten animals (NPWS, 1999m). This species utilises tree hollows for sheltering and breeding (Suckling, 1998), and a number of tree cavities are often used within a home range (Quin, 1993). Two offspring are produced, twice a year, which remain in the pouch for around 30 days (Suckling, 1998). The diet of the Squirrel Glider consists of insects, acacia gum, eucalypt sap, nectar and pollen (Suckling, 1998). Squirrel Glider's forage in the upper and lower forest canopies and in the shrub understorey (NPWS, 1999m). Squirrel Gliders appear to be restricted to stands of mixed forest that contain at least one species of winter-flowering eucalypt or banksia that can contribute to a reliable, year-round food supply (NPWS, 2000c). The estimated home range size for this species varies from 2 - 13 hectares, with densities from 0.4-3 individuals per hectare (Quin, 1993; Traill and Coates, 1993; Suckling, 1998). The home-range of a family group is likely to vary according to habitat quality and availability of resources (Quin, 1995).

Loss, fragmentation and degradation of habitat, the removal of hollow bearing trees, inappropriate fire regimes, and competition and predation by Foxes and Cats are relevant threats to this species (NPWS, 1999m).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; an increase in exotic predator species; and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency or exotic pest species that could adversely impact on this species. Hence it is very unlikely that the Project would adversely impact the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Squirrel Glider requires hollow bearing trees and a mix of eucalypts, acacias and banksias within dry sclerophyll forests and woodland.

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. To minimise impacts on terrestrial vegetation, vegetation clearance would be restricted to the slashing of vegetation (i.e. leaving the lower stem and roots *in-situ* to maximise the potential for natural regrowth) and lopping of branches, where practicable, rather than the removal of trees. Reduction of habitat for the Squirrel Glider due to surface infrastructure would be very small in comparison with the amount of habitat available. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project would not have a significant impact on the locally available habitat of the Squirrel Glider.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Squirrel Glider is distributed widely in eastern Australia, from northern Queensland, through eastern NSW to Victoria (NPWS, 2000c).

During recent targeted surveys within the Project area and surrounds, Western Research Institute and Biosphere Environmental Consultants (2008) recorded the call of a Squirrel Glider in woodland habitat (Figure 5).

The Project is located within the known distribution of the Squirrel Glider and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Further, a FFMP to be developed for the Project would include measures to minimise the occurrence of pest fauna species. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Squirrel Glider.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of its habitat or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Squirrel Glider. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.5.4 Eastern Pygmy-possum

The Eastern Pygmy-possum inhabits a wide range of habitats including rainforest, wet and dry sclerophyll forest, subalpine woodland, coastal banksia woodland and wet heath (Turner and Ward, 1998; Menkhorst and Knight, 2001). In drier habitats banksias and myrtaceous shrubs and trees are favoured as food sources and nesting sites (Turner and Ward, 1998). The Eastern Pygmy-possum is sparse to locally common in a wide range of vegetation on the Great Dividing Range, including the western slopes and coastal plains from south-east Queensland to south-east South Australia, extending into Victoria (Menkhorst and Knight, 2001; Turner and Ward, 1998). The Eastern Pygmy Possum is also found in Tasmania (Menkhorst and Knight, 2001; Turner and Ward, 1998).

During recent targeted surveys within the Project area and surrounds, Western Research Institute and Biosphere Environmental Consultants (2008) recorded the Eastern Pygmy-possum in Banksia-dominated heath (Figure 5) and it is likely that a viable population(s) of the species is/are present.

The Eastern Pygmy-possum is nocturnal, becoming active shortly after dusk (Turner and Ward, 1998). An agile climber, the Eastern Pygmy-possum predominantly feeds on nectar and pollen, which it gathers, from banksias, eucalypts and bottlebrushes (*ibid.*). This species has also been known to feed on soft fruits and insects (Menkhorst and Knight, 2001). The activity of the Eastern Pygmy-possum is reduced in winter when time is spent in torpor (Turner and Ward, 1998).

Tree hollows are favoured nesting sites however, small spherical nests have been found between the wood and bark of eucalypts (Turner and Ward, 1998). Abandoned birds nests and shredded bark in the forks of tea-trees have also been used as nests (*ibid.*). The Eastern Pygmy-possum appears to be mainly solitary and each individual uses several nests (Turner and Ward, 1998). On mainland Australia, births may occur any time of year if food supplies are abundant; however most occur in late spring to early autumn. The young remain in the pouch for 30 days, after which they are left in a nest and weaned when 65 days old. Two litters are usually produced per season. The home range of the males of this species (about 0.68 hectares) is larger than that of females (about 0.35 hectares) and is not exclusive (Turner and Ward, 1998).

Threats to this species include habitat fragmentation and loss, inappropriate fire regimes that affect understorey plants, the loss of nest sites and predation by Foxes and Cats (NSW Scientific Committee, 2001f). Habitat alteration by longwall mining is also considered a threat to this species (NSW Scientific Committee, 2005a).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; an increase in exotic predator species, and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact this species. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or exotic pest species that could adversely impact on this species. Hence it is very unlikely that the Project would adversely impact the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Eastern Pygmy-possum inhabits a wide range of habitats including rainforest, wet and dry sclerophyll forest, subalpine woodland, coastal banksia woodland and wet heath (Turner and Ward, 1998; Menkhorst and Knight, 2001). In drier habitats banksias and myrtaceous shrubs and trees are favoured as food sources and nesting sites (Turner and Ward, 1998). The Project area and/or surrounds is considered to contain high quality habitat for the Eastern Pygmy-possum (DECC, 2007a).

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Reduction of habitat for the Eastern Pygmy-possum due to surface infrastructure would be very small in comparison with the amount of habitat available.

Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project would not have a significant impact on the locally available habitat of the Eastern Pygmy-possum.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Eastern Pygmy-possum is sparse to locally common in a wide range of vegetation on the Great Dividing Range, including the western slopes and coastal plains from south-east Queensland to south-east South Australia, extending into Victoria (Menkhorst and Knight, 2001; Turner and Ward, 1998). The Eastern Pygmy Possum is also found in Tasmania (Menkhorst and Knight, 2001; Turner and Ward, 1998).

During recent targeted surveys within the Project area and surrounds, Western Research Institute and Biosphere Environmental Consultants (2008) recorded the Eastern Pygmy-possum in Banksia-dominated heath (Figure 5).

The Project is located within the known distribution of the Eastern Pygmy-possum and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Further, a FFMP to be developed for the Project would include measures to minimise the occurrence of pest fauna species. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Eastern Pygmy Possum.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of its habitat or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Eastern Pygmy-possum. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEWHA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.5.5 Other Arboreal Mammals – Yellow-bellied Glider and Koala

Neither the Yellow-bellied glider nor the Koala was located during recent surveys of the Project area (Western Research institute and Biosphere Environmental Consultants, (2008). It is unlikely that a viable population of either species exists within the Project area. However both species have been located within the southern area of the Sydney catchment. As described in Section 5.5, Western Research Institute and Biosphere Environmental Consultants (2008) assessed whether SEPP 44 applied in consideration of the potential Koala habitat available and the presence of core Koala habitat. While potential Koala habitat occurs in the Project area and surrounds, the Project area does not fall within the definition of core Koala habitat. There was no evidence of the presence of Koalas within the study area during the surveys. No characteristic scratches or faecal pellets were observed, despite searching smooth-barked trees and the base of trees. Based on the above, it was concluded that the provisions of SEPP 44 did not apply.

Within its range, the Yellow-bellied Glider is restricted to tall, mature forests in regions of high rainfall (NPWS, 1999n). This species favours productive, tall open sclerophyll forests with mature trees, which provide shelter and nesting hollows and year round forage resources (NPWS, 1999n; NPWS, 2002). Essential elements of habitat include sap-site trees, winter flowering eucalypts, mature trees suitable for den sites and a mosaic of forest types (Tanton, 1994).

The Koala occurs in certain Eucalypt forest and woodland depending on a number of factors including the size and species of trees, soil nutrients, climate, rainfall and amount of past disturbance (NPWS, 1999o).

The Yellow-bellied Glider is gregarious, living in family groups of between three and six individuals (NPWS, 1999n). A single young is born between May and September and remains in the pouch for up to 100 days (NPWS, 1999n). This species has a large home range of between 30 and 65 ha and usually occurs in densities of 0.05-0.14 individuals per hectare (NPWS, 1999n). The diet of the Yellow-bellied Glider predominantly consists of plant and insect exudates, such as nectar, sap, honeydew and manna and invertebrates found under decorticating bark (NPWS, 1999n; NPWS, 2002). A characteristic habit of the species involves incising the bark of eucalypts, which often leaves a triangular or v-shaped mark at the sap site (*ibid*.).

A nocturnal species, the Koala rests in tree forks during the day (Martin and Handasyde, 1998). Koalas breed in summer (Martin and Handasyde, 1998). Tree species preferred by Koalas in NSW as their principal food source include *Eucalyptus punctata, E. tereticornis, E. robusta, E. microcorys, E. viminalis, E. camaldulensis, E. haemastoma, E. signata, E. albens* and *E. populnea* (SEPP, 1995). Koalas have however been observed to feed on the leaves of approximately 70 species of Eucalypt and 30 non-Eucalypt species (Phillips, 1990). The Koala is regarded as a solitary species that spends most of its time in defined home ranges (Martin and Handasyde, 1998; Ayers *et al.,* 1996). Koalas live in complex groups and individuals have overlapping home range areas (Martin and Handasyde, 1998). Dispersal distances generally range from 1–11 km, although movements in excess of 50 km have been recorded (NPWS, 1999o).

Threats relevant to the Yellow-bellied Glider include habitat loss and fragmentation, logging of old growth trees, which remove the number of hollow bearing trees available for nesting, inappropriate fire regimes and predation by Cats and Foxes (NPWS, 1999n).

Threats to the Koala include loss or modification of habitat (e.g. fire, weed invasion, climate change), road mortalities, Dog attacks, fire and disease (NPWS, 1999o; NPWS, 2003e).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of these two species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; an increase in exotic predator species, and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact these species. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or an increase in feral exotic species that could adversely impact on these species. Hence it is very unlikely that the Project would adversely impact the lifecycle of these species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

Within its range, the Yellow-bellied Glider is restricted to tall, mature forests in regions of high rainfall (NPWS, 1999n). This species favours productive, tall open sclerophyll forests with mature trees, which provide shelter and nesting hollows and year round forage resources (NPWS, 1999n; NPWS, 2002). Essential elements of habitat include sap-site trees, winter flowering eucalypts, mature trees suitable for den sites and a mosaic of forest types (Tanton, 1994).

The Koala occurs in certain Eucalypt forest and woodland depending on a number of factors including the size and species of trees, soil nutrients, climate, rainfall and amount of past disturbance (NPWS, 1999o).

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. To minimise impacts on terrestrial vegetation, vegetation clearance would be restricted to the slashing of vegetation (i.e. leaving the lower stem and roots *in-situ* to maximise the potential for natural regrowth) and lopping of branches, where practicable, rather than the removal of trees. Reduction of habitat for these two species due to surface infrastructure would be very small in comparison with the amount of habitat available, if it was to occur at all. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project would not have a significant impact on the locally available habitat of these two species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Yellow-bellied Glider has a patchy distribution along the east coast and adjacent ranges of Australia from southeastern South Australia to North Queensland (NPWS, 1999n). In NSW, the distribution of the Yellow-bellied Glider is essentially coastal, extending inland to adjacent ranges (NPWS, 2002).

The Koala has a fragmented distribution throughout eastern Australia, from north-east Queensland to the Eyre Peninsula in South Australia (Martin and Handasyde, 1998). In NSW, the Koala mainly occurs on the central and north coasts (NPWS, 1999o).

The Project is located within the known distribution of the Yellow-bellied Glider and Koala and does not represent a distributional limit for these species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Further, a FFMP to be developed for the Project would include measures to minimise the occurrence of pest fauna species. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Koala and the Yellow-bellied Glider.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of its habitat or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for these two species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for these species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Yellow-bellied Glider or Koala. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.5.6 Grey-headed Flying Fox

The Grey-headed Flying Fox inhabits rainforests, open forests, closed and open woodlands, *Melaleuca* swamps, *Banksia* woodlands, as well as mangroves (Churchill, 1998; Duncan *et al*., 1999a). The Grey-headed Flying Fox is distributed in coastal southeastern Australia, from Victoria to Miriam Vale in Queensland and inland to the western slopes (Hall and Richards, 2000).

During recent targeted surveys within the Project area and surrounds, Western Research Institute and Biosphere Environmental Consultants (2008) recorded the Grey-headed Flying Fox flying over tall forest (Figure 5). It could not be determined whether or not a viable population of the species exists within the Project area.

The Grey-headed Flying Fox is an obligate nectarivore and frugivore (Eby, 2000). This species feeds on a wide variety of flowering and fruiting plants and is responsible for the seed dispersal of many rainforest trees, such as native figs and palms (Tidemann, 1998). The Grey-headed Flying Fox also feeds extensively on the blossoms of eucalypts, angophoras, tea-trees and banksias, as well as in introduced tree species in urban areas and in commercial fruit crops (Tidemann, 1998; Duncan *et al.*, 1999a).

Roost sites of the Grey-headed Flying Fox (known as camps) are commonly formed in gullies, typically not far from water and usually in vegetation with a dense canopy (Tidemann, 1998). Mating, birth and the rearing of young occur at the roost sites (*ibid*.). Mating occurs at any time of the year, however most conceptions occur in March or April (Tidemann, 1998). The majority of reproductively mature females give birth to a single young each October/November (NPWS, 2001f). Known camps (colony roost sites) in the Wollongong local government area include Mt. Kembla (NPWS, undated c).

The Grey-headed Flying Fox commutes daily to foraging areas, usually within 15 km of the day roost, while a few individuals may travel up to 50 km (Tidemann, 1998). The Grey-headed Flying Fox responds to changes in the amount and location of available food by migrating in irregular patterns (Eby, 2000). Migration patterns vary between years in association with the changing location of flowering trees (*ibid*.).

Loss of foraging habitat, disturbance at roosting sites, unregulated shooting, electrocution on power lines and competition and hybridisation with the Black Flying Fox (*Pteropous alecto*) are threats to this species (NPWS, 2001f). Habitat alteration by longwall mining is also considered a threat to this species (NSW Scientific Committee, 2005a).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency or vegetation clearing impacting the species habitat. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Hence it is very unlikely that the Project would adversely impact the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Grey-headed Flying Fox inhabits rainforests, open forests, closed and open woodlands, *Melaleuca* swamps, *Banksia* woodlands, as well as mangroves (Churchill, 1998; Duncan *et al*., 1999a).

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Reduction of habitat for the Grey-headed Flying Fox due to surface infrastructure would be very small in comparison with the amount of habitat available. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The Project would not have a significant impact on the locally available habitat of the Grey-headed Flying Fox.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Grey-headed Flying Fox is distributed in coastal southeastern Australia, from Victoria to Miriam Vale in Queensland and inland to the western slopes (Hall and Richards, 2000).

During recent targeted surveys within the Project area and surrounds, Western Research Institute and Biosphere Environmental Consultants (2008) recorded the Grey-headed Flying Fox flying over tall forest (Figure 5).

The Project is located within the known distribution of the Grey-headed Flying Fox and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance*;* limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Grey-headed Flying Fox.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of its habitat or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Grey-headed Flying Fox. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.5.7 Eastern Bentwing Bat

The Eastern Bentwing Bat occupies a range of habitat types including rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grasslands (Churchill, 1998).

The Eastern Bentwing Bat is distributed in Northern Australia from the Kimberley through the Top End to the western Gulf of Carpentaria (Churchill, 1998; Dwyer, 1998). In eastern Australia, the Eastern Bentwing Bat is distributed from north Queensland to far south-east South Australia (*ibid*.). In NSW, the Eastern Bentwing Bat is found along the coast and western slopes, including high altitude elevations of the Great Dividing Range (NPWS, 2000b).

The Eastern Bentwing Bat is an obligate cave dweller, however it also uses cave substitutes such as mine adits and road culverts (Churchill, 1998). The maternity cave is used annually for the birth and development of young (Churchill, 1998). In temperate regions mating takes place during May to June. In October, adult females congregate in maternity colonies and give birth to their single young in December to mid January (Churchill, 1998). Once the young have been weaned, the mothers disperse to their winter roosts. There is a mass exodus of juveniles a few weeks thereafter and the maternity colony is deserted by April (*ibid*.). This species forages in forested areas, catching moths and other flying insects above the tree tops (DECC, 2008z).

Disturbance to colonies (particularly in maternity or hibernating caves), destruction or modification of caves, rehabilitation of derelict mines, changes to habitat (particularly surrounding maternity caves) and insecticide use are relevant threats to this species (NPWS, 2000b).

During recent targeted surveys within the Project area and surrounds, Western Research Institute and Biosphere Environmental Consultants (2008) recorded the Eastern Bentwing Bat over woodland vegetation (Figure 5). It is likely that a viable population of this species exists within the Project area.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; changed surface hydrological conditions leading to a reduced availability of habitat and resources; an increase in the rate of rock fall and/or cliff face collapse with associated caves; and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Changes in surface hydrology are likely to impact marginally, if at all, on the habitat of this species (Sections 5.1 to 5.4). MSEC (2008) have predicted only minor increases in rock fall and cliff face collapse, with likely only small impacts, if any, on potential roosting or breeding habitat for the Eastern Bentwing Bat. Hence it is very unlikely that the Project would adversely impact the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Eastern Bentwing Bat utilises a range of habitat types including rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grasslands (Churchill, 1998). Furthermore it is an obligate cave dweller or uses appropriate substitutes.

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Reduction of habitat for the Eastern Bentwing Bat due to surface infrastructure would be very small in comparison with the amount of habitat available. Further, given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Mine subsidence also has the potential to cause cracking and alter the availability of water (e.g. in Waratah Rivulet), however the changes described would not be of an extent that would significantly affect the availability of habitat resources for this species. A significant loss of cave habitats due to mine subsidence associated with the Project is unlikely based on the relatively small predicted increase in rock fall and cliff face collapse. The Project is unlikely to significantly reduce the quality or availability of habitat for the Eastern Bentwing Bat.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Eastern Bentwing Bat is distributed in Northern Australia from the Kimberley through the Top End to the western Gulf of Carpentaria (Churchill, 1998; Dwyer, 1998). In eastern Australia, the Eastern Bentwing Bat is distributed from north Queensland to far south-east South Australia (*ibid*.). In NSW, the Eastern Bentwing Bat is found along the coast and western slopes, including high altitude elevations of the Great Dividing Range (NPWS, 2000b).

During recent targeted surveys within the Project area and surrounds, Western Research Institute and Biosphere Environmental Consultants (2008) recorded the Eastern Bentwing Bat over woodland vegetation (Figure 5).

The Project is located within the known distribution of the Eastern Bentwing Bat and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance*;* limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Eastern Bentwing Bat.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of its habitat or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Eastern Bentwing Bat. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEWHA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.5.8 Large-footed Myotis

The Large-footed Myotis will live in most habitat types (including mangroves, paperbark swamps, riverine monsoon rainforest, wet and dry sclerophyll forest, open woodland and River Red Gum woodland), as long as they are close to water (ranging from rainforest streams to large lakes and reservoirs) (Richards, 1998b; Churchill, 1998; NPWS, 2000b). Riparian habitat is thought to be preferred (Duncan *et al.*, 1999b).

The Large-footed Myotis was previously considered to only occur disjunctly along the coast of Australia from Victoria to south-east Queensland and inland along waterways (Duncan *et al*., 1999b). However, a recent taxonomic assessment of the Australian *Myotis* group (*M. adversus, M. macropus* and *M. moluccarum*) showed that these taxa form a monophyletic group that was given the name *M. macropus* (Cooper *et al.*, 2004). Hence, the general distributional range is now considered to be across northern Australia, coastally to Victoria (DECC, 2008zi).

During recent targeted surveys within the Project area and surrounds, Western Research Institute and Biosphere Environmental Consultants (2008) recorded the Large-footed Myotis flying above water in the eastern arm of the Woronora Reservoir. The Large-footed Myotis has also been recorded in the Metropolitan, O'Hares and Woronora Special Areas (DECC, 2007b) and is considered to be a species of high regional priority (DECC, 2007a). However it was not possible to determine if a viable population of the species exists within the Project area.

Colonies of the Large-footed Myotis roost during the day, predominantly in caves or their substitutes (such as mines and tunnels), however have also been known to roost in tree hollows and disused bird nests (NPWS, 2000z). In cooler regions this species hibernates in winter, remaining in roosts, which are separate from the maternity sites (Richards, 1998). Within breeding colonies, males establish a territory, excluding other males and form a harem of females during the breeding periods (Richards, 1998). When not breeding, males roost alone (*ibid.*). In NSW, females of this species give birth to one young each year, usually in November or December (Richards, 1998). The Large-footed Myotis forage most commonly over water, raking its surface with the sharp claws of their large feet to catch aquatic insects and small fish, which make up most of their diet (Richards, 1998; Churchill, 1998; NPWS, 2000zi). The Large-footed Myotis may also forage aerially and may forage individually or hunt together (*ibid.*).

Threats to the Large-footed Myotis are currently poorly known but possible threats are suggested to include sensitivity to changes in water quality caused by sedimentation, eutrophication, alteration of flow regimes and other pollution (Duncan *et al*., 1999b) as well as disturbance to roosting sites by activities such as recreational caving and/or roadworks, particularly during the colder months when the species is hibernating (Ayers *et* al., 1996; Duncan *et al*., 1999b; Gilmore and Parnaby, 1994).

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of this species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; changed surface hydrological conditions leading to a reduced availability of habitat and resources; an increase in the rate of rock fall and/or cliff face collapse with associated caves; and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact this species. Changes in surface hydrology are likely to impact marginally, if at all, on the habitat of this species (Sections 5.1 to 5.4). Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. MSEC (2008) have predicted only minor increases in rock fall and cliff face collapse, with likely only small impacts, if any, on potential roosting or breeding habitat for the Large-footed Myotis. Hence it is very unlikely that the Project would adversely impact the lifecycle of this species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Large-footed Myotis will live in most habitat types (including mangroves, paperbark swamps, riverine monsoon rainforest, wet and dry sclerophyll forest, open woodland and River Red Gum woodland), as long as they are close to water (ranging from rainforest streams to large lakes and reservoirs) (Richards, 1998; Churchill, 1998; NPWS, 2000b). Riparian habitat is thought to be preferred (Duncan *et al.*, 1999b). As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Reduction of habitat for the Large-footed Myotis due to surface infrastructure would be very small in comparison with the amount of habitat available. Further, given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Mine subsidence also has the potential to cause cracking and alter the availability of water (e.g. in Waratah Rivulet), however the changes described would not be of an extent that would significantly affect the availability of habitat resources for this species. A significant loss of cave habitats due to mine subsidence associated with the Project is unlikely based on the relatively small increase in rock fall and cliff face collapse predicted to occur by MSEC (2008). The Project is unlikely to significantly reduce the quality or availability of habitat for the Large-footed Myotis.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Large-footed Myotis was previously considered to only occur disjunctly along the coast of Australia from Victoria to south-east Queensland and inland along waterways (Duncan *et al*., 1999b). However, a recent taxonomic assessment of the Australian *Myotis* group (*M. adversus, M. macropus* and *M. moluccarum*) showed that these taxa form a monophyletic group that was given the name *M. macropus* (Cooper *et al.*, 2004). Hence, the general distributional range is now considered to be across northern Australia, coastally to Victoria (DECC, 2008zi).

During recent targeted surveys within the Project area and surrounds, Western Research Institute and Biosphere Environmental Consultants (2008) recorded the Large-footed Myotis flying above water in the eastern arm of the Woronora Reservoir. The Large-footed Myotis has also been recorded in the Metropolitan, O'Hares and Woronora Special Areas and is considered to be a species of high regional priority (DECC, 2007a).

The Project is located within the known distribution of the Large-footed Myotis and does not represent a distributional limit for this species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency, exotic species diversity or invasions, and erosion. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on the Large-footed Myotis.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of its habitat or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for this species.

6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Large-footed Myotis. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

5.6.5.9 Other Bat Fauna - Yellow-bellied Sheathtail Bat, Eastern Freetail Bat, Eastern False Pipistrelle, Greater Broad-nosed Bat and Large-eared Pied Bat

The Yellow-bellied Sheathtail Bat inhabits a wide range of habitats including wet and dry sclerophyll forest, open woodland, Acacia shrubland, mallee, grasslands and desert (Churchill, 1998). The Eastern Freetail Bat inhabits dry sclerophyll forest, woodland and coastal dune vegetation. The Eastern False Pipistrelle prefers moist habitats, with a canopy height exceeding 20 m (DECC, 2008zii). The Greater Broad-nosed Bat prefers moist gullies in mature coastal forest or rainforest between the Great Dividing Range and the coast, however, has also been recorded in open woodland and wet and dry sclerophyll forest (Churchill, 1998). The Large-eared Pied Bat occurs in moderately well wooded habitats (Ayers *et al*., 1996).

The distribution of the Yellow-bellied Sheathtail Bat, Eastern Freetail Bat, Eastern False Pipistrelle, Greater Broad-nosed Bat and Large-eared Pied Bat includes the eastern coast of NSW.

The Eastern Freetail Bat and Eastern False Pipistrelle have also been recorded in the Woronora Special Area by DECC (2007a), while the Yellow-bellied Sheathtail Bat, Greater Broad-nosed Bat and Large-eared Pied Bat have been recorded in the wider surrounds.

The Yellow-bellied Sheathtail Bat roosts in tree hollows in a wide range of habitats and has been found to utilise multiple roost sites. The Yellow-bellied Sheathtail Bat is insectivorous and forages above the tree canopy. A variety of prey items are eaten including long-horned grasshoppers, shield bugs and flying ants, while beetles comprise up to 90% of this species' diet (Churchill, 1998).

The Eastern Freetail Bat mainly roosts in tree hollows, however has also been recorded roosting under bark or in man-made structures (DECC, 2008ziii). Little is known about the reproduction and diet of the Eastern Freetail Bat. However, some data suggests the males and females of this species separate at certain times of the year possibly for birth and raising of young (Allison and Hoye, 1998).

The Eastern False Pipistrelle predominantly roosts in tree hollows, as well as abandoned buildings (Parnaby, 1983), and there is also one record from the Jenolan Caves. Breeding occurs in late spring and early summer (Churchill, 1998). This species forages within or just below the tree canopy (Churchill, 1998). The diet of mainland bats consists of moths, beetles, weevils, bugs, flies and ants (Menkhorst and Lumsden, 1995). The Eastern False Pipistrelle has been recorded travelling 12 km from foraging areas to roosting sites (Churchill, 1998). During winter, some populations of the Eastern False Pipistrelle may migrate from highland to coastal areas, while others may hibernate (Parnaby, 1983).

The Greater Broad-nosed Bat is thought to be highly mobile with a large foraging range (Phillips, 1998). The diet of the Greater Broad-nosed Bat consists of insects including moths, beetles and chafers, while this species has also been known to eat other bat species (Churchill, 1998). This species roosts in tree hollows, however may occasionally be found in buildings (Churchill, 1998). Females congregate in maternity colonies and single young are born in January (Churchill, 1998).

