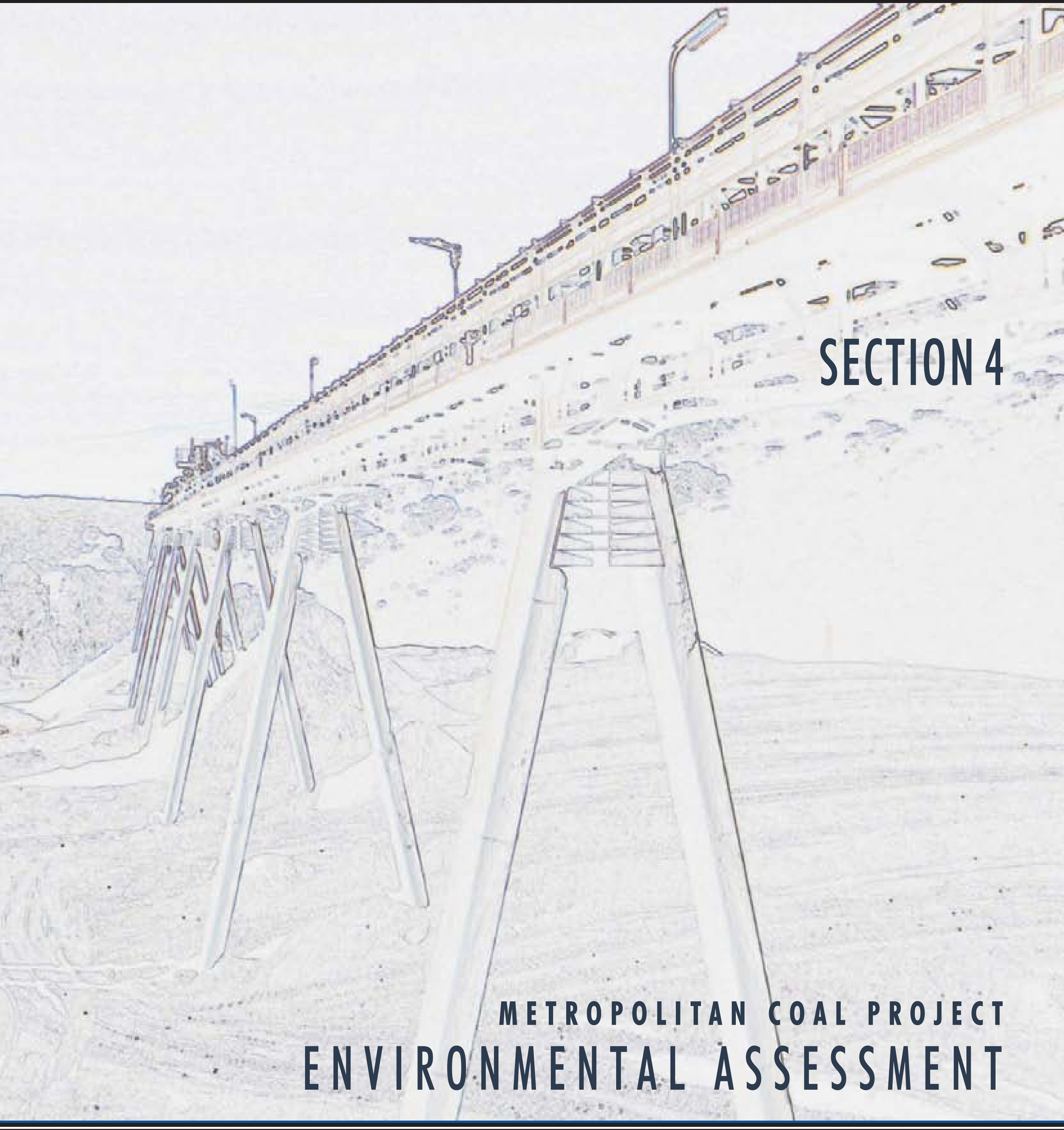

SECTION 4

METROPOLITAN COAL PROJECT

ENVIRONMENTAL ASSESSMENT

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4 ENVIRONMENTAL ASSESSMENT

The following section presents the environmental assessment for the Project including: a description of the existing environment (including the existing Metropolitan Colliery operations where relevant); an assessment of the potential impacts of the Project; and a description of Project environmental mitigation measures, management and monitoring that would be implemented.

Compensatory measures, rehabilitation and stream restoration activities are presented in Sections 3.9.3 and 5. HCPL's Statement of Commitments is provided in Section 6.

4.1 LAND RESOURCES, CLIMATE AND BUSHFIRE REGIME

The Major Surface Facilities Area is located in close proximity to suburban areas of Helensburgh (Figure 1-3).

The Metropolitan Colliery Completed Underground Mining Area extends north from the Major Surface Facilities Area into the Royal National Park and Garawarra State Conservation Area, east into the Royal National Park, south to Stanwell Tops and extend west of the Princes Highway into CCL 724 (Figure 1-2).

The Metropolitan Colliery Current Underground Mining Area (Longwalls 14 to 19A) is a western extension of the Completed Underground Mining Area towards Darkes Forest Road (Figure 1-2).

4.1.1 Existing Environment

Presented below is a description of land resources including landuse, topography, soils and land capability at the Project area and surrounds. An overview of the climate and bushfire regime in the vicinity of the Project is also provided.

Landuse

Landuses in the vicinity of the Project are varied (Figures 1-1 and 1-2).

Some of the major reserves in the wider Project setting include those set aside for conservation (e.g. Garawarra and Dharawal State Conservation Areas and the Heathcote and Royal National Parks), the Holsworthy Military Reserve located to the north-west of the Woronora Reservoir and water catchment areas (e.g. the Metropolitan and Woronora Special Areas) (Figure 1-1).

Special Areas are those lands that surround Sydney's drinking water storages (SCA, 2007). They are lands declared under the *Sydney Water Catchment Management Act, 1998* (SWCM Act) for their value in protecting the quality of the raw water used to provide drinking water to Sydney, the Illawarra and the Blue Mountains and for their ecological integrity (SCA, 2007).

As can be seen on Figure 1-1, major man-made water storage facilities including the Woronora Reservoir, Cataract Reservoir and Cordeaux Reservoir are significant features of the regional setting.

The following discussion of landuse in the vicinity of the Project has been divided into three main segments, comprising the Completed Underground Mining Area (including the Major Surface Facilities Area), the Current Underground Mining Area and the Project Underground Mining Area.

Section 3.2.4 describes the land zoning in the vicinity of the Project. Public access to the Woronora Special Area is restricted by the SCA.

Completed Underground Mining Area

The Metropolitan Colliery has been operating for over 100 years and hence the Completed Underground Mining Area is quite extensive (Figure 1-2). Within the Completed Underground Mining Area a range of landuses are now present, including the township of Helensburgh which grew to service the mine.

Landuses in the Completed Underground Mining Area include (Figures 1-1, 1-2 and 2-1):

- the Garawarra State Conservation Area which is located to the west and north-west of Helensburgh and east of the Major Surface Facilities Area;
- the Royal National Park, which is located to the north of Helensburgh and also extends down the coast towards Stanwell Park;
- the Woronora Special Area;
- a range of public roads including the F6 Southern Freeway, Princes Highway, Lawrence Hargrave Drive, Lady Wakehurst Drive and the Helensburgh street network;
- the Illawarra Railway and associated Metropolitan Colliery rail spur;
- the township of Helensburgh including residential, business, light industrial and recreational areas;

- environmental protection areas associated with the Hacking River to the east of Helensburgh;
- electricity transmission lines and associated facilities;
- the Major Surface Facilities Area (refer below); and
- other mining related landuses of the Metropolitan Colliery including exploration, environmental monitoring, stream restoration works, Ventilation Shaft No. 3 and associated electrical infrastructure.

Local landuses in Helensburgh proximal to the Major Surface Facilities Area include residential areas; environmental protection areas (Figure 3-1), the Illawarra Railway and the Garawarra State Conservation Area (Figure 1-4a).

As described in Section 2.1, the Metropolitan Colliery utilises both the Illawarra Railway and the public road network for the transport of coal, coal reject and consumables.

Current Underground Mining Area

Landuse in the Current Underground Mining Area (Figure 1-2) is largely restricted to use for water catchment in the Woronora Special Area. Underground longwall mining occurs at depth, and environmental monitoring and other minor activities associated with the Metropolitan Colliery underground mining operations occur at the surface.

Project Underground Mining Area

The Project Underground Mining Area would extend the Metropolitan Colliery longwall mining area north to the Woronora Dam Road and east to the F6 Southern Freeway (Figures 1-2 and 2-1).

Landuses in the Project Underground Mining Area include:

- the Woronora Special Area (and associated fire trails and Woronora Reservoir);
- the Garrawarra Centre aged care facility, associated housing and cemetery;
- an old quarry (now used for a model aeroplane club);
- public road corridors including the F6 Southern Freeway and Princes Highway; and
- infrastructure (e.g. electricity transmission lines, optical cables and water pipelines).

A limited number of rural residences/sheds are also located in close proximity to the Project Underground Mining Area (Appendix A).

Topography

The Project is located towards the east of the Woronora Plateau, which is a dissected sandstone plateau composed largely of Triassic Hawkesbury Sandstone. At its eastern extent, the Hawkesbury Sandstone forms the steep and imposing cliffs of the Illawarra Escarpment, which tower over Wollongong and the settled coastal plains of the Illawarra.

Topography in the vicinity of the Project varies. In the north of the Project Underground Mining Area elevations vary from approximately 300 m Australian Height Datum (AHD) at the Garrawarra Centre, adjacent to the Princes Highway, to approximately 170 m AHD at the Woronora Reservoir full supply level. In the south-west of the Current Underground Mining Area elevations generally are up to approximately 350 m AHD.

In the Completed Underground Mining Area, to the east of the F6 Southern Freeway, the topography begins to fall away to the east, with elevations as low as 50 m AHD at the Hacking River in the north-east of CCL 703.

In Helensburgh, elevations generally range from approximately 300 m AHD at the junction of Parkes Street and the Princes Highway to approximately 150 m AHD at the Royal National Park boundary to the north of the town. The Major Surface Facilities Area is located at lower elevation than the town, with the majority of infrastructure at elevations of approximately 130 m AHD to 150 m AHD.

Soils and Land Capability

Soil landscapes in the vicinity of the Project have been mapped by the Soil Conservation Service of NSW as described in the document *Soil Landscapes of the Wollongong – Port Hacking 1:100,000 Sheet* (Hazelton and Tille, 1990).

Two dominant soil landscapes (i.e. Hawkesbury and Bundeena) were identified in the vicinity of Project. Of these, the Hawkesbury colluvial soil landscape dominates the valleys of the Waratah Rivulet and Woronora Reservoir, Wilsons Creek and Hacking River systems, while the Bundeena is a residual soil landscape, which dominates the ridges and areas of higher elevation between the valleys.

Major soil types of the Hawkesbury soil landscape identified include (Hazelton and Tille, 1990):

- loose, coarse quartz sand, which generally occurs as topsoil;
- earthy, yellowish brown sandy clay loam, which generally occurs as subsoil; and
- pale, strongly pedal light clay, which commonly occurs as subsoil derived from shale lenses within the Hawkesbury Sandstone.

Major soil types of the Bundeena soil landscape identified include (Hazelton and Tille, 1990):

- loose, stony dull yellowish brown sandy loam, which generally occurs as topsoil;
- earthy, yellowish brown, light sandy clay loam, which generally occurs as subsoil; and
- friable yellowish brown clayey sand, which occurs as subsoil in wet areas.

In addition, small areas of the Gymea erosional soil landscape were also identified in the mapping to the east of the Garrawarra Centre, west of Helensburgh at the F6 Southern Freeway and near the junction of the Princes Highway and Lawrence Hargrave Drive (Hazelton and Tille, 1990).

The Gymea soil landscape is characterised by undulating to rolling low hills and soils in this landscape range from coarse sandy loams to pedal yellowish to brown clay (*ibid.*).

Hazelton and Tille's (1990) analysis of the limitations of the soils indicated that the Hawkesbury, Bundeena and Gymea soil landscapes have low fertility, exhibit high erosion potential, and are not capable of being cultivated or grazed.

NSW Agriculture produces agricultural land classification maps on a local government area basis, which rank land on its suitability for agricultural production (NSW Agriculture, 2002). However, limited agricultural land classification mapping is available in the vicinity of the Project, due to the limited applicability of agricultural activity (as lands are primarily reserved for other uses and/or are generally unsuitable for cultivation or grazing).

Meteorology

Regional and local meteorological data is available from the Bureau of Meteorology (BoM) weather stations at Lucas Heights, Darkes Forest and Helensburgh. Details of the BoM stations are provided in Table 4-1. Meteorological data collected from these sources, and SCA evaporation data at the Woronora Reservoir is summarised in Table 4-2 and discussed below.

Table 4-1
Bureau of Meteorology Monitoring Station Locations and Recording Periods

Station Name	Station Number	Location	Latitude (degrees S)	Longitude (degrees E)	Elevation m AHD	Period of Record
Lucas Heights (ANSTO)	66078	Approximately 15 km north of the Project	34.0517	150.9800	140	1958 to 2008
Helensburgh (Sawan Street)	68028	Approximately 2 km south-west of the Project Major Surface Facilities Area	34.1908	150.9746	238	1889 to 2005
Darkes Forest (Kintyre)	68024	Approximately 8 km south-west of the Project Major Surface Facilities Area	34.2272	150.9111	370	1894 to 2008

Source: BoM (2008).