The Large-eared Pied Bat roosts in caves, mine tunnels and the abandoned mud nests of Fairy Martins (Hoye and Dwyer, 1998). Females give birth in November and young are independent by late February (Hoye and Dwyer, 1998). Young leave the cave soon after, while the females remain another month before abandoning the roost in late March for winter (Churchill, 1998). This species is thought to spend the coldest months in hibernation (Hoye and Dwyer, 1998). The Large-eared Pied Bat forages for small flying insects below the forest canopy (Hoye and Dwyer, 1998; Churchill, 1998).

Threats relevant to the Yellow-bellied Sheathtail Bat, Eastern Freetail Bat, Eastern False Pipistrelle, Greater Broad-nosed Bat and/or Large-eared Pied Bat include loss of roost or maternity sites (e.g. hollow-bearing trees and caves), loss of foraging habitat and application of pesticides in or adjacent to foraging areas.

The five bats described were not located in the Project area during the current surveys by Western Research Institute and Biosphere Environmental Consultants (2008). It is unlikely that viable populations of these species exist within the Project area.

1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The lifecycle of these five species has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; changed surface hydrological conditions leading to a reduced availability of habitat and resources; an increase in the rate of rock fall and/or cliff face collapse with associated caves; and clearing of vegetation.

Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact these species. Changes in surface hydrology are likely to impact marginally, if at all, on the habitat of these species (Sections 5.1 to 5.4). Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. MSEC (2008) have predicted only minor increases in rock fall and cliff face collapse, with likely only small impacts, if any, on potential roosting or breeding locations for the Large-eared Pied Bat. Hence it is very unlikely that the Project would adversely impact the lifecycle of these species.

2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Yellow-bellied Sheathtail Bat inhabits a wide range of habitats including wet and dry sclerophyll forest, open woodland, Acacia shrubland, mallee, grasslands and desert (Churchill, 1998). The Eastern Freetail Bat inhabits dry sclerophyll forest, woodland and coastal dune vegetation. The Eastern False Pipistrelle prefers moist habitats, with a canopy height exceeding 20 m (DECC, 2008zii). The Greater Broad-nosed Bat prefers moist gullies in mature coastal forest or rainforest between the Great Dividing Range and the coast, however, has also been recorded in open woodland and wet and dry sclerophyll forest (Churchill, 1998). The Large-eared Pied Bat occurs in moderately well wooded habitats (Ayers *et al*., 1996).

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. To minimise impacts on terrestrial vegetation, vegetation clearance would be restricted to the slashing of vegetation (i.e. leaving the lower stem and roots *in-situ* to maximise the potential for natural regrowth) and lopping of branches, where practicable, rather than the removal of trees. Reduction of habitat for these bat species due to surface infrastructure would be very small in comparison with the amount of habitat available. Further, given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Mine subsidence also has the potential to cause cracking and alter the availability of water (e.g. in Waratah Rivulet), however the changes described would not be of an extent that would significantly affect the availability of habitat resources for these species. A significant loss of cave habitats for the Large-eared Pied Bat due to mine subsidence associated with the Project is unlikely based on the relatively small increase in rock fall and cliff face collapse predicted to occur by MSEC (2008). The Project is unlikely to significantly reduce the quality or availability of habitat for these five bat species.

3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The distribution of the Yellow-bellied Sheathtail Bat, Eastern Freetail Bat, Eastern False Pipistrelle, Greater Broad-nosed Bat and Large-eared Pied Bat includes the eastern coast of NSW.

The Eastern Freetail Bat and Eastern False Pipistrelle have also been recorded in the Woronora Special Area by DECC (2007a), while the Yellow-bellied Sheathtail Bat, Greater Broad-nosed Bat and Large-eared Pied Bat have been recorded in the wider surrounds.

The Project is located within the known distribution of the Yellow-bellied Sheathtail Bat, Eastern Freetail Bat, Eastern False Pipistrelle, Greater Broad-nosed Bat and Large-eared Pied Bat and does not represent a distributional limit for these species.

4. How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes within the Project area are or are likely to be:

> Fire; limited trails for fire fighting and access; fire trail maintenance; limited weed invasions associated with edges or recently disturbed micro-locations; limited traffic and human access (e.g. activities associated with on ground management, mining exploration, stream restoration or scientific studies); vertebrate pest species; limited erosion from fire trails and associated drainage gutters, and possibly pathogens such as Chytrid fungus (impacting amphibians) and Phytophthora (impacting native plants).

All of the above disturbances are primarily a direct result of human actions. Activities associated with management actions by the SCA would continue and would be unaffected by the proposed Project. The disturbance regime most critical to the lifecycles and survival of terrestrial fauna on the study area is likely to be fire. The frequency or intensity of fires is unlikely to be altered by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence it is very unlikely that the Project would lead to a significant increase in existing disturbance regimes and therefore increased adverse impacts on these bat species.

5. How is the proposal likely to affect habitat connectivity?

Loss of habitat connectivity for this species within the Project area would only be likely if there was widespread clearing of their habitat or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for these five vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence the Project is very unlikely to adversely impact habitat connectivity for these species.

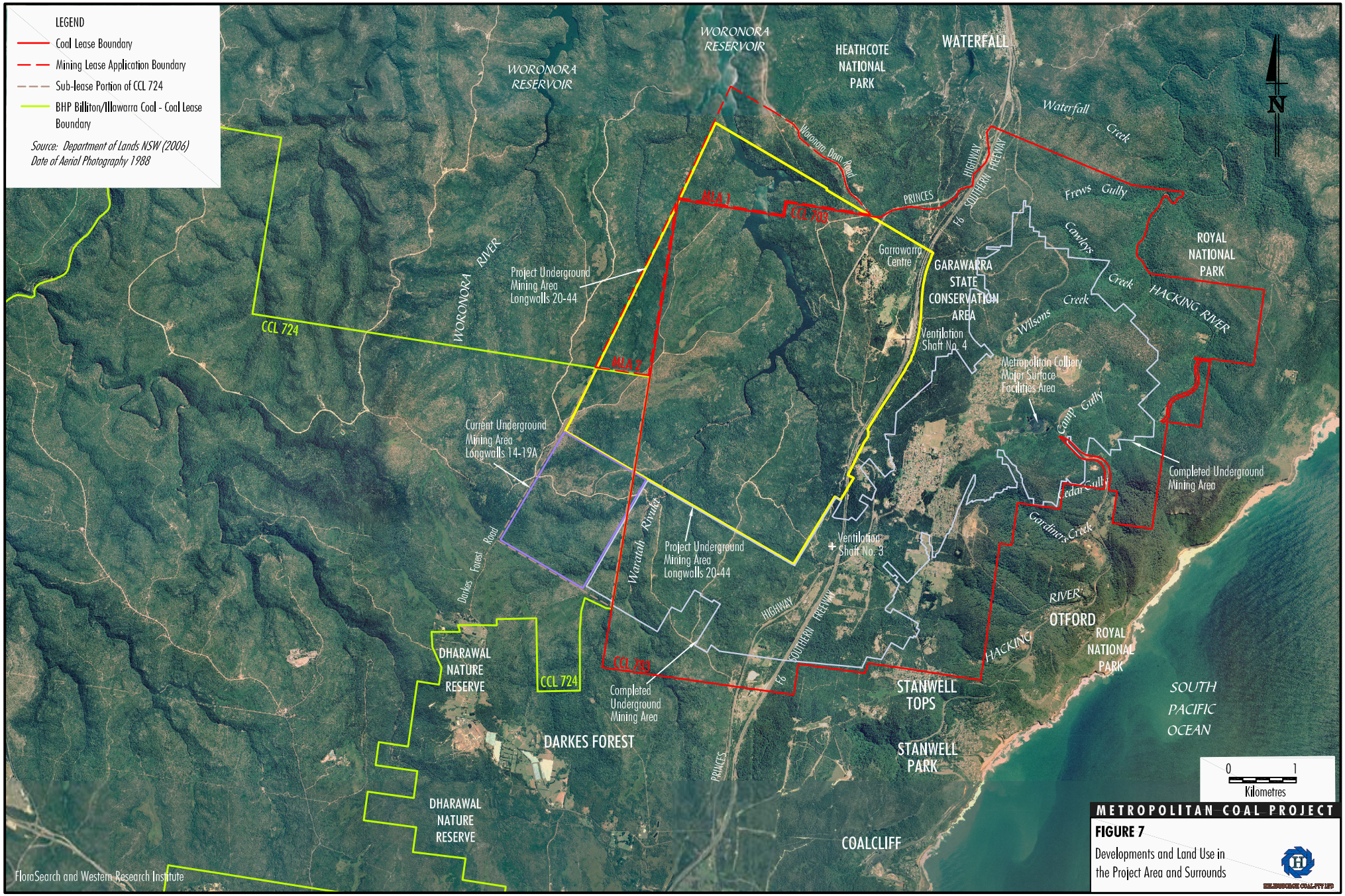
6. How is the proposal likely to affect critical habitat?

Critical habitat, as defined by the TSC Act, has not been declared for the Yellow-bellied Sheathtail Bat, Eastern Freetail Bat, Eastern False Pipistrelle, Greater Broad-nosed Bat or Large-eared Pied Bat. There is no critical habitat as listed on the NPWS Critical habitat register (NPWS, 2008) or DEHWA Register of Critical Habitat (2008a) located in the Project area or surrounds.

6 CUMULATIVE IMPACTS ON TERRESTRIAL FLORA AND FAUNA

Cumulative impacts can be defined as the total impact on the environment that result from the incremental impacts of the action (the Project) added to other past, present, and reasonably foreseeable future actions in a defined area. Cumulative impacts include direct and indirect impacts on the environment. An assessment of the cumulative impacts of the Project on terrestrial flora, fauna and their habitats is provided below.

In regard to past and present actions, there are a number of historic (e.g. Darkes Forest and Metropolitan Colliery workings) and present (e.g. Metropolitan Colliery Longwalls 14-19A) mining operations that are located in the vicinity of the Project (Figure 7). Underground mining to extract coal from the Bulli seam at the Metropolitan Colliery has progressively occurred since the 1880s. The Metropolitan Colliery has its main surface facilities adjacent to the town of Helensburgh (Figure 7).



METROPOLITAN COAL PROJECT

FIGURE 7

Developments and Land Use in the Project Area and Surrounds

MET-06-02 EA FFIA_1088

A large proportion of the Project underground mining area and surrounds occurs within the Woronora Special Area, which is largely undeveloped and covered predominantly by native vegetation. A limited trail system exists for fire management and access for a range of catchment matters and those associated with Metropolitan Colliery surface activities. The Woronora Reservoir supplies water to residents including those in Sutherland, Helensburgh, Stanwell Park, Lucas Heights and Bundeena.

A number of other land uses exist in the vicinity of mining operations including national parks and reserves (e.g. Garawarra State Conservation Area and Royal National Park), residential areas (e.g. Helensburgh), infrastructure (e.g. the F6 Southern Freeway and electricity transmission lines) and private land (Figure 7). These past and present actions have been considered in the assessment of cumulative impacts.

In regard to future actions, the likely extent and nature of impacts of any future mining in the vicinity of the Project (e.g. potential mining in CCL 724) (Figure 7) is unknown at this stage. Future mining would be subject to separate assessment (including the assessment of cumulative impacts) and approvals and therefore the extent and nature of the impacts is yet to be determined. Notwithstanding, activities at the Metropolitan Colliery major surface facilities such as the potential future construction of the approved Camp Gully waste emplacement have been considered in the cumulative impact assessment.

The cumulative impact assessment has considered the species present (species diversity, abundance and dynamics), patterns of species distribution (the communities and ecosystem present that encompass all species), broad habitat types (the ecological niches for the range of species present), and ecosystem processes (how species interact through their involvement in key cycles, e.g. carbon, water and nutrient cycles, and the interception and flow of solar energy).

Based on the studies carried out for the Project, other studies and available literature, the ecosystems and their associated communities in the Project area appear to be in good condition at all scales, and key ecosystem processes appear to be functionally intact. System resilience (the capacity of an ecosystem to self repair in response to perturbations such as fire etc) appears to be very high. The terrestrial vertebrate fauna diversity is consistent with being in mid succession recovery from the 2001/2 wildfire. The terrestrial flora is very diverse and species rich. The area subject to this analysis is one with high ecological values. The ecology of much of the designated areas is reasonably well understood. The past and present actions described above, considered as part of this cumulative impact assessment, are located in a similar land-system to that within the Project area, comprising similar topographies, sandstone vegetation communities and vertebrate faunal habitats, climate, geology and hydrology. Furthermore the coal seams previously mined or to be mined lie at a similar depth (380-480 m) below the surface.

In relation to past and present mining, it is likely that the range and scale of impacts would be similar to those described for the Project. It is also likely that the accumulating impacts would increase linearly and proportionally with the area of longwall mining completed, given that the past and likely future impacts have or will occur within the one landsystem. Potential impacts of the Project on terrestrial flora, fauna and their habitats are described in Sections 4 and 5 and include those associated with mine subsidence effects and other direct and indirect potential impacts. Other land uses described in the vicinity of the Project (e.g. Woronora Reservoir and other surface infrastructure) have primarily impacted on terrestrial flora, fauna and their habitats through vegetation/habitat clearance and associated secondary impacts (e.g. the introduction or spread of weeds).

The following aspects have been considered in assessing cumulative impacts:

- The likely nature of the cumulative impacts.
- Whether the cumulative impacts, including those associated with the Project, are likely to be linear or exponential in nature.
- Whether or not some or all impacts might interact synergistically to produce an overall impact greater than the sum of individual impacts.
- Whether the Project is likely to cause an ecological threshold to be exceeded and thereby lead to a change in ecological state as a result of any impacts.
- Whether or not the Project is likely to lead to a significant decline in the resilience of terrestrial ecosystems.
- Whether or not key ecosystem cycles are likely to remain intact (e.g. carbon, water and nutrients) and whether or not solar energy interception is compromised as a result of cumulative impacts.
- Whether or not impact outcomes stabilise relatively quickly (e.g. in 1-2 years), take many year to fully express themselves (e.g. 10 year or more), or continue to develop over much longer periods of time.

Conclusions

When the cumulative impacts of the past and present actions described have peaked within the footprint area under consideration, the following outcomes are predicted. These predictions are based on the surface water assessment (Appendix C of the Metropolitan Coal Project Environmental Assessment) and subsidence assessment (Appendix A of the Metropolitan Coal Project Environmental Assessment) and consequently rely on the precision, rigour and predictive capacity of these studies and the models therein. Therefore the predictions presented below are contingent on the actual surface water and subsidence effects being equal to or less than those predicted.

- The impacts on terrestrial flora, fauna and their habitats are likely to increase linearly and proportionally with the longwall area mined.
- No ecological threshold(s) would be exceeded at point or landscape scale.
- Ecological resilience across the footprint landscape would remain high and intact.
- Key ecosystem cycles would remain intact at point and landscape scale.
- Energy interception across the footprint landscape would not be compromised.
- The impacts described are likely to be fully expressed within a few years of the completion of site-specific mining and similarly at landscape scale when all mining ceases.

7 POTENTIAL IMPACTS OF THE PROJECT ON MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

The potential impacts of the Project on matters of national environmental significance are evaluated in this section. These evaluations are based on the *Significant Impact Guidelines – Matters of National Environmental Significance* (DEH, 2006b).

7.1 WORLD HERITAGE PROPERTIES

A declared World Heritage property is an area that has been included in the World Heritage List or declared by the Minister to be a World Heritage property under the EPBC Act (DEH, 2006b). World Heritage properties are places with natural or cultural heritage values which are recognised to have outstanding universal value (DEH, 2006b).

No world heritage properties are situated in the Project area or surrounds. The closest world heritage property to the Project is The Greater Blue Mountains Area, situated approximately 40 km to the north-west of the Project. The Greater Blue Mountains Area is particularly noted for providing outstanding examples representing on-going ecological and biological processes significant in the evolution of Australia's highly diverse ecosystems and communities of plants and animals, particularly eucalypt-dominated ecosystems. The Greater Blue Mountains Area includes significant habitats for *in situ* conservation of biological diversity, including the eucalypts and eucalypt-dominated communities, taxa with Gondwanan affinities, and taxa of conservation significance (DEWHA, 2008b).

The Greater Blue Mountains Area is situated approximately 40 km north-west of the Project and a considerable distance from the area of any potential direct or indirect effect of the Project. Any secondary effects associated with the Project such as global warming would be negligible when compared to the effect of national and global emissions. The Project would not have a significant impact on the World Heritage values of The Greater Blue Mountains Area given the Project would not cause one or more of the World Heritage values to be lost, one or more of the World Heritage values to be degraded or damaged, or one or more of the World Heritage values to be notably altered, modified, obscured or diminished.

7.2 NATIONAL HERITAGE PLACES

The National Heritage List comprises a list of places with outstanding natural, Indigenous or historic heritage value to the nation. To be included on the National Heritage List, a place must meet one or more of nine National Heritage List criteria.

The Royal National Park and Garawarra State Conservation Area were both listed as a place on the National Heritage List in 2006 in accordance with criteria (a) *the place has outstanding heritage value to the nation because of the place's importance in the course, or pattern, of Australia's natural or cultural history.* The locations of the Royal National Park and Garawarra State Conservation Area National Heritage Place are shown on Figure 1.

The Garawarra State Conservation Area is located within the Coal Lease Boundary CCL 703, immediately east of the F6 Southern Freeway (Figure 2). Longwalls 20-44 are situated immediately to the west of the F6 Freeway and longwall mining would not occur beneath the Garawarra State Conservation Area. Further, the surface lands of the Garawarra State Conservation Area are not included in the Project and accordingly, surface activities and works would not occur within the Garawarra State Conservation Area.

The Royal National Park abuts the north-eastern and eastern boundaries of Garawarra State Conservation Area and a portion of Royal National Park is located within the Coal Lease Boundary CCL 703.

Longwalls 20-44 are situated immediately to the west of the F6 Freeway and Garawarra State Conservation Area. Hence the boundaries of the proposed underground mining areas are well outside of the adjacent Royal National Park. Further, the surface lands of the Royal National Park are not included in the Project and accordingly, surface activities and works would not occur within the Royal National Park.

The official values of the Royal National Park and Garawarra State Conservation Area National Heritage Place are outlined below (DEWHA, 2008c).

Criteria	Values
A Events, Processes	*Royal National Park and Garawarra State Conservation Area constitute a major centre of plant species richness, having one of the richest concentrations of plant species in temperate Australia with more than 1000 species. The place is important for its richness in a wide array of species including heaths (Epacridaceae), peas and wattles (Mimosaceae and Fabaceae), orchids (Orchidaceae), grevilleas and banksias (Proteaceae) and members of the eucalypt family (Myrtaceae). The place is also extremely important as a centre of temperate animal species richness for a range of groups including perching birds (Passeriformes) especially honeyeaters (Meliphagidae), tree-frogs (Hylidae), reptiles (Reptilia) and butterflies (Lepidoptera). The place can be regarded as exemplifying the biodiverse Hawkesbury Sandstone environment (Braby, 2000; DEH, 2004; DEH, 2006; NPWS, 2000).*
A Events, Processes	*Royal National Park was the first National Park to be established in Australia in 1879 and this event is seen as the beginning of the Australian conservation movement (Heathcote 1988). The permanent reservation of a large natural area for the purposes of public recreation marked the start of the development of Australia's National Park system of protected areas (Worboys et al., 2005).*

The following evaluation assesses the potential impacts of the Project on the Royal National Park and Garawarra State Conservation Area National Heritage Place.

1. Is there a real chance or possibility that the proposal will cause one or more of the National Heritage values to be lost?

The proposed underground longwall mining would not occur beneath the Royal National Park or the Garawarra State Conservation Area. Further, the Project would not include surface activities or works in the Royal National Park or Garawarra State Conservation Area. The potential direct (e.g. subsidence) and indirect (e.g. introduction or spread of weeds) impacts associated with the Project are very unlikely to impact on flora or fauna species diversity in the Royal National Park or Garawarra State Conservation Area given the National Heritage Place is located well away from the proposed activities, the nature and extent of the potential impacts, and the proposed implementation of management measures described in Sections 4 and 5. Any secondary effects associated with the Project such as global warming would be negligible when compared to the effect of national and global emissions. In addition, the historical values of the National Heritage Place would not be impacted by the Project (Heritage Management Consultants, 2008). The Project would not cause one or more of the National Heritage values to be lost.

2. Is there a real chance or possibility that the proposal will cause one or more of the National Heritage values to be degraded or damaged?

The proposed underground longwall mining would not occur beneath the Royal National Park or the Garawarra State Conservation Area and the National Heritage Place is located well away from the surface activities. Given the nature and extent of the potential impacts and the proposed implementation of management measures described in Sections 4 and 5, it is very unlikely that the Project would cause one or more of the National Heritage values to be degraded or damaged.

Further, any secondary effects associated with the Project such as global warming would be negligible when compared to the effect of national and global emissions.

3. Is there a real chance or possibility that the proposal will cause one or more of the National Heritage values to be notably altered, modified, obscured or diminished?

The proposed underground longwall mining would not occur beneath the Royal National Park or the Garawarra State Conservation Area and they are located well away from the surface activities. Further, any secondary effects associated with the Project such as global warming would be negligible when compared to the effect of national and global emissions. Given the nature and extent of the potential impacts and the proposed implementation of management measures described in Sections 4 and 5, it is very unlikely that the Project would cause one or more of the National Heritage values to be notably altered, modified, obscured or diminished.

Summary

The Project is considered unlikely to have a real chance or possibility of having a significant impact on the National Heritage values of the Royal National Park and Garawarra State Conservation Area.

7.3 WETLANDS OF INTERNATIONAL SIGNIFICANCE

The closest Ramsar wetland is the Towra Point Nature Reserve, which is situated approximately 25 km north of the Project on the northern side of Kurnell Peninsula which forms the southern shore of Botany Bay. The Towra Point Nature Reserve contains approximately half the mangrove communities remaining in the Sydney region (DEWHA, 2008d). These wetland communities are considered important as they provide habitat for over thirty species of migratory birds listed on the Japan-Australia Migratory Bird Agreement (*ibid*.). They are also significant for wading and wetland birds in the Sydney region (*ibid*.).

The Project is situated within the same catchment as the Towra Point Nature Reserve. The following evaluation considers potential impacts of the Project on this Ramsar wetland.

1. Is there a real chance or possibility that the proposal will result in areas of the wetland being destroyed or substantially modified?

The Towra Point Nature Reserve is situated approximately 25 km north of the Project and a considerable distance from the area of any potential direct (e.g. mine subsidence and vegetation clearance) or indirect (e.g. potential for the spread of weeds) effect of the Project. Any secondary effects associated with the Project such as global warming would be negligible when compared to the effect of national and global emissions. The Project would not result in areas of the wetland being destroyed or substantially modified.

2. Is there a real chance or possibility that the proposal will result in a substantial and measurable change in the hydrological regime of the wetland?

The Towra Point Nature Reserve is situated approximately 25 km north of the Project and a considerable distance from the area of any potential direct (e.g. changes to hydrology as a result of mine subsidence) or indirect (e.g. impacts on water quality) effect of the Project. Any secondary effects associated with the Project such as global warming would be negligible when compared to the effect of national and global emissions. The Project would not result in a substantial and measurable change in the hydrological regime of the wetland. There would be no measurable change in downstream water quality as a result of the Project (Gilbert and Associates, 2008).

HCPL would operate at the mine's major surface facilities (near Helensburgh) in accordance with the requirements of an Environmental Protection Licence which regulates the controlled discharge of treated water to Camp Gully. It is also anticipated that augmentation of the major surface facilities for the Project would improve water management at the site.

3. Is there a real chance or possibility that the proposal will result in the habitat or lifecycle of native species, including invertebrate fauna and fish species, dependant upon the wetland being seriously affected?

The Towra Point Nature Reserve is situated approximately 25 km north of the Project and a considerable distance from the area of any potential direct or indirect effect of the Project. Any secondary effects associated with the Project such as global warming would be negligible when compared to the effect of national and global emissions. The Project would not result in the habitat or lifecycle of native species, including invertebrate fauna and fish species, dependant upon the wetland being seriously affected. Assessment of the Project's potential impacts on threatened, migratory and marine protected species is also provided in Sections 7.4, 7.6 and 7.7.

4. Is there a real chance or possibility that the proposal will result in a substantial and measurable change in the water quality of the wetland?

The Towra Point Nature Reserve is situated approximately 25 km north of the Project and a considerable distance from the area of any potential direct or indirect effect of the Project. Any secondary effects associated with the Project such as global warming would be negligible when compared to the effect of national and global emissions. The Project would not result in a substantial and measurable change in the water quality of the wetland. There would be no measurable change in downstream water quality as a result of the Project (Gilbert and Associates, 2008). HCPL would operate at the mine's major surface facilities (near Helensburgh) in accordance with the requirements of an Environmental Protection Licence which regulates the controlled discharge of treated water to Camp Gully. It is also anticipated that augmentation of the major surface facilities for the Project would improve water management at the site.

5. Is there a real chance or possibility that the proposal will result in an invasive species that is harmful to the ecological character of the wetland being established (or an existing invasive species being spread) in the wetland?

The Towra Point Nature Reserve is situated approximately 25 km north of the Project and a considerable distance from the area of any potential direct or indirect effect of the Project. Any secondary effects associated with the Project such as global warming would be negligible when compared to the effect of national and global emissions. The Project would not result in an invasive species that is harmful to the ecological character of the wetland being established (or an existing invasive species being spread) in the wetland.

Summary

The Project would not have a significant impact on the ecological character of the Towra Point Nature Reserve Ramsar wetland.

7.4 THREATENED SPECIES

A number of flora and fauna species known to occur or that could possibly occur in the Project area or surrounds are listed as threatened species under the EPBC Act. Evaluations for threatened flora and fauna species are provided in Sections 7.4.1 and 7.4.2, respectively[1].

7.4.1 Flora

The baseline flora survey conducted by Bangalay Botanical Surveys (2008) targeted 21 threatened flora species listed under the EPBC Act for field searches. The targeted species included threatened flora known to occur in a 40 × 40 km square centred on the study area. Many of the targeted species have not previously been recorded on the Woronora Plateau. Some occur in similar habitats to the north or south, while others occur naturally close to the Woronora Plateau, but in different habitats to those on the study area. The assessment in this section is confined to threatened flora species known to occur on the Woronora Plateau. Table 8 lists 13 of the targeted EPBC Act listed species that have been excluded from this assessment, with reasons for their exclusion.