Table 4-2
Relevant Meteorological Information

Month	Relative Humidity Monthly Average (%)		Average Daily Temperature (°C)		Average Monthly Rainfall (mm)			Average Monthly Evaporation (mm)
	Lucas Heights		Lucas Heights		Lucas Heights	Helensburgh	Darkes Forest	Woronora Reservoir
	9.00 am	3.00 pm	Max.	Min.				
January	72	62	25.9	17.4	96.2	142.8	133.8	158
February	74	63	26.0	17.6	104.6	158.6	159.8	126
March	73	63	24.7	16.1	112.2	177.2	152.2	106
April	70	58	22.3	13.3	91.4	144.7	125.4	72
May	72	58	18.9	10.1	81.1	147.4	132.0	64
June	73	61	16.2	8.2	100.8	145.5	143.4	43
July	68	52	15.8	6.6	59.7	106.4	98.6	46
August	65	51	17.2	7.4	73.3	91.2	93.7	66
September	63	52	19.5	9.4	52.6	76.4	76.9	90
October	64	57	21.6	11.9	72.9	89.8	92.3	124
November	66	57	23.4	13.7	92.5	103.0	104.1	135
December	67	57	25.7	15.9	81.5	103.0	106.4	168
Annual Average	**69**	**57**	**21.4**	**12.3**	-	-	-	-
				Annual Average Total	**1,018.8**	**1,486.0**	**1,418.8**	**1,198**

Source: Appendix K; BoM (2008); Appendix C.

Rainfall

Rainfall records are available from a number of locations, including Lucas Heights, Helensburgh and Darkes Forest. The average annual rainfall at these stations is approximately 1,018 mm (Lucas Heights), 1,486 mm (Helensburgh), and 1,418.8 mm (Darkes Forest).

Generally the rainfall records indicate moderate seasonality, with higher rainfall being recorded in late summer and autumn and lower rainfall in the winter and spring (Table 4-2).

Temperature

The data presented in Table 4-2 indicate that temperatures are warmest from November to March and coolest in the winter months of June, July and August. Average daily temperatures vary from 6.6^{o}C in July to 26^{o}C in February.

Relative Humidity

Relative humidity records exhibit a relatively uniform seasonal pattern (Table 4-2). The lowest morning (9.00 am) average monthly relative humidity has been recorded in September (63%) and the highest recorded in February (74%). The lowest afternoon (3.00 pm) average monthly relative humidity has been recorded in August (51%) and the highest recorded in February and March (63%).

Evaporation

Evaporation records indicate a distinct seasonality, with higher evaporation rates in summer months and lower evaporation in winter (Table 4-2). The highest average monthly evaporation has been recorded at the Woronora Reservoir in December (168 mm) and the lowest in June (43 mm).

Table 4-2 indicates local annual rainfall exceeds the annual evaporation recorded at the Woronora Reservoir.

Wind Speed and Direction

Figure 4-1 provides annual average and seasonal wind roses for the Project Major Surface Facilities Area, compiled from data produced by the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) prognostic model known as The Air Pollution Model (TAPM) (Appendix K).

On an annual basis, the most common winds are from the west and south south-east. Winds from the west, north-west, south-southeast are also common (Appendix K). North-easterly winds are dominant during the summer, while westerly winds are common in the winter (Appendix K). In spring, winds are highly variable, while in autumn winds from the south-southeast and west dominate (Figure 4-1).

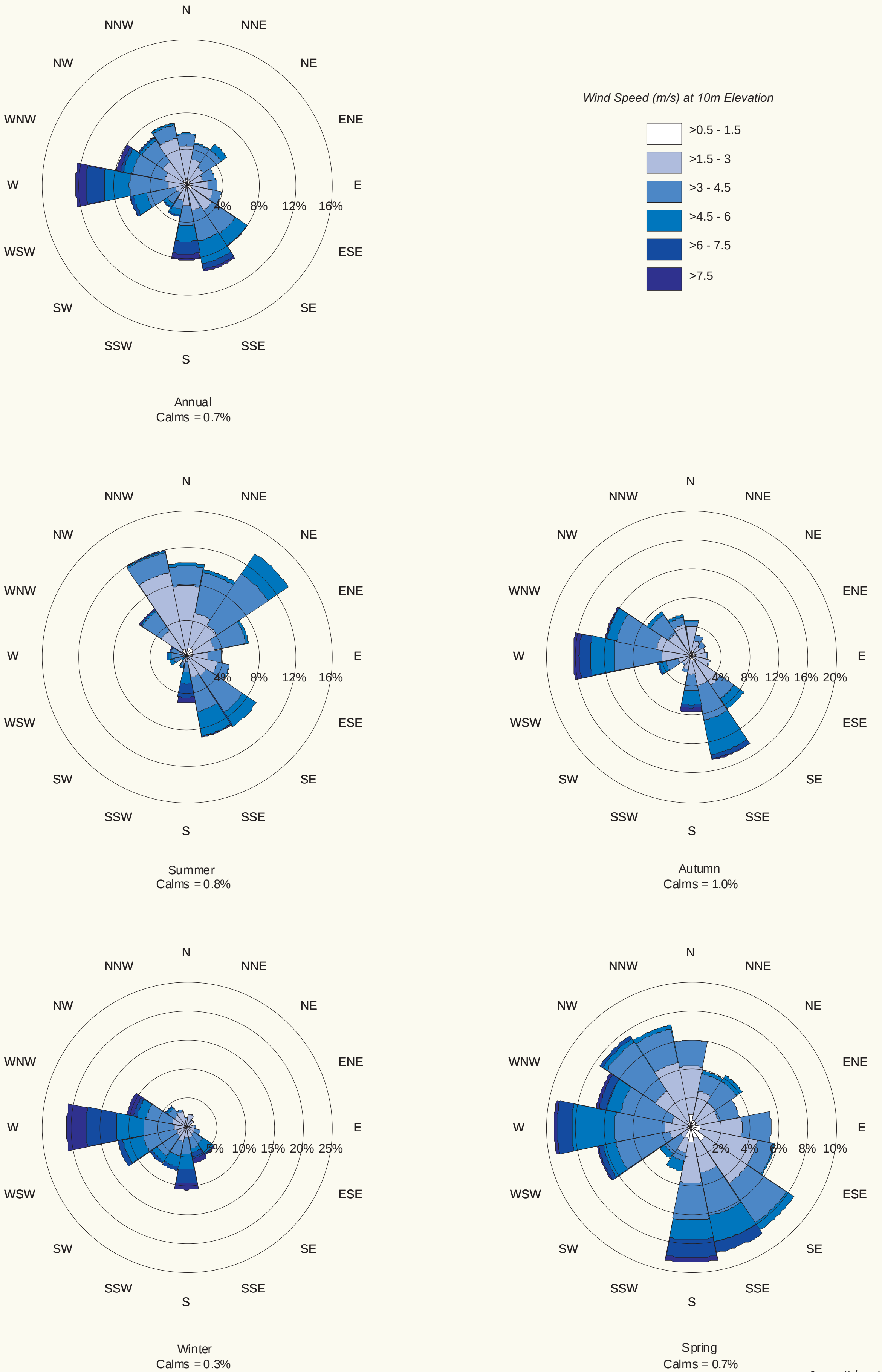
Bushfire Regime

The Project is located in the jurisdiction of the Illawarra Bush Fire Management Committee (Illawarra BFMC), which includes the local government areas of Wollongong, Shellharbour and Kiama (Illawarra BFMC, 2007). The fire season for the Illawarra Region is predominantly from August/September (Illawarra BFMC, 2007), although it is dependant on weather conditions such as the onset of summer rains and fuel loads.

Strong west to north-westerly winds are typically associated with bushfires in the area and southerly and/or easterly winds also have the potential to intensify wildfires burning on or along the escarpment (Illawarra BFMC, 2007). The major causes of fire ignition in the region are arson, car dumping, lightning, electrical power lines (i.e. arcing in high winds) and fires that escape from legal and illegal burning activities (Illawarra BFMC, 2007).

The Illawarra Bush Fire Risk Management Plan (BFRMP) indicates that smoke from bushfires can have adverse impacts on the operation of transportation routes, mine ventilation, tourism, urban interface areas and hospitals (and the Garrawarra Centre is identified as being potentially susceptible to smoke effects) (Illawarra BFMC, 2007).

The Illawarra BFRMP indicates that significant fire activity occurred in the Illawarra in September 1939, October 1968 and 1974, November 1980 and 1983, January 1994, December 1997 and 2001, January 2002 and October 2002. Of these, the December 2001 fires are of particular relevance to the Project, as large areas of the Woronora Special Area in the vicinity of the Project were affected.



Source: Holmes Air Sciences (2008)

METROPOLITAN COAL PROJECT

FIGURE 4-1
Annual and Seasonal Wind Roses - Metropolitan Colliery

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MET-06-02 Section 4_020C

4.1.2 Potential Impacts

As described in Section 2, the Project would largely comprise underground mining activities, with only limited surface development activities being required outside of the Major Surface Facilities Area.

Lands in the vicinity of the Project are generally not suitable for agricultural production and/or such uses are not permitted (e.g. in the Garawarra State Conservation Area and the Woronora Special Area). Hence potential impacts on rural land capability and agricultural suitability are not considered relevant to the Project.

Landuse

Along with the continued use and upgrade of the Major Surface Facilities Area and Ventilation Shaft No. 3 and associated facilities, the Project would also require the development of an additional ventilation shaft (No. 4) and associated electrical facilities. Ventilation Shaft No. 4 would be located to the east of the Woronora Special Area immediately west of the F6 Southern Freeway in an area that has already been disturbed by previous extraction of materials for road building (Figure 1-2).

In addition, the Project would require additional limited areas of land disturbance associated with on-going surface exploration activities, environmental monitoring equipment installation and other Project surface activities such as stream restoration. The majority of these activities would occur in the Woronora Special Area, and would require only short-term disturbance (e.g. exploration bores) with the disturbance area subsequently being rehabilitated.

Consideration of the potential impacts of the Project on the Woronora Special Area water supply catchment (e.g. yield and water quality) are provided in Section 4.4 and indicate that the development of the Project would not adversely affect the Woronora Reservoir water supply.

Potential subsidence effects on the surface features associated with other landuses that are above or in close proximity to the Project Underground Mining Area are considered in Appendix A. This includes the Garrawarra Centre, roads, rural buildings, structures, linear infrastructure (e.g. electricity transmission lines) and the nearby Heathcote National Park and Garawarra State Conservation Area.

The Subsidence Assessment (Appendix A) concludes that potential subsidence impacts on these features can either be readily managed to minimise impacts (e.g. Garrawarra Centre, electricity transmission lines) or would be negligible in nature (e.g. Heathcote National Park, Garawarra State Conservation Area). As described in Section 3.3.1, SMPs would be prepared to detail specific measures that would be implemented for the management of key surface features as the Project progresses.

Topography

Underground mining would result in subsidence (i.e. lowering of the ground surface - along with associated tilts, far field effects and localised valley closure and upsidence effects) as described in Section 4.2 and detailed in Appendix A. The potential environmental impacts associated with subsidence effects are considered in Sections 4.3 to 4.9.

The other modifications to existing topography at the Project would relate to the construction of additional surface infrastructure, *viz.*:

- Ventilation Shaft No. 4 (excavated material from the shaft to provide a construction pad and/or bunding); and
- the temporary coal reject stockpile (eastern extension of the existing coal stockpiles).

The topographical alterations associated with these structures would be generally minor in nature and are associated with components of the Project that would be removed at the cessation of the Project.

Soils and Erosion Potential

As described in Section 4.1.1, the soil landscapes in the vicinity of the Project are susceptible to erosion.

Potential impacts of the Project on soils would be largely restricted to upgrades to Ventilation Shaft No. 3, the construction of Ventilation Shaft No. 4, various limited surface activities above mining areas and activities in the Major Surface Facilities Area and would relate primarily to:

- disturbance of *in-situ* soil resources within areas not currently disturbed by existing operations (e.g. Ventilation Shaft No. 4);

- alteration of soil structure beneath infrastructure and hardstand areas;
- soil contamination resulting from spillage of fuels, lubricants and other chemicals;
- increased erosion and sediment movement due to exposure of soils during construction of mine infrastructure or during stream restoration activities; and
- alteration of physical and chemical soil properties (e.g. structure, fertility, permeability and microbial activity) during soil stripping and stockpiling operations (where applicable).

Land Contamination Potential

The potential land contamination risks have been identified as spills, fires or explosions associated with the transport, storage and usage of fuels and chemicals and explosives, including land contamination arising from potential accidents within the Woronora Special Area.

Bushfire Hazard

Fires originating at the Project would present potentially serious impacts to the township of Helensburgh, the Woronora Special Area, the Garawarra State Conservation Area, the Royal National Park and other surrounding areas. Similarly, fires originating in nearby bushland and suburban areas could pose a significant risk to Project infrastructure and HCPL staff, contractors and equipment.

The continuation and expansion of Metropolitan Colliery mining operations with the Project upgrades of the Major Surface Facilities Area, operation of the methane flare unit at Ventilation Shaft No. 3, and construction of Ventilation Shaft No. 4 and associated facilities could increase the risk of fire generation. Limited surface activities in the Woronora Special Area also pose potential fire generation risks associated with the operation of mobile equipment and other activities.

4.1.3 Mitigation Measures, Management and Monitoring

Landuse

Surface works in the Woronora Special Area would be undertaken in consultation with the SCA and in accordance with approved environmental management plan controls, and hence would not result in any significant adverse impacts on existing landuse in the Woronora Special Area. Management measures to minimise the potential impacts of subsidence on man-made surface infrastructure are provided in Section 4.2.

Management and mitigation measures with respect to potential impacts of the extension of underground mining for the Project on surface water, aquatic ecology, terrestrial flora and fauna in the Woronora Special Area are provided in Sections 4.4.3, 4.5.3, 4.5.4, 4.6.3, 4.6.4, 4.7.3 and 4.7.4.

Section 5 provides methods that would be used to rehabilitate land disturbance areas (e.g. in the Woronora Special Area) as required. Project rehabilitation works would include activities that are to be undertaken progressively (e.g. rehabilitation of minor disturbance areas associated with exploration activities) and that would be undertaken at the cessation of the Project (e.g. the rehabilitation of the Major Surface Facilities Area).

Soils and Erosion Potential

Erosion and sediment control strategies for the Project would be based on accepted practices established for the existing Metropolitan Colliery and would be further documented in relevant environmental management plans (e.g. the Waratah Rivulet Management Plan, Flora and Fauna Management Plan [FFMP], Surface Water Management Plan [SWMP] and Environmental Monitoring Programme [EMP]).

The primary objectives of these erosion control measures would be to:

- control soil erosion and sediment generation from areas disturbed by construction activities; and
- maintain water quality (primarily in terms of total suspended solids content) in watercourses.

Specific mitigation measures to control soil erosion and sediment migration would include:

- minimising surface disturbance and restricting access to disturbed areas;
- rehabilitation and revegetation of mine infrastructure areas, if no longer required;
- minimising compaction during soil excavation and movement;
- use of erosion control features (e.g. silt fences and temporary sediment traps, diversion banks, channels and rip-rap structures) to minimise sediment migration, divert surface water around disturbed areas and to control runoff velocity; and
- use of sediment retention storages to contain runoff from disturbed areas.

Where relevant (e.g. Ventilation Shaft No. 4) recovered topsoil and subsoil would be stockpiled for later use in rehabilitation. Any long-term soil stockpiles would be managed to ensure long-term viability through implementation of the following management practices:

- soil stockpiles to be located outside of active operational areas;
- construction of stockpiles with a "rough" surface condition to reduce erosion hazard, improve drainage and promote revegetation;
- stockpiles which are inactive for extended periods to be fertilised and seeded, to maintain soil structure, organic matter and microbial activity;
- silt fences to be installed around soil stockpiles to control potential loss of soil where necessary; and
- soil stockpiles to be deep-ripped to establish aerobic conditions, prior to soil use in rehabilitation.

As described above, surface works in the Woronora Special Area would be conducted in consultation with the SCA. It is expected that other specific erosion and sediment control works and additional minor controls may be required from time to time over the Project life in association with HCPL's activities within the catchment.

Land Contamination

General measures to reduce the potential for contamination of land include the following:

- Contractors carrying dangerous goods loads would be appropriately licensed in accordance with the provisions of the *Australian Code for the Transport of Dangerous Goods by Road and Rail* (ADG Code) (Commonwealth Department of Transport and Regional Services [DTRS], 2000). Contractors would operate under the provisions of HCPL contractor management plans to meet statutory requirements.
- Carriers of dangerous goods would maintain a communications system (e.g. two-way radio or mobile telephone) in truck cabs to allow for prompt notification in the event of an accident. Trucks would carry fire fighting equipment.
- On-site consumable storage areas would be designed with appropriate bunding and would be operated, where applicable, in compliance with the requirements of AS 1940 *The Storage and Handling of Flammable and Combustible Liquids* and AS2187.1 *Explosives – Storage, Transport and Use – Storage.* Storage areas would be regularly inspected and maintained as required.
- Project truck and train loading activities and infrastructure would be regularly inspected and maintained as required. Rail and road transport contractors would also operate under the provisions of HCPL contractor management plans, where relevant.

Additional general fuel and waste management measures that would typically be implemented to reduce the potential for land contamination in the Woronora Special Area would include:

- the provision and maintenance of portable chemical toilet facilities (personnel would be instructed to use the facility and sewage wastes would be removed from the site by a registered contractor and disposed of in an appropriate manner);
- managing the use of fuels, oils etc. to minimise the risk of spills or leaks which could cause soil contamination;
- the collection of rubbish and waste materials for daily disposal off-site; and
- the removal of construction equipment from the site on completion of construction activities.

Bushfire Hazard

Fire awareness and fire safety training would be included in the induction of all HCPL staff and contractors. In addition to environmental responsibilities, there exists significant economic incentive to prevent fire damage to mining infrastructure, equipment and surrounding landuses. Suitable fire breaks and/or radiation zones would be established to reduce bushfire hazards, where required (e.g. methane flare unit).

In accordance with existing arrangements, HCPL would continue to consult with the SCA with respect to the management of activities in the Woronora Special Area. Bushfire management measures in these areas would continue to include:

- HCPL would obtain SCA Hot Work Permits as necessary; and

- implementation of a Bushfire Preparedness Plan for works within the Woronora Special Area.

The HCPL Bushfire Preparedness Plan would be reviewed and updated for the Project as required and would include fuel management and general housekeeping measures, procedures to minimise the risk of bushfire, respond to bushfire and to evacuate the area in case of an emergency.

Other hazard treatment and mitigation measures are described in a range of existing Metropolitan Colliery management plans that are of potential relevance to the minimisation of bushfire risks as described in Section 4.15.

Meteorological Monitoring

An automated meteorological monitoring station would be installed at the Project Major Surface Facilities Area to record temperature, relative humidity, net solar radiation, rainfall, wind speed, wind direction and sigma theta (the rate of change of wind direction). Meteorological data would be continuously monitored.

Meteorological monitoring would form a key component of the Project environmental monitoring programmes and would be utilised in conjunction with air quality monitoring (Section 4.11) and operational noise monitoring (Section 4.10), where required.

4.2 SUBSIDENCE

Subsidence is the vertical and horizontal movement of the land surface as a result of the extraction of underlying coal. A detailed Subsidence Assessment is presented in Appendix A (MSEC, 2008) and includes predictions of the potential subsidence effects of the proposed mine plan(s), sensitivity analysis of these predictions and assessment of the potential subsidence effects on the natural and built environment, paying particular attention to significant features.

The proposed longwall widths for Longwalls 20 to 44 are much narrower than the typical longwall widths that are currently being extracted at other collieries in the Southern Coalfield (Appendix A). These narrower longwall widths reduce surface subsidence movements, impacts and consequences relative to those for the typical wider longwall widths (Appendix A).

Section 4.2.1 describes the subsidence prediction methodology, while Section 4.2.2 summarises subsidence predictions for Longwalls 20 to 44. Section 4.2.3 summarises the main findings of the subsidence assessment for key surface features and Section 4.2.4 describes subsidence mitigation measures, management and monitoring.

Assessments of the environmental consequences of subsidence effects on groundwater, surface water, aquatic ecology, terrestrial flora, terrestrial fauna, Aboriginal heritage, non-Aboriginal heritage and visual character are provided in Sections 4.3 to 4.9, Section 4.16 and Appendices B to I.

4.2.1 Prediction Methodology

Predictions of the systematic subsidence parameters for the Project longwalls were made using the Incremental Profile Method (MSEC, 2008). This method is an empirical model based on a large database of observed monitoring data from within the Southern, Newcastle, Hunter and Western Coalfields of NSW.

Subsidence predictions made using the Incremental Profile Method use the database of observed incremental subsidence profiles, the proposed longwall geometries, local surface and seam information, and geology. The predicted systematic subsidence parameters were determined using the standard Incremental Profile Model for the Southern Coalfield, based on monitoring data from the Bulli Seam, calibrated with local data using observed subsidence monitoring data for previously extracted longwalls at the Metropolitan Colliery.

The Incremental Profile Method has a tendency to over-predict the systematic subsidence parameters where the proposed mining geometry and geology are within the range of the empirical database (i.e. the method is generally conservative). To provide additional conservatism for site-specific predictions, the maximum predicted values of the systematic subsidence parameters were determined within 20 m of the perimeter of key surface features (Appendix A).

Appendix A provides a more detailed description of the subsidence prediction methodologies, including a description of previous subsidence monitoring at Metropolitan Colliery and how the data has been used for the Project subsidence predictions.

4.2.2 Maximum Systematic Subsidence Predictions for Longwalls 20 to 44

Systematic subsidence movements are described by the following parameters: subsidence, tilt, curvature and strain (including tensile and compressive strains).

Incremental subsidence parameters are the subsidence, tilt, curvatures and strains that occur as a result of the extraction of a single longwall. Cumulative subsidence parameters are the accumulated subsidence, tilt, curvature and strains that occur as a result of the proposed extraction of Longwalls 20 to 44.

Total subsidence parameters are the accumulated subsidence, tilt, curvature and strains that occur as a result of Metropolitan Colliery Longwalls 1 to 19A plus the proposed extraction of Longwalls 20 to 44. Travelling subsidence parameters are the transient tilts, curvatures and strains that occur as the proposed longwall extraction faces mine directly beneath a point.

The predicted cumulative and total subsidence values are summarised below. A description of incremental and travelling subsidence parameters for Longwalls 20 to 44 is provided in Appendix A.

Cumulative Subsidence Parameters

The maximum predicted cumulative systematic subsidence of 1,280 mm would occur over Longwall 23. The maximum predicted cumulative systematic tilt of 7.4 millimetres per metre (mm/m) (0.7%), or a change in grade of 1 in 135, would occur near the centre of Longwall 21. The maximum predicted cumulative systematic tensile strains of 1.7 mm/m would occur over Longwall 20. The maximum predicted cumulative compressive strain of 1.9 mm would occur above Longwalls 24 and 27. The minimum radii of curvatures associated with the maximum predicted cumulative systematic tensile and compressive strains are 9 km and 8 km, respectively.

Total Subsidence Parameters

The maximum predicted total systematic subsidence of 1,280 mm would occur above Longwall 23 after the extraction of Longwall 26. The maximum predicted total systematic tilt of 7.5 mm/m (0.8%), or a change in grade of 1 in 135, would occur at the finishing end of Longwall 11 to Longwall 13 after the extraction of Longwall 19A.

The maximum predicted total systematic tensile strain of 1.7 mm/m would occur over Longwall 20 after the extraction of Longwall 23. The maximum predicted total systematic compressive strain of 1.9 mm/m, would occur above Longwalls 24 and 27. The minimum radii of curvatures associated with the maximum predicted total systematic tensile and compressive strains are 9 km and 8 km, respectively.

4.2.3 Non-Systematic Subsidence Movements

Non-systematic subsidence movements include far-field horizontal movements, irregular subsidence movements and valley related movements, as described below. A more detailed description is provided in Appendix A.

Fair-Field Horizontal Movements

In addition to the systematic horizontal movements which occur above and adjacent to extracted longwalls, it is likely that some far-field horizontal movements would also be experienced during the extraction of the proposed longwalls. The expected far-field horizontal movements resulting from the extraction of the Longwalls 20 to 44 are small and could only be detected by precise surveys. Such movements tend to be bodily movements towards the extracted goaf area, and are accompanied by low levels of strain, which are generally less than 0.1 mm/m (Appendix A).

Irregular Subsidence Movements

Where faults, dykes and abrupt changes in geology are present at the surface, irregularities in the subsidence profiles can occur. Similarly, where surface rocks are thinly bedded, and where cross-bedded strata exist close to the surface, it is possible for surface buckling to occur, leading to irregular subsidence movements (Appendix A). Given the relatively low density of surface features, the probability of an anomalous movement coinciding with a surface feature is assessed as low (Appendix A). Notwithstanding, geological investigations would be conducted progressively ahead of Project mining operations (Section 4.2.5).

Valley Related Movements

Watercourses may be subject to valley related movements, which are commonly observed along stream alignments in the Southern Coalfield.

Valley related movements are described using the following parameters: upsidence (the reduced subsidence, bulging, or net uplift movement within the base of a valley), closure (the reduction in the horizontal distance between the valley sides), compressive strains (occur within the valley as the result of valley closure movements) and tensile strains (occur adjacent to the valley as the result of valley closure movements).

A number of factors affect valley related movements, including (Kay *et al.*, 2007):

- Longwall geometry, such as panel width, panel length and pillar width.
- Depth of cover, seam extraction height and direction of mining.
- Position of longwall within a series of longwalls and previous adjacent mining.
- Magnitude of subsidence resulting from mining.
- Distance of the valley from mining, orientation of the valley to mining and whether the valley is directly mined beneath.
- Height, width and shape of the valleys, as well as the type of topography in the vicinity of the valleys.
- Geology in the overburden and in the base of the valley, including the type of strata, bedding, jointing and geomechanical properties.
- Composition of the valley sides, whether comprising cliff lines, large talus slopes or colluvium.

Non-systematic subsidence movements are considered in the subsidence impact assessments for key surface features which are summarised in Section 4.2.4. Further detail is provided in Appendix A.

4.2.4 Subsidence Impact Assessment for Key Surface Features

Waratah Rivulet

The MSEC (2008) findings for potential subsidence impacts to the Waratah Rivulet are described in Appendix A. Key findings include (Appendix A):

- The magnitudes of the predicted systematic and/or valley related movements are likely to result in some fracturing and dilation of the underlying strata of the Waratah Rivulet above and immediately adjacent to the proposed longwalls.
- Cracking and dilation of bedrock may result in the localised diversion of a portion of the surface flow into subterranean flows or leakage through rock bars (Figure 4-2).
- Potential changes in bed gradients could occur, however, are anticipated to be small relative to the existing grades.
- An increased potential for scouring of the stream banks (at locations where the predicted tilts considerably increase the natural pre-mining stream gradients). The potential for scouring is greatest in stream sections with alluvial deposits, however since the streambed of the Waratah Rivulet is predominantly Hawkesbury Sandstone, the potential for scouring is expected to be very low.
- The potential for changes to stream alignment as a result of mine subsidence effects is considered to be low.