Table 8
Threatened Flora Species Listed under the EPBC Act Excluded from Further Assessment

Scientific Name	Common Name	Reasons for Exclusion
Acacia pubescens	Downy Wattle	Confined to the Cumberland Plain, particularly to shale/sandstone transition soils.
Boronia deanei	Deane's Boronia	Tableland species only.
Caladenia tessellata	Tesselated Spider Orchid	Mainly near coastal, not on sandstone plateaux areas.
Cryptostylis hunteriana	Leafless Tongue Orchid	Coastal lowland species in southern NSW.
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	Occurs on shale/sandstone transition soils on Cumberland Plain and western margins of the Woronora Plateau only.
Haloragis exalata var. *exalata*	Square Raspwort	Mainly coastal lowlands on rainforest margins and moist creeks.
Lasiopetalum joyceae	-	Restricted distribution north of Parramatta River.
Persoonia mollis subsp. *maxima*	-	A narrow range endemic confined to a small area north of Sydney.
Prasophyllum affine	Jervis Bay Leek Orchid	Confined to Jervis Bay area on coastal sedgeland-heath.
Prostanthera densa	Villous Mintbush	Confined to coastal clifftops and headlands.
Pterostylis saxicola	Sydney Plains Greenhood	Confined to Cumberland Plain, mainly shale/sandstone transitional soils on the margins.
Tetratheca glandulosa	-	Only occurs north of the Parramatta River.
Thesium australe	Austral Toadflax	Occurs in grassy woodland, especially that dominated by Kangaroo Grass, *Themeda australis*. Habitat unlikely in Project area.

Table 9 lists the eight assessed species. These eight species are grouped for assessment according to their habitats in the following sections, since the species' habitats are likely to be impacted by the Project in similar ways. Of the eight species, four, *Acacia bynoeana, Astrotricha crassifolia, Melaleuca deanei* and *Pultenaea aristata* were found by the field surveys on or near the Project area. Non-flowering plants tentatively identified as *Leucopogon exolasius* were also found, but the lack of flowers prevented positive identification.

[1] The evaluations have been prepared for the Vulnerable and Endangered Species in accordance with the *Significant Impact Guidelines – Matters of National Environmental Significance* (DEH, 2006b).

Table 9
EPBC Act Threatened Flora Species Known to Occur on the Woronora Plateau

Scientific Name	Common Name	EPBC Act[1]
Acacia bynoeana	Bynoe's Wattle	V
Astrotricha crassifolia	Thick-leaf Star-hair	V
Darwinia biflora	-	V
Eucalyptus camfieldii	Camfield's Stringybark	V
Leucopogon exolasius	Woronora Beard-heath	V
Melaleuca deanei	Deane's Paperbark	V
Persoonia hirsuta subsp. *hirsuta*	-	E
Pultenaea aristata	Prickly Bush-pea	V

[1] E=Endangered, V=Vulnerable

7.4.1.1 Ridgetops and Slopes

All eight species in Table 9 have some or all of their populations and/or potential habitat on ridgetops or gully slopes. Most species are largely confined to plateau woodlands, heaths and/or rock plates, however *Astrotricha crassifolia* and *Leucopogon exolasius* mostly occur on sheltered slopes, while *Pultenaea aristata* is equally likely to occur on ridges and slopes (Section 4.5.3).

1. Is there a real chance or possibility that the proposal will lead to a long-term decrease in the size of a population of a species?

Potential impacts to threatened flora species occurring on ridgetops and slopes in the Project area are summarised in Sections 4.2 and 4.4.

The discussion in these sections demonstrates that potential impacts related to mine subsidence on flora (such as ridgetop tension cracks and rock falls from subsidence movements) on ridges and slopes are likely to be minor. The magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes in these areas and is unlikely to have any biologically significant effect on the soil moisture regime that sustains existing vegetation in these areas (Gilbert and Associates, 2008). Further, the effects of ridgetop tension cracks and rock falls are likely to be localised and small.

Various mining related surface disturbances also have potential to impact on threatened species (Section 4.4). These include vegetation clearance for surface infrastructure, colonisation of disturbed areas by weeds, generation of dust on fire trails and the spread of plant pathogens, particularly *Phytophthora cinnamomi*. Surface infrastructure for the Project includes a ventilation shaft, exploration and monitoring boreholes, monitoring equipment and access tracks. As described in Section 4.4, Project infrastructure would occupy only very small areas of the surface. Vegetation clearance would be managed through the development and implementation of a FFMP which would require surveys for threatened flora species prior to disturbance and relocation of works to avoid disruption to any threatened species population (refer Section 4.4). Similarly, the FFMP would contain protocols for minimising the risk of spread of *Phytophthora cinnamomi* and weeds in the Project area, and the generation of dust by vehicles.

It is highly unlikely that the Project would lead to a long term decrease in the size of a population of any threatened flora species occurring on ridgetops and slopes.

2. Is there a real chance or possibility that the proposal will reduce the area of occupancy of a population?

The distributions of plant communities and populations on the Woronora Plateau would undergo natural fluctuations due to normal climatic variability and the effects of wildfires (Keith *et al.*, 2006). The effects of ridgetop tension cracks and rock falls on threatened flora species as a result of mine subsidence would be minor. The magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes on ridgetops and slopes and is unlikely to have any biologically significant effect on the soil moisture regime that sustains vegetation in these areas (Gilbert and Associates, 2008). Further, procedures would be adopted under the FFMP, including surveys for threatened flora species prior to disturbance, so that surface infrastructure development does not result in reductions of the area of occupancy of populations of threatened flora species.

3. Is there a real chance or possibility that the proposal will fragment an existing population into two or more populations?

The most likely mechanism for fragmentation of populations is the construction of access tracks to surface infrastructure (e.g. exploration boreholes and environmental monitoring sites). The need for such tracks would be minimised by siting surface infrastructure beside or close to existing SCA roads and tracks wherever possible. Vegetation and soil disturbance would be minimised during track construction and temporary tracks would be closed and allowed to regenerate as soon as they are no longer needed. Weed control measures would also be implemented, where required. In addition, under the FFMP, proposed track alignments would be surveyed for the presence of threatened species prior to disturbance and would be relocated to avoid disruption to populations of threatened species. It is considered highly unlikely the Project would result in the fragmentation of a population of any of the threatened flora species.

4. Is there a real chance or possibility that the proposal will adversely affect habitat critical to the survival of a species?

None of the threatened slope and ridgetop plant species is wholly or largely dependent on the Project area for their survival, i.e. the habitat within the Project area is not critical to their survival. In any event the Project is unlikely to alter the habitat sufficiently to place the survival of any of the threatened plant species at risk on the Project area. Subsidence effects would be of a scale that would be unlikely to affect the moisture available to plants, particularly when compared to the fluctuations associated with normal climatic variation (Section 4.2). Subsidence induced tension cracks or rock falls would impact only point locations, not habitat wide areas. Thus, it is highly unlikely that the Project would adversely affect habitat critical to the survival of any of the threatened flora species.

5. Is there a real chance or possibility that the proposal will disrupt the breeding cycle of a population?

Many factors may influence the breeding cycle of plants including temperature, soil moisture, nutrient availability, pollinator populations and activity, seed dispersal, seed germination etc. Soil moisture is important to plant health and reproductive potential, however subsidence effects would be of a scale that would be unlikely to affect the moisture available to plants (Section 4.2). Dust has the potential to disrupt the breeding cycle of plants by preventing access by pollen to the stigma of the flower. There would potentially be an increase in dust generated by Project-related vehicle traffic on the SCA roads/tracks in the Project area. This effect would be concentrated close to the road verge and is unlikely to be significant given that traffic volumes are unlikely to be high enough for the effect to be noticeable. In addition, speed limits on SCA roads limit the amount of dust generated. It is considered that dust effects on the reproduction of threatened species would be small and localised, if they were to occur at all.

6. Is there a real chance or possibility that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

Possible modes of habitat alteration include changes to hydrology due to mine subsidence and vegetation clearance for surface infrastructure (e.g. ventilation shaft, exploration bores and access tracks). The studies summarised in Section 4.2 indicate that subsidence effects would be of a scale that would be unlikely to affect soil moisture available to plants. Mine subsidence is therefore highly unlikely to adversely affect the habitat of any ridgetop or slope threatened species to the extent that it is likely to decline.

Vegetation clearance for infrastructure, exploration drilling, monitoring sites and access tracks is also unlikely to lead to the decline of ridgetop and slope threatened species because:

- The total amount of habitat likely to be affected is very small (described in Section 4.4).
- The amount of soil disturbance would be minimised.
- The ventilation shaft site would be located on an area of existing highly disturbed habitat.
- Where practicable, exploration and monitoring sites would be located next to existing SCA roads/tracks.
- Any access tracks would involve minimal clearance and be allowed to regenerate when no longer needed.

7. Is there a real chance or possibility that the proposal will result in invasive species that are harmful to a species becoming established in the species' habitat?

Introduced plant species in the Project area are largely confined to disturbed sites (Bangalay Botanical Surveys, 2008), including fire roads, cleared areas in the north east of the Project area and along the verges of the F6 Freeway and Princes Highway. Bangalay Botanical Surveys (2008) noted that the incidence of introduced species along fire roads in the Woronora Special Area involved infrequent occurrences of widespread, common species in low numbers. In general, introduced species are absent from all areas of undisturbed natural habitat in the Woronora Special Area. By contrast, the disturbed areas around the Garrawarra Hospital, retirement village, private land and major roads support a wide variety of introduced species, nine of which are listed as Noxious for the Wollongong Local Government Area and 46 that are listed as environmental weeds by Blood (2001). Three species, the Blackberry complex (*Rubus fruticosus* agg. sp.), Bridal Creeper (*Asparagus asparagoides*) and Lantana (*Lantana camara*) are listed as Weed Species of National Significance under the National Weed Strategy (Agriculture and Resource Management Council of Australia and New Zealand [ARMCANZ], Australian and New Zealand Environment and Conservation Council [ANZECC] and Forestry Ministers, 1999).

There is potential for introduced species to invade areas of disturbed soils in the Project area. However, it is unlikely that introduced species would invade intact natural habitats in the absence of soil disturbance. Therefore, the key to avoiding the establishment and spread of invasive plant species in the Project area is to minimise soil disturbance. This would be achieved by:

- Siting infrastructure such as the ventilation shaft in areas that have already been disturbed.
- Siting exploration drillholes and monitoring equipment within the slashed verges of existing fire roads, where practicable.
- Restricting the number of access tracks, minimising soil disturbance associated with their construction and allowing vegetation to regenerate from the soil seed bank when no longer required.

- Minimising vegetation clearance and soil disturbance in setting up monitoring and exploration sites, and allowing them to regenerate from the soil seed bank.

The FFMP would describe the measures to be implemented to minimise soil disturbance and the spread of weeds.

In addition, previous road and track construction by the SCA in the Woronora Special Area, and their regular use and maintenance, has not resulted in the invasion of bushland by introduced plant species. Therefore, it is unlikely the Project would result in the harmful invasion and alienation of the habitats of threatened flora species by introduced flora.

8. Is there a real chance or possibility that the proposal will introduce disease that may cause the species to decline?

Diseases are not listed as a specific threat under the EPBC Act to any of the threatened species found on ridgetops and slopes in the Project area. However, *Phytophthora cinnamomi* is an introduced disease capable of causing the death of many species of native Australian plants (O'Gara *et al.*, 2005). Disease in natural ecosystems of Australia, caused by the introduced plant pathogen *Phytophthora cinnamomi*, is listed as a key threatening process under the EPBC Act (*ibid.*). *P. cinnamomi* has been known to cause the decline of plant populations and habitat quality over wide areas of Australia where the rainfall exceeds 600 mm per annum (*ibid.*). While specific data is lacking on the susceptibility to *P. cinnamomi* of the species under discussion here, the available information indicates several belong to genera with many species susceptible, moderately susceptible or highly susceptible to *P. cinnamomi* (McDougall, 2005). This suggests that *Acacia bynoeana*, *Astrotricha crassifolia*, *Leucopogon exolasius*, *Persoonia hirsuta* var. *hirsuta* and *Pultenaea aristata* are likely to be susceptible to *P. cinnamomi*. However, it should also be noted that *P. cinnamomi* has not often been reported as a serious problem in NSW by contrast with more southern areas in Western Australia, Victoria and Tasmania (O'Gara *et al*., 2005).

In view of the potential threat of *P. cinnamomi*, the FFMP for the Project would include a range of measures to minimise the potential for the introduction or spread of *P. cinnamomi* in the Project area. The most likely means of spreading *P. cinnamomi* is in mud on vehicles, mainly 4WDs and equipment that have recently been in infected areas, and on similarly infected soiled footwear and tools. Measures for the management of *P. cinnamomi* within the Project area would be consistent with the DEH (2006a) *Management of Phytophthora cinnamomi for Biodiversity Conservation in Australia.* Given the proposed implementation of measures to prevent the spread of *P. cinnamomi* through implementation of a FFMP, it is unlikely the Project would introduce disease that may cause *Acacia bynoeana*, *Astrotricha crassifolia*, *Leucopogon exolasius*, *Persoonia hirsuta* var. *hirsuta* and *Pultenaea aristata* to decline.

9. Is there a real chance or possibility that the proposal will interfere with the recovery of the species?

In highly disturbed areas with remnant populations of threatened species, developments may hinder the recovery of the species and their habitats. The Woronora Special Area comprises largely undisturbed habitat, in which it can be expected existing populations of threatened flora species are at or near their natural abundances and are unlikely to have potential for further increase that could be inhibited by the Project.

7.4.1.2 Riparian Habitats

Threatened flora species in Table 9 that may have some of their populations and/or potential habitat in the riparian zone are *Pultenaea aristata*, *Astrotricha crassifolia* and *Leucopogon exolasius* (Section 4.5.3).

1. Is there a real chance or possibility that the proposal will lead to a long-term decrease in the size of a population of a species?

Potential impacts to threatened flora species occurring in riparian habitats in the Project area are summarised in Sections 4.1 and 4.4.

The discussion in these sections demonstrates that potential impacts related to mine subsidence on flora in the riparian zone are likely to be greater than on ridges and slopes or in upland swamps. Riparian zones are subject to mine subsidence (including upsidence and valley closure) which results in fracturing of the rock strata in streams and diversion of a portion of stream flows through subsurface pathways and a reduction in water level in pools as they become hydraulically connected with the fracture network. There is also likely to be reduced continuity of flow between affected pools during dry weather. This can alter the availability of water to riparian vegetation. Monitoring of riparian vegetation on previously undermined sections of the Waratah Rivulet has revealed localised short term dieback due to changed water levels which are limited in extent (Gingra Ecological Surveys, 2007). Localised dieback of riparian vegetation due to emission of methane gas from cracks in the bedrock of creeks has been reported once in the Southern Coalfield (Section 4.1), but has not occurred in Metropolitan Colliery operations to date. There is also potential for changes to stream gradients and alignments, resulting in streambank erosion. These effects are likely to be relatively localised and minor, with the stream establishing a new dynamic equilibrium to which the vegetation would adapt (Section 4.1).

The Project could result in some vegetation clearance/disturbance in riparian zones associated with activities such as stream remediation and monitoring. However, vegetation clearance would be kept to a minimum. Vegetation clearance would be managed through the development and implementation of a FFMP which would require surveys for threatened flora species prior to disturbance and relocation of works to avoid disruption to any threatened species population (refer Section 4.4). Access to these sites would typically be by helicopter or on foot from existing SCA roads/tracks.

Pultenaea aristata, Astrotricha crassifolia and *Leucopogon exolasius* are not specialised riparian zone species. Individuals in the riparian zone represent only small proportions of populations that occur predominantly on the gully slopes adjoining the riparian zone. Any loss of individuals in the riparian zone is unlikely to lead to a long-term decrease in the size of a population of these species.

2. Is there a real chance or possibility that the proposal will reduce the area of occupancy of a population?

In the riparian zone mine subsidence has the potential to result in dieback or death of some plants close to the stream channel. However, the studies summarised in Section 4.1 indicate that the occurrence of plant dieback or death in the riparian zone of Waratah Rivulet in previously mined areas has been localised and limited in extent (e.g. dieback has been observed in some areas of the stream bank on Waratah Rivulet to be restricted to a fringe approximately 10 cm wide), with most plants recovering upon the return of stream flows. There is a possibility that the effects on riparian vegetation may reduce the area of occupancy of a population of these threatened species were individuals to be affected. However, the magnitude of the change is unlikely to be anything other than minimal, if there is a change at all. Further, the potential impacts of mine subsidence on the riparian zone are unlikely to result in a net loss of habitat for these species as based on observation of similar streams that have been affected by subsidence, it is expected that bank erosion would be relatively minor and comprise a slow retreat of the bank until a new dynamic equilibrium is reached.

Vegetation clearance (associated with works such as exploration and stream restoration activities) would be managed through the development and implementation of a FFMP which would require surveys for threatened flora species prior to disturbance and relocation of works to avoid disruption to any threatened species population (refer Section 4.4). Access to these sites would typically be by helicopter or on foot from existing SCA roads/tracks.

3. Is there a real chance or possibility that the proposal will fragment an existing population into two or more populations?

The most likely mechanism for fragmentation of populations is vegetation clearance (e.g. stream remediation activities). As described above, vegetation clearance would be managed through the development and implementation of a FFMP which would require surveys for threatened flora species prior to disturbance and relocation of works to avoid disruption of a threatened species population. Effects of the Project on the riparian zone would be localised to small lengths of watercourses and would be very narrow in extent across watercourses (Section 4.1). Any loss of individuals is highly unlikely to fragment existing populations on the same side of the watercourse since habitat upslope of the riparian zone would generally not be affected. Any populations across Waratah Rivulet would already be fragmented by the watercourse itself. Additional cross watercourse fragmentation would be very low due to the narrow width of riparian zones in the Project area and the limitation of potential plant loss to the fringes of the riparian zone adjacent to the watercourse (Section 4.1). It is unlikely that the Project would result in the fragmentation of an existing population into two or more populations.

4. Is there a real chance or possibility that the proposal will adversely affect habitat critical to the survival of a species?

Neither *Pultenaea aristata, Astrotricha crassifolia* nor *Leucopogon exolasius* are dependent on the riparian zone for the survival of their populations in the Project area. That is, the riparian zone is not critical to the survival of the species owing to the majority of their populations occupying the slopes adjacent to the riparian zone, rather than the riparian zone itself. It is highly unlikely that the Project would adversely affect habitat critical to the survival of these threatened flora species.

5. Is there a real chance or possibility that the proposal will disrupt the breeding cycle of a population?

Many factors may influence the breeding cycle of plants including temperature, soil moisture, nutrient availability, pollinator populations and activity, seed dispersal, seed germination etc. In the riparian zone the factor most likely to be influenced by mine subsidence is moisture availability, which could be affected by diversion of a stream flows through subsurface pathways and a reduction in water level in pools as they become hydraulically connected with the fracture network. There is also potential for changes to stream gradients and alignments. This may potentially result in dieback or death of some plants close to the stream channel with a consequent decline in reproduction in the population. However, the studies summarised in Section 4.1 indicate that the occurrence of plant dieback or death in the riparian zone of Waratah Rivulet in previously mined areas has been localised and limited in extent, with most plants recovering upon the return of stream flows. In addition, only a very small part of the *Pultenaea aristata, Astrotricha crassifolia* and potential *Leucopogon exolasius* populations occur in the riparian zone, such that any disruption to the breeding cycle of their overall populations would be insignificant were individuals to be affected.

6. Is there a real chance or possibility that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

Only very small proportions of the *Pultenaea aristata, Astrotricha crassifolia* and potential *Leucopogon exolasius* populations occur in the riparian zone. Most of the populations of the species occur on the adjoining slopes. Therefore, any loss of habitat or decline in habitat quality in the riparian zone would not be sufficient to cause a decline in the species.

7. Is there a real chance or possibility that the proposal will result in invasive species that are harmful to a species becoming established in the species' habitat?

Invasive species are most likely to establish where significant soil disturbance displaces the seed banks of native species, and where foreign seed is introduced on the wind, on vehicles or footwear. The undisturbed natural communities of the Woronora Special Area, including the riparian zone of Waratah Rivulet, are largely weed free (Bangalay Botanical Surveys, 2008), indicating that these communities are not prone to invasion by exotic species. However, there is potential for introduced species to invade areas of disturbed soils in the Project area, for example, where streambed remediation works disturb very limited areas of riparian and lower slope vegetation. Nevertheless, it is unlikely that introduced species from disturbance areas would invade or establish in adjoining intact natural habitats in the absence of further soil disturbance. The FFMP would include measures to minimise soil disturbance and the spread of weeds. Weed management measures for surface activities in the Woronora Special Area would be developed in consultation with the SCA. Therefore, it is considered unlikely that the Project would result in the establishment of invasive species in the riparian habitats of *Pultenaea aristata, Astrotricha crassifolia* and *Leucopogon exolasius*.

8. Is there a real chance or possibility that the proposal will introduce disease that may cause the species to decline?

Pultenaea aristata, Astrotricha crassifolia and *Leucopogon exolasius* are likely to be susceptible to the introduced plant pathogen, *Phytophthora cinnamomi*. However, it should be noted that *P. cinnamomi* has not often been reported as a serious problem in NSW by contrast with more southern areas in Western Australia, Victoria and Tasmania (O'Gara *et al*., 2005). This disease is mainly spread in mud on equipment and 4WDs that have been in infected areas, as well as on the shoes of bushwalkers etc. The most likely potential route to infection of plants would be via equipment and personnel accessing the riparian zone (e.g. for stream remediation activities or monitoring purposes). In view of the potential threat of *P. cinnamomi*, the FFMP for the Project would include a range of measures to minimise the potential for the spread of *P. cinnamomi* in the Project area (e.g. inspection and cleaning of vehicles and footwear). Measures for the management of *P. cinnamomi* within the Project area would be consistent with the DEH (2006a) *Management of Phytophthora cinnamomi for Biodiversity Conservation in Australia.* Given the proposed implementation of measures to prevent the spread of *P. cinnamomi* through implementation of a FFMP, it is unlikely the Project would introduce disease that may cause *Pultenaea aristata, Astrotricha crassifolia* or *Leucopogon exolasius* to decline.

9. Is there a real chance or possibility that the proposal will interfere with the recovery of the species?

In disturbed areas with remnant populations of threatened species, developments may hinder the recovery of the species and their habitats. The Woronora Special Area comprises largely undisturbed habitat, in which it can be expected existing populations of threatened flora species are at or near their natural abundances and are unlikely to have potential for further increase that could be inhibited by the Project.

7.4.1.3 Headwater Upland Swamps

One threatened plant species listed in Table 9 has been recorded or is likely to occur in upland swamps in the Project area, the Prickly Bush-pea, *Pultenaea aristata* (Section 4.5.3). Prickly Bush-pea is often found around the outer margins of headwater swamps in the Fringing Eucalypt Woodland community and the Sedgeland-Heath vegetation community complex.

1. Is there a real chance or possibility that the proposal will lead to a long-term decrease in the size of a population?

Potential impacts to threatened flora species occurring in upland swamp habitats are summarised in Sections 4.3 and 4.4.

A number of headwater upland swamps are situated within the proposed underground mining area (Longwalls 20-44) and within the potential extent of mine subsidence effects. MSEC (2008) has predicted the maximum potential subsidence effects within 20 m of the perimeter of the upland swamps. The discussion in Section 4.3 demonstrates that impacts related to mine subsidence in upland swamps are likely to be very low. Surface cracking of this nature is not expected to result in an increase in the vertical movement of water from the perched water table into the regional aquifer, or changes to the fundamental surface hydrological processes or upland swamp vegetation. Swamp grades vary naturally and the predicted maximum mining-induced tilts are generally orders of magnitude lower than the existing natural grades within the swamps. The predicted tilts would not have any significant affect on the localised or overall gradient of the swamp or the flow of water. Vegetation clearance for surface infrastructure would not take place in swamp environments except for monitoring purposes. Any vegetation clearance for monitoring equipment would require surveys for threatened plant species prior to disturbance and relocation of works to avoid disruption to any threatened species population. Establishment of monitoring sites would involve minimal vegetation clearance for the equipment and access.

The Proposal would have minimal impact on headwater upland swamps, and hence swamp populations of *Pultenaea aristata.* Accordingly, it is unlikely that the Project would lead to a long term decrease in the size of a population.

2. Is there a real chance or possibility that the proposal will reduce the area of occupancy of the species?

The size and vegetation composition of headwater upland swamps, and hence the potential area of occupancy of *Pultenaea aristata*, are influenced in nature mainly by climate and the frequency and intensity of fire (Keith *et al.*, 2006). Surface cracking of the minor nature predicted and changes in swamp grade due to mine subsidence would not result in a change to surface hydrological processes or swamp vegetation (Section 4.3). Any monitoring sites established in headwater upland swamps would be sited to avoid populations of *P. aristata* through surveys of proposed disturbance areas and relocation of works to avoid disruption to any threatened species population. It is highly unlikely therefore that the Project would reduce the area of occupancy of *P. aristata*.

3. Is there a real chance or possibility that the proposal will fragment an existing population into two or more populations?

Pultenaea aristata is widespread and relatively common in the Project area with many populations, some of which comprise thousands of individuals over areas of several hectares (Bangalay Botanical Surveys, 2008; Bower, personal observations). The only mechanisms that could fragment these populations are relatively large scale vegetation clearance or an increase in the road network in the Woronora Special Area. Neither activity would occur as a result of this Project.

Clearance for surface infrastructure would be located as far as possible in already disturbed areas or on the slashed verges of existing SCA roads/tracks. Upland swamp habitats and areas occupied by threatened plant species would be avoided under the proposed FFMP. While some monitoring sites may need to be established in upland swamps, these would be at point locations that would not contribute to fragmentation of *P. aristata* populations. Access to monitoring sites in upland swamps would involve minimal disturbance to vegetation and avoidance of any *P. aristata*. The Project is therefore highly unlikely to cause fragmentation of *P. aristata* populations.

4. Is there a real chance or possibility that the proposal will adversely affect habitat critical to the survival of a species?

Critical habitat for *Pultenaea aristata* has not been defined or listed under the EPBC Act. While headwater upland swamps are a major habitat for *P. aristata*, they are not critical as the species also occurs commonly in heathy woodlands on plateaux and in gullies. *P. aristata* is widespread on upland swamp margins in the Woronora Special Area and given that mine subsidence cracking and tilting are unlikely to result in a change to surface hydrological processes (Section 4.3) the habitat is unlikely to be affected. Similarly, the point nature of monitoring activities in swamps is unlikely to alienate this important habitat for *P. aristata*, particularly since monitoring sites would be located to avoid *P. aristata* populations under the proposed FFMP. Therefore, it is highly unlikely that upland swamp habitat critical to the survival of *P. aristata* would be adversely affected by the Project.

5. Is there a real chance or possibility that the proposal will disrupt the breeding cycle of a population?

Many factors may influence the breeding cycle of plants including temperature, soil moisture, nutrient availability, pollinator populations and activity, seed dispersal, seed germination etc. In upland swamps the factor most likely to be influenced by longwall mining is moisture availability through mine subsidence cracking and tilting. However, the detailed studies summarised in Section 4.3 indicate that mine subsidence is unlikely to result in a change to surface hydrological processes. Mine subsidence is therefore unlikely to alter swamp hydrology such that the breeding cycle of *Pultenaea aristata* would be disrupted.

6. Is there a real chance or possibility that the proposal will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The effects of mine subsidence on the headwater upland swamp habitat of *Pultenaea aristata* are likely to be imperceptible in comparison with those of normal long term climatic fluctuations and fire (Section 4.3). The hydrological effects of mine subsidence on moisture availability in the upland swamps of the Project area are likely to be insignificant and would not contribute to declines in availability or quality of habitat, or its modification, removal, destruction or isolation. Apart from some environmental monitoring equipment, no surface infrastructure would be located in upland swamps. The environmental monitoring sites would have only point impacts and would be located to avoid *P. aristata* through the survey of proposed disturbance areas under the proposed FFMP. Accordingly, it is highly unlikely the Project would lead to declines in *P. aristata* through adverse effects on its upland swamp habitats.

7. Is there a real chance or possibility that the proposal will result in invasive species that are harmful to a species becoming established in the species' habitat?

Invasive species are most likely to establish where significant soil disturbance displaces the seed banks of native species, and where foreign seed is introduced on the wind, on vehicles or by other human means.

The undisturbed natural communities of the Woronora Special Area, including the upland swamps, are largely weed free (Bangalay Botanical Surveys, 2008), indicating that these communities are not prone to invasion by exotic species. Experience in the Southern Coalfield indicates that severe soil disturbance does not occur as a result of mine subsidence in upland swamps or elsewhere in the landscape (Section 4.3). Nor will upland swamps be affected by Project related vegetation clearance or earthworks, except for environmental monitoring sites, which will affect only point locations. Soil disturbance would be minimised for the establishment of monitoring sites in upland swamps and access to them. Vegetation at the sites and access tracks would be allowed to regenerate when no longer required. It is therefore considered highly unlikely that the Project would result in the establishment of invasive species in the upland swamp habitats of *Pultenaea aristata*.

8. Is there a real chance or possibility that the proposal will introduce disease that may cause the species to decline?

Pultenaea aristata is likely to be susceptible to the introduced plant pathogen, *Phytophthora cinnamomi*. However, it should be noted that *P. cinnamomi* has not often been reported as a serious problem in NSW by contrast with more southern areas in Western Australia, Victoria and Tasmania (O'Gara *et al*., 2005). This disease is mainly spread in mud on equipment and 4WDs that have been in infected areas, as well as on the shoes of bushwalkers etc. Measures for the management of *P. cinnamomi* within the Project area would be consistent with the DEH (2006a) *Management of Phytophthora cinnamomi for Biodiversity Conservation in Australia.* Given the proposed implementation of measures to prevent the spread of *P. cinnamomi* through implementation of a FFMP, it is unlikely the disease would cause the decline of populations of *P. aristata* in upland swamps.

9. Is there a real chance or possibility that the proposal will interfere with the recovery of the species?

This question is not relevant to most of the Woronora Special Area since it refers to situations involving greatly diminished populations of threatened species occupying disturbed habitats. By contrast, the Woronora Special Area, including the upland swamps, comprises mainly pristine habitat, in which it can be expected that existing populations of *Pultenaea aristata* are at or near their natural abundances and are unlikely to have potential for further increase that could be inhibited by the Project.

7.4.2 Fauna

The potential impacts of the Project associated with mine subsidence effects on terrestrial vertebrate fauna and their habitats have been described above in Sections 5.1 to 5.4 (e.g. cliff face collapse and rock fall, surface tension cracks, buckling and/or dilating, and changes in surface or groundwater hydrology). Additional potential direct or indirect impacts on vertebrate fauna and their habitats are described in Section 5.5, namely, habitat disturbance, fire, fauna traps, road traffic, noise, artificial lighting, exotic pest species, Chytrid fungus and greenhouse gas emissions/climate change effects. Cumulative impacts of the Project are described in Section 6.

The following evaluations consider potential impacts of the Project on fauna species listed as Vulnerable or Endangered under the EPBC Act for threatened fauna recorded in the proposed underground mining area or surrounds, as well as for threatened fauna for which potential habitat occurs, namely:

- Vulnerable species – Giant Burrowing Frog, Stuttering Frog, Littlejohn's Tree Frog, Green and Golden Bell Frog, Broad-headed Snake, Superb Parrot, Long-nosed Potoroo, Grey-headed Flying Fox and Large-eared Pied Bat; and

- Endangered species - Swift Parrot, Regent Honeyeater, Eastern Bristlebird, Southern Brown Bandicoot and Spotted-tailed Quoll.

As described in Section 3.3.3, threatened fauna species listed as Vulnerable under the EPBC Act recorded by the Project surveys include the Giant Burrowing Frog, Broad-headed Snake and Grey-headed Flying Fox (Western Research Institute and Biosphere Environmental Consultants, 2008). In addition, diggings that could potentially belong to the Southern Brown Bandicoot listed as Endangered, Long-nosed Potoroo listed as Vulnerable, or the Long-nosed Bandicoot not listed, under the EPBC Act was recorded by the Project surveys. The locations at which these threatened fauna species were recorded are shown on Figure 5.

7.4.2.1 Giant Burrowing Frog

Much of the Giant Burrowing Frog's existence is spent burrowed underground sometimes beneath deep leaf-litter or in earth-filled rock crevices interspersed with brief periods of activity throughout the year during rainy weather (NPWS, 2001b). Burrows are excavated into the earth around, or associated with rocks fissures or boulders (NPWS, 2001b). It has also been reported that yabbie holes are utilised along the beds and banks of drying creeks (NPWS, 2001b). The Giant Burrowing Frog mainly breeds between mid summer and autumn (Cogger, 2000). Males call from within or adjacent to the breeding burrows or amongst accumulated vegetation debris (NPWS, 2001b). Tadpoles develop in three to six months (NPWS, 2001b). The diet of the Giant Burrowing Frog mainly consists of invertebrates including ants, beetles, cockroaches, spiders, centipedes and scorpions (NPWS, 2001b). The Giant Burrowing Frog is thought to have a large home range; having been recorded at considerable distances from suitable moist habitat (Hoser, 1989; Gillespie, 1990). Individuals have been recorded to move up to 200-300 m in a night (NPWS, 2001b).

The Giant Burrowing Frog has been located within the Project area (Figure 5) and it is likely that a viable population(s) of the species is/are present. The Giant Burrowing Frog is listed as Vulnerable under the EPBC Act.

1. Is there a real chance or possibility that the proposal will lead to a long-term decrease in the size of a population of a species?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. Mine subsidence has the potential to impact marginally on populations through limited rock fall and surface tension cracks impacting on particular individuals but not at a level likely to have a negative impact on population dynamics. Changes in surface hydrology have the potential to impact on the habitats of the Giant Burrowing Frog (Sections 5.1 to 5.4) including potential impacts on habitats likely important in the species' breeding. However, the magnitude of surface cracking is too small to influence the hydrological processes and vegetation on slopes/ridgetops and in upland swamps and is unlikely to have any biologically significant effect on the availability of water (Sections 5.1 to 5.4). There is the potential for mine subsidence to alter the availability of water in streams, particularly during times of low flow. However, Gilbert and Associates (2008) indicate that mine subsidence associated with the Project would have a negligible effect on moderate and larger flows in streams. While mine subsidence has the potential to increase the rate of leakage (and consequently pool level recession) of pools, it is likely that a portion of the pools subject to mine subsidence effects will hold some water during prolonged dry periods (Gilbert and Associates, 2008). As described above, much of the Giant Burrowing Frog's existence is spent burrowed underground interspersed with brief periods of activity throughout the year during rainy weather (NPWS, 2001b). An increase in fire frequency also has the potential to impact on this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency resulting from the Project. Further, the Project would involve minimal vegetation clearance. Hence it is very unlikely of there being a chance or possibility that the Project would lead to a long-term decrease in the size of a population of the Giant Burrowing Frog.

2. Is there a real chance or possibility that the proposal will reduce the area of occupancy of a population?

The Giant Burrowing Frog is within its core range in the Sydney sandstone. Here the Giant Burrowing Frog is largely confined to sandstone ridgetop habitat and broader upland valleys, where the species is associated with small headwater creek lines and slow flowing to intermittent creek lines in undisturbed areas (NPWS, 2001b). The vegetation in these areas is typically woodland, open woodland and heath.

Very limited clearing of native habitats would occur as a result of the Project and changes to the sandstone matrix as a result of mine subsidence are likely to be limited to minor cracking and some rock fall (Section 5). Further, the magnitude of surface cracking is considered too small to have any biologically significant effect on the availability of non-persistent sources of water (e.g. drainage lines and ephemeral streams that occur during and for a period following rain) that are likely to be utilised by the Giant Burrowing Frog. Mine subsidence (including upsidence and valley closure) would result in fracturing of the rock strata in watercourses which may result in conveyance of a portion of low flows via the fracture network, and a reduction in water level in pools as they become hydraulically connected with the fracture network. There is also likely to be reduced continuity of flow between affected pools during dry weather.

Gilbert and Associates (2008) estimate that in Waratah Rivulet, typical underflow via the fracture network is expected to increase the average frequency of no flow days from 2% to 15%, with the average frequency of low flows (less than 2 ML/day) increasing from 36% to 40% of days. Gilbert and Associates (2008) also indicate that mine subsidence associated with the Project would have a negligible effect on moderate and larger flows. During prolonged dry periods when flows recede to low levels, a greater proportion of the lower flows would be conveyed via the fracture network. Such abnormally persistent low flows have been observed in the Waratah Rivulet in recent times. Despite prolonged dry periods, pools (albeit smaller, with reduced connectivity) have been observed to be present in Waratah Rivulet. That is, a number of micro-pools remain which hold water. Tributaries of Waratah Rivulet also contain numerous in-stream pools, which are however relatively much smaller, both in plan area, depth and volume relative to runoff flow rates than those on the rivulet. The effects of subsidence on typical tributary pools can be seen as lower pool levels during the longer recessionary periods with little observable effect during periods of normal creek flow. In longer recessionary periods pool water levels can decline below the 'cease to flow' level at a rate faster than it did prior to being undermined (Gilbert and Associates, 2008). Mine subsidence also has the potential to result in changes in stream water quality.

Given the nature of the hydrological changes, the habitats predominantly utilised by the Giant Burrowing Frog and other Project potential impacts, it is unlikely of there being a chance or possibility that the Project would reduce the area of occupancy of a population of the Giant Burrowing Frog.

3. Is there a real chance or possibility that the proposal will fragment an existing population into two or more populations?

It is very likely that a viable population(s) of Giant Burrowing Frog exists within the Project area with genetic exchange between meta–populations possible because of the species mobility. It is also likely that the existing populations are undergoing recovery following the 2001 bushfires. Fragmentation of existing populations would be possible following events such as significant habitat clearing, extensive rock falls or major surface cracking that create a barrier to movement, or the complete and permanent drying of streams that separate existing meta-populations. However only minimal clearing would result from the Project and rock fall and surface cracking are predicted to be relatively minor (Sections 5.1 to 5.4). Potential impacts along streams where the Giant Burrowing Frog occurs, are very unlikely to fragment existing populations. Hence it is very unlikely of there being a chance or possibility that the Project would fragment an existing population into two of more populations.

4. Is there a real chance or possibility that the proposal will adversely affect habitat critical to the survival of a species?

Much of the Giant Burrowing Frog's existence is spent underground in burrows sometimes beneath deep leaf-litter or in earth-filled rock crevices interspersed with brief periods of activity throughout the year during rainy weather (NPWS, 2001b). Burrows are excavated into the earth around, or associated with rocks fissures or boulders (NPWS, 2001b). It has also been reported that yabbie holes are utilised along the beds and banks of drying creeks (NPWS, 2001b). The northern populations of the Giant Burrowing Frog are largely confined to sandstone ridgetop habitat and broader upland valleys, where the species is associated with small headwater creek lines and slow flowing to intermittent creek lines in undisturbed areas (NPWS, 2001b). The vegetation in these areas is typically woodland, open woodland and heath, with riparian components in and along the sides of early order streams. The species may also utilise upland swamps as a component of the range of habitats it is able to exploit.

There is the potential for relatively small components of each of the broad habitat types identified as being part of the Giant Burrowing Frog's 'habitat' to be impacted by the Project (e.g. via rock fall and sub surface and surface tension cracking), however the likely impacts of the potential changes have been demonstrated to be relatively minor and localised. Mine subsidence also has the potential to cause cracking and alter the availability of water. However, the Project is unlikely to alter the habitat sufficiently to place the survival of the Giant Burrowing Frog at risk in the Project area. As described above, the magnitude of surface cracking is considered too small to have any biologically significant effect on the availability of non-persistent sources of water (e.g. drainage lines and ephemeral streams that occur during and for a period following rain) that are likely to be utilised by the Giant Burrowing Frog. Potential impacts on riparian vegetation would be localised and limited in extent. Very limited clearing of native habitats would occur as a result of the Project, and natural regeneration or active rehabilitation would be undertaken in areas disturbed by the Project. Hence it is very unlikely of there being a real chance or possibility that the Project would adversely affect habitat critical to the survival of the Giant Burrowing Frog.

5. Is there a real chance or possibility that the proposal will disrupt the breeding cycle of a population?

It is very likely that a viable population(s) of the Giant Burrowing Frog exists within the Project area with genetic exchange between meta–populations possible because of the species mobility. It is also likely that the existing populations are undergoing recovery following the 2001 bushfires. Disruption to the breeding cycle of the Giant Burrowing Frog would be possible following events such as a loss of key Giant Burrowing Frog habitat, a significant reduction in water quality, available surface water or riparian flows, or if food resources of the Giant Burrowing Frog were significantly diminished. It is unlikely that the potential impacts of the Project would significantly impact on the Giant Burrowing Frog's habitat, water quality, available surface water and riparian flows, or food resources. Hence there is unlikely to be a real chance or possibility that the Project would disrupt the breeding cycle of a population of the Giant Burrowing Frog.

6. Is there a real chance or possibility that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The northern populations of the Giant Burrowing Frog are largely confined to sandstone ridgetop habitat and broader upland valleys, where the species is associated with small headwater creek lines and slow flowing to intermittent creek lines in undisturbed areas (NPWS, 2001b). The vegetation in these areas is typically woodland, open woodland and heath, with riparian components in and along the sides of early order streams. The species may also utilise upland swamps as a component of the range of habitats it is able to exploit.

There is the potential for relatively small components of each of the broad habitat types identified as being part of the Giant Burrowing Frog's 'habitat' to be impacted by the Project. However, adverse impacts to the extent and quality of habitats utilised by the Giant Burrowing Frog are likely to be minor, and likely to occur at point scale, rather than being widespread. As described in Section 5.5, the Project would include some minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Hence it is unlikely that a real chance or possibility exists that the Project would modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

7. Is there a real chance or possibility that the proposal will result in invasive species that are harmful to a species becoming established in the species' habitat?

The Giant Burrowing Frog is a relatively small vertebrate species that is likely to provide an opportunistic prey target for a range of native predators, and likely from time to time for non-native predators such as the Fox, Dog and Cat. The species protects itself through its burrowing lifestyle, intermittent weather-dependent surface emergence, camouflage, the species nocturnal nature, and use of cracks and crevices. There is no evidence of the Giant Burrowing Frog being other than a very minor prey component of the established vertebrate non-native predators. Furthermore, roads and tracks throughout the habitats of the Giant Burrowing Frog are relatively limited and likely to provide relatively few opportunities of predator-Giant Burrowing Frog interaction. Surface infrastructure for the Project includes a ventilation shaft, exploration and monitoring boreholes, monitoring equipment and access tracks. As described in Section 4.4, Project infrastructure would occupy only very small areas of the surface. Further, any access tracks would involve minimal clearance and would be allowed to regenerate when no longer needed. Deer, Rabbit, Goat and the Pig have the potential to impact adversely on habitats. The FFMP to be developed for the Project would include measures developed in consultation with the SCA to minimise the occurrence of pest fauna species. Hence it is very unlikely that a real chance or possibility exists that the Project would result in invasive species, native or non-native, that are harmful to the Giant Burrowing Frog becoming established in the Giant Burrowing Frog's habitat.

8. Is there a real chance or possibility that the proposal will introduce disease that may cause the species to decline?

Infection of frogs by amphibian Chytrid fungus causing the disease Chytridiomycosis is listed as a key threatening process under the EPBC Act.

A water-borne fungal pathogen *Batrachochytrium dendrobatidis*, commonly known as the amphibian or frog Chytrid fungus, is responsible for the disease Chytridiomycosis (Berger *et al.*, 1999). Infection occurs through water-borne zoospores released from an infected amphibian in water (NPWS, 2001a). Collection and handling of frogs and inadvertent transport of infected material between frog habitats may also promote the disease's spread (NSW Scientific Committee, 2003a).

To reduce the likelihood of spreading infection, personnel conducting amphibian surveys or surface water sampling for the Metropolitan Colliery would observe appropriate hygiene protocols in accordance with the NPWS (2001a) *Hygiene Protocols for the Control of Disease in Frogs*.

Given the protocols that would be in place, it is unlikely that the Project would introduce disease that may cause the Giant Burrowing Frog to decline.

9. Is there a real chance or possibility that the proposal will interfere with the recovery of the species?

In fire-prone habitats such as those that occur in the Project area, many vertebrate species will undergo a cycle of loss and recovery following high impact fires as occurred in 2001. The Giant Burrowing Frog was located on three occasions during recent surveys within the Project area and surrounds (Western Research Institute and Biosphere Environmental Consultants, 2008). The species' status within the Project area is considered as being in recovery in response to the 2001 bushfire. However it is not possible to determine whether or not the species within the Project area is undergoing long term decline, or is a relatively stable population when viewed over the long term. It is very likely that the dynamics of population recovery of the Giant Burrowing Frog following fire, commences within refugia and increases slowly and simultaneously with successional vegetation changes that follow fire. It is unlikely that the Project would initiate a decline in population numbers, rather there may be some point-located losses of individuals across the landscape. It is likely that changes in population numbers would continue to fluctuate in response to fire or other natural causes rather than to any significant impact due to the Project. Hence it is very unlikely of there being a real chance or possibility that the Project would interfere with any ongoing recovery that may be occurring for the species independent of recovery from bushfire.

7.4.2.2 Stuttering Frog, Littlejohn's Tree Frog, Green and Golden Bell Frog

The Stuttering Frog is typically found in association with permanent streams through temperate and sub-tropical rainforest and wet sclerophyll forest, rarely in dry open tableland riparian vegetation (Mahony *et al*., 1997), and also in moist gullies in dry forest (Gillespie and Hines, 1999). The ecological requirements of adults and larvae are poorly known. In north eastern NSW the species has been found to occur along first order streams and is occasionally associated with springs. The species is not associated with ponds or ephemeral pools. Very limited areas of potential habitat suitable for this species is located within the Project area with very limited connectivity with other suitable areas outside of the Project area.

Littlejohn's Tree Frog is known to inhabit forest, coastal woodland and heath from 100 to 950 m above sea level (White and Ehmann, 1997), but the species is not associated with any specific vegetation types (Lemckert in prep.). Breeding habitat has been variously reported as rocky streams and semi-permanent dams (Barker *et al*., 1995), still water in dams, ditches, isolated pools and flooded hollows (Hero *et al.*, 1991), dams, creeks and lagoons (Griffiths, 1997), semi-permanent or permanent dams, ponds and creeks (Anstis, 2002) and temporary pools when sufficient run-off water was available (White *et al.*, 1994). White and Ehmann (1997) describe broad breeding habitats of temporary pools in forested areas, deep permanent pools of slow creeks (in hanging swamps) or slow, rock-lined rivers, and in fire dams within undisturbed natural vegetation. Lemckert (in prep.) presents evidence that the species has been recorded calling at temporary pools, permanent ponds and streams, and therefore that all of the above habitat types are potential breeding habitat. Non-breeding habitats are poorly understood. Other species in the *Litoria ewingii* species complex appear to spend their time in leaf litter and low shrubs and this may be the same for Littlejohn's Tree Frog. However they have well-developed suckers on their toes which suggests they could be inclined to climb (Hero *et al*., 2002). Significant areas of potentially suitable habitat are located within the Project area with good connectivity to areas adjacent to the Project area.

The Green and Golden Bell Frog can be found in a diversity of terrestrial habitats including lowland forest, banksia woodland, wet heathland, riparian scrub complex, riparian shrubland, riparian forest, damp forest, shrubby dry forest and cleared pastoral lands (Gillespie, 1996). The Green and Golden Bell Frog has been found in association with almost every type of water body except fast flowing streams (Pyke and White, 1996). In NSW, it inhabits many disturbed sites including abandoned mines and quarries (Pyke *et al*., 2002). Pyke and White (1996) examined sites in NSW, where Green and Golden Bell Frogs are known to have been present.

Sites which supported breeding populations were found to contain water bodies which were still, shallow, ephemeral, unpolluted, unshaded, with aquatic plants and free of Mosquitofish and other predatory fish, with terrestrial habitats that consisted of grassy areas and vegetation no higher than woodlands, and a range of diurnal shelter sites.

Breeding occurred in a significantly higher proportion of sites with ephemeral (temporary) ponds, rather than sites with fluctuating or permanent ponds, and where predatory fish were absent. Mahony (1999) suggested that the results of the study do not necessarily identify the requirements of the species prior to declines. In NSW, the species commonly occupies disturbed habitats, and breeds largely in ephemeral ponds (Pyke and White, 1996). A study in 2002 on Kooragang Island in the Hunter River estuary found that the diversity of vegetation on the banks of waterbodies was positively associated with the presence of Green and Golden Bell Frogs. Frogs were found sheltering in and basking on these plants (Pyke and White, 2001). Areas of potentially suitable habitat are located in the uplands of the Project area, away from the Waratah Rivulet. Potential connectivity with areas adjacent to the Project area are available.

These three frogs are listed as Vulnerable under the EPBC Act. None were located during fauna surveys within the Project area or surrounds although the Project area is within the recognised ranges of these species. It is unlikely that viable populations of these three species exist within the Project area.

1. Is there a real chance or possibility that the proposal will lead to a long-term decrease in the size of a population of a species?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. Mine subsidence has the potential to impact marginally on populations through limited rock fall and surface tension cracks impacting on particular individuals but not at a level likely to have a negative impact on population dynamics. Changes in surface hydrology have the potential to impact on potential habitat of the Stuttering Frog, Littlejohn's Tree Frog and the Green and Golden Bell Frog (Sections 5.1 to 5.4). There is the potential for mine subsidence to alter the availability of water in streams, particularly during times of low flow. However, Gilbert and Associates (2008) indicate that mine subsidence associated with the Project would have a negligible effect on moderate and larger flows in streams. While mine subsidence has the potential to increase the rate of leakage (and consequently pool level recession) of pools, it is likely that a portion of the pools subject to mine subsidence effects will hold some water during prolonged dry periods (Gilbert and Associates, 2008). An increase in fire frequency also has the potential to impact on these species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency due to the Project. Further, the Project would involve minimal vegetation clearance. Hence it is very unlikely of there being a chance or possibility that the Project would lead to a long-term decrease in the size of populations of these species were such populations demonstrated to exist in the Project area.

2. Is there a real chance or possibility that the proposal will reduce the area of occupancy of a population?

Very limited clearing of native habitats would occur as a result of the Project and changes to the sandstone matrix as a result of mine subsidence are likely to be limited to minor cracking and some rock fall (Section 5). Further, the magnitude of surface cracking is considered too small to have any biologically significant effect on the availability of non-persistent sources of water (e.g. drainage lines and ephemeral streams that occur during and for a period following rain) that are likely to be utilised by the Giant Burrowing Frog. Mine subsidence (including upsidence and valley closure) would result in fracturing of the rock strata in watercourses which may result in conveyance of a portion of low flows via the fracture network, and a reduction in water level in pools as they become hydraulically connected with the fracture network. There is also likely to be reduced continuity of flow between affected pools during dry weather.

Gilbert and Associates (2008) estimate that in Waratah Rivulet, typical underflow via the fracture network is expected to increase the average frequency of no flow days from 2% to 15%, with the average frequency of low flows (less than 2 ML/day) increasing from 36% to 40% of days. Gilbert and Associates (2008) also indicate that mine subsidence associated with the Project would have a negligible effect on moderate and larger flows. During prolonged dry periods when flows recede to low levels, a greater proportion of the lower flows would be conveyed via the fracture network. Such abnormally persistent low flows have been observed in the Waratah Rivulet in recent times. Despite prolonged dry periods, pools (albeit smaller, with reduced connectivity) have been observed to be present in Waratah Rivulet. That is, a number of micro-pools remain which hold water. Tributaries of Waratah Rivulet also contain numerous in-stream pools, which are however relatively much smaller, both in plan area, depth and volume relative to runoff flow rates than those on the rivulet. The effects of subsidence on typical tributary pools can be seen as lower pool levels during the longer recessionary periods with little observable effect during periods of normal creek flow. In longer recessionary periods pool water levels can decline below the 'cease to flow' level at a rate faster than it did prior to being undermined (Gilbert and Associates, 2008). Mine subsidence also has the potential to result in changes in stream water quality.

Hence it is very unlikely of there being a chance or possibility that the Project would reduce the area of occupancy of populations of these three species, were such populations to exist.

3. Is there a real chance or possibility that the proposal will fragment an existing population into two or more populations?

The three species are within their known ranges in the Project area although none were located during the recent surveys (Western Research Institute and Biosphere Environmental Consultants, 2008). It is very unlikely that viable populations of these three species exist within the Project area. Fragmentation of existing populations were they demonstrated to exist would be possible following events such as significant habitat clearing, extensive rock falls or major surface cracking that create a barrier to movement, or the complete and permanent drying of streams that separate existing meta-populations. However only minimal clearing would result from the Project and rock fall and surface cracking are predicted to be relatively minor (Sections 5.1 to 5.5). Potential impacts on terrestrial habitats, hydrological processes and upland streams would be very unlikely to fragment existing populations were such populations to exist. Hence it is very unlikely of there being a chance or possibility that the Project would fragment an existing population of these three species into two of more populations, were such populations to exist.

4. Is there a real chance or possibility that the proposal will adversely affect habitat critical to the survival of a species?

There is the potential for relatively small components of each of the broad habitat types identified as being part of these three species' habitats to be impacted by the Project (e.g. via rock fall and sub surface and surface tension cracking), however the likely impacts of the potential changes have been demonstrated to be relatively minor and localised. Mine subsidence also has the potential to cause cracking and alter the availability of water, however the Project is unlikely to alter the habitat sufficiently to place the survival of these three species at risk on the Project area, were they to occur. As described above, the magnitude of surface cracking is considered too small to have any biologically significant effect on the availability of non-persistent sources of water (e.g. drainage lines and ephemeral streams that occur during and for a period following rain) that are likely to be utilised by the Giant Burrowing Frog. Potential impacts on riparian vegetation would be localised and limited in extent. Very limited clearing of native habitats would occur as a result of the Project, and natural regeneration or active rehabilitation would be undertaken in areas disturbed by the Project. Hence it is very unlikely of there being a real chance or possibility that the Project would adversely affect habitat critical to the survival of any of these three species were populations to exist in the Project area.

5. Is there a real chance or possibility that the proposal will disrupt the breeding cycle of a population?

The Stuttering Frog constructs a nest in the shallow running water (in the gravel or leaf litter) that occurs between pools in relatively wide, flat sections of mountain streams (Knowles *et al.*, 1998). Approximately 500 to 550 pigmented eggs (2.8 mm diameter) are deposited in a shallow excavation in the stream bed or pasted directly onto bed rock (Knowles *et al.*, 1998; Knowles pers. comm. in Daly 1998; Watson and Martin, 1973). Some eggs get mixed in with the leaf litter or gravel but most clump together (Frogs Australia Network, 2005). The stream microhabitats used by this species for oviposition are limited (Knowles *et al.*, 1998). Tadpoles develop in pools and shallow water with the aquatic phase of the life cycle lasting approximately one year (Daly, 1998).