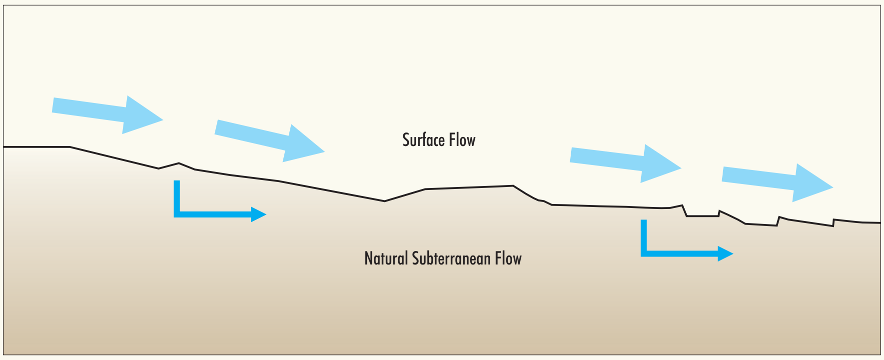
Potential impacts on surface water in Waratah Rivulet, including flows to the Woronora Reservoir are discussed in Section 4.4.2 and Appendix C.

Tributaries of the Waratah Rivulet and Woronora Reservoir

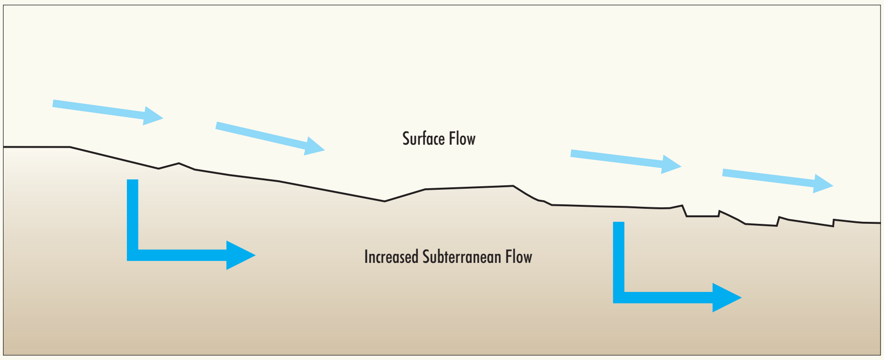
The MSEC (2008) findings for potential subsidence impacts to the tributaries of Waratah Rivulet and Woronora Reservoir are described in Appendix A. Key findings include (Appendix A):

- The magnitudes of the predicted systematic and/or valley related movements are likely to result in some fracturing and dilation of the underlying strata of the tributaries above and immediately adjacent to the proposed longwalls.
- Cracking and dilation of bedrock may result in the localised diversion of a portion of the surface flow into subterranean flows or leakage from pools.
- The potential changes in bed gradients along the tributaries are anticipated to be small proportions of the existing grades.

Potential impacts on surface water in these tributaries, including flows to the Woronora Reservoir are discussed in Section 4.4.2 and Appendix C.

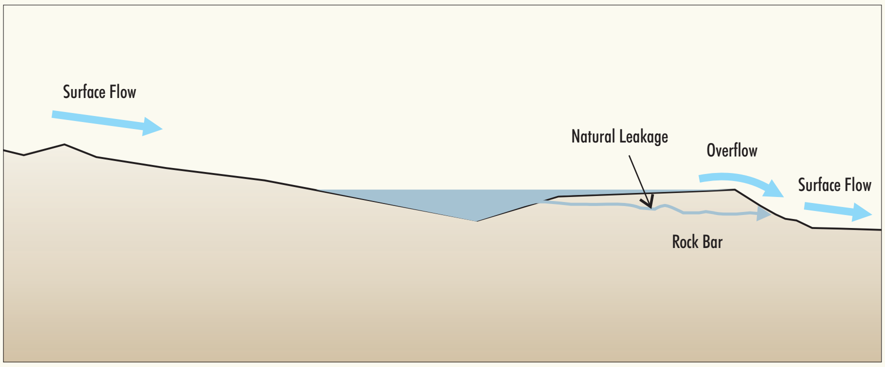


Prior to Mining



Following Mining

Diagrammatic Representation of Subterranean Flows



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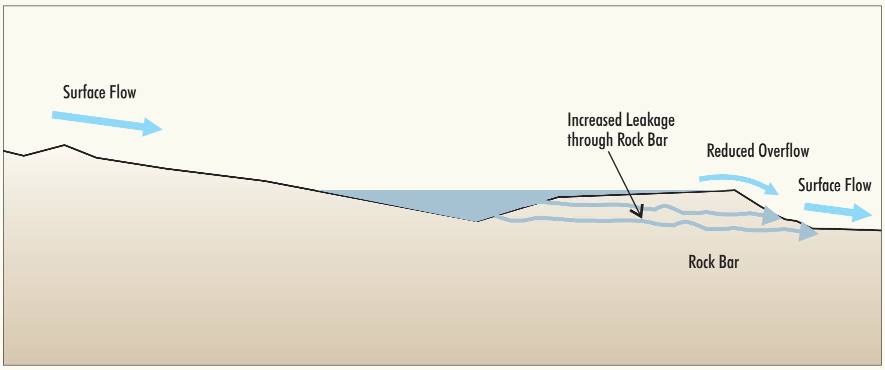

Following Mining

Diagrammatic Representation of Rock Bar Leakage

Source: After MSEC (2008)

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FIGURE 4-2
Diagrammatic Representation
of Subsidence Related Flow Diversion

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Woronora Reservoir

As described in Section 2.5.2, within the Woronora Notification Area (Figure 2-1), the Project mine layout has been varied to conform with the preliminary guideline provided by the Dams Safety Committee (DSC) *Mining in Notification Areas of Prescribed Dams* (DSC, 1998).

The MSEC (2008) findings for potential subsidence impacts to the Woronora Reservoir are described in Appendix A. Key findings include (Appendix A):

- The magnitudes of the predicted systematic and/or valley related movements are likely to result in some fracturing and dilation of the bedrock within the inundation area and stored water area.
- During periods when the reservoir level is lower than the Full Water Supply Level in the inundation area, fracturing and dilation may result in the localised diversion of a portion of the surface flow into subterranean flows or leakage through rock bars (Figure 4-2).
- Although small far-field horizontal movements could potentially be observed at the Woronora Dam, the movements resulting from the extraction of the proposed longwalls are anticipated to be insignificant and would only be detected by precise surveys.

Potential impacts on surface water in Waratah Rivulet, including flows to the Woronora Reservoir are discussed in Section 4.4.2 and Appendix C.

Upland Swamps

The swamps within the Project Underground Mining Area are classified as headwater upland swamps. One in-valley upland swamp is situated outside of the Project Underground Mining Area, but within the potential extent of mine subsidence effects. The MSEC (2008) findings for potential subsidence impacts to upland swamps are described in Appendix A. Key findings include (Appendix A):

- Any cracking within upland swamps 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. The minor cracking within the swamps would generally not be expected to propagate through swamp soil profiles.
- Swamp grades vary naturally and the predicted maximum tilts induced by mine subsidence are generally orders of magnitude lower than the existing natural grades within the swamps. Significant changes in grade within the swamps as a result of mine subsidence are not anticipated.

Potential impacts on upland swamp hydrology as a result of subsidence effects are discussed in Sections 4.3 and 4.4, and Appendices B and C. Potential impacts on upland swamp vegetation as a result of subsidence effects are discussed in Section 4.6 and Appendix G.

Endangered Ecological Communities

The MSEC (2008) findings for potential subsidence impacts to the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC are described in Appendix A. Key findings 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 Underground Mining Area include (Appendix A):

- The maximum predicted tensile and compressive strains (due to systematic subsidence and/or upsidence and closure movements) are likely to be of sufficient magnitude to cause cracking, buckling and/or dilating. Any surface cracking is anticipated to be isolated and of a minor nature due to the relatively low magnitudes of the predicted strains and due to the relatively high depths of cover.
- The potential changes in gradient are anticipated to be small in comparison to the existing natural surface gradients.

Potential impacts on the EEC as a result of subsidence effects are discussed in Section 4.6 and Appendix G.

Cliffs, Overhangs and Slopes

The MSEC (2008) findings for potential subsidence impacts to cliffs, overhangs and slopes are described in Appendix A. Key findings include (Appendix A):

- The magnitudes of the predicted systematic and/or valley related movements are likely to result in some fracturing of sandstone at cliffs and overhangs, and potentially some cliff instabilities and rock fall.
- The lengths of potential instabilities along the cliffs and overhangs resulting from the extraction of the Longwalls 20 to 44 are anticipated to be less than 3% of the lengths of these cliffs and overhangs.
- The aesthetics of the landscape could potentially be temporarily altered by isolated rock falls (e.g. exposure of fresh rock faces and debris around the base of cliffs).
- The incidence of rock falls is expected to be low.
- The magnitudes of the predicted systematic and valley related movements have the potential to cause surface cracking, including surface tension cracking near the tops of slopes. To date, the only surface tension crack reported at Metropolitan Colliery is adjacent to Fire Road 9H which is near the top of a steep slope. The size and extent of surface cracking on slopes is expected to be minor, which is consistent with that observed during the extraction of previous longwalls at the Metropolitan Colliery.
- Mine subsidence would be unlikely to result in any significant slope failure, as such failures have not been observed as the result of longwall mining in the Southern Coalfield.

Consideration of the potential impacts on terrestrial flora and fauna and Aboriginal heritage associated with these effects is provided in Sections 4.6 to 4.8, and Appendices G and H.

Aboriginal Heritage

The MSEC (2008) findings for potential subsidence impacts to Aboriginal heritage sites are described in Appendix A. Key findings include (Appendix A):

- Some 188 Aboriginal heritage sites have been identified within the Project Underground Mining Area or surrounds (Appendix H) and are broadly characterised as open sites or overhang sites.
- Open Aboriginal heritage sites can potentially be impacted by the cracking of sandstone resulting from systematic movements and/or valley related movements. Any cracking of the exposed sandstone is expected to be isolated and of a minor nature, due to the relatively low magnitudes of the predicted strains and due to the relatively high depths of cover.
- Overhang sites can potentially be impacted by the cracking of sandstone, rock falls or water seepage through joints which may impact artwork. The Project may result in the cracking of sandstone and where cracking coincides with an overhang, may result in an isolated rock fall.

Potential impacts on Aboriginal heritage sites are discussed in Section 4.8 and Appendix H.

Infrastructure, Improvements and Private Land Holdings

The potential subsidence impacts on infrastructure, improvements and private land holdings are assessed in Appendix A.

Infrastructure, improvements and private land holdings located within the potential extent of mine subsidence effects (including far field horizontal movements, upsidence and closure movements) include:

- the Garrawarra Complex;
- the Illawarra Railway;
- public roads (e.g. F6 Southern Freeway and Princes Highway);
- fire trails, four wheel drive tracks and other minor roads;
- bridges;
- electrical services (e.g. electricity transmission lines and towers);
- Sydney Water infrastructure;
- telecommunications lines (e.g. optical fibre and copper cables);
- houses;
- rural building structures (e.g. farm sheds, garages and other non-residential structures);
- tanks;
- farm dams; and
- survey marks.

Potential impacts that have been identified with respect to such structures include cracking of road surfaces, opening of joints in pipelines, alteration of tension of electricity transmission lines and cracks in masonry. However, in each case, consultation with the infrastructure owners (Section 3.5.6) and studies by MSEC (2008) have identified suitable monitoring, remediation or mitigation measures to be applied via the SMP process (Section 3.3.1), where required. Potential subsidence impacts on items of surface infrastructure arising from the Project can be managed by the preparation and implementation of suitable management strategies (Appendix A).

4.2.5 Mitigation Measures, Management and Monitoring

In mines where the depth of cover is low and the excavation width to depth ratio is high (e.g. Newcastle Coalfield), subsidence over each excavation may develop independently of that over the adjacent longwall panels. This results in near symmetrical subsidence with compression of the pillars between the panels making only a minor contribution to vertical displacement. In these circumstances, over 90% of the final vertical displacement, tilt and strain at a surface point is usually reached within weeks of the completion of mining beneath (DoP, 2008). There is generally a high degree of predictability for subsidence profiles and a close correlation between predicted and observed outcomes.

At mines with an increased depth of cover, such as those in the Southern Coalfield, a greater proportion of the weight of the overburden above an excavation is transferred onto the panel abutments (DoP, 2008). As a result, a number of adjacent panels may need to be extracted before the overall mining span is sufficiently large to result in the full deadweight load of the overburden acting on the mine workings (incremental displacement). Hence, it might be several years after initial undermining before final vertical displacement, tilt and strain are reached at a point on the surface (DoP, 2008). Consequently, minor step-backs from particular surface features generally cannot be utilised in the Southern Coalfield as a method of minimising/avoiding subsidence impacts at the surface.

Prior to the commencement of longwall mining and periodically during the life of the Project, SMPs would be developed in consultation with the relevant authorities (Section 3.3.1). The SMPs would document the monitoring and management measures for potential subsidence impacts on key surface features.

Geological investigations would be undertaken progressively during the life of the Project and would inform subsidence prediction and the development of subsidence management measures where relevant (Section 3.7.2).

Management, mitigation and monitoring measures of relevance to potential subsidence impacts on groundwater, surface water, aquatic ecology, terrestrial flora and fauna, Aboriginal heritage, non-Aboriginal heritage and visual character are described in Sections 4.3 to 4.9 and Section 4.16.

Section 5 describes HCPL's proposed subsidence monitoring and adaptive management approach with respect to subsidence effects at the Waratah Rivulet over the life of the Project.

Measures to manage the impacts of mine subsidence on other man-made surface infrastructure would be developed in consultation with the infrastructure owners via the SMP process and is likely to include the aspects described below and in Appendix A.

Consideration of Project alternatives is provided in Section 3.9.

Garrawarra Centre

HCPL identified that control measures were required for the management of potential subsidence effects on longer building structures at the Garrawarra Centre. Detailed mine design in the vicinity of the Garrawarra Centre would be constrained such that any impacts to the buildings resulting from systematic subsidence movements would be negligible (Appendix A).

Management and mitigation measures for the Garrawarra Centre are described in Section 4.9 and Appendices A and I.

Illawarra Railway

A monitoring, management and response plan would be established for the Illawarra Railway to the satisfaction of RailCorp. As part of detailed mine design studies and SMP preparation, a design review would be undertaken including a review of predicted far-field horizontal movements for the railway near Cawley's Creek crossing. Subsidence assessment undertaken as part of this EA indicates that management of potential subsidence effects on this structure would be readily achievable. Monitoring of the railway would be undertaken as relevant Project longwalls are mined to confirm that the observed ground movements are consistent with predictions.

Public Roads

As part of detailed mine design studies and SMPs, a design review would be undertaken to determine any specific management measures required to be implemented for the F6 Southern Freeway. A monitoring, management and response plan for the F6 Southern Freeway would be prepared to the satisfaction of the RTA in order to monitor subsidence movements and maintain the pavement in a safe and serviceable condition throughout the Project life.

A similar monitoring management and response plan for the Princes Highway would be prepared to the satisfaction of the RTA and WCC. This would include monitoring of the Princes Highway so that potential impacts can be identified and remediated accordingly and to maintain the road in a safe and serviceable condition throughout the Project life.

Fire Trails, Four Wheel Drive Tracks and Other Minor Roads

Woronora Dam road, fire trails in the Woronora Special Area and other minor roads would be monitored during mining in accordance with SMP requirements. Any subsidence related cracking observed would be repaired to the satisfaction of the relevant land owner or the WCC.

Bridges

As described in Section 3.5.3, in accordance with the recommendations of the Subsidence Assessment (Appendix A) and in consultation with the RTA, HCPL commissioned a supplementary assessment *Bridges near Proposed Longwalls 18 to 44 at Metropolitan Colliery* (Cardno, 2008) for three key structures on the F6 Southern Freeway (*viz*. Underpass No. 1; Princes Highway Underpass No. 2 and the Cawley Road Overbridge). Cardno (2008) identified that Underpass No. 2 and Cawley Bridge have the capacity to tolerate only low magnitudes of ground movement. Cardno (2008) indicated that potential impacts from far field movements can be managed through the establishment of a suitable management plan.

Detailed engineering management measures and a risk assessment would be conducted for these bridges during the SMP process to meet RTA requirements.

Electrical Services

A monitoring, management and response plan would be established to the satisfaction of electrical services owners and would include transmission line inspections prior to mining to assess existing condition. Suitable management measures would be developed based on the findings of the detailed design to maintain the transmission lines in a safe and serviceable condition throughout the Project life.

Sydney Water Infrastructure

Predicted subsidence movements along the Sydney Water pipelines would be reviewed by Sydney Water, to inform the design of any specific management measures required for the SMPs. Regular monitoring of pipelines or particular points along the water distribution system may be required to maintain them in a safe and serviceable condition throughout the Project life.

Optical Fibre and Copper Telecommunications Cables

A monitoring, management and response plan would be established for optical fibre and copper cables prior to mining the Project longwalls, to the satisfaction of the cable owners. Optical fibre cables would be monitored during the extraction of the Project longwalls using optical fibre sensing techniques, such as Optical Time Domain Reflector (OTDR) monitoring. Management measures (e.g. excavating and exposing the cables) would be undertaken if a strain concentration was detected during mining that required management.

Houses

The limited number of houses in close proximity to the Project Underground Mining Area would be inspected prior to extraction of nearby longwalls to assess the existing condition of the house and to identify if any specific management measures are required. The houses would also be regularly visually monitored during the extraction of the nearby longwalls, with any minor effects remediated as required.

Rural Buildings, Structures Tanks and Dams

Rural buildings (e.g. sheds, garages), tanks and farm dams within the vicinity of the Project longwalls would be inspected prior to mining to assess existing condition and to identify whether any management measures may be required.

Visual monitoring of rural buildings, tanks and farm dams would be undertaken during the extraction of nearby longwalls, with any minor effects remediated as required.

Survey marks

Survey marks would be re-established, as required following mining, in consultation with the Department of Lands.

4.3 GROUNDWATER

A Groundwater Assessment for the Project was conducted by Heritage Computing (Dr Noel Merrick) and is presented in Appendix B. A description of the groundwater resources is provided in Section 4.3.1. Section 4.3.2 describes the potential impacts of the Project on groundwater resources, while Section 4.3.3 outlines mitigation measures, management and monitoring.

The findings of the Groundwater and Surface Water Assessment reports are consistent and independently reinforce each other.

4.3.1 Existing Environment

Hydrogeological Data

A number of groundwater studies and monitoring programmes have been undertaken at the Metropolitan Colliery and surrounds. The Groundwater Assessment analysed a comprehensive data set including:

- Southern Coalfield geology mapping;
- local and regional geological bore logs;
- relevant data from the DWE register on the Natural Resources Atlas;
- hydrogeological monitoring and assessments undertaken for Metropolitan Colliery and other Southern Coalfield mining operations;
- hydrogeological investigations and assessments undertaken for the Upper Nepean (Kangaloon) Borefield Project for the SCA;
- Metropolitan Colliery deep borehole groundwater investigations (i.e. Longwall 10 goaf hole and PM02 hole described below); and
- groundwater level and groundwater quality monitoring data from bores in the Woronora Special Area (Figure 4-3).

As a component of the Groundwater Assessment piezometric monitoring and geological information was obtained from a borehole developed from the surface at Longwall 10 in the Completed Underground Mining Area (the Longwall 10 goaf hole). The Longwall 10 goaf hole was drilled to the east of Waratah Rivulet adjacent to a fire road (Figure 4-3) in February to April 2007.

The bore was developed to a depth of approximately 327 m, which is approximately 130 m above the goaf zone (Appendix B). At the time of drilling of the Longwall 10 goaf hole, mining was advancing along Longwall 14 about 700 to 900 m to the west.

Investigations undertaken at the Longwall 10 goaf hole included (SCT Operations, 2007; Waring *et al*., 2007; Heritage Computing, 2008):

- lithological logging;
- geophysical logging – natural gamma, caliper and density;
- installation and monitoring of vibrating wire piezometers;
- falling head tests;
- packer tests;
- core fracture analysis;
- core measurements of hydraulic conductivity;
- geophysical logging – prompt gamma neutron activation, caliper and density; and
- geochemical analysis at two intervals with probable fractures.

In addition, an exploration borehole (PM02) was drilled in December 2007 to the west of Woronora Reservoir in the central Project Underground Mining Area (Figure 4-3). The PM02 bore reached a depth of approximately 575 m and extends from the surface to below the Bulli Seam. Vibrating wire piezometers were installed in the hole and hydrostatic pressure heads were recorded. Further details of the Longwall 10 goaf hole and PM02 exploration borehole investigations are provided in Appendix B.

Examination of the hydrogeological data has facilitated an understanding of the existing groundwater systems and the scale and nature of the existing effects of the Metropolitan Colliery (and other nearby mines) on local and regional groundwater systems.

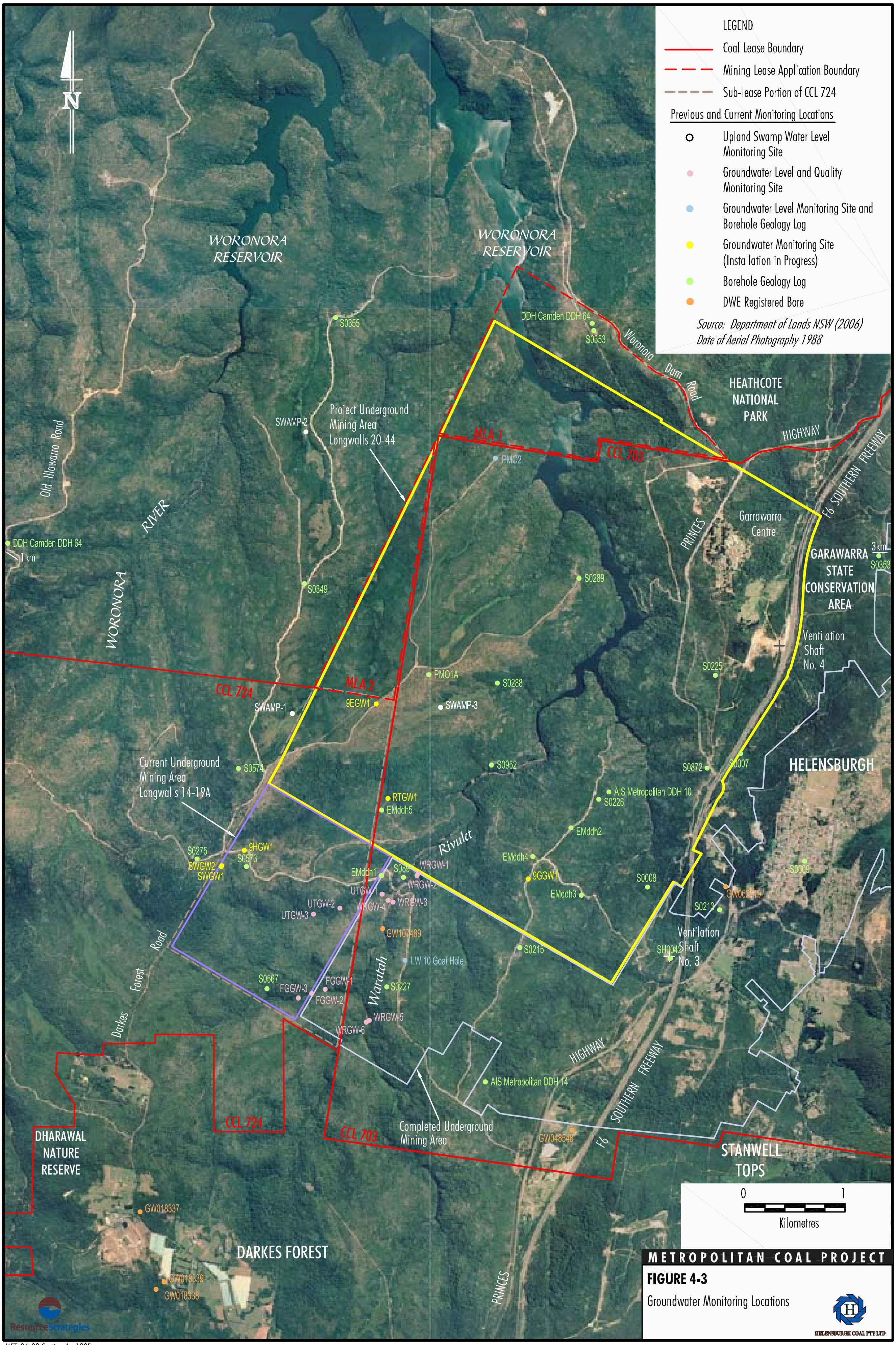

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FIGURE 4-3

Groundwater Monitoring Locations

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Hydrogeological Regime

Apart from coal seam aquifers at depths of greater than 400 m from the surface, the recognised aquifers in the stratigraphic sequence at the Project include the Hawkesbury Sandstone and the sandstones of the Narrabeen Group (Appendix B and Figure 4-4). Whilst of very low permeability, the Hawkesbury Sandstone has the relatively higher permeability compared to other units and is therefore capable of higher groundwater yields.

The Hawkesbury Sandstone outcrops over the area in the form of the Woronora Plateau, and due to alternation of sheet and massive facies, groundwater flow is primarily horizontal with minor vertical leakage (Appendix B).

A conceptual model of the hydrogeological regime was developed based on the review of hydrogeological data. The data supports three separate groundwater systems (Appendix B), including:

- Perched groundwater system – controlled more by depth below ground than by regional gradients. Apart from shallow sandstone, perched water tables also occur in upland swamps which are described below.
- Shallow groundwater system - the shallow groundwater system is separate from the perched groundwater system. The groundwater levels in the mid Hawkesbury Sandstone have a hydraulic gradient of approximately 1:120 which is similar to the natural surface water gradient and suggest that groundwater levels in the shallow groundwater system define a regional water table. There is a clear lateral hydraulic gradient for shallow groundwater flow towards the Waratah Rivulet and the Woronora Reservoir (Appendix B).
- Deep groundwater system – there is a hydraulic disconnect between the deep groundwater system and shallow groundwater systems due to the low permeabilities of the Bald Hill Claystone and the Upper Bulgo Sandstone which lie beneath the Hawkesbury Sandstone that hosts shallow groundwater (Figure 4-4). This is consistent with SCA's findings in the *Upper Nepean (Kangaloon) Borefield Project Environmental Assessment* (KBR, 2008) which states:

  > *At depth, the Bald Hill Claystone also stops the vertical flow of groundwater because it, too, acts as an effective confining layer.*

  The base of the Narrabeen Group, at the top of the Bulli Seam is marked by the Wombarra Claystone (Figure 4-4). This unit is an aquitard that limits vertical flow into mine workings in the Bulli Seam (Appendix B and Figure 4-4). The Coal Cliff Sandstone lies between the Wombarra Claystone and Bulli Seam (Figure 4-4).