Calling activity of the Littlejohn's Tree Frog has been variously reported as April to October (Barker *et al.*, 1995), August to January (Hero *et al.*, 1991), during the cooler months (Griffiths, 1997), late winter and spring (Anstis, 2002) and at any time of year except mid-winter (White *et al.*, 1994). Lemckert (in prep.) presents evidence that calling can occur at any time of year with a possible peak from February to April. Males call from elevated positions on vegetation beside or above water. Clusters of up to 60 eggs are attached to submerged twigs, stems or branches, often near the banks of still pools in clear, slowly flowing streams. Hatching occurs seven to eight days after laying. Metamorphosis occurs mainly in December and January. Larval life span of a group of captive tadpoles was 124 days (Anstis, 2002).

The Green and Golden Bell Frog uses still, relatively unshaded water bodies that are low in salinity (fewer than 7.3 parts per thousand) as breeding sites. All breeding sites are disturbed, either due to human activities or natural flooding. It usually breeds in ponds that are smaller than 1000 square metres in area, less than a metre deep, that are either ephemeral or fluctuate substantially in water level, are free of predatory fish, and have emergent aquatic vegetation (Pyke and White, 2001).

The breeding cycle of these three frogs could be disrupted if one or more of the following events occurred as a result of the Project: a loss of key habitats, a significant reduction in water quality, available surface water or riparian flows or if food resources were significantly diminished. It is unlikely that the potential impacts of the Project would significantly impact the habitats, water quality, available surface water and riparian flows, or food resources of these three species, if populations of the species were demonstrated to exist within the Project area. Hence there is unlikely to be a real chance or possibility that the Project would disrupt the breeding cycle of a population of these three species were such populations to exist within the Project area.

6. Is there a real chance or possibility that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The Stuttering Frog is typically found in association with permanent streams through temperate and sub-tropical rainforest and wet sclerophyll forest, rarely in dry open tableland riparian vegetation (Mahony *et al.*, 1997), and also in moist gullies in dry forest (Gillespie and Hines, 1999). The ecological requirements of adults and larvae are poorly known. Very limited areas of potential habitat suitable for this species is located within the Project area with very limited connectivity with other suitable areas outside of the Project area.

Littlejohn's Tree Frog is known to inhabit forest, coastal woodland and heath from 100 to 950 m above sea level (White and Ehmann, 1997), but the species is not associated with any specific vegetation types (Lemckert in prep.). Significant areas of potentially suitable habitat are located within the Project Area with good connectivity to areas adjacent with the Project area.

The Green and Golden Bell Frog can be found in a diversity of terrestrial habitats including lowland forest, banksia woodland, wet heathland, riparian scrub complex, riparian shrubland, riparian forest, damp forest, shrubby dry forest and cleared pastoral lands (Gillespie, 1996). The Green and Golden Bell Frog has been found in association with almost every type of water body except fast flowing streams (Pyke and White, 1996). Areas of potentially suitable habitat are located in the uplands of the Project area, away from the Waratah Rivulet. Potential connectivity with areas adjacent with the Project area is available.

There is the potential for relatively small components of each of the broad habitat types identified as being part of these three species' habitats to be impacted by the Project. However, adverse impacts to the habitats utilised by these species, were they to exist within the Project area, are likely to be minor, and likely to occur at point scale, rather than being widespread. Hence it is very unlikely of there being a real chance or possibility that the Project would adversely modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that these three species are likely to decline, were such populations to exist in the Project area.

7. Is there a real chance or possibility that the proposal will result in invasive species that are harmful to a species becoming established in the species' habitat?

The three species are relatively small native vertebrates that are likely to provide an opportunistic prey target for a range of native predators, and likely from time to time for non-native predators such as the Fox, Dog and Cat. These three species protect themselves through their cryptic nature, intermittent weather-dependent emergence, camouflage, their nocturnal nature, and ability to hide in vegetation or under rocks, or in cracks and crevices. There is no evidence of these species being other than a very minor potential prey component of the established vertebrate non-native predators. Furthermore, roads and tracks throughout the potential habitats within the Project area are relatively limited and likely to provide relatively few opportunities of potential predator-prey interaction. Surface infrastructure for the Project includes a ventilation shaft, exploration and monitoring boreholes, monitoring equipment and access tracks. As described in Section 4.4, Project infrastructure would occupy only very small areas of the surface. Further, any access tracks would involve minimal clearance and would be allowed to regenerate when no longer needed. The FFMP to be developed for the Project would include measures developed in consultation with the SCA to minimise the occurrence of pest fauna species. Hence it is very unlikely that a real chance or possibility exists that the Project would result in invasive species that are harmful to these three species becoming established in their habitat, were these species to exist within the Project area.

8. Is there a real chance or possibility that the proposal will introduce disease that may cause the species to decline?

Infection of frogs by amphibian Chytrid fungus causing the disease Chytridiomycosis is listed as a key threatening process under the EPBC Act.

A water-borne fungal pathogen *Batrachochytrium dendrobatidis*, commonly known as the amphibian or frog Chytrid fungus, is responsible for the disease Chytridiomycosis (Berger *et al*., 1999). Infection occurs through water-borne zoospores released from an infected amphibian in water (NPWS, 2001a). Collection and handling of frogs and inadvertent transport of infected material between frog habitats may also promote the disease's spread (NSW Scientific Committee, 2003a).

To reduce the likelihood of spreading infection, personnel conducting amphibian surveys or surface water sampling for the Metropolitan Colliery would observe appropriate hygiene protocols in accordance with the NPWS (2001a) *Hygiene Protocols for the Control of Disease in Frogs*.

Hence it is unlikely of there being a real chance or possibility that the Project would introduce disease that may cause these three species to decline, were they to exist within the Project area.

9. Is there a real chance or possibility that the proposal will interfere with the recovery of the species?

In fire-prone habitats such as those that occur in the Project area, many vertebrate species will undergo a cycle of loss and recovery following high impact fires as occurred in 2001. Although the three species are within their known ranges in the Project area none were located during the recent surveys (Western Research Institute and Biosphere Environmental Consultants, 2008). It is very unlikely that viable populations of these three species exist within the Project area.

Very limited areas of potential habitat suitable for the Stuttering Frog are located within the Project area and furthermore there is very limited connectivity provided by suitable habitat with other appropriate areas outside of the Project area. In contrast significant areas of potentially suitable habitat for Littlejohn's Tree Frog are located within the Project area with good connectivity to areas adjacent to the Project area. Areas of potentially suitable habitat for the Green and Golden Bell Frog are located in the uplands of the Project area, away from the Waratah Rivulet. Potential connectivity with areas adjacent to the Project area is available. The likely impacts on vertebrate species described in Sections 5.1 to 5.5 have the potential to impact on existing populations, were they demonstrated to exist, in only minor ways: rock fall, surface tension cracking and modification of surface flows.

Hence it is very unlikely of there being a real chance or possibility that the Project would interfere with any ongoing recovery that may be occurring for these species independent of recovery from bushfire, were these species to exist in the Project area.

7.4.2.3 Broad-headed Snake

The Broad-headed Snake is found in rocky outcrops and adjacent sclerophyll forest and woodland (Cogger *et al*., 1993; NPWS, 2001d). Most suitable sites occur in sandstone ridgetops (Cogger *et al*., 1993). Suitable habitat is patchily distributed throughout the species range (Cogger *et al*., 1993). Adult snakes show a seasonal, temperature induced, shift in habitat use (Webb and Shine, 1998a). Adults use rocks and crevices as shelter sites in rocky outcrops in autumn, winter and early spring (Webb and Shine, 1994). Juvenile snakes remain in rocky habitat year round (Downes, 1999). Snakes shelter under thin (<20 cm) rocks on exposed sites, which fit closely with a rocky substrate (Webb and Shine, 1994; Webb and Shine, 1998b). Occupied crevices have a sunny aspect (Webb and Shine, 1998b) and rocks used by snakes are those that receive the most warmth from the sun (Pringle *et al.*, 2003). The majority of occupied retreat sites occur on exposed cliff edges (Webb and Shine, 1994). Thermally suitable microhabitat may be a limiting resource for the species (Pringle *et al.*, 2003). Snakes often spend long periods of inactivity in a retreat site.

During the surveys, the Broad-headed Snake was found to be relatively common in appropriate habitat and it is very likely that viable populations of the Broad-headed Snake are located within the Project area. The Broad-headed Snake is listed as Vulnerable under the EPBC Act.

1. Is there a real chance or possibility that the proposal will lead to a long-term decrease in the size of a population?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. Potential impacts that could lead to a long-term decrease in population size would be: an increase in the frequency of bushfire; an increase in exotic predator species; an increase in the rate of rock fall; and clearing of vegetation. The Broad-headed Snake is well protected from predation because it is a top order predator but likely more susceptible to predation in its juvenile phase, given its relatively limited home range within sandstone habitats and the protection offered by infinite nooks and crannies within sandstone habitats.

Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or exotic pest species that could adversely impact on Broad-headed Snake populations. The Project area is associated with rocky platforms, beehive formations, and free standing or groups of smaller rocks and mid–sized to large boulders with infinite numbers of crevices, cracks and hiding places. Many sites offer potential habitat for the Broad-headed Snake. Rock falls have the potential to reduce the terrestrial fauna habitat resources within the Project area (e.g. crooks and crannies for reptiles) or result in the loss of individuals in a few cases, either by entrapment or direct fatal rock fall. However, the predicted incidence of rock falls is likely to be low (MSEC, 2008). Further, very limited clearing would occur within the Project area and is unlikely to impact this species. Hence it is very unlikely that the Project would lead to a long-term decrease in the size of a Broad-headed Snake population.

2. Is there a real chance or possibility that the proposal will reduce the area of occupancy of the species?

In the Project area the Broad-headed Snake appears to be associated primarily with sandstone formations although it can also be associated with woodland and forest formations. The sandstone, woodland and forest habitats would be subject to minimal disturbance by the Project. As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Sandstone habitat for the Broad-headed Snake would only be marginally impacted by small predicted increases in rock fall and ground cracking (MSEC, 2008). Hence it is very unlikely of there being a real chance or possibility that the Project would reduce the area of occupancy of the Broad-headed Snake.

3. Is there a real chance or possibility that the proposal will fragment an existing population into two or more populations?

The sandstone, woodland and forest habitats would be subject to minimal disturbance as a result of the Project. Minor impacts on micro-habitats such as limited local rock fall and ground cracking are predicted to occur as a result of the Project (MSEC, 2008). However, such relatively minor impacts cannot be equated with habitat fragmentation on a scale that could lead to the creation of two or more populations. Further, very limited clearing would occur within the Project area. Hence it is very unlikely that the Project would fragment an existing population into two or more populations.

4. Is there a real chance or possibility that the proposal will adversely affect habitat critical to the survival of a species?

The sandstone, woodland and forest habitats would be subject to minimal disturbance as a result of the Project. Reduction of habitat for the Broad-headed Snake due to surface infrastructure would be very small in comparison with the amount of habitat available. Further, given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or an increase in exotic pest species that could adversely impact habitat. A significant loss of shelter/retreat sites for the Broad-headed Snake due to mine subsidence associated with the Project is unlikely based on the relatively small increase in rock fall and cliff face collapse predicted to occur by MSEC (2008). Minor impacts on micro-habitats such as limited local rock fall and ground cracking are predicted to occur as a result of the Project (MSEC, 2008). Hence it is very unlikely of there being a real chance or possibility that the Project would adversely affect habitat critical to the survival of the Broad-headed Snake.

5. Is there a real chance or possibility that the proposal will disrupt the breeding cycle of a population?

Disruption to the breeding cycle of a Broad-headed snake population would be possible if there were to be an increase in mortality of life cycle components (adult, juvenile, newborn) (e.g. due to predation or accidents), an increase in a specific disease, or through an adverse impact on the population's genetic health. It is very unlikely that there would be any increase in predation, accidents, disease or impacts on the genetic health of a Broad-headed Snake population due to the Project. Hence it is very unlikely of there being a real chance or possibility that the Project would disrupt the breeding cycle of a Broad-headed Snake population.

6. Is there a real chance or possibility that the proposal will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The extent of sandstone habitat would remain unchanged as a result of the Project. Minor impacts on micro-habitats such as limited local rock fall and ground cracking are predicted to occur as a result of the Project (MSEC, 2008). However the extensive matrix of sandstone formations would remain high quality Broad-headed Snake habitat without loss of extent, and with existing species specific connectivity remaining intact. Hence it is very unlikely of there being a real chance or possibility that the Project would modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

7. Is there a real chance or possibility that the proposal will result in invasive species that are harmful to a species becoming established in the species' habitat?

The Broad-headed Snake is well protected from predation because it is a top order predator and is likely to be more susceptible to predation in its juvenile phase, given its relatively limited home range within sandstone habitats, camouflage, and the protection offered by infinite nooks and crannies within sandstone habitats. There is no evidence of predators such as the Dog, Cat and Fox being other than a minor impact on the Broad-headed Snake. Furthermore, roads and tracks throughout the potential habitats within the Project area are relatively limited and likely to provide relatively few opportunities of potential predator-prey interaction. Given the range of management protocols proposed to be in place, including management measures relevant to exotic vertebrate predator species, it is unlikely that there would be an increase in exotic species diversity and numbers due to the Project. Goats are also known to impact adversely on Broad-headed Snake habitats but have not been found within the Project area. Hence it is very unlikely of there being a real chance or possibility that the Project would result in invasive species that are harmful to the Broad-headed Snake becoming established in this species' habitat.

8. Is there a real chance or possibility that the proposal will introduce disease that may cause the species to decline?

Diseases of the Broad-headed Snake have not been well researched, however there is no evidence of any disease being a threatening process for the species. Nor is it conceivable how the Project might introduce a species-specific disease that would adversely impact on the Broad-headed Snake population. Hence it is very unlikely that there is a real chance or possibility that the Project would introduce disease that may cause the Broad-headed Snake to decline.

9. Is there a real chance or possibility that the proposal will interfere with the recovery of the species?

The likely impacts on the Broad-headed Snake already described have the potential to impact on existing populations in minor ways primarily through subsidence effects (i.e. rock fall and ground cracking) and some vegetation clearance activities. During the surveys, the Broad-headed Snake was found to be relatively common in appropriate habitat and it is very likely that viable populations of the Broad-headed Snake are located within the Project area. It is also likely that this species is less prone to adverse impacts from bushfire because of the protection the sandstone habitat offers against radiant heat. It is likely that populations of the Broad-headed Snake are already near optimal in appropriate habitats within the Project area. Hence it is very unlikely of there being a real chance or possibility that the Project would interfere with any ongoing recovery that may be occurring for the Broad-headed Snake.

7.4.2.4 Superb Parrot

The Superb Parrot is associated with eucalypt forest, open woodland and near watercourses, particularly where River Red Gum, White Box and Yellow Box occur (Schodde and Tidemann, 1997; Pizzey and Knight, 1998). Two main breeding centres are known *viz.* Murray-Riverina district and the south-west slopes (bounded by Cowra, Rye Park, Yass, Grenfell, Young, Cootamundra and Coolac) (Weber and Ahern, 1992). The Superb Parrot nests in hollows or holes in tall trees such as the River Red Gum and Box woodland species (Ayers *et al.*, 1996; Schodde and Tidemann, 1997; Pizzey and Knight, 1998). The Superb Parrot exhibits high nest site fidelity, while non-breeding flocks are nomadic and partly migratory (Ayers *et al.*, 1996). This species diet ranges from grass seed to nectar (Lindsey, 1992; Webster, 1988) and the flowers, fruits and young buds of Box species (Ayers *et. al*, 1996; Webster, 1998).

The Superb Parrot was not located in surveys of the Project area (Western Research Institute and Biosphere Environmental Consultants, 2008). It is very unlikely that a viable population of this species exists within the Project area. However the species has been located within the Sydney catchment and immediate surrounds near Port Hacking and near the northern boundary of the catchment. There may be small pockets of suitable woodland and forest habitat available in the Project area but marginal rather than prime habitat. The Superb Parrot is listed as Vulnerable under the EPBC Act.

1. Is there a real chance or possibility that the proposal will lead to a long-term decrease in the size of a population of a species?

In the event of an unexpected small number of individuals being present within the Project area, it is likely that they would be present as vagrants or nomadics. Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The Superb Parrot has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency or clearing of vegetation impacting the species' habitat. Since very limited clearing would occur within the Project area, it is unlikely that clearing activities would impact this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Hence it is very unlikely of there being a real chance or possibility that the Project would lead to a long-term decrease in the size of a population.

2. Is there a real chance or possibility that the proposal will reduce the area of occupancy of a population?

In the event of an unexpected small number of individuals being present within the Project area, it is likely that they would be present as vagrants or nomadics. As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Reduction of habitat for the Superb Parrot due to surface infrastructure would be very small in comparison with the amount of habitat available. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Mine subsidence also has the potential to cause cracking and alter the availability of water (e.g. in Waratah Rivulet), however the changes described would not be of an extent or nature that would reduce the area of occupancy of the Superb Parrot. Hence it is very unlikely of there being a real chance or possibility that the Project would reduce the area of occupancy of the species.

3. Is there a real chance or possibility that the proposal will fragment an existing population into two or more populations?

In the event of an unexpected small number of individuals being present within the Project area, it is likely that they would be present as vagrants or nomadics and represent an outlier component of a 'population'. Given the nature and extent of the potential Project impacts, it is very unlikely of there being a real chance or possibility that the Project would fragment an existing population into two or more populations.

4. Is there a real chance or possibility that the proposal will adversely affect habitat critical to the survival of a species?

In the event of an unexpected small number of individuals being present within the Project area, it is likely that they would be present as vagrants or nomads. There may be small pockets of suitable woodland and forest habitat available in the Project area but marginal rather than prime habitat. There is potential for limited vegetation clearance of these habitats, however these areas would not be critical to the survival of the Superb Parrot. Hence it is very unlikely of there being a real chance or possibility that the Project would adversely affect habitat critical to the survival of this species.

5. Is there a real chance or possibility that the proposal will disrupt the breeding cycle of a population?

Two main breeding centres are known *viz.* Murray-Riverina district and the south-west slopes (bounded by Cowra, Rye Park, Yass, Grenfell, Young, Cootamundra and Coolac) (Weber and Ahern, 1992). The Superb Parrot nests in hollows or holes in tall trees such as the River Red Gum and Box woodland species (Ayers *et al.*, 1996; Schodde and Tidemann, 1997; Pizzey and Knight, 1998). The Superb Parrot exhibits high nest site fidelity, while non-breeding flocks are nomadic and partly migratory (Ayers *et al.*, 1996).

In the event of an unexpected small number of individuals being present within the Project area, it is likely that they would be present as vagrants or nomads, rather than as potential breeders. Hence it is very unlikely that the Project would disrupt the breeding cycle of a population of the Superb Parrot, were such a population to exist.

6. Is there a real chance or possibility that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

There may be small pockets of suitable woodland and forest habitat available in the Project area but marginal rather than prime habitat. In the event of an unexpected small number of individuals being present within the Project area, it is likely that they would be present as vagrants or nomads. The potential impacts of the Project on habitats within the Project area would be very marginal and at point scales rather than being landscape impacts. Hence it is very unlikely of there being a real chance or possibility that the Project would modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

7. Is there a real chance or possibility that the proposal will result in invasive species that are harmful to a species becoming established in the species' habitat?

Invasive species likely to impact this species are birds of prey, cuckoo species and to a lesser extent the Cat and the Fox. A number of potential predator species are already present within the Project area. The FFMP to be developed for the Project would include measures developed in consultation with the SCA to minimise the occurrence of exotic vertebrate species. It is very unlikely of there being a real chance or possibility that the Project would result in invasive species that are harmful to the species becoming established in the species' habitat.

8. Is there a real chance or possibility that the proposal will introduce disease that may cause the species to decline?

Diseases of the Superb Parrot have not been well researched but there is no evidence of any disease being a threatening process for the species. Nor is it conceivable how the Project might introduce a species-specific disease that would adversely impact on the Superb Parrot if the species were to be located within the Project area. Hence it is very unlikely that there is a real chance or possibility that the Project would introduce disease that may cause the Superb Parrot to decline.

9. Is there a real chance or possibility that the proposal will interfere with the recovery of the species?

The Superb Parrot was not located in surveys of the Project area. It is very unlikely that a viable population of this species exists within the Project area. However the species has been located within the Sydney catchment and immediate surrounds near Port Hacking and near the northern boundary of the catchment. Their core breeding area is on the south-western slopes where their habitat consists of Box Woodland-Cypress Pine formations, and River Red Gum Forest. There may be small pockets of suitable woodland and forest habitat available in the Project area but marginal rather than prime habitat. It is very unlikely of there being a real chance or possibility that the Project would interfere with the recovery of the Superb Parrot if the species were to be located within the Project area.

7.4.2.5 Swift Parrot and Regent Honeyeater

The Swift Parrot only breeds in Tasmania, always within 8 km of the coast (Brereton, 1998) and nests in tree cavities or hollows, usually high in a Eucalypt (Lindsey, 1992; Pizzey and Knight, 1999). The Swift Parrot migrates to mainland Australia from May to August (Swift Parrot Recovery Team, 2001; NSW Scientific Committee, 2000d). Non-breeding birds are highly mobile and their movements vary between years (Hindwood and Sharland, 1964; Brown, 1989). Generally a canopy feeder, the Swift Parrot congregates where there is profuse flowering of Eucalypts (Blakers *et al.*, 1984; Brouwer and Garnett, 1990). *Eucalyptus robusta*, *Corymbia maculata* and Red Bloodwood (*C. gummifera*) are utilised by this species on the coast of NSW (Swift Parrot Recovery Team, 2001).

If sufficient food is available this species will remain in an area and return to the same tree to roost (Pizzey and Doyle, 1980).

The Regent Honeyeater usually nests in isolated pairs, although they sometimes breed in loose colonies (NPWS, 1999h). The nest is a thick walled cup of bark strips bound with cobwebs and lined with dry grass and bark shreds (Geering and French, 1998). There are only a small number of known breeding sites in NSW, the most important being in the Capertee Valley (DEC, 2004) although other important breeding areas are situated in Warrumbungle National Park, Pilliga Nature Reserve, Barraba district, the central coast around Gosford, and the Hunter Valley (Ayers *et al.*, 1996; NPWS, 1999h). Although nectar is their main food source, Regent Honeyeaters also eat insects, lerps and fruit (Ayers *et al.*, 1996). The Regent Honeyeater has demonstrated a preference for larger trees to forage and the preference for particular species may be related to the timing of flowering (DEC, 2004). The Regent Honeyeater is regarded as a single population (DEC, 2004). The birds are partly migratory, shifting generally northwards in autumn and winter and returning south to breed in spring (Schodde and Tidemann, 1997). Individuals have been found to travel over 350 km between the Capertee Valley and Canberra (David Geering *pers comm.*, 2004). The movements of the Regent Honeyeater are related to the regional patterns of flowering of the key forage species (DEC, 2004).

These two species were not observed during the recent fauna surveys and are unlikely to be represented by viable populations within the Project area. However both the Swift Parrot and the Regent Honeyeater have been reported at numerous locations within the Sydney catchment and the immediate surrounds. Furthermore the Swift Parrot has been reported immediately west of the Project area and just south of Darkes Forest, whereas the Regent Honeyeater has been reported from areas adjacent to the Project area in the north, west and south.

The Swift Parrot and Regent Honeyeater are listed as Endangered under the EPBC Act.

1. Is there a real chance or possibility that the proposal will lead to a long-term decrease in the size of a population of a species?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The Swift Parrot and Regent Honeyeater have the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency or clearing of vegetation impacting the species' habitat. Since very limited clearing would occur within the Project area, it is unlikely that clearing activities would impact these species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Hence, It is very unlikely of there being a real chance or possibility that the Project would lead to a long-term decrease in the size of a population of these two species, were such populations located within the Project area.

2. Is there a real chance or possibility that the proposal will reduce the area of occupancy of a population?

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Reduction of habitat for the Swift and Superb Parrots or the Regent Honeyeater due to surface infrastructure would be very small in comparison with the amount of habitat available. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Mine subsidence also has the potential to cause cracking and alter the availability of water (e.g. in Waratah Rivulet), however the changes described would not be of an extent or nature that would reduce the area of occupancy of these two species.

Hence it is very unlikely of there being a real chance or possibility that the Project would reduce the area of occupancy of these species, were there to be extant viable populations, within the Project area.

3. Is there a real chance or possibility that the proposal will fragment an existing population into two or more populations?

The potential for populations of these two species within the Project area to be fragmented into two or more populations, were such populations to exist, could only occur through widespread clearing or a significant increase in fire frequency. Since this would not occur, it is very unlikely of there being a real chance or possibility that the Project would fragment a population of these two species, were they to occur within the Project area, into two or more populations.

4. Is there a real chance or possibility that the proposal will adversely affect habitat critical to the survival of a species?

There is potential for the Project to result in limited vegetation clearance of these species' habitats, however these areas would not be critical to the survival of the Swift Parrot or Regent Honeyeater. Vegetation clearance would be progressive over the life of the mine. Reduction of habitat for the Swift Parrot or Regent Honeyeater due to surface infrastructure would be very small in comparison with the amount of habitat available. Further, given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Hence it is very unlikely of there being a real chance or possibility that the Project would adversely affect habitat critical to the survival of these species.

5. Is there a real chance or possibility that the proposal will disrupt the breeding cycle of a population?

The Swift Parrot breeds only in northern Tasmania and this component of its breeding cannot be impacted by the Project. There are areas of forest habitat that would be potentially suitable for breeding by the Regent Honeyeater. Only very limited areas of potential habitat for the Regent Honeyeater would be cleared in the Project area. Hence it is very unlikely that the Project would disrupt the breeding cycle of a population of the Swift Parrot or Regent Honeyeater.

6. Is there a real chance or possibility that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The potential impacts of the Project on habitats within the Project area are predicted to be very marginal and at point scales rather than being landscape impacts. Hence it is very unlikely of there being a real chance or possibility that the Project would modify, destroy, remove, isolate or decrease the availability or quality of potential habitat to the extent that these two species, were they to occur in the Project area, are likely to decline.

7. Is there a real chance or possibility that the proposal will result in invasive species that are harmful to a species becoming established in the species' habitat?

Invasive species likely to impact these species are birds of prey, cuckoo species and to a lesser extent the Cat and the Fox. A number of potential predator species are already present within the Project area. The FFMP to be developed for the Project would include measures developed in consultation with the SCA to minimise the occurrence of exotic pest species. It is very unlikely of there being a real chance or possibility that the Project would result in invasive species that are harmful to these species becoming established in the species' habitat.

8. Is there a real chance or possibility that the proposal will introduce disease that may cause the species to decline?

Diseases of these two species have not been well researched but there is no evidence of any disease being a threatening process for these species. Nor is it conceivable how the Project might introduce a species-specific disease that would adversely impact on these species were they to be located within the Project area. Hence it is very unlikely that there is a real chance or possibility that the Project would introduce disease that may cause these two species to decline.