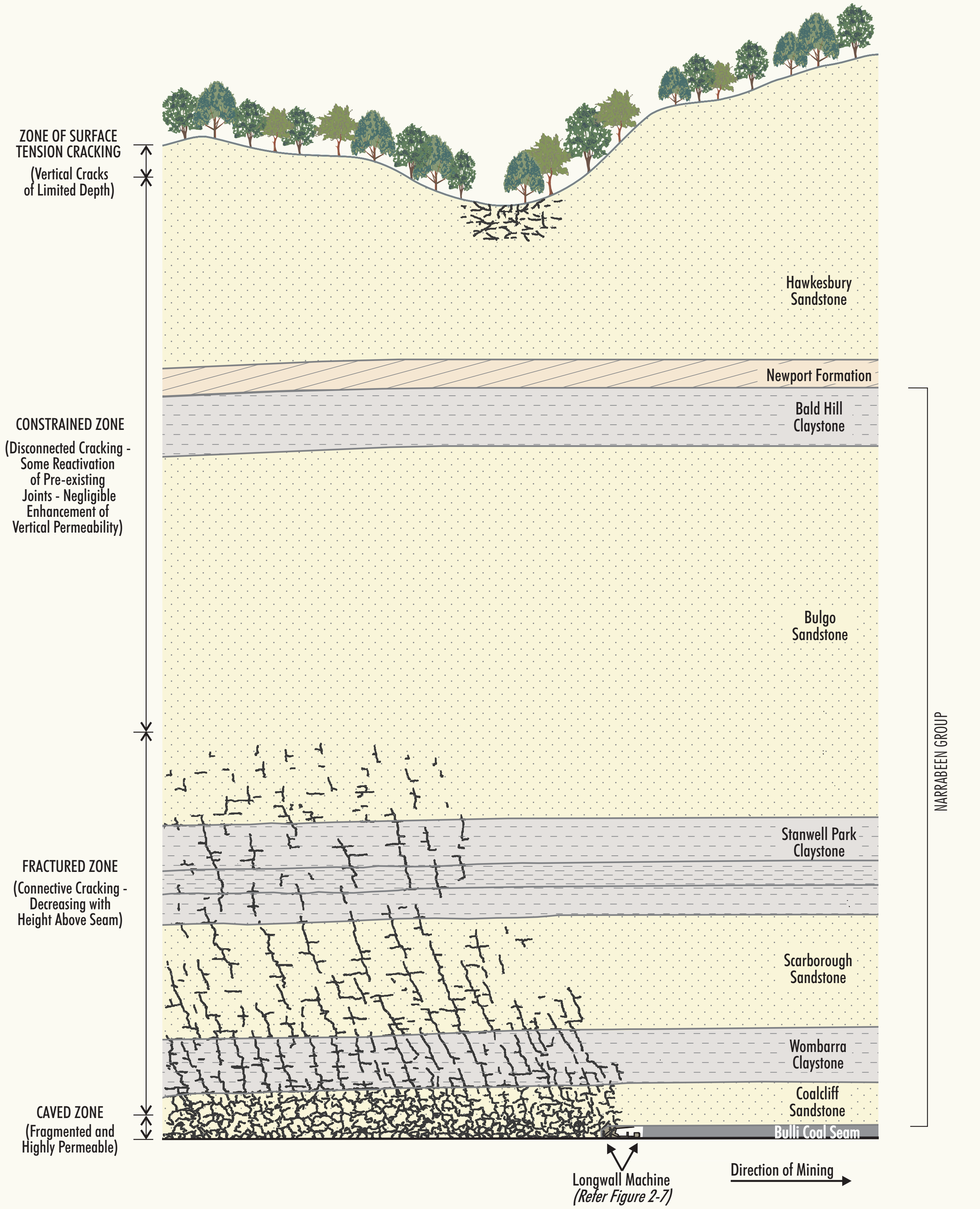
Recharge to the groundwater system is from rainfall and from lateral groundwater flow. Although groundwater levels are sustained by rainfall infiltration, they are controlled by ground surface topography and surface water levels. A local groundwater mound develops beneath the sandstone hills with ultimate discharge to incised creeks and waterbodies. Loss by evapotranspiration through vegetation where the water table is within a few metres of the ground surface occurs within upland swamps and outcropping sandstone.

During short events of high surface flow, streams can lose water to the sandstone aquifers that host the streams, but during stream flow recession, the sandstone will discharge water slowly back into the stream from bank storage. Groundwater also discharges naturally to cliff faces and ultimately to the sea. In places where mining has occurred, groundwater discharge is expected to occur to the mined seam from above and below in proportion to local permeabilities (Appendix B).

Upland Swamp Hydrology

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*.). 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).

Topographically, upland swamps occur mainly on the eastern, higher parts of the Woronora Plateau. In more dissected catchments, the swamps are confined largely to headwater tributaries (Young, 1986). Hawkesbury Sandstone provides a low permeability base on which the swamp sediments and organic matter rest (Appendix B). Hawkesbury Sandstone is also the predominant source of sediment for the upland swamps (*ibid*.).



Not to Scale

After: Geosensing Solutions (2008), Heritage Consulting (2008)

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FIGURE 4-4
Schematic - Longwall Mining and Subsidence Profile

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The sandy sediment accumulation in the swamps traps rainfall infiltration, seepage and low-flow runoff. Rainfall saturates the accumulating swamp material with drainage impeded by low floor slope, the low permeability sandstone base and the dense swamp vegetation (Appendix B). Partially decayed organic matter accumulates in the sediments, further increasing their water-holding capacity (Young, 1986).

Broadly, upland swamps can be classified as headwater upland swamps or in-valley upland swamps (Appendix B), as described below.

Headwater upland swamps 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. 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 regional water table in the underlying Hawkesbury Sandstone. During rain events, some stream flow and runoff along indistinct braided channels occurs. The growth of dense vegetation and the low land gradient prevent the formation of an open drainage 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 (Appendix B).

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 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 in-valley swamps 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 (Appendix B).

All swamps within the Project Underground Mining Area are classified as headwater upland swamps (Figure 4-5). One in-valley upland swamp is situated outside of the Project Underground Mining Area, but within the potential extent of mine subsidence effects (Figure 4-5). This in-valley swamp overlies completed Longwalls 7 and 8 and consequently has already experienced mine subsidence from operations in the Completed Underground Mining Area. Site inspections of this in-valley swamp by FloraSearch indicate that the previous mine subsidence has not had a detrimental effect on vegetation health, vegetation community composition or abundance in the swamp and the swamp is considered to be in a healthy condition (Appendix G).

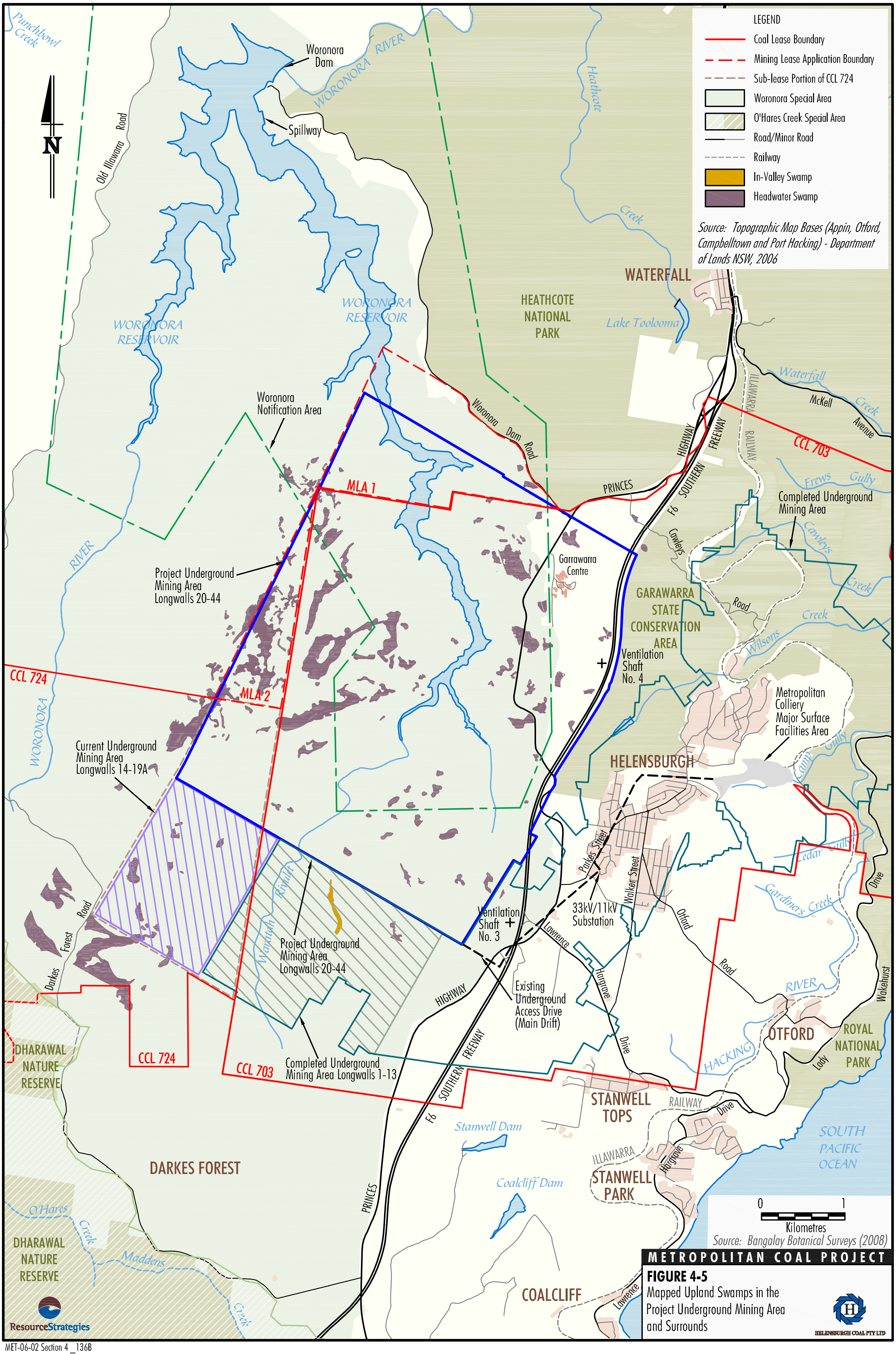
Groundwater Use

As described above, the only recognised economic aquifer in the area is the Hawkesbury Sandstone. The Metropolitan Colliery lies within the Hawkesbury Sandstone–South-East groundwater flow system as defined by Grey and Ross (2003). This groundwater flow system includes the Nepean, Avon, Cordeaux, Cataract and Woronora Reservoirs. According to the Natural Resources Atlas, there are seven registered bores in the vicinity of the Metropolitan Colliery (detailed in Appendix B). There is no known use of the Narabeen Group aquifer in the Southern Coalfield (Appendix B).

Groundwater dependent ecosystems that occur within the Project Underground Mining Area and surrounds are described in Sections 4.4 to 4.7 and Appendices C to G.

Groundwater Quality

The Hawkesbury Sandstone is a low yield aquifer of generally good quality beneath the Woronora Plateau and the Illawarra Plateau, although the water quality deteriorates rapidly towards the northern limits of the Southern Coalfield. In the vicinity of the Metropolitan Colliery, the salinity is generally in the range 1,000 to 3,000 milligrams per litre (mg/L) (Appendix B).


LEGEND
Coal Lease Boundary
Mining Lease Application Boundary
Sub-lease Portion of CCL 724
Woronora Special Area
O'Hares Creek Special Area
Road/Minor Road
Railway
In-Valley Swamp
Headwater Swamp
Source: Topographic Map Bases (Appin, Otford, Campbelltown and Port Hacking) - Department of Lands NSW, 2006
Woronora Dam
Spillway
WORONORA RIVER
WORONORA RESERVOIR
Woronora Notification Area
Project Underground Mining Area Longwalls 20-44
Current Underground Mining Area Longwalls 14-19A
Completed Underground Mining Area Longwalls 1-13
Completed Underground Mining Area
Existing Underground Access Drive (Main Drift)
Ventilation Shaft No. 3
Ventilation Shaft No. 4
33kV/11kV Substation
Garrawarra Centre
Metropolitan Colliery Major Surface Facilities Area
MLA 1
MLA 2
CCL 724
CCL 703
WATERFALL
HEATHCOTE NATIONAL PARK
GARAWARRA STATE CONSERVATION AREA
HELENSBURGH
OTFORD
ROYAL NATIONAL PARK
STANWELL TOPS
STANWELL PARK
COALCLIFF
DARKES FOREST
DHARAWAL NATURE RESERVE
SOUTH PACIFIC OCEAN
Lake Toolooma
Stanwell Dam
Coalcliff Dam
PRINCES HIGHWAY
SOUTHERN FREEWAY
ILLAWARRA RAILWAY
Kilometres
Source: Bangalay Botanical Surveys (2008)
METROPOLITAN COAL PROJECT
FIGURE 4-5
Mapped Upland Swamps in the Project Underground Mining Area and Surrounds
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Resource Strategies
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Table 4-3 summarises the water quality attributes of monthly groundwater samples taken between March 2007 and February 2008 at shallow groundwater monitoring sites in the Woronora Special Area by HCPL and the SCA (Figure 4-3). This data includes monitoring sites that have previously experienced subsidence effects.

The groundwater is fresh, as indicated by a median electrical conductivity of 230 microSiemens per centimetre (µS/cm). Although there are no deep groundwater quality samples available, the salinity of deeper waters is expected to be much higher (Appendix B).

4.3.2 Potential Impacts

The potential impacts of the Project on groundwater resources are described in Appendix B and summarised below.

Perched Groundwater Systems

Excess rainfall produces a permanent perched water table within swamp sediments and outcropping sandstone that is independent of the regional water table in the Hawkesbury Sandstone. As the swamps are essentially rainfall-fed, water levels within upland swamps fluctuate seasonally with climatic conditions.

Surface cracking resulting from mine subsidence within the upland swamps is not expected to result in an increase in the vertical movement of water from the perched water table into the regional aquifer as the sandstone bedrock is massive in structure and permeability decreases with depth.

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 (Appendix B). 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.
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 (Appendix B).

Available data from studies undertaken by the SCA for the Kangaloon borefield supports the overall assessment that the shallow regional aquifer is hydraulically disconnected from perched water in upland swamps.

Table 4-3
Summary at Shallow Groundwater Monitoring Sites
(March 2007 to February 2008)

Analyte	Unit	Median	Minimum	Maximum	Average
pH	-	6.3	4.0	8.2	6.3
Total Dissolved Solids	mg/L	145.0	58.0	519.2	165.7
Electrical Conductivity	µS/cm	230.0	95.0	683.0	261.2
Turbidity	NTU	50.0	0.1	1,700.0	93.4
Iron (Fe)	mg/L	0.5	0.01	16.0	3.2
Aluminium (Al)	mg/L	0.1	0.01	0.6	0.1
Manganese (Mn)	mg/L	0.3	0.001	1.3	0.3
Sodium (Na)	mg/L	24.0	13.0	109.0	28.8
Calcium (Ca)	mg/L	15.0	0.7	90.0	20.2
Potassium (K)	mg/L	1.0	0.2	4.0	1.3
Magnesium (Mg)	mg/L	5.6	2.1	16.0	6.7
Ammonium Nitrogen (NH_4-N)	mg/L	0.1	0.1	0.3	0.1
Chloride (Cl)	mg/L	40.0	19.8	53.0	39.9
Fluoride (F)	mg/L	0.1	0.1	0.2	0.1
Sulphate (SO_4)	mg/L	8.0	1.0	23.0	7.8
Bicarbonate (HCO_3)	mg/L	72.0	1.0	330.0	100.0
Phosphate (PO_4)	mg/L	0.1	0.1	0.5	0.1

Source: Appendix B.

Shallow Groundwater Systems and Inflows to the Woronora Reservoir

Permanent mining-induced changes in the groundwater levels of shallow aquifers in connection with streams and ecosystems at the Metropolitan Colliery have not been observed to occur (Appendix B).

Stream beds at the Metropolitan Colliery have experienced cracking in response to subsidence effects. This has been observed to result in the diversion of a portion of surface water flows through fractures beneath the stream bed to move as underflow through the aquifer immediately beneath the stream, with emergence further downstream (Figure 4-2). This process is described further in Section 4.4. There is no evidence that cracking in streambeds causes any net change in the overall water balance of a stream (Appendices B and C).

At the goaf hole drilled above Longwall 10 (which has already been mined by HCPL) the direction of shallow groundwater system flow (i.e. in the Hawkesbury Sandstone) has not been altered by mining, and the Waratah Rivulet is still gaining baseflow from the shallow groundwater aquifer (Appendix B). The head difference between the shallow groundwater system at the Longwall 10 goaf hole and the Waratah Rivulet is about 30 m, and the horizontal hydraulic gradient is about 1:10. This gradient maintains horizontal flow through the Hawkesbury Sandstone to the Waratah Rivulet (Appendix B).

As there is an alternation of thick sandstone/ claystone lithologies, there is a constrained zone in the overburden that remains rigid and acts as a bridge which isolates shallow and deep aquifers. At the substantial depths of cover at the Project, there would not be connective cracking from the mined seam to the surface (Appendix B).

The depressurisation effects described below for the deep groundwater system would not propagate to the Hawkesbury Sandstone where the shallow groundwater system is located (Appendix B). Hence no impacts on registered bores in the wider Project area and surrounds would be expected.

Based on the analysis of the conceptual groundwater system, there would be no loss of groundwater yield to the Woronora Reservoir. This is reinforced by the groundwater modelling which indicates negligible reduction in cumulative average inflows to the Woronora Reservoir (Appendix B).

This is consistent with the findings of the SCPR (DoP, 2008) which states:

> *No evidence was presented to the Panel to support the view that subsidence impacts on rivers and significant streams, valley infill or headwater swamps, or shallow or deep aquifers have resulted in any measurable reduction in runoff to the **water supply system** operated by the Sydney Catchment Authority or to otherwise represent a threat to the water supply of Sydney or the Illawarra region.*

Surface Water Quality Impacts

Local surface water quality impacts as a result of enhanced groundwater-surface water interactions are discussed in Appendix C and Section 4.4.

Depressurisation of the Deep Groundwater System

Immediately above a mined coal seam, rocks collapse into the void created by removal of the coal to form a caved zone and a fractured zone develops above the caved zone (Figure 4-4). This causes aquifer properties to change (e.g. permeability and porosity) and results in a higher vertical permeability as a result of mining.

Experience at the Metropolitan Colliery suggests that substantial depressurisation of the deep aquifers in the fractured zone above the goaf is restricted to a height of less than 130 m from the top of the goaf (Figure 4-4), while transient pressure effects have been observed to propagate to a height of about 300 m above the goaf (Appendix B). There is a pronounced increase in vertical hydraulic gradient in the deep groundwater system over the current Metropolitan Colliery longwalls (Appendix B).

Above goaf zones there would be substantial changes in fracture porosity and permeability, due to opening up of existing joints, new fractures and bed separation. Permeability increases would have accompanying reductions in hydraulic gradients, with associated changes in groundwater levels and pressures. Pronounced changes in groundwater levels can occur without any significant drainage into a mine, particularly from the Narrabeen Group sandstones (Appendix B).

Groundwater discharge to the mined seam would occur from above and below the seam in proportion to local permeabilities. Although there is no metered water balance for the existing Metropolitan Colliery longwall mining area, it is described as a "dry mine" and the water make (inflow) is expected to be less than 0.1 megalitres per day (ML/day) (Appendix B).

There is also likely to be inflows of about 1.5 ML/day to old workings at Darkes Forest and Helensburgh, and development workings at North Cliff (about 0.5 ML/day each) (Appendix B). The final Project mine inflow is predicted to be in the order of 0.5 ML/day from the deep groundwater system at the completion of the Project (Appendix B). At the substantial depths of cover at the Metropolitan Colliery (Figure 4-4), there would be no connective cracking from the ground surface to the mined coal seam (Appendix B). Groundwater modelling for the Project indicates that there is expected to be eventual recovery of deep groundwater system pressures over many decades following the cessation of mining (Appendix B).

Underground Disposal of Coal Rejects

Underground backfilling of the mine void by goaf injection or underground emplacement into the old underground workings has been considered in the Groundwater Assessment. Relative to other transmissive and storage properties of overburden rock, backfilling would have negligible influence on the groundwater resource (Appendix B).

Climate Change and Groundwater

Climate change and greenhouse gas emissions associated with the Project are discussed in Section 3.8 including the potential groundwater impacts of the Project in the context of global climate change.

4.3.3 Mitigation Measures, Management and Monitoring

As described in Section 3.3.1, over the life of the Project SMPs would progressively be prepared. Project geological investigations, groundwater monitoring and response measures would be detailed in these SMPs, where relevant.

Geological Investigation Programme

Geological investigations would be undertaken progressively over the life of the Project. The key components of the geological investigation programme would include:

- long in-seam exploration boreholes to identify any geological anomalies in advance of longwall mining;
- mapping of geological structures intersected by underground workings;
- surface mapping (ground-truthing) of geological characteristics; and
- further analysis of geomorphic expressions.

The above activities would focus on the identification of potential conduits (e.g. faults, dykes, joint seams) and include extrapolation from areas external to the Project Underground Mining Area.

Groundwater Monitoring

The existing groundwater monitoring programme for Longwalls 14 to 17 at the Metropolitan Colliery would be augmented by the groundwater monitoring program developed for Longwalls 18 to 19A in the Current Underground Mining Area which includes (Appendix B):

- three sets of deep multi-level piezometers to the Bulli Seam on ridgelines (i.e. in recharge areas) along Fire Roads 9E, 9G and 9H;
- three sets of deep multi-level groundwater sampling boreholes on ridgelines (i.e. in recharge areas) along Fire Roads 9E, 9G and 9H;
- paired bores at a swamp location (SWGW1 and SWGW2); and
- nested piezometers to approximately 60 m (near the base of the Hawkesbury Sandstone) immediately adjacent to a pool on a tributary stream (RTGW1).

This groundwater monitoring programme and any supplementary components that may be required for the Project would be detailed in a Project EMP. The groundwater monitoring programme for the Project would be supplemented with additional deep monitoring bores in consultation with the DSC. The frequency, parameters and locations monitored as part of the groundwater quality monitoring programme would be described in the EMP (Section 6).

Stream Restoration Measures

HCPL has successfully demonstrated restoration of the WRS4 rock bar through the application of polyurethane (PUR) in accordance with the strict requirements of the SCA (HCPL, 2008b). HCPL is committed to undertaking restoration works at the WRS5, 6, 7 and/or 8 rock bars, where future assessment indicates the need (Sections 5 and 6).

4.4 SURFACE WATER

A Surface Water Assessment for the Project was conducted by Gilbert and Associates and was peer reviewed by Dr Walter Boughton (Attachment 3), an internationally recognised hydrological expert. The Surface Water Assessment is presented in Appendix C. A description of the surface water resources is provided in Section 4.4.1. Section 4.4.2 describes the potential impacts of the Project on surface water resources, while Section 4.4.3 outlines mitigation measures, management and monitoring.

4.4.1 Existing Environment

Surface Water Data

A range of surface water studies and sampling programmes have been undertaken at the Metropolitan Colliery and surrounds. The Surface Water Assessment analysed a comprehensive data set including:

- rainfall records from BoM, SCA and HCPL pluviometers;
- SCA gauging station flow data (continuous – hourly) for Woronora River and Waratah Rivulet (Figure 4-6);
- HCPL gauging station flow data for Waratah Rivulet (Figure 4-6);
- DWE O'Hares Creek gauging stations (Darkes Forest/Wedderburn) flow data;
- HCPL pool water level data for Waratah Rivulet and other local streams (Figure 4-6);
- SCA and HCPL water quality data for Waratah Rivulet and other local streams (Figure 4-6);
- SCA Woronora Reservoir spill volumes;
- SCA Woronora Reservoir extraction volumes; and
- SCA Woronora Reservoir water storage and quality data.

Regional Hydrology

The Project is situated on the Woronora Plateau, within the Woronora Reservoir and the Hacking River catchments. The Woronora Reservoir is a public water supply dam which supplies water to consumers within the Sutherland Shire Council area. A large portion of the Project is located within the Woronora Special Area, which is approximately 75 square kilometres (km^2) in area and includes all the land draining to the Woronora Reservoir (Appendix C) (Figure 2-1).

Part of the Project Underground Mining Area is located within the DSC Notification Area for the Woronora Reservoir (Figure 2-1).

The Woronora River is a tributary of the Woronora Reservoir (Figure 4-6). The Woronora River is unaffected by longwall mining activities. Overflow from the Woronora Reservoir flows into the lower reaches of the Woronora River (Figure 1-1) and ultimately the Georges River.

Local Hydrology – Project Underground Mining Area

The Project Underground Mining Area includes the Waratah Rivulet catchment and tributaries that flow directly to the Woronora Reservoir, as well as the upper reaches of the Woronora Reservoir (Figure 4-6). The headwaters of Cawley's Creek and Wilson's Creek, which drain in an easterly direction away from Woronora Reservoir into the Hacking River are also situated within the Project Underground Mining Area (Figure 1-2). An overview of the watercourses is provided below.

Waratah Rivulet

The Waratah Rivulet is some 9 km in length from its headwaters to the full supply level of the Woronora Reservoir.

The Waratah Rivulet flows through a relatively steep valley and has been subject to previous underground mining (Figure 2-1). The stream channel in Waratah Rivulet in the Project Underground Mining Area is characterised by a gently meandering, relatively shallow, wide channel with a sandstone bed (Appendix C). The channel contains a series of in-stream pools that have formed in local depressions in the bedrock and behind rock bars. There are also reaches that are covered in large boulders.