9. Is there a real chance or possibility that the proposal will interfere with the recovery of the species?

These species have been reported at numerous locations within the Sydney catchment and immediate surrounds. The likely impacts on the Swift Parrot and Regent Honeyeater already described have the potential to have a minor, if any, impact on existing populations primarily through vegetation clearance activities. Hence it is very unlikely of there being a real chance or possibility that the Project would interfere with the recovery of these two species if the species were to be located within the Project area.

7.4.2.6 Eastern Bristlebird

The Eastern Bristlebird inhabits a wide range of vegetation communities including rainforest, eucalypt forest, woodland, mallee, shrubland, swamp, heathland and sedgeland where there is low dense cover (Baker, in press). The Eastern Bristlebird is considered to be a cover-dependent and fire-sensitive species (NPWS, 1999k). Eastern Bristlebirds have low fecundity; generally laying a clutch of two eggs and raising only one fledgling (NPWS, 1999k). Habitat is characterised by dense, low vegetation including heath and open woodland with a heathy understorey. Age of habitat since fires is of particular importance with unburnt periods of 15 years or more necessary to optimise population density. Eastern Bristlebird nests are elliptical domes constructed in low dense vegetation, usually in tufted plants (NPWS, 1999k). The diet of the Eastern Bristlebird includes ants, beetles and weevils (Baker, 1998). Individuals have a home range of more than 10 ha and are presumed to be sedentary (Baker, 1998).

The Eastern Bristlebird was not located during the recent terrestrial fauna surveys. The Eastern Bristlebird is believed to be extinct within the Sydney catchment and the immediate surrounds with historical records only from the coastal strip near Botany Bay. It is highly unlikely that a viable population of this species exists within the Project area. The Eastern Bristlebird is listed as Endangered under the EPBC Act.

1. Is there a real chance or possibility that the proposal will lead to a long-term decrease in the size of a population of a species?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The Eastern Bristlebird has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; an increase in exotic predator species, changed surface hydrological conditions leading to a reduced availability of habitat and resources; and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing activities would impact this species. Vegetation clearance for surface infrastructure would not take place in upland swamps except for monitoring purposes. Establishment of monitoring sites would involve minimal vegetation clearance for the equipment and access.

The magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes on ridgetops/slopes and in upland swamps and is unlikely to have any biologically significant effect on the soil moisture regime that sustains vegetation/habitats in these areas. As a result, mine subsidence is unlikely to result in a reduction in availability of habitat and resources that would impact on the Eastern Bristlebird. In regard to fire it is likely that current fire frequency is likely to have non-optimal outcomes on potential Eastern Bristlebird habitats. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or exotic pest species that could adversely impact on this species. Further, the Project would not involve the conduct of any prescribed burns in native remnant vegetation. Hence it is very unlikely of there being a real chance or possibility that the Project would lead to a long-term decrease in the size of a population of this species, were such populations to be located within the Project area.

2. Is there a real chance or possibility that the proposal will reduce the area of occupancy of a population?

The Eastern Bristlebird inhabits a wide range of vegetation communities including rainforest, eucalypt forest, woodland, mallee, shrubland, swamp, heathland and sedgeland where there is low dense cover (Baker, in press). The Eastern Bristlebird is considered to be a cover-dependent and fire-sensitive species (NPWS, 1999k). Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Further, the Project would not involve the conduct of any prescribed burns in native remnant vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing activities would have a significant impact on the habitat of this species. Vegetation clearance for surface infrastructure would not take place in upland swamps except for monitoring purposes. The magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes on ridgetops/slopes and in upland swamps and is unlikely to have any biologically significant effect on the soil moisture regime that sustains vegetation/habitats in these areas. The FFMP to be developed for the Project would also include measures to minimise the potential for the introduction or spread of weeds and feral pests. Hence it is very unlikely of there being a real chance or possibility that the Project would reduce the area of occupancy of this species, were there to be extant viable populations, within the Project area.

3. Is there a real chance or possibility that the proposal will fragment an existing population into two or more populations?

Fragmentation of populations of the Eastern Bristlebird would be possible if there was widespread clearing of their habitats, a significant increase in fire frequency or if changes in surface hydrology impacted adversely and at landscape scale on forest, woodland, heathland or upland swamp habitats. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Gilbert and Associates (2008) have demonstrated that mine subsidence effects would not result in changes to surface hydrology that would impact on forest, woodland, heathland or upland swamp habitats or habitat connectivity. Hence it is very unlikely of there being a real chance or possibility that the Project would fragment a population of this species were it to occur within the Project area, into two or more populations.

4. Is there a real chance or possibility that the proposal will adversely affect habitat critical to the survival of a species?

There is potential for the Project to result in limited vegetation clearance of this species' habitats, however these areas would not be critical to the survival of the Eastern Bristlebird.

Vegetation clearance would be progressive over the life of the mine. Reduction of habitat for the Eastern Bristlebird due to surface infrastructure would be very small in comparison with the amount of habitat available. Further, given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Hence it is very unlikely of there being a real chance or possibility that the Project would adversely affect habitat critical to the survival of this species, were populations of the species found to be extant within the Project area.

5. Is there a real chance or possibility that the proposal will disrupt the breeding cycle of a population?

The Eastern Bristlebird inhabits a wide range of vegetation communities including rainforest, eucalypt forest, woodland, mallee, shrubland, swamp, heathland and sedgeland where there is low dense cover (Baker, in press). The Eastern Bristlebird is considered to be a cover-dependent and fire-sensitive species (NPWS, 1999k). Eastern Bristlebirds have low fecundity; generally laying a clutch of two eggs and raising only one fledgling (NPWS, 1999k). Eastern Bristlebird nests are elliptical domes constructed in low dense vegetation, usually in tufted plants (NPWS, 1999k). There are areas of habitat available that would be potentially suitable for breeding use by the Eastern Bristlebird. Only very limited areas of appropriate potential habitat for the Eastern Bristlebird would be cleared in the Project area. Hence it is very unlikely that the Project would disrupt the breeding cycle of a population in the Project area were such a population to exist.

6. Is there a real chance or possibility that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The potential impacts of the Project on habitats within the Project area are predicted to be very marginal and at point scales rather than being landscape impacts. Hence it is very unlikely of there being a real chance or possibility that the Project would modify, destroy, remove, isolate or decrease the availability or quality of potential habitat to the extent that the Eastern Bristlebird, were the species located in the Project area, is likely to decline.

7. Is there a real chance or possibility that the proposal will result in invasive species that are harmful to a species becoming established in the species' habitat?

Invasive species likely to impact on this species are birds of prey, cuckoo species and to a lesser extent the Cat and the Fox. A number of potential predator species are already present within the Project area. The FFMP to be developed for the Project would include measures developed in consultation with the SCA to minimise the occurrence of exotic pest species. It is very unlikely of there being a real chance or possibility that the Project would result in invasive species that are harmful to this species becoming established in the species' habitat.

8. Is there a real chance or possibility that the proposal will introduce disease that may cause the species to decline?

Diseases of this species have not been well researched but there is no evidence of any disease being a threatening process for this species. Nor is it conceivable how the Project might introduce a species-specific disease that would adversely impact on this species were it to be located within the Project area. Hence it is very unlikely that there is a real chance or possibility that the Project would introduce diseases that may cause this species to decline.

9. Is there a real chance or possibility that the proposal will interfere with the recovery of the species?

The Eastern Bristlebird is believed to be extinct within the Project area. There are areas of suitable heath, woodland and forest habitat available in the Project area but these areas contain marginal rather than prime habitat. It is very unlikely of there being a real chance or possibility that the Project would interfere with the recovery of this species if the species were to be located within the Project area.

7.4.2.7 Southern Brown Bandicoot

The species prefers heath and scrubby habitats that are successional following fire. The Southern Brown Bandicoot is nocturnal and prefers to stay close to cover when in search of food on the surface of the ground and in the shallow, conical holes that it digs with its foreclaws. It is omnivorous, feeding on earthworms, other invertebrates, insects (both adult and larval), fungi and other subterranean plant material (NPWS, 2001e; Strahan, 1998). The Southern Brown Bandicoot usually nests during the day in shallow depressions in the ground covered by leaf litter, grass or other plant material (NPWS, 2001e; DECC, 2008x). Breeding begins in winter and usually last six to eight months; under favourable conditions reproduction is high producing up to 6 young per litter (Strahan, 1998; Braithwaite, 1983). The Southern Brown Bandicoot is found in the south-east and south-west of mainland Australia, Tasmania, Cape York Peninsula and a few islands off the coast of South Australia (NPWS, 2001e). In NSW, this species is thought to be restricted to the coastal fringe, from the southern side of the Hawkesbury River in the north to the Victorian border.

During recent targeted surveys within the Project area and surrounds, Western Research Institute and Biosphere Environmental Consultants (2008) noted diggings that could potentially belong to the Southern Brown Bandicoot (or Long-nosed Bandicoot or Long-nosed Potoroo) in ridgetop woodlands and heath-mallee thickets, both habitats with intermittent sandy patches (Figure 5). The Southern Brown Bandicoot is listed as Endangered under the EPBC Act.

1. Is there a real chance or possibility that the proposal will lead to a long-term decrease in the size of a population of a species?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The Southern Brown Bandicoot has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; an increase in exotic predator species; and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact this species. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or an increase in exotic pest species that could adversely impact on this species. Further, speed limits would be imposed on fire trails to reduce the potential for vehicle strike on native fauna. Hence it is very unlikely of there being a chance or possibility that the Project would lead to a long-term decrease in the size of a population of the Southern Brown Bandicoot.

2. Is there a real chance or possibility that the proposal will reduce the area of occupancy of a population?

The Southern Brown Bandicoot prefers heath and scrubby habitats that are successional following fire. However too frequent burning of preferred habitats may impact adversely on local populations. Given the range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there will be an increase in fire frequency or exotic pest species due to the Project.

As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Where practicable, surface works would be sited to minimise the amount of vegetation clearance required. Reduction of habitat for the Southern Brown Bandicoot due to surface infrastructure would be very small in comparison with the amount of habitat available. Hence it is very unlikely that there would be a real chance or possibility that the Project would reduce the area of occupancy of the Southern Brown Bandicoot.

3. Is there a real chance or possibility that the proposal will fragment an existing population into two or more populations?

Fragmentation of existing populations would be possible following events such as significant habitat clearing or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence it is very unlikely of there being a chance or a possibility that the Project would fragment an existing population into two of more populations.

4. Is there a real chance or possibility that the proposal will adversely affect habitat critical to the survival of a species?

The preferred habitat of the Southern Brown Bandicoot is scrubby woodland-heath vegetation, in early to mid succession following fire, a habitat type found extensively in the ridge tops and valley slopes of the Project area. Habitat critical to the survival of the species is also potentially at risk if the Project resulted in an increased fire frequency that resulted in a less favourable plant succession outcome for the species. Given the range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency. The Project would involve minimal vegetation clearance for surface infrastructure, which would be progressive over the life of the mine. Reduction of habitat for the Southern Brown Bandicoot due to surface infrastructure would be very small in comparison with the amount of habitat available. Adverse impacts to the habitats utilised by the Southern Brown Bandicoot are likely to be minor, and likely to occur at point scale, rather than being widespread. Hence it is very unlikely of there being a real chance or possibility that the Project would adversely affect habitat critical to the survival of the Southern Brown Bandicoot.

5. Is there a real chance or possibility that the proposal will disrupt the breeding cycle of a population?

The breeding cycle of the Southern Brown Bandicoot has the potential to be disrupted if one of the following events occurred as a result of the Project: loss of key habitat, food resources were significantly diminished, or predation of the species increased. It is unlikely that the Project would significantly impact on the Southern Brown Bandicoot's habitat and food resources or increase the rate of predation of the species. Only very limited areas of potential habitat for the Southern Brown Bandicoot would be cleared in the Project area. Hence there is unlikely to be a real chance or a possibility that the Project would disrupt the breeding cycle of the Southern Brown Bandicoot.

6. Is there a real chance or possibility that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The northern population of the Southern Brown Bandicoot is largely confined to sandstone ridgetop habitat and broader upland valleys, where the species is associated with scrubby mallee and heath formations in mid to early post fire succession (NPWS, 2001e).

The ongoing viability of this population is therefore very dependent on the presence of a mosaic of habitats at varying stages of plant succession. As described in Section 5.5, the Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. Reduction of habitat for the Southern Brown Bandicoot due to surface infrastructure would be very small in comparison with the amount of habitat available. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or exotic pest species that could adversely impact habitat. Adverse impacts to the extent and quality of habitats potentially utilised by the Southern Brown Bandicoot are likely to be minor, and likely to occur at point scale, rather than being widespread. Hence it is unlikely that a real chance or possibility exists that the Project would modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

7. Is there a real chance or possibility that the proposal will result in invasive species that are harmful to a species becoming established in the species' habitat?

The Southern Brown Bandicoot may provide an opportunistic prey target for a range of native predators, and likely from time to time for non-native predators such as the Fox, Dog and Cat. All the latter species are known to occur in the Woronora Special Area, although they appear to be in low numbers. The species protects itself from predation primarily through rapid flight responses, camouflage and its nocturnal nature. Current roads and tracks throughout the potential habitats of the Southern Brown Bandicoot are relatively limited and likely to provide relatively few opportunities of predator-prey interaction. As described in Section 4.4, Project infrastructure would occupy only very small areas of the surface. Further, any access tracks would involve minimal clearance and would be allowed to regenerate when no longer needed. The FFMP to be developed for the Project would include measures to minimise the occurrence of exotic pest species. Given the range of management protocols proposed to be in place to manage the area it is unlikely that there would be an increase in predator species numbers. It is very unlikely that a real chance or possibility exists that the Project would result in further invasive species becoming established in Southern Brown Bandicoot habitat.

8. Is there a real chance or possibility that the proposal will introduce disease that may cause the species to decline?

Like all native fauna, population numbers of the Southern Brown Bandicoot are partly controlled through a range of diseases and parasites caused by bacteria, viruses, fungi and nematodes. Such diseases and parasites come to the fore under conditions such as loss of habitat health, inadequate diet, stress, extreme climatic conditions and old age. Healthy animals may carry disease organisms but ward off effects through active immune systems. There is no known disease that the Project could possibly introduce that would impact adversely on the Southern Brown Bandicoot. Nor is the Project likely to change the dynamics whereby individual animals or any Southern Brown Bandicoot population is likely to be further stressed above natural levels thereby increasing the risk of individuals contracting diseases. Hence it is very unlikely of there being a real chance or possibility that the Project would introduce disease that may cause the species to decline.

9. Is there a real chance or possibility that the proposal will interfere with the recovery of the species?

In fire-prone habitats such as occur in the Project area, many vertebrate species will undergo a cycle of loss and recovery following high impact fires as occurred in 2001. It is likely that the dynamics of population recovery of the Southern Brown Bandicoot following fire, commences within refugia and increases slowly and simultaneously with successional vegetation changes that follow fire. It is unlikely that the Project would initiate a decline in population numbers, rather there may be some point located losses across the landscape that are unlikely to trigger a major decline in population numbers.

Hence it is likely that changes in population numbers would continue to fluctuate in response to fire or other natural causes rather than to any significant impact due to the Project. Hence it is very unlikely of there being a real chance or possibility that the Project would interfere with any ongoing recovery that may be occurring for the species independent of recovery from bushfire.

7.4.2.8 Long-nosed Potoroo

The Long-nosed Potoroo has been found in coastal NSW north and south of the Sydney catchment. The species coastal range runs from Queensland to eastern Victoria and Tasmania. It inhabits coastal heaths and dry and wet sclerophyll forests. The species requires dense understorey with occasional open areas. Underground fruiting fungi, roots, tubers and insects constitute their major diet components. The animals are normally solitary and mainly nocturnal (DECC, 2008y).

Extensive areas of potentially suitable habitat for the Long-nosed Potoroo are located within the Project area. During recent targeted surveys within the Project area and surrounds, Western Research Institute and Biosphere Environmental Consultants (2008) noted diggings that could potentially belong to the Long-nosed Potoroo (or Long-nosed Bandicoot or Southern Brown Bandicoot) in ridgetop woodlands and heath-mallee thickets, both habitats with intermittent sandy patches (Figure 5). The Long-nosed Potoroo is listed as Vulnerable under the EPBC Act.

1. Is there a real chance or possibility that the proposal will lead to a long-term decrease in the size of a population of a species?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The Long-nosed Potoroo has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; an increase in exotic predator species; and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact this species. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or exotic pest species due to the Project. Hence it is very unlikely of there being a real chance or possibility that the Project would lead to a long-term decrease in the size of a population.

2. Is there a real chance or possibility that the proposal will reduce the area of occupancy of a population?

The Project would involve minimal vegetation clearance for surface infrastructure, which would be progressive over the life of the mine. As a result, at any one time some small areas are likely to be disturbed (in the order of two hectares), while previously disturbed areas would be in various stages of rehabilitation. Natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. Hence it is very unlikely of there being a real chance or possibility that the Project would reduce the area of occupancy of a population.

3. Is there a real chance or possibility that the proposal will fragment an existing population into two or more populations?

Very limited clearing would occur as part of the Project. Roads already fragment the potential habitat of this species. Any Project access tracks would involve minimal clearance and would be allowed to regenerate when no longer needed. Hence it is very unlikely of there being a real chance or possibility that the Project would fragment an existing population into two or more populations.

4. Is there a real chance or possibility that the proposal will adversely affect habitat critical to the survival of a species?

The Project would involve minimal vegetation clearance for surface infrastructure. Reduction of habitat for the Long-nosed Potoroo due to surface infrastructure would be very small in comparison with the amount of habitat available. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or exotic pest species that could adversely impact habitat. Hence it is very unlikely of there being a real chance or possibility that the Project would adversely affect habitat critical to the survival of the species were such a population to exist.

5. Is there a real chance or possibility that the proposal will disrupt the breeding cycle of a population?

Possible disruptions to the breeding cycle could result from increased predation due to increase in predator populations, loss of key habitat, loss of food resources and an increase in fire frequency. It is very unlikely that any of these scenarios would occur as a result of the Project. Hence it is very unlikely that the Project would disrupt the breeding cycle of a population in the Project area were such a population to exist.

6. Is there a real chance or possibility that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The species inhabits coastal heaths and dry and wet sclerophyll forests. The species requires dense understorey with occasional open areas. Extensive areas of potentially suitable habitat for the Long-nosed Potoroo are located within the Project area. The potential impacts of the Project on habitats within the Project area are predicted to be very marginal and at point scales rather than being landscape impacts. Only limited clearing would occur as a result of the Project, and fire regimes or exotic pest species are unlikely to increase. Hence it is very unlikely of there being a real chance or possibility that the Project would modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the Long-nosed Potoroo is likely to decline.

7. Is there a real chance or possibility that the proposal will result in invasive species that are harmful to a species becoming established in the species' habitat?

Invasive species likely to impact the Long-nosed Potoroo are birds of prey, the Domestic Dog, the Cat and the Fox. A number of potential predator species are already present within the Project area. As described in Section 4.4, Project infrastructure would occupy only very small areas of the surface. Further, any access tracks would involve minimal clearance and would be allowed to regenerate when no longer needed. The FFMP to be developed for the Project would also include measures to minimise the occurrence of exotic pest species. It is very unlikely of there being a real chance or possibility that the Project would result in invasive species that are harmful to the Long-nosed Potoroo becoming established in this species' habitat.

8. Is there a real chance or possibility that the proposal will introduce disease that may cause the species to decline?

Diseases of the Long-nosed Potoroo have not been well researched but there is no evidence of any disease being a threatening process for the species. Nor is it conceivable how the Project might introduce a species-specific disease that would adversely impact on the Long-nosed Potoroo. Hence it is very unlikely that there is a real chance or possibility that the Project would introduce disease that may cause the Long-nosed Potoroo to decline.

9. Is there a real chance or possibility that the proposal will interfere with the recovery of the species?

In fire-prone habitats such as occur in the Project area, many vertebrate species will undergo a cycle of loss and recovery following high impact fires as occurred in 2001. It is very likely that dynamics of population recovery following fire, commences within refugia and increases slowly and simultaneously with successional vegetation changes that follow fire. It is unlikely that the Project would initiate a decline in population numbers, rather there may be some point located losses across the landscape that are unlikely to trigger a major decline in population numbers. Hence it is likely that changes in population numbers would continue to fluctuate in response to fire or other natural causes rather than to any significant impact due to the Project. Hence it is very unlikely of there being a real chance or possibility that the Project would interfere with any ongoing recovery that may be occurring for the species independent of recovery from bushfire. Hence it is very unlikely of there being a real chance or possibility that the Project would interfere with the recovery of the species within the Project area or elsewhere.

7.4.2.9 Spotted-tailed Quoll

The Spotted-tailed Quoll was not located during the current fauna surveys. However it has been located within the Sydney catchment and the immediate surrounds. It has also previously been located within the Royal National Park to the east of the Project area, in Darkes Forest immediately to the south and within the Project area and its immediate surrounds. Hence it is possible that a scattered population of this species occurs in the southern part of the Sydney catchment but it is unlikely that a viable population exists within thre Project area. The Spotted-tailed Quoll is listed as Endangered under the EPBC Act. It occurs across a wide range of habitat types including forest, woodland, coastal heaths and landscape sized areas of rocky outcrops such as the Sydney sandstone. The Spotted-tailed Quoll utilises numerous dens (such as hollow logs, tree hollows, rock outcrops or caves) within its home range (NPWS, 1999l). Both sexes of the Spotted-tailed Quoll become sexually mature when they reach about one year old (Edgar and Belcher, 1998). The Spotted-tailed Quoll requires an abundance of food (such as birds and small mammals) and large areas of relatively intact vegetation through which to forage (Ayers *et al*., 1996; NPWS, 1999l). This species is primarily solitary and nocturnal, although it may forage during the day (NPWS, 1999l). Prey items of this carnivore include birds, reptiles, small mammals (e.g. gliders, possums, rats and small macropods), arthropods and carrion (Edgar and Belcher, 1998; Ayers *et al.,* 1996; NPWS, 1999l). This species is thought to occupy large home ranges (between 800 ha and 2,000 ha) and has been known to move several kilometres overnight (NPWS, 1999l).

1. Is there a real chance or possibility that the proposal will lead to a long-term decrease in the size of a population of a species?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The Spotted-tailed Quoll has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; an increase in exotic predator species; increased rock fall due to subsidence, and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact this species. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or an increase in exotic pest species that could adversely impact on the Spotted-tailed Quoll. In rocky areas this species often makes use of small to large caves, hence it could be impacted by rock fall. However the anticipated low incidence of rock fall predicted is unlikely to significantly impact on this species. Hence it is very unlikely of there being a chance or a possibility that the Project would lead to a long-term decrease in the size of a population of the Spotted-tailed Quoll.

2. Is there a real chance or possibility that the proposal will reduce the area of occupancy of a population?

The Project would involve minimal vegetation clearance for surface infrastructure (e.g. exploration activities, ventilation shaft, access tracks and environmental monitoring and management activities), which would be progressive over the life of the mine. As a result, at any one time some small areas are likely to be disturbed (in the order of two hectares), while previously disturbed areas would be in various stages of rehabilitation. Vegetation clearance would be restricted to the slashing of vegetation (i.e. leaving the lower stem and roots *in-situ* to maximise the potential for natural regrowth) and lopping of branches, where practicable, rather than the removal of trees. Natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or exotic pest species that could adversely impact habitat. Further, loss of potential habitat due to increased rock fall associated with mine subsidence is likely to be minimal (MSEC, 2008). Hence it is very unlikely that there would be a real chance or possibility that the Project would reduce the area of occupancy of the Spotted-tailed Quoll.

3. Is there a real chance or possibility that the proposal will fragment an existing population into two or more populations?

Fragmentation of existing populations would only be likely if there was widespread clearing of habitats or a significant increase in fire frequency. Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project. Hence it is very unlikely of there being a chance or possibility that the Project would fragment an existing population into two of more populations.

4. Is there a real chance or possibility that the proposal will adversely affect habitat critical to the survival of a species?

The Project would involve minimal vegetation clearance for surface infrastructure, which would be progressive over the life of the mine. Reduction of habitat for the Spotted-tailed Quoll due to surface infrastructure would be very small in comparison with the amount of habitat available. Habitat critical to the survival of the species is also potentially at risk if the Project resulted in an increased fire frequency that resulted in a less favourable plant succession outcome for the species. Given the range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or exotic pest species that could adversely impact habitat. Further, loss of potential habitat due to increased rock fall associated with mine subsidence is likely to be minimal (MSEC, 2008). Hence it is very unlikely of there being a real chance or possibility that the Project would adversely affect habitat critical to the survival of the Spotted-tailed Quoll.

5. Is there a real chance or possibility that the proposal will disrupt the breeding cycle of a population?

The breeding cycle of the Spotted-tailed Quoll has the potential to be disrupted if one of the following events occurred as a result of the Project: loss of key habitat, if food resources were significantly diminished, or predation of the species increased. It is unlikely that the Project would significantly impact on the Spotted-tailed Quoll's habitat and food resources or increase the rate of predation of the species. Hence there is unlikely to be a real chance or a possibility that the Project would disrupt the breeding cycle of the Spotted-tailed Quoll.

6. Is there a real chance or possibility that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The Spotted-tailed Quoll occurs in a range of habitats that include sclerophyll forests and woodlands, rainforests and coastal heathlands and require large areas of relatively intact vegetation for foraging as well as hollow logs, tree hollows, rock outcrops and caves to use as den sites (NPWS, 1999l). The Project would involve minimal vegetation clearance for surface infrastructure, which would be progressive over the life of the mine. Reduction of habitat for the Spotted-tailed Quoll due to surface infrastructure would be very small in comparison with the amount of habitat available. Given a range of management protocols proposed to be in place to manage the behaviour of people and exotic pest species in the Project area, it is unlikely that there would be an increase in fire frequency or exotic pest species that could adversely impact habitat. Loss of potential habitat due to increased rock fall associated with mine subsidence is likely to be minimal (MSEC, 2008). Adverse impacts to the extent and quality of habitats utilised by the Spotted-tailed Quoll are likely to be minor, and likely to occur at point scale, rather than being widespread. Hence it is unlikely that a real chance or possibility exists that the Project would modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

7. Is there a real chance or possibility that the proposal will result in invasive species that are harmful to a species becoming established in the species' habitat?

The Spotted-tailed Quoll is likely to provide an opportunistic prey target for a very limited range of native predators, and likely from time to time for non-native predators such as the Fox, Dog and Cat. All the latter species are known to occur in the Woronora Special Area, although they appear to be in low numbers. The species protects itself from predation primarily through rapid flight responses, camouflage, well-hidden dens and its nocturnal nature. Current roads and tracks throughout the habitats of the Spotted-tailed Quoll are relatively limited and likely to provide relatively few opportunities of predator-prey interaction. However they do traverse some prime Spotted-tailed Quoll habitat. There is little evidence of the Spotted-tailed Quoll being other than a minor prey component of vertebrate non-native predators. As described in Section 4.4, Project infrastructure would occupy only very small areas of the surface. Further, any access tracks would involve minimal clearance and would be allowed to regenerate when no longer needed. The FFMP to be developed for the Project would include measures to minimise the occurrence of exotic pest species. Given the range of management protocols proposed to be in place to manage the area it is unlikely that there would be an increase in predator species numbers. It is very unlikely that a real chance or possibility exists that the Project would result in further invasive species becoming established in Spotted-tailed Quoll habitat.

8. Is there a real chance or possibility that the proposal will introduce disease that may cause the species to decline?

Like all native fauna, population numbers of the Spotted-tailed Quoll are partly controlled through a range of diseases and parasites caused by bacteria, viruses, fungi and nematodes. Such diseases and parasites come to the fore under conditions such as loss of habitat health, inadequate diet, stress, extreme climatic conditions and old age. Healthy animals may carry disease organisms but ward off effects through active immune systems. There is no known disease that the Project could possibly introduce that would impact adversely on a potential Spotted-tailed Quoll population. Nor is the Project likely to change the dynamics whereby individual animals of such a potential population is likely to be further stressed above natural levels thereby increasing the risk of individuals contracting diseases. Hence it is very unlikely of there being a real chance or possibility that the Project would introduce disease that may cause the species to decline.

9. Is there a real chance or possibility that the proposal will interfere with the recovery of the species?

In fire-prone habitats such as occur in the Project area, many vertebrate species will undergo a cycle of loss and recovery following high impact fires as occurred in 2001. The Spotted-tailed Quoll was not located during current fauna surveys but nevertheless population(s) of this species likely exists in the south of the Sydney catchment. Given the status of this species within NSW it is likely that populations of the species in the wider Sydney catchment is undergoing long-term decline. It is very likely that the dynamics of population recovery of the Spotted-tailed Quoll following fire, commences within refugia and increases slowly and simultaneously with successional vegetation changes that follow fire. It is unlikely that the Project would initiate a decline in population numbers, were the species demonstrated to exist within the Project area, rather there may be some point located losses across the landscape that are unlikely to trigger a major decline in population numbers. Hence it is likely that changes in a potential population, numbers will continue to fluctuate in response to fire or other natural causes rather than to any significant impact due to the Project. Hence it is very unlikely of there being a real chance or possibility that the Project would interfere with any ongoing recovery that may be occurring for the species independent of recovery from bushfire.

7.4.2.10 Grey-headed Flying Fox

The Grey-headed Flying Fox was located during recent fauna surveys in the Project area flying over tall forest (Western Research Institute and Biosphere Environmental Consultants, 2008). It has also been recorded at a number of other locations within the Project area, in Darkes Forest and the Royal National Park, as well as the immediate surrounds. It could not be determined whether a viable population (s) of the species exists in the Project area. The Grey-headed Flying Fox is an obligate nectarivore and frugivore (Eby, 2000). This species feeds on a wide variety of flowering and fruiting plants including the extensive use of blossoms of eucalypts, angophoras, tea-trees and banksias, as well as in introduced tree species in urban areas and in commercial fruit crops (Tidemann, 1998; Duncan *et al.*, 1999a).

Roost sites of the Grey-headed Flying Fox are commonly formed in gullies, typically not far from water and usually in vegetation with a dense canopy (Tidemann, 1998). Mating, birth and the rearing of young occur at the roost sites (*ibid*.). Mating occurs at any time of the year, however most conceptions occur in March or April (Tidemann, 1998). The Grey-headed Flying Fox commutes daily to foraging areas, usually within 15 km of the day roost, while a few individuals may travel up to 50 km (Tidemann, 1998). The Grey-headed Flying Fox responds to changes in the amount and location of available food by migrating in irregular patterns (Eby, 2000). Migration patterns vary between years in association with the changing location of flowering trees (*ibid*.).

The Grey-headed Flying Fox is listed as Vulnerable under the EPBC Act.

1. Is there a real chance or possibility that the proposal will lead to a long-term decrease in the size of a population of a species?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The Grey-headed Flying Fox has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency or vegetation clearing impacting the species habitat. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Hence it is very unlikely of there being a chance or a possibility that the Project would lead to a long-term decrease in the size of a population of the Grey-headed Flying Fox.

2. Is there a real chance or possibility that the proposal will reduce the area of occupancy of a population?

The Project would involve minimal vegetation clearance for surface infrastructure, which would be progressive over the life of the mine. As a result, at any one time some small areas are likely to be disturbed (in the order of two hectares), while previously disturbed areas would be in various stages of rehabilitation. Vegetation clearance would be restricted to the slashing of vegetation (i.e. leaving the lower stem and roots *in-situ* to maximise the potential for natural regrowth) and lopping of branches, where practicable, rather than the removal of trees. Natural regeneration would be encouraged or active rehabilitation undertaken in areas disturbed by the Project. Hence it is very unlikely of there being a chance or a possibility that the Project would reduce the area of occupancy of the Grey-headed Flying Fox in the Project area.

3. Is there a real chance or possibility that the proposal will fragment an existing population into two or more populations?

Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency as a result of the Project that would impact on habitat. Hence it is very unlikely of there being a chance or a possibility that the Project would fragment an existing population into two or more populations.

4. Is there a real chance or possibility that the proposal will adversely affect habitat critical to the survival of a species?

Minimal vegetation clearance for surface infrastructure would be required and vegetation clearance would be progressive over the life of the mine. Reduction of habitat for the Grey-headed Flying Fox due to surface infrastructure would be very small in comparison with the amount of habitat available. Further, given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. Hence it is very unlikely of there being a chance or possibility that the Project would adversely affect habitat critical to the survival of the species.

5. Is there a real chance or possibility that the proposal will disrupt the breeding cycle of a population?

Roost sites of the Grey-headed Flying Fox are often associated with gullies and forest formations not far from water. Mating, birth and the rearing of young occur at roost sites. Mating occurs at any time of the year, however most conceptions occur in March or April (Tidemann, 1998). The majority of reproductively mature females give birth to a single young each October/November (NPWS, 2001f). Very limited clearing of native habitats would occur as a result of the Project. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there will be an increase in fire frequency due to the Project that could impact habitat. Hence it is very unlikely of there being a chance or possibility that the Project would disrupt the breeding cycle of a population of the Grey-headed Flying Fox.

6. Is there a real chance or possibility that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The exact locations of roost sites are unknown but such sites are often associated with gullies and forest formations not far from water and usually in vegetation with a dense canopy (Tidemann, 1998). Feeding habitats occur both within the Project area and in the wider surrounds.

Very limited clearing of native habitats would occur as a result of the Project, and would be progressive over the life of the mine. Reduction of habitat for the Grey-headed Flying Fox due to surface infrastructure would be very small in comparison with the amount of habitat available. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. The potential impacts of the Project on habitats within the Project are predicted to be very marginal and at point sacles rather than being landscape impacts. Hence it is very unlikely of there being a chance or possibility that the Project would modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

7. Is there a real chance or possibility that the proposal will result in invasive species that are harmful to a species becoming established in the species' habitat?

Invasive species likely to impact the Grey-headed Flying Fox are likely very limited and would include birds of prey, tree climbing reptiles, and very occasionally the Domestic Dog, the Cat and the Fox. A number of potential predator species are already present within the Project area. The FFMP to be developed for the Project would include measures to minimise the occurrence of exotic vertebrate species. It is very unlikely of there being a real chance or possibility that the Project would result in invasive species that are harmful to the Grey-headed Flying Fox, already present in low numbers, building substantially in number within this species' habitat.

8. Is there a real chance or possibility that the proposal will introduce disease that may cause the species to decline?

Diseases of the Grey-headed Flying Fox have not been well researched but there is no evidence of any disease being a threatening process for the species. Nor is it conceivable how the Project might introduce a species-specific disease that would adversely impact on this species. Hence it is very unlikely that there is a real chance or possibility that the Project would introduce disease that may cause the Grey-headed Flying Fox to decline.

9. Is there a real chance or possibility that the proposal will interfere with the recovery of the species?

In fire-prone habitats such as those that occur in the Project area, many vertebrate species will undergo a cycle of loss and recovery following high impact fires as occurred in 2001. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency due to the Project. Hence it is very unlikely of there being a real chance or possibility that the Project would interfere with any ongoing recovery that may be occurring for this species independent of recovery from bushfire.

7.4.2.11 Large-eared Pied Bat

This small to medium sized bat is found in areas with extensive cliffs and caves from Rockhampton south to Bungonia in the NSW southern highlands and as far west as the western slopes. It has a very patchy distribution (DECC, 2008ziv).

The Large-eared Pied Bat was not located during the surveys but previously had been located in the southern section of the Project area north of Darkes Forest, in the Royal National Park and within the immediate surrounds. Hence it is likely that a viable population of the species could exist within the Project area. The Large-eared Pied Bat roosts in caves, crevices in cliffs, old mine workings and disused mud nests of the Fairy Martin. It frequents low to mid elevation dry open forest and woodland close to such features, and in well-timbered gullies. It forages for insects usually below forest and woodland canopies (DECC, 2008ziv). The Large-eared Pied Bat is listed as Vulnerable under the EPBC Act.

1. Is there a real chance or possibility that the proposal will lead to a long-term decrease in the size of a population of a species?

Potential impacts of the Project on vertebrate fauna are summarised in Sections 5.1 to 5.5. The Large-eared Pied Bat has the potential to be adversely impacted if one or more of the following were to occur as a result of the Project: an increase in fire frequency impacting the species habitat; an increase in the rate of rock fall and/or cliff face collapse with associated caves; and clearing of vegetation. Since very limited clearing would occur within the Project area, it is unlikely that clearing would impact this species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. MSEC (2008) have predicted only minor increases in rock fall and cliff face collapse, with likely only small impacts, if any, on potential roosting or breeding locations for the Large-eared Pied Bat. Hence it is very unlikely of there being a chance or possibility that the Project would lead to a long-term decrease in the size of a population of the Large-eared Pied Bat.

2. Is there a real chance or possibility that the proposal will reduce the area of occupancy of a population?

The area of occupancy of this species has the potential to be reduced by significant clearing of vegetation, an increase in fire frequency or an increased rate of rock fall and cliff face collapse leading to a reduction in potential rocky habitat roost sites. The Project would involve minimal vegetation clearance for surface infrastructure, which would be progressive over the life of the mine. As a result, at any one time some small areas are likely to be disturbed (in the order of two hectares), while previously disturbed areas would be in various stages of rehabilitation. Vegetation clearance would be restricted to the slashing of vegetation (i.e. leaving the lower stem and roots *in-situ* to maximise the potential for natural regrowth) and lopping of branches, where practicable, rather than the removal of trees.. Further, given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. MSEC (2008) has predicted only minor increases in rock fall and cliff face collapse, with likely only small impacts, if any, on potential roosting or breeding locations for the Large-eared Pied Bat. Hence it is very unlikely of there being a real chance or possibility that the Project would reduce the area of occupancy of the species within the Project area.

3. Is there a real chance or possibility that the proposal will fragment an existing population into two or more populations?

Very limited clearing of habitat potentially of benefit to this species would occur at point scale rather than at landscape scale thereby not impacting on habitat connectivity for this vagile species. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency due to the Project. Hence it is very unlikely of there being a chance or a possibility that the Project would fragment an existing population into two or more populations.

4. Is there a real chance or possibility that the proposal will adversely affect habitat critical to the survival of a species?

The exact locations of roost sites are unknown but such sites are often associated with rocky area offering caves and fissures. Very limited clearing of native habitats would occur as a result of the Project. Reduction of habitat for the Large-eared Pied Bat due to surface infrastructure would be very small in comparison with the amount of habitat available. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there will be an increase in fire frequency that could adversely impact habitat. Hence it is very unlikely of there being a chance or a possibility that the Project would adversely affect habitat critical to the survival of the species.

5. Is there a real chance or possibility that the proposal will disrupt the breeding cycle of a population?

Roost sites are often associated with rocky habitats providing cave and fissure niches. Mating, birth and the rearing of young occur at roost sites and the subsequent feeding of young will be dependent of the maintenance of suitable habitat in the wider surrounds. An increased rate of rock fall and cliff face collapse leading to a reduction in potential rocky habitat roost sites, is likely to be limited (MSEC, 2008). Very limited clearing of native habitats would occur as a result of the Project. Further, given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there will be an increase in fire frequency due to the Project. Hence it is very unlikely of there being a chance or possibility that the Project would disrupt the breeding cycle of a population.

6. Is there a real chance or possibility that the proposal will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

It is likely that viable populations of the species exist in the Project area. The exact locations of roost sites are unknown but such sites are often associated with rocky formations offering cave and fissure niche space. Feeding habitats occur both within the Project area and surrounds. Very limited clearing of native habitats would occur as a result of the Project and would be progressive over the life of the mine. Reduction of habitat for the Large-eared Pied Bat due to surface infrastructure would be very small in comparison with the amount of habitat available. Given a range of management protocols proposed to be in place to manage the behaviour of people in the Project area, it is unlikely that there would be an increase in fire frequency that could adversely impact habitat. An increased rate of rock fall and cliff face collapse leading to a reduction in potential rocky habitat roost sites, is likely to be limited (MSEC, 2008). Hence it is very unlikely of there being a chance or possibility that the Project would modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

7. Is there a real chance or possibility that the proposal will result in invasive species that are harmful to a species becoming established in the species' habitat?

Invasive species likely to impact the Large-eared Pied Bat are likely very limited and would include birds of prey, reptiles, and very occasionally the Domestic Dog, the Cat and the Fox. A number of potential predator species are already present within the Project area. The FFMP to be developed for the Project would include measures to minimise the occurrence of exotic vertebrate species. It is very unlikely of there being a real chance or possibility that the Project would result in invasive species that are harmful to the Large-eared Pied Bat, already present in low numbers, building substantially in number within this species' habitat.

8. Is there a real chance or possibility that the proposal will introduce disease that may cause the species to decline?

Diseases of the Large-eared Pied Bat have not been well researched but there is no evidence of any disease being a threatening process for the species. Nor is it conceivable how the Project might introduce a species-specific disease that would adversely impact on this species. Hence it is very unlikely that there is a real chance or possibility that the Project would introduce disease that may cause the Large-eared Pied Bat to decline.

9. Is there a real chance or possibility that the proposal will interfere with the recovery of the species?

In fire-prone habitats such as occur in the Project area, many vertebrate species will undergo a cycle of loss and recovery following high impact fires as occurred in 2001.

While roosts in caves are offered some protection from bushfire, impacts from fire are likely to be very variable depending on the location, volume and aspect of such cave roosts. The likely impacts on the Large-eared Pied Bat already described have the potential to impact on the existing population in only minor ways: loss of cave and fissure roost sites, human induced disturbances including vegetation clearing and increased fire frequency. These relatively minor potential impacts have been demonstrated previously to likely be of limited consequences to vertebrate species including the Large-eared Pied Bat. Hence it is very unlikely of there being a real chance or possibility that the Project would interfere with any ongoing recovery that may be occurring for this species independent of recovery from bushfire.

7.5 THREATENED ECOLOGICAL COMMUNITIES

A search of the EPBC Act database using the Protected Matters Search Tool for the Project area and surrounds indicates that the Turpentine-Ironbark Forest in the Sydney Basin Bioregion critically endangered ecological community may possibly occur within the area. The Turpentine-Ironbark Forest occurs mainly on the Cumberland Plain of the Sydney region, with patches extending onto the adjoining plateaux (DEH, 2005a). It is known from the Local Government Areas of Auburn, Bankstown, Baulkham Hills, Blue Mountains, Campbelltown, Canterbury, Concord, Hawkesbury, Hornsby, Kogarah, Ku-ring-gai, Lane Cove, Liverpool, Parramatta, Penrith, Ryde, Sutherland, Wingecarribee, Wollongong and Wollondilly (DEH, 2005a). This community is recognised as two separate EECs under the TSC Act, namely, the Sydney Turpentine-Ironbark Forest EEC and the Blue Mountains Shale Cap Forest EEC (*ibid*.).

An indicative map showing the possible distribution of the Turpentine-Ironbark Forest critically endangered ecological community in the Sydney Basin Bioregion (DEH, 2005b) indicates that a patch of this community may occur to the south of the proposed underground mining area in the Longwalls 18 to 19A area. However, detailed baseline flora surveys (Bangalay Botanical Surveys, 2007; 2008) indicate that the O'Hares Creek Shale Forest vegetation community (listed as an EEC under the TSC Act) occurs in this particular location.

No ecological communities listed as critically endangered or endangered under the EPBC Act occur within the Project area or immediate surrounds.

7.6 MIGRATORY SPECIES

Migratory species are those animals that migrate to Australia and its external territories, or pass though or over Australian waters during their annual migrations (DEWHA, 2008e). The following evaluation considers potential impacts of the Project on migratory species listed under the EPBC Act that are known or could possibly occur in the Project area or surrounds.

Only one migratory species, the Rufous Fantail, was recorded in the Project area (Western Research Institute and Biosphere Environmental Consultants, 2008).

Of the migratory species that have been recorded in the wider area but not from within the Project area by Western Research Institute and Biosphere Environmental Consultants (2008), 33 marine and coastal species from the following nine families have not been further assessed: Chelonildae, Diomededidae, Procellarlidae, Hydrobatidae, Phaethontidae, Fregatidae, Sulidae, Laridae and Stercorariidae.

The remaining migratory species have been placed into five groups in Table 10 and Groups 1 to 5 have been assessed per individual group.

Table 10
Potential Migratory Species

Group	Migratory Species Category	Species
1	Unlikely to be present within the Project area due to lack of suitable habitat	Black-winged Stilt, Grey Plover, Lesser Golden Plover, Australian Painted Snipe, Lathams Snipe, Ruddy Turnstone, Great Knot, Red Knot, Sanderling, Broad-billed Sandpiper, Oriental Cuckoo and Rainbow Bee-eater
2	Located within the Project area during Project surveys	Rufous Fantail
3	Potential residents associated with limited habitats of the Woronora Reservoir and Waratah Rivulet	Cattle Egret, Great Egret, Osprey and White-bellied Sea Eagle
4	Predominantly coastal species that could be occasionally associated with limited habitats of the Woronora Reservoir and Waratah Rivulet	Black-tailed Godwit, Bar-tailed Godwit, Marsh Sandpiper, Common Greenshank, Terek Sandpiper, Red-necked Stint, Sharp-tailed Sandpiper and Curlew Sandpiper
5	Other migratory species	White-throated Needletail, Fork-tailed Swift, Black-faced Monarch and Satin Flycatcher

Source: after Western Research Institute and Biosphere Environmental Consultants (2008)

Group 1 Black-winged Stilt, Grey Plover, Lesser Golden Plover, Australian Painted Snipe, Lathams Snipe, Ruddy Turnstone, Great Knot, Red Knot, Sanderling, Broad-billed Sandpiper, Oriental Cuckoo and Rainbow Bee-eater

These species could conceivably be present for short periods of time within the Project area, as vagrants or nomads, or while migrating, but lack the extent of suitable habitat for their ecological needs to be met.

1. Is there a real chance or possibility that the proposal will substantially modify, destroy or isolate an area of important habitat for a migratory species?

The Project area lacks the extent or presence of habitat needed to support these species other than to allow for occasional appearances as nomads, vagrants or 'passing through' status. Potential impacts of the Project are predicted to be very marginal and at point scales rather than being landscape impacts. Very limited clearing of native habitats would occur as a result of the Project. Hence there is no real chance or possibility that the Project would substantially modify, destroy or isolate an area of important habitat for these migratory species.

2. Is there a real chance or possibility that the proposal will result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species?

These species could conceivably be present for short periods of time within the Project area, as vagrants or nomadics, or while migrating, but lack the extent of suitable habitat for their ecological needs to be met. Since exotic vertebrate predatory species such as the Dog, Cat and Fox are known to be present within the Project area albeit in low numbers, it is conceivable that from time to time individuals from this group may be predated. However no important habitat exists for these species with the extent needed to support viable populations. Hence there is no real chance or possibility that the Project would result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species.

3. Is there a real chance or possibility that the proposal will seriously disrupt the lifecycle of an ecologically significant proportion of the population of a migratory species?

The Project area lacks the extent or presence of habitat needed to support these species other than to allow for occasional appearances as nomadics, vagrants or to provide 'passing through' status. Potential impacts of the Project are predicted to be very marginal and at point scales rather than being landscape impacts. Very limited clearing of native habitats would occur as a result of the Project.

Other possible disruptions to the species' lifecycle are disease and increases in exotic predator species, both unlikely to be influenced adversely by the Project. Hence it is very unlikely that there would be a real chance or possibility that the Project would seriously disrupt the lifecycle of an ecologically significant proportion of the species in this group.

Group 2 Rufous Fantail

1. Is there a real chance or possibility that the proposal will substantially modify, destroy or isolate an area of important habitat for a migratory species?

One sighting of a Rufous Fantail was made during surveys (Western Research Institute and Biosphere Environmental Consultants, 2008). It is unlikely that a viable population of the Rufous Fantail exists within the Project area. The habitat of the Rufous Fantail includes forest, woodland, wooded riparian areas, and open country when migrating. None of these habitats would be substantially modified, destroyed or isolated as a result of the Project. Hence it is very unlikely of there being a real chance or possibility that the Project would substantially modify, destroy or isolate an area of important habitat for the Rufous Fantail.

2. Is there a real chance or possibility that the proposal will result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species?

Possible non-native predators of the Rufous Fantail include the Black Rat, House Mouse, Cat, Domestic Dog and Red Fox, all present or potentially present within the Project area and independent of the Project. Given that these species are already established within the Project area or within the immediate surrounds, they cannot be 'introduced' within the Project area as a direct result of the Project. The FFMP to be developed for the Project would include measures developed in consultation with the SCA to minimise the occurrence of exotic vertebrate species. Hence it is very unlikely of there being a real chance of possibility that the Project would result in additional invasive species that are harmful to the Rufous Fantail becoming established in an area of important habitat for the migratory species.

3. Is there a real chance or possibility that the proposal will seriously disrupt the lifecycle of an ecologically significant proportion of the population of a migratory species?

One sighting of a Rufous Fantail was located during surveys (Western Research Institute and Biosphere Environmental Consultants, 2008). It is unlikely that a viable population of Rufous Fantail exists within the Project area, although it may do so at some future point in time. The habitat of the Rufous Fantail includes forest, woodland, wooded riparian areas, and open country when migrating. None of these habitats would be substantially modified, destroyed or isolated as a result of the Project. Other possible disruptions to the species' lifecycle are disease and increases in exotic predator species, both unlikely to be influenced adversely by the Project. Hence it is very unlikely that there would be a real chance or possibility that the Project would seriously disrupt the lifecycle of an ecologically significant proportion of the population of the Rufous Fantail.

Group 3 Cattle Egret, Great Egret, Osprey and White-bellied Sea-Eagle

These species are potential residents associated with limited habitats (e.g. the Woronora Reservoir and Waratah Rivulet). These three species are likely to appear from time to time as nomadics, temporary residents or as semi-permanent breeding residents.

1. Is there a real chance or possibility that the proposal will substantially modify, destroy or isolate an area of important habitat for a migratory species?

The habitat requirements of these species are:

Cattle Egret – moist pastures with tall grassland, shallow open woodlands and their margins;

Great Egret - wetlands, flooded pastures, dams, estuarine mudflats, mangroves and reefs;

Osprey – follows major rivers and wetlands; and

White-bellied Sea-Eagle – seasonally flooded areas, follows major rivers and wetlands.

It is likely that from time to time breeding pairs or individuals of these species would appear along the reaches of the Woronora Reservoir or the Waratah Rivulet. Potential impacts on these species include changes in water quality and surface water flows.

Gilbert and Associates (2008) estimate that in Waratah Rivulet, typical underflow via the fracture network is expected to increase the average frequency of no flow days from 2% to 15% and to increase the average frequency of low flows (less than 2 ML/day) from 36% to 40% of days. Gilbert and Associates (2008) also indicate that mine subsidence associated with the Project would have a negligible effect on moderate and larger flows. During prolonged dry periods when flows recede to low levels, a greater proportion of the lower flows would be conveyed via the fracture network. Such abnormally persistent low flows have been observed in the Waratah Rivulet in recent times. In terms of water quality, Gilbert and Associates (2008) conclude that the effects of subsidence on water quality has been most noticeable as localised and transient changes caused by flushing of minerals from freshly exposed fractures, the changes being isolated and non-persistent. None of the extant habitats for these species are likely to be substantially modified, destroyed or isolated as a result of the Project.

2. Is there a real chance or possibility that the proposal will result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species?

Possible non-native predators of the egrets include the Black Rat (eggs), the Cat, Domestic Dog and Red Fox, all present or potentially present within the Project area and independent of the Project. Given that these species are already established within the Project area or within the immediate surrounds, they cannot be 'introduced' within the Project area as a direct result of the Project. The FFMP to be developed for the Project would include measures developed in consultation with the SCA to minimise the occurrence of exotic vertebrate species. It is unlikely that any of these predator species adversely impact the Osprey or the Sea-Eagle, other than on rare occasions. Hence it is very unlikely of there being a real chance of possibility that the Project would result in invasive species that are harmful to the Group 3 species becoming established in an area of important habitat for the migratory species.

3. Is there a real chance or possibility that the proposal will seriously disrupt the lifecycle of an ecologically significant proportion of the population of a migratory species?

Group 3 species are potential residents associated with limited habitats (e.g. the Woronora Reservoir and Waratah Rivulet). These species are likely to appear from time to time as nomadics, temporary residents or as semi-permanent breeding residents. It is unlikely that they would be found in any other locations within the Project area. At any one time appearances of these species with the Project area would represent a very small sample of the wider populations. It is unlikely that the Project would adversely impact any of these species. Hence it is very unlikely of there being a real chance or possibility that the Project would seriously disrupt the lifecycle of an ecologically significant proportion of the population of these migratory species.

Group 4 Black-tailed Godwit, Bar-tailed Godwit, Marsh Sandpiper, Common Greenshank, Terek Sandpiper, Red-necked Stint, Sharp-tailed Sandpiper and Curlew Sandpiper

Group 4 species are predominantly coastal species that could be occasionally associated with limited habitats (e.g. the Woronora Reservoir and Waratah Rivulet), most likely as temporary visitors, vagrants or nomadics.

1. Is there a real chance or possibility that the proposal will substantially modify, destroy or isolate an area of important habitat for a migratory species?

It is likely that from time to time individual or small numbers of these species would appear along the reaches of the Woronora Reservoir or the Waratah Rivulet. Potential impacts on these species include changes in water quality and surface water flows. Gilbert and Associates (2008) estimate that in Waratah Rivulet, typical underflow via the fracture network is expected to increase the average frequency of no flow days from 2% to 15% and to increase the average frequency of low flows (less than 2 ML/day) from 36% to 40% of days. Gilbert and Associates (2008) also indicate that mine subsidence associated with the Project would have a negligible effect on moderate and larger flows. During prolonged dry periods when flows recede to low levels, a greater proportion of the lower flows would be conveyed via the fracture network. Such abnormally persistent low flows have been observed in the Waratah Rivulet in recent times. In terms of water quality, Gilbert and Associates (2008) conclude that the effects of subsidence on water quality has been most noticeable as localised and transient changes caused by flushing of minerals from freshly exposed fractures, the changes being isolated and non-persistent. None of the extant habitats for these species are likely to be substantially modified, destroyed or isolated as a result of the Project.

2. Is there a real chance or possibility that the proposal will result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species?

Possible non-native predators of Group 4 species within the Project area include the Cat, Domestic Dog and Red Fox, all present or potentially present within the Project area, independent of the Project. Given that these predator species are already established within the Project area or within the immediate surrounds, they cannot be 'introduced' within the Project area as a direct result of the Project. The FFMP to be developed for the Project would include measures developed in consultation with the SCA to minimise the occurrence of exotic vertebrate species. The extent and quality of habitats for these species within the Project area is very limited in comparison with their available coastal habitats. Hence it is very unlikely of there being a real chance or possibility that the Project would result in invasive species that are harmful to the Group 4 species becoming established in an area of important habitat for the migratory species.

3. Is there a real chance or possibility that the proposal will seriously disrupt the lifecycle of an ecologically significant proportion of the population of a migratory species?

Group 4 species are potential temporary residents associated with limited habitats (e.g. the Woronora Reservoir and Waratah Rivulet). These species are likely to appear from time to time as nomadics, temporary residents but unlikely as breeding residents. It is unlikely that they would be found in any other locations within the Project area other than habitats associated with waterbodies (e.g. the Woronora Reservoir and Rivulet). At any one time appearances of these species within the Project area would represent a very small sample of the wider populations. It is unlikely that the Project would adversely impact any of these species. Hence it is very unlikely of there being a real chance or possibility that the Project would seriously disrupt the lifecycle of an ecologically significant proportion of the population of these migratory species.

Group 5 Other Migratory Species

Group 5 includes the White-throated Needletail, Fork-tailed Swift, Black-faced Monarch, and Satin Flycatcher. Needletails and Swifts are hawking species that continuously over fly a range of potential habitats including those available within the Project area. The Black-faced Monarch is an eastern coastal species frequenting woodland and forest. The Satin Flycatcher frequents woodland, forest and coastal heath scrub. Potential habitats for all Group 5 species exist within the Project area.

1. Is there a real chance or possibility that the proposal will substantially modify, destroy or isolate an area of important habitat for a migratory species?

Group 5 species have not been observed within the Project area. It is unlikely that viable populations of these species exist within the Project area. The habitat of these species includes aerial space, forest, woodland and heaths. None of these habitats would be substantially modified, destroyed or isolated as a result of the Project. Hence it is very unlikely of there being a real chance or possibility that the Project would substantially modify, destroy or isolate an area of important habitat for Group 5 species.

2. Is there a real chance or possibility that the proposal will result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species?

Possible non-native predators of the monarchs within the Project area include the Black Rat, House Mouse, Cat, Domestic Dog and Red Fox, all present or potentially present within the Project area, independent of the Project. Given that these predator species are already established within the Project area or within the immediate surrounds, they cannot be 'introduced' within the Project area as a direct result of the Project. The FFMP to be developed for the Project would include measures developed in consultation with the SCA to minimise the occurrence of exotic vertebrate species. Swifts and Needletails are unlikely to be impacted by these predator species, but are predated on by a range of aerial predator species. Hence it is very unlikely of there being a real chance or possibility that the Project would result in invasive species that are harmful to Groups 5 species becoming established in an area of important habitat for these migratory species.

3. Is there a real chance or possibility that the proposal will seriously disrupt the lifecycle of an ecologically significant proportion of the population of a migratory species?

No sightings of Group 5 species have occurred within the Project area (Western Research Institute and Biosphere Environmental Consultants, 2008). It is unlikely that viable populations of these species exist within the Project area, although they may do so at some future point in time. The habitat of these species includes forest, woodland, heath-lands and aerial space. None of these habitats would be substantially modified, destroyed or isolated as a result of the Project.

Other possible disruptions to the species' lifecycle are disease and increases in exotic predator species, both unlikely to be influenced adversely by the Project. Hence it is very unlikely that there would be a real chance or possibility that the Project would seriously disrupt the lifecycle of an ecologically significant proportion of the population of these migratory species.

7.7 COMMONWEALTH MARINE AREAS

The Commonwealth marine area is any part of the sea, including the waters, seabed, and airspace, within Australia's exclusive economic zone and/or over the continental shelf of Australia, that is not State or Northern Territory waters (DEWHA, 2008f). The Commonwealth marine area stretches from three to 200 nautical miles from the coast. Further, a number of marine protected species are listed under the EPBC Act.

The following evaluation considers potential impacts of the Project on Commonwealth marine areas. A description of the marine protected species that are known or could possibly occur in the Project area or surrounds is provided in Section 3.3.5. These species are assessed together.

1. Is there a real chance or possibility that the proposal will result in a known or potential pest species becoming established in the Commonwealth marine area?

The Project area is situated approximately 6 to 8 km west of the eastern seaboard. It is very unlikely that there would be a real chance or possibility that the Project would result in a known or potential pest species becoming established in the Commonwealth marine area.

2. Is there a real chance or possibility that the proposal will modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in a Commonwealth marine area results?

The Project area is situated approximately 6 to 8 km west of the eastern seaboard. It is very unlikely that there would be a real chance or possibility that the Project would modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in a Commonwealth marine area results.

3. Is there a real chance or possibility that the proposal will have a substantial adverse effect on a population of a marine species or cetacean including its life cycle (e.g. breeding, feeding, migration behaviour, life expectancy) and spatial distribution?

The following evaluation considers potential impacts of the Project on marine protected species listed under the EPBC Act that are known to or could possibly occur in the Project area or surrounds.

Thirteen marine protected bird species were recorded during the Project surveys, *viz*. the Nankeen Night Heron, Australian Kestrel, Brown Goshawk, Pallid Cuckoo, Fan-tailed Cuckoo, Channel-billed Cuckoo, Southern Boobook, White-throated Nightjar, Sacred Kingfisher, Rufous Fantail, Black-faced Cuckoo-Shrike, Welcome Swallow and Silvereye (Western Research Institute and Biosphere Environmental Consultants, 2008). DECC (2007a) has also recorded the Whistling Kite and White-bellied Cuckoo-shrike in the Woronora Special Area.

Of the marine species that have been recorded in the wider area but not from within the Project area by Western Research Institute and Biosphere Environmental Consultants (2008), 77 species from the following thirteen families have not been further assessed: Chelonildae, Elapidae, Spheniscidae, Diomededidae, Procellarlidae, Hydrobatidae, Phaethontidae, Fregatidae, Pelecanidae, Sulidae, Burhinidae, Laridae and Stercorariidae.

The remaining species have been placed into five groups in Table 11 and Groups 1 to 5 have been assessed per individual group.

Table 11
Potential Marine Protected Species

Group	Marine Protected Species Category	Species
1	Unlikely to be present within the Project area due to lack of suitable habitat	Black-winged Stilt, Grey Plover, Lesser Golden Plover, Australian Painted Snipe, Latham's Snipe, Ruddy Turnstone, Great Knot, Red Knot, Sanderling, Broad-billed Sandpiper, Oriental Cuckoo, Rainbow Bee-eater, Stubble Quail, Cape Baron Goose, Red-capped Plover, Double-banded Plover, Hooded Plover, Eastern Curlew, Grey-tailed Tattler, Wandering Tattler, Pectoral Sandpiper and Superb Fruit-Dove
2	Located within the Project area during Project surveys (Western Research Institute and Biosphere Environmental Consultants, 2008) or in the Woronora Special Area (DECC, 2007a)	Rufous Fantail, Nankeen Night Heron, Australian Kestrel, Brown Goshawk, Pallid Cuckoo, Fan-tailed Cuckoo, Channel-billed Cuckoo, Southern Boobook, White-throated Nightjar, Sacred Kingfisher, Black-faced Cuckoo-Shrike, Welcome Swallow, Silvereye, Whistling Kite and White-bellied Cuckoo-shrike
3	Potential residents associated with limited habitats of the Woronora Reservoir and Waratah Rivulet	Cattle Egret, Great Egret, Osprey and White-bellied Sea Eagle, Australian White Ibis, Straw-necked Ibis, Intermediate Egret and Little Egret.
4	Predominantly coastal species that could be occasionally associated with limited habitats of the Woronora Reservoir and Waratah Rivulet	Black-tailed Godwit, Bar-tailed Godwit, Marsh Sandpiper, Common Greenshank, Terek Sandpiper, Red-necked Stint, Sharp-tailed Sandpiper, Curlew Sandpiper, Musk Duck, Eastern Reef Egret, Spotless Crake, Purple Swamphen and Red-necked Avocet
5	Other marine protected species	White-throated Needletail, Fork-tailed Swift, Black-faced Monarch and Satin Flycatcher, Brahminy Kite, Swamp Harrier, Swift Parrot, Horsefield's Bronze-Cuckoo, Shining Bronze-Cuckoo, Dollarbird, Forest Kingfisher, Pink Robin, Flame Robin, Spangled Drongo, Cicadabird and Tree Martin

Source: after Western Research Institute and Biosphere Environmental Consultants (2008)

The Project area is situated approximately 6-8 km west of the eastern seaboard. It is very unlikely that there would be a real chance or possibility that the Project would have a substantial adverse effect on a population of a marine species including its life cycle (e.g. breeding, feeding, migration behaviour, life expectancy) and spatial distribution.

Group 1 Black-winged Stilt, Grey Plover, Lesser Golden Plover, Australian Painted Snipe, Latham's Snipe, Ruddy Turnstone, Great Knot, Red Knot, Sanderling, Broad-billed Sandpiper, Oriental Cuckoo, Rainbow Bee-eater, Stubble Quail, Cape Baron Goose, Red-capped Plover, Double-banded Plover, Hooded Plover, Eastern Curlew, Grey-tailed Tattler, Wandering Tattler, Pectoral Sandpiper and Superb Fruit-Dove

Some of these species could conceivably be present for short periods of time within the Project area, as vagrants or nomads, or while migrating, but lack the extent of suitable habitat for their ecological needs to be met.

Is there a real chance or possibility that the proposal will have a substantial adverse effect on a population of a marine species or cetacean including its life cycle (e.g. breeding, feeding, migration behaviour, life expectancy) and spatial distribution?

The Project area lacks the extent or presence of habitat needed to support these species other than to allow for occasional appearances as nomadics, vagrants or to provide 'passing through' status. Potential impacts of the Project are predicted to be very marginal and at point scales rather than being landscape impacts. Very limited clearing of native habitats would occur as a result of the Project. Other possible disruptions to the species' lifecycle are disease and increases in exotic predator species, both unlikely to be influenced adversely by the Project. Hence it is very unlikely that there would be a real chance or possibility that the Project would have a substantial adverse effect on a population of a Group 1 marine protected species including their life cycle and spatial distribution.

Group 2 Rufous Fantail, Nankeen Night Heron, Australian Kestrel, Brown Goshawk, Pallid Cuckoo, Fan-tailed Cuckoo, Channel-billed Cuckoo, Southern Boobook, White-throated Nightjar, Sacred Kingfisher, Black-faced Cuckoo-Shrike, Welcome Swallow, Silvereye, Whistling Kite and White-bellied Cuckoo-shrike

Is there a real chance or possibility that the proposal will have a substantial adverse effect on a population of a marine species or cetacean including its life cycle (e.g. breeding, feeding, migration behaviour, life expectancy) and spatial distribution?

These species have been recorded in the Project area by Western Research Institute and Biosphere Environmental Consultants (2008) or in the Woronora Special Area (DECC, 2007a). None of the habitats potentially utilised by these species would be substantially modified, destroyed or isolated as a result of the Project. Other possible disruptions to the species' lifecycle are disease and increases in exotic predator species, both unlikely to be influenced adversely by the Project. Hence it is very unlikely that there would be a real chance or possibility that the Project would have a substantial adverse effect on a population of a Group 2 marine protected species including their life cycle and spatial distribution.

Group 3 Cattle Egret, Great Egret, Osprey and White-bellied Sea Eagle, Australian White Ibis, Straw-necked Ibis, Intermediate Egret and Little Egret

These species are potential residents associated with limited habitats (e.g. the Woronora Reservoir and Waratah Rivulet). These species are likely to appear from time to time as nomadics, temporary residents or as semi-permanent breeding residents.

Is there a real chance or possibility that the proposal will have a substantial adverse effect on a population of a marine species or cetacean including its life cycle (e.g. breeding, feeding, migration behaviour, life expectancy) and spatial distribution?

Group 3 species are potential residents associated with limited habitats (e.g. the Woronora Reservoir and Waratah Rivulet). These species are likely to appear from time to time as nomadics, temporary residents or as semi-permanent breeding residents. It is unlikely that they would be found in any other locations within the Project area. At any one time appearances of these species with the Project area would represent a very small sample of the wider populations. It is unlikely that the Project would adversely impact any of these species. Hence it is very unlikely that there would be a real chance or possibility that the Project would have a substantial adverse effect on a population of a Group 3 marine protected species including their life cycle and spatial distribution.

Group 4 Black-tailed Godwit, Bar-tailed Godwit, Marsh Sandpiper, Common Greenshank, Terek Sandpiper, Red-necked Stint, Sharp-tailed Sandpiper, Curlew Sandpiper, Musk Duck, Eastern Reef Egret, Spotless Crake, Purple Swamphen and Red-necked Avocet

Group 4 species are predominantly coastal species that could be occasionally associated with limited habitats (e.g. the Woronora Reservoir and Waratah Rivulet), most likely as temporary visitors, vagrants or nomadics.

Is there a real chance or possibility that the proposal will have a substantial adverse effect on a population of a marine species or cetacean including its life cycle (e.g. breeding, feeding, migration behaviour, life expectancy) and spatial distribution?

Group 4 species are potential temporary residents associated with limited habitats (e.g. the Woronora Reservoir and Waratah Rivulet). These species are likely to appear from time to time as nomadics, temporary residents but unlikely as breeding residents. It is unlikely that they would be found in any other locations within the Project area other than habitats associated with waterbodies (e.g. the Woronora Reservoir and Rivulet). At any one time appearances of these species within the Project area would represent a very small sample of the wider populations. It is unlikely that the Project would adversely impact any of these species. Hence it is very unlikely that there would be a real chance or possibility that the Project would have a substantial adverse effect on a population of a Group 4 marine protected species including their life cycle and spatial distribution.

Group 5 Other Marine Protected Species

Group 5 includes the White-throated Needletail, Fork-tailed Swift, Black-faced Monarch, Satin Flycatcher, Brahminy Kite, Swamp Harrier, Swift Parrot, Horsefield's Bronze-Cuckoo, Shining Bronze-Cuckoo, Dollarbird, Forest Kingfisher, Pink Robin, Flame Robin, Spangled Drongo, Cicadabird and Tree Martin. Potential habitats for all Group 5 species exist within the Project area.

Is there a real chance or possibility that the proposal will have a substantial adverse effect on a population of a marine species or cetacean including its life cycle (e.g. breeding, feeding, migration behaviour, life expectancy) and spatial distribution?

Group 5 species have not been observed within the Project area. It is unlikely that viable populations of these species exist within the Project area, although they may do so at some future point in time. The habitat of these species includes aerial space, forest, woodland and heaths. None of these habitats would be substantially modified, destroyed or isolated as a result of the Project. Other possible disruptions to the species' lifecycle are disease and increases in exotic predator species, both unlikely to be influenced adversely by the Project. Hence it is very unlikely that there would be a real chance or possibility that the Project would have a substantial adverse effect on a population of a Group 5 marine protected species including their life cycle and spatial distribution.

4. Is there a real chance or possibility that the proposal will result in a substantial change in air quality or water quality (including temperature) which may adversely impact on biodiversity, ecological integrity; social amenity or human health?

The Project area is situated approximately 6 to 8 km west of the eastern seaboard. It is very unlikely that there would be a real chance or possibility that the Project would result in a substantial change in air quality or water quality (including temperature) which may adversely impact on biodiversity, ecological integrity; social amenity or human health. Any secondary effects associated with the Project such as global warming would be negligible when compared to the effect of national and global emissions.

5. Is there a real chance or possibility that the proposal will result in persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, social amenity or human health may be adversely affected?

The Project area is situated approximately 6 to 8 km west of the eastern seaboard. It is very unlikely that there would be a real chance or possibility that the Project would result in persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, social amenity or human health may be adversely affected.

6. Is there a real chance or possibility that the proposal will have a substantial adverse impact on heritage values of the Commonwealth marine area, including damage or destruction of an historic shipwreck?

The Project area is situated approximately 6 to 8 km west of the eastern seaboard. It is very unlikely that there would be a real chance or possibility that the Project would have a substantial adverse impact on heritage values of the Commonwealth marine area, including damage or destruction of an historic shipwreck.

Summary

The Project is considered very unlikely to have a significant impact on the environment in a Commonwealth marine area.

8 SUMMARY AND CONCLUSION

Metropolitan Colliery is an underground coal mining operation located approximately 30 km north of Wollongong in NSW. A Flora and Fauna Impact Assessment has been prepared for the Metropolitan Coal Project, which comprises the continuation, upgrade and extension of underground coal mining operations and surface facilities for the production of coal products at the existing Metropolitan Colliery. The Flora and Fauna Impact Assessment has been prepared in accordance with Part 3A of the EP&A Act and Director-General's Environmental Assessment Requirements.

Baseline flora and terrestrial vertebrate fauna surveys have been conducted for the Project by Bangalay Botanical Surveys (2008) and Western Research Institute and Biosphere Environmental Consultants (2008), respectively using recognised survey techniques. A number of reference sources containing the results of local or regional flora and fauna surveys, database records and other scientific studies and literature were also reviewed and where appropriate included in the baseline flora and fauna assessments (Bangalay Botanical Surveys, 2008; Western Research Institute and Biosphere Environmental Consultants, 2008). Further to the conduct of the baseline flora and fauna surveys, an investigation of upland swamps and impacts of underground mining was conducted by FloraSearch to inform the upland swamp assessment contained in this Flora and Fauna Impact Assessment.

The Flora and Fauna Impact Assessment draws on the potential subsidence, groundwater and surface water impacts described by MSEC (2008), Heritage Computing (2008) and Gilbert and Associates (2008). The assessment of potential impacts has also been based on surveys in the Project area and surrounds, data on distribution of species, ecological theory including current understanding of population dynamics, knowledge of fire history in this location and the known impacts of fire on vertebrate distribution and abundance and in consideration of relevant legislation including the TSC Act and EPBC Act.

Potential adverse impacts of the Project on terrestrial flora, fauna, and their habitats have been assessed and include those associated with mine subsidence effects (e.g. surface cracking, buckling and/or dilating and changes to surface or groundwater hydrology).

Potential subsidence effects on streams and riparian zones include changes in stream gradients, increased scouring of stream banks, changes to stream alignments, cracking and/or changes in stream water levels and gas emissions. Mine subsidence impacts on riparian vegetation are expected to be similar to those experienced at the Metropolitan Colliery to date (i.e. localised and limited in their extent). Recovery of riparian vegetation following mine subsidence has also been observed at Metropolitan Colliery.

Mine subsidence also has the potential to alter the availability of water in streams to terrestrial fauna. Mine subsidence (including upsidence and valley closure) would result in fracturing of the rock strata in watercourses which may result in conveyance of a portion of low flows via the fracture network, and a reduction in water level in pools as they become hydraulically connected with the fracture network. There is also likely to be reduced continuity of flow between affected pools during dry weather. Pool water levels would fluctuate in response to stream flow variability (i.e. increasing during periods of increasing flow and reducing with flow recession). During periods of moderate to high flow, the pool water level behaviour in areas subject to subsidence is expected to be similar to pre-subsidence behaviour (i.e. pool levels persist, rockbars experience overflow and significant surface flows occur) (Gilbert and Associates, 2008). During prolonged dry periods when flows recede to low levels, a greater proportion of the lower flows would be conveyed via the fracture network (Gilbert and Associates, 2008). Mine subsidence also has the potential to result in changes in stream water quality. The effects of subsidence on water quality have been most noticeable as localised and transient changes (spikes or pulses) in iron, manganese and to a lesser extent aluminium and minor associated increases in electrical conductivity (Gilbert and Associates, 2008). The most likely mechanism for this appears to be flushing of minerals from freshly exposed fractures created by upsidence and valley closure (*ibid*.). By nature, these pulses are isolated and non-persistent (Gilbert and Associates, 2008). It is also apparent that the pulses have not had any measurable effect on water quality in the Woronora Reservoir downstream (*ibid*.).

A range of fauna species are likely to utilise stream pools for drinking, feeding, bathing or breeding. In consideration of the nature of the potential impacts and the lifecycle components of terrestrial vertebrate fauna that may utilise the riparian (and watercourse) habitat, it is unlikely that any vertebrate population would be put at risk by the potential subsidence-related impacts. Many of the terrestrial vertebrate fauna species are known to utilise a range of habitats, or are mobile allowing them to move to alternative habitat in response to changes in stream flows or water levels. For species that are likely to utilise small pools in Waratah Rivulet rather than the large body of water in Woronora Reservoir, a number of micro-pools remain which hold water even during times of abnormally persistent low flows. Observations indicate that although mine subsidence has the potential to increase the rate of leakage (and consequently pool level recession) of tributary pools, it is likely that a portion of the pools subject to mine subsidence effects will hold some water during prolonged dry periods (Gilbert and Associates, 2008). These latter pools would remain full during most typical wetting and drying cycles (*ibid*.).

Mine subsidence has the potential to cause surface and sub-surface cracking on slopes and ridgetops. This includes the potential for surface tension cracking near the tops of slopes. To date, the only surface tension crack reported at Metropolitan Colliery is adjacent to Fire Road 9C which is near the top of a steep slope. The size and extent of surface cracking on slopes and ridgetops is expected to be minor, which is consistent with that observed during the extraction of previous longwalls at the Metropolitan Colliery. Surface and sub-surface cracking has the potential to alter, albeit at a small local scale, the movement of water in the plateau and hillslope areas. However, the magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes in these areas and is unlikely to have any biologically significant effect on the soil moisture regime that sustains the existing vegetation communities in these areas or the availability of non-persistent sources of water to terrestrial fauna.

There have been no reported observations of changes to ridgetop and slope vegetation that have been attributed to mine subsidence. Surface cracking (e.g. tension cracks) also has the potential to form areas capable of 'trapping' some ground dwelling fauna in the same way that pitfall traps operate. Any impacts on vertebrate fauna due to surface cracking are likely to be relatively minor and very unlikely to result in an impact that would threaten the viability of any vertebrate species population.

One EEC listed under the TSC Act was recorded by the Project baseline flora surveys, *viz*. Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC. In addition, the O'Hares Creek Shale Forest EEC occurs to the south of the proposed underground mining area in the vicinity of Longwalls 18-19A. Surface cracking as the result of systematic subsidence movements at the occurrence of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC in the far north-east of the Project area is expected to be isolated and of a minor nature due to the relatively low magnitudes of the predicted strains and the relatively high depths of cover. Further, the maximum predicted systematic tilt is small when compared to the existing natural surface gradients. Given the magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes in this area, it is unlikely that subsidence effects would have any biologically significant effect on the soil moisture regime that sustains the EEC in this area. As a result, it is unlikely that the EEC would be adversely affected by mine subsidence.

Mine subsidence also has the potential to cause rockfall. Rock falls occur naturally, however subsidence movements have the potential to further reduce the stability of features and increase the incidence of rock fall. However, given the predicted low incidence of rock falls, the potential impacts on flora and fauna as a result of rock fall are likely to be minor.

A number of upland swamps are situated within the proposed underground mining area (Longwalls 20-44) and within the potential extent of mine subsidence effects. The upland swamps within the Project area and surrounds are not situated in the four key clusters of swamps identified by DECC (2007c) as being of particular conservation significance in the Southern Coalfield. However, it is recognised that upland swamps are of particular ecological significance. The upland swamp assessment considered potential mine subsidence effects on the water balance of upland swamps and potential for: subsequent desiccation of the swamp; increased susceptibility to fire; erosion; and associated loss of specialised swamp biota. With the exception of one in-valley upland swamp, all upland swamps within the Project area are headwater upland swamps. The in-valley swamp is situated on a tributary (a third order watercourse) of Waratah Rivulet and outside of the proposed underground mining area (Longwalls 20-44), but within the potential extent of mine subsidence effects (i.e. angle of draw). The in-valley swamp overlies completed Longwalls 7 and 8 and consequently has already experienced mine upsidence from Metropolitan Colliery's existing operations. Site inspections of this in-valley swamp indicate that there was no observable effect of previous mine subsidence on vegetation health, erosion or vegetation community composition or abundance in the swamp.

Surface cracking resulting from mine subsidence is not expected to result in an increase in the vertical movement of water from the perched water table into the regional aquifer (Heritage Computing, 2008). Significant changes in grade within the swamps as a result of mining-induced tilt are not anticipated (MSEC, 2008). The predicted tilts would not have any significant affect on the localised or overall gradient of the swamp or the flow of water (Gilbert and Associates, 2008). Any minor mining-induced tilting of the scale and nature predicted is not expected to significantly increase lateral surface water movements which are small in relation to the other components in the swamp water balance (Gilbert and Associates, 2008). Given the above, no change to the fundamental surface hydrological processes (Gilbert and Associates, 2008) and upland swamp vegetation are expected within upland swamps situated within the proposed underground mining area (Longwalls 20-44) and within the potential extent of mine subsidence effects.

Other direct and indirect potential impacts of the Project on terrestrial flora, fauna, and their habitats have also been assessed (e.g. vegetation clearance/habitat disturbance, fire, weeds and exotic pests, the plant pathogen, *Phytophthora cinnamomi*, amphibian Chytrid fungus, dust, noise, fauna traps, road traffic, artificial lighting and greenhouse gas emissions/climate change effects). The Project would include minimal vegetation clearance (i.e. up to 10 hectares), which would be progressively implemented over the life of the mine. As a result, at any one time some small areas are likely to be disturbed (in the order of two hectares), while previously disturbed areas would be in various stages of natural regeneration/rehabilitation. The effects of projected climate change on the nature and extent of the potential Project impacts have also been considered. Cumulative impacts of the Project have also been considered.

Evaluations have been conducted to assess the potential impacts of the Project on threatened flora, fauna, and their habitats in accordance with the draft *Guidelines for Threatened Species Assessment* (DEC and DPI, 2005). The evaluations indicate that the Project is unlikely to have a significant impact on any threatened flora or fauna species, populations, ecological communities, or their habitats.

Evaluations have also been conducted to assess the potential impacts of the Project on matters of national environmental significance in accordance with the *Significant Impact Guidelines – Matters of National Environmental Significance* (DEH, 2006b). The evaluations indicate that the Project is unlikely to have a significant impact on any matters of national environmental significance.

A FFMP would be developed for the Project and would include measures to minimise impacts on terrestrial flora, fauna, and their habitats. The management plan would include protocols for the management of sites where vegetation/habitat removal is necessary, the control of weed and exotic pests, the diseases *P. cinnamomi* and amphibian Chytrid fungus, bushfire and natural regeneration/rehabilitation management measures, amongst others.

9 REFERENCES

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