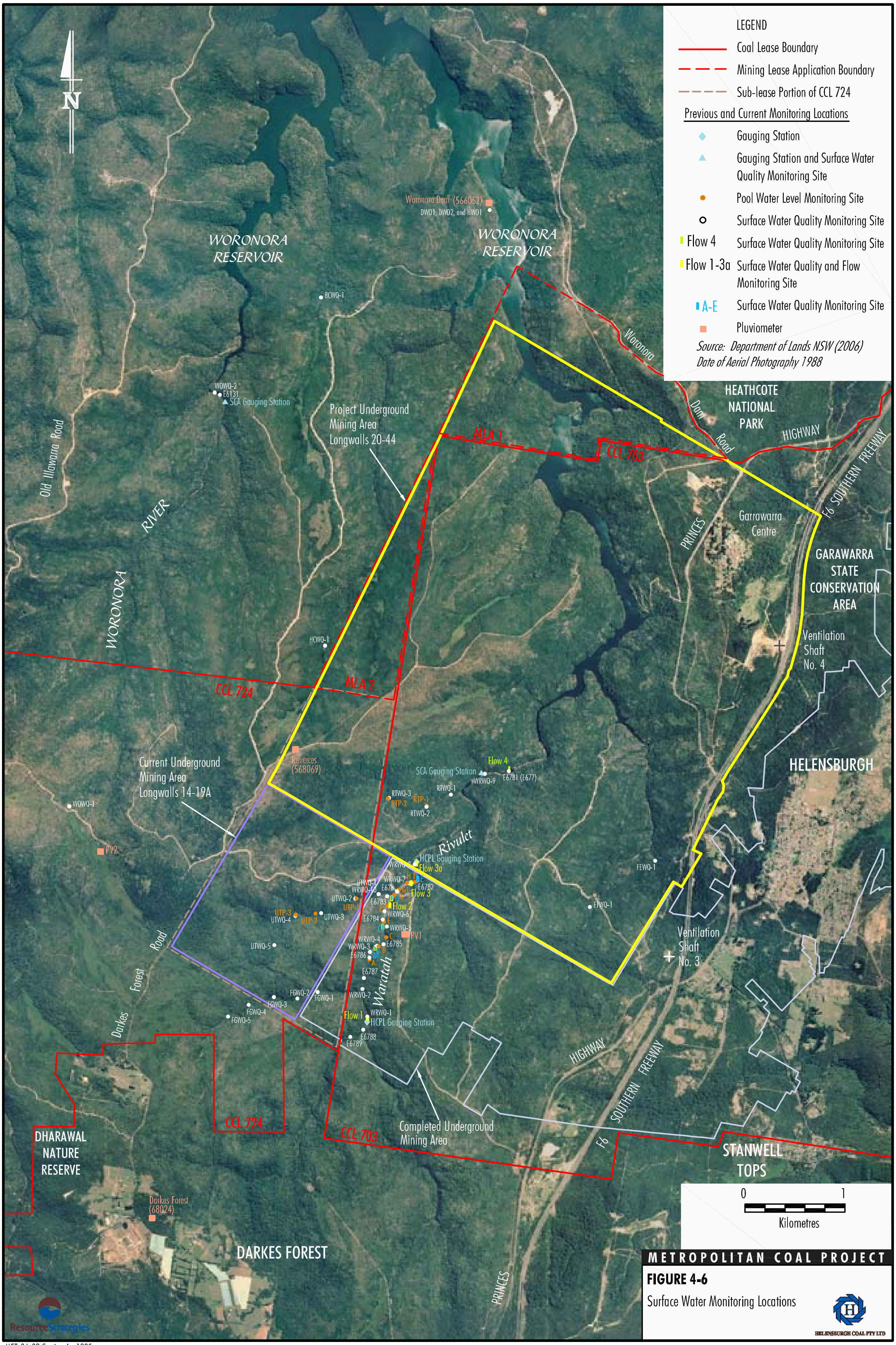

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FIGURE 4-6

Surface Water Monitoring Locations

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Flows during and following the frequent rainfall events typical of the area are characteristically chaotic, high energy and high velocity (Appendix C). These conditions typically prevent the build up of loose sediment or vegetation in the stream bed. During dry periods, flow is characterised by shallow, wide sections of slow moving (non turbulent) flow in the flatter sections and pools interspersed by narrow, shallow fast moving flows over the steeper inter-connecting cascades and rock bars. Flow in some sections of the rivulet is frequently not visible and is dominated by specific pathways through a boulder maze (Appendix C).

Tributaries of Waratah Rivulet

A number of tributaries flow into the Waratah Rivulet. The tributaries are situated within moderately steep incised gullies and contain numerous small in-stream pools. During the frequent occurrences of runoff producing storms, flow in the tributaries of Waratah Rivulet comprises shallow, high energy and high velocity flow (Appendix C). Flow patterns in smaller tributaries tend to be more variable responding to incident rainfall over a small area and therefore are less affected by baseflow (i.e. have lower flow persistence), particularly at higher elevations.

Tributaries of Woronora Reservoir

A number of tributaries in the Project Underground Mining Area flow direct to the Woronora Reservoir including the Eastern Tributary, Honeysuckle Creek and other tributaries with headwater upland swamps. The Eastern Tributary is situated in a moderately steep incised valley with numerous in-stream pools, while Honeysuckle Creek has a medium sized catchment and a relatively large upland swamp in its headwaters (Appendix C).

A number of small tributary catchments that drain direct to Woronora Reservoir contain headwater upland swamps.

Cawley's and Wilson's Creeks

As described above, a portion of the Project Underground Mining Area is overlain by the headwaters of Cawley's and Wilson's Creeks which drain in an easterly direction away from Woronora Reservoir and into the Hacking River.

Woronora Reservoir Inundation Area

The Woronora Reservoir inundation area is characterised by alluvial deposition in the reservoir bed (Appendix C).

Woronora Reservoir Inflows

Gilbert and Associates (2008) examined whether stream flows were being lost from the Woronora Reservoir catchment as a result of existing mining at the Metropolitan Colliery using three different methods, namely:

- the examination and comparison of stream flows from mined and nearby unmined catchments;
- modelling of stream flows with and without a flow loss factor to examine whether the observed stream behaviour supported a loss from Waratah Rivulet; and
- a comparison of modelled and recorded inflows into the Woronora Reservoir.

These investigations are described below.

The SCA maintains gauging stations on the Waratah Rivulet and Woronora River (both tributaries of the Waratah Reservoir) (Figure 4-6). Waratah Rivulet has previously experienced mine subsidence effects, Woronora River has not. In addition, the DWE has historically maintained a gauging station on O'Hares Creek at Darkes Forest and currently maintains a gauging station on O'Hares Creek at Wedderburn (located further to the west of Woronora River and the closest gauging station with concurrent gauging records). O'Hares Creek has not been affected by mine subsidence. The approximate locations of the Waratah Rivulet and Woronora River gauging stations are shown on Figure 4-6.

A summary of the approximate catchment area and length of record for the gauging stations on the Waratah Rivulet, Woronora River and O'Hares Creek is provided in Table 4-4.

Table 4-4
Waratah Rivulet, Woronora River and O'Hares Creek Gauging Stations

Gauging Station	Catchment Area (km^2)	Full Record Length
Woronora River (GS2132101)	12.4	Feb 2007 to present
Waratah Rivulet (GS2132102)	20.2	Feb 2007 to present
O'Hares Creek at Darkes Forest (GS213002)	16	1924 to 1930
O'Hares Creek at Wedderburn (GS213200)	73	1978 to present

Source: After Appendix C.

The concurrent streamflow data from the gauging stations on the three watercourses (Table 4-4) was plotted with streamflow expressed on a per unit catchment area basis to allow direct comparison of flow magnitudes. The results are shown on Figure 4-7, with the upper plot showing all recorded flows, while the lower plot emphasises the lower flow range. The plots indicate (Appendix C):

- The streamflows (both magnitudes and patterns of flow) recorded at the three sites are very similar.
- Waratah Rivulet appears to be the highest yielding of the three catchments in total over the period of record, although O'Hares Creek has higher peak flows.
- The Woronora River appears to be the lowest yielding of the three streams, although the amount by which recorded flow is lower than the other two stations varies significantly with time (being much lower in February to April 2007 and only slightly lower in later months and even higher than O'Hares Creek flow at times).

The streamflow data (Figure 4-7) does not indicate any loss of flow in Waratah Rivulet at low flows in periods of prolonged dry weather and flow recession. Such an effect would be expected if flow were being affected by mining (Appendix C).

A streamflow model was calibrated to the Waratah Rivulet and O'Hares Creek gauging station data using the nationally recognised Australian Water Balance Model (AWBM). The AWBM is a catchment-scale water balance model that estimates streamflow from rainfall and evaporation. Figure 4-8 shows a plot of recorded data at the Waratah Rivulet gauging station and AWBM model generated flows and illustrates the model gives a very good fit to the observed data (Appendix C).

The streamflow model was also used to introduce a loss function to simulate how the Waratah Rivulet flows would be expected to behave if a loss of water from the catchment was occurring. Figure 4-8 indicates that measured flows in Waratah Rivulet do not support flow loss as the modelling indicates flow loss would result in a significant departure from the observed stream behaviour (particularly during periods of low flow) (Appendix C).

The SCA provided recorded daily Woronora Reservoir extraction and concurrent storage volume data since 1977 and data on spill volumes since late 1987. In order to assess if calculated stream inflow exhibited any notable changes since the commencement of mining, the calibrated AWBM of the Waratah Rivulet was used to calculate reservoir inflows for the period of available concurrent reservoir data (Figure 4-9). Figure 4-9 indicates that there has been no discernable departure of the model predicted inflows from those calculated from recorded data following the commencement of mining in 1995 (Appendix C).

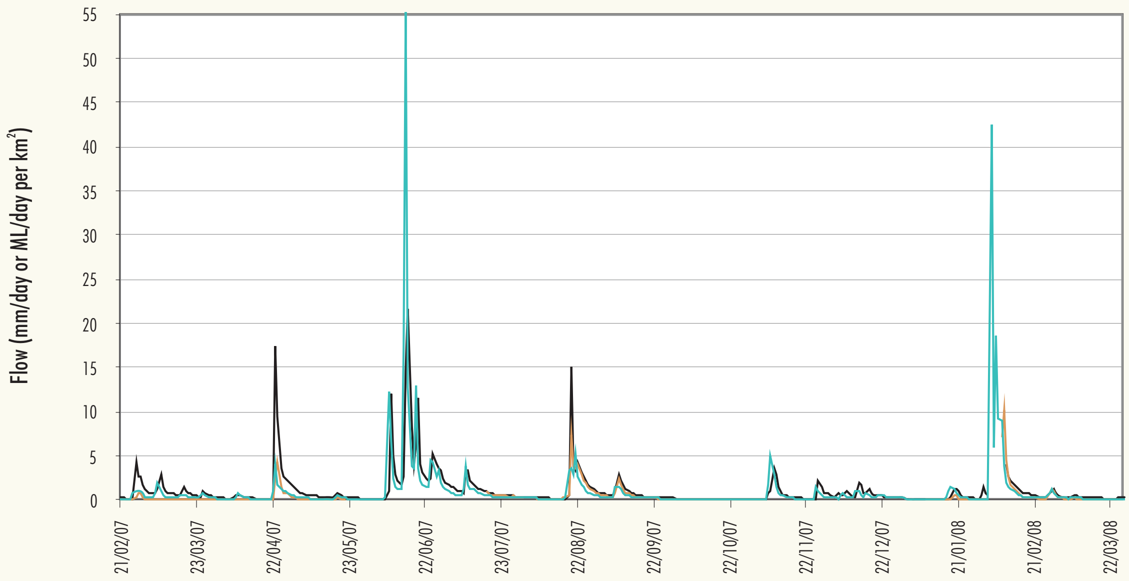
In summary, a comprehensive analysis of stream flow data and data on the yield behaviour of Woronora Reservoir indicates that past mining at the Metropolitan Colliery has had no discernable effect on the inflow to, or yield from, the reservoir. This finding is supported by the SCPR (DoP, 2008) which states:

> *No evidence was presented to the Panel to support the view that subsidence impacts on rivers and significant streams, valley infill or headwater swamps, or shallow or deep aquifers have resulted in any measurable reduction in runoff to the **water supply system** operated by the Sydney Catchment Authority or to otherwise represent a threat to the water supply of Sydney or the Illawarra region.*

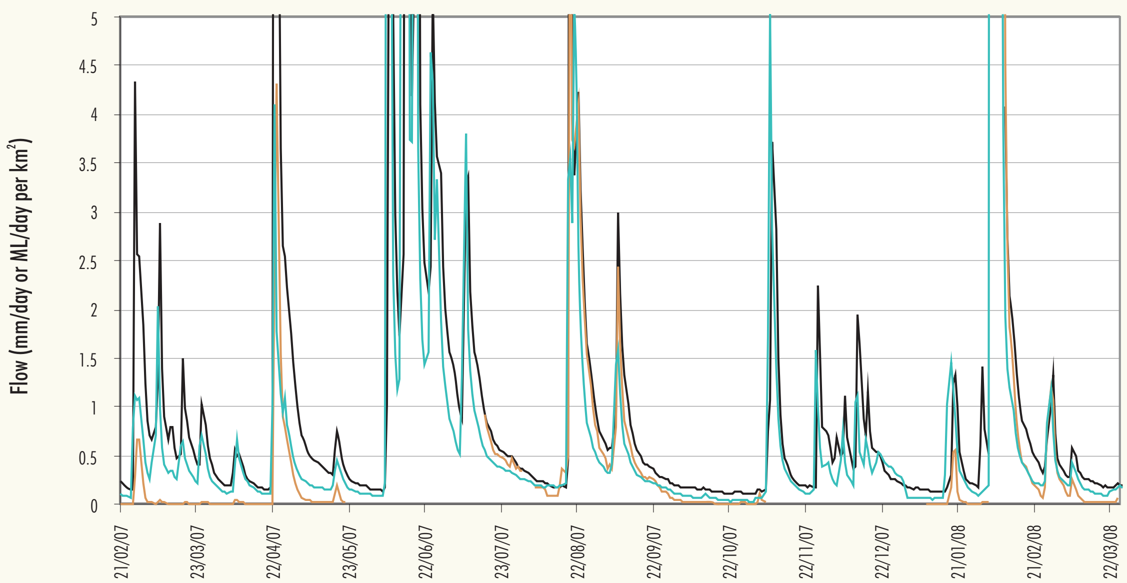
Boughton (2008) (Attachment 3) concurs that Waratah Rivulet stream hydrographs, comparisons of flow in the Waratah Rivulet with other unmined streams (e.g. Woronora River and O'Hares Creek) and calibrations of the AWBM model indicate that there is no evidence of any transmission loss or similar loss in the low flows in the Waratah Rivulet that might be attributed to effects of underground mining.

Stream Flows

Analysis of flows at the SCA gauging station on Waratah Rivulet indicates that during normal climatic conditions, no flow days occur approximately 2% of the time, low flow days (i.e. less than 2 ML/day) occur 36% of the time. Higher flow days (i.e. greater than 10 ML/day) occur approximately 27% of the time (Appendix C). Flow characteristics of other streams in the Project Underground Mining Area are described in the discussion of local hydrology above.



Comparative Streamflow Graph



Comparative Streamflow Graph (Zoom)

Waratah Rivulet GS 2132102
Woronora River GS 2132101
O'Hares Creek GS 213200

Source: Gilbert and Associates (2008)

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FIGURE 4-7
Comparative Streamflow Graphs of Waratah Rivulet, Woronora River and O'Hares Creek

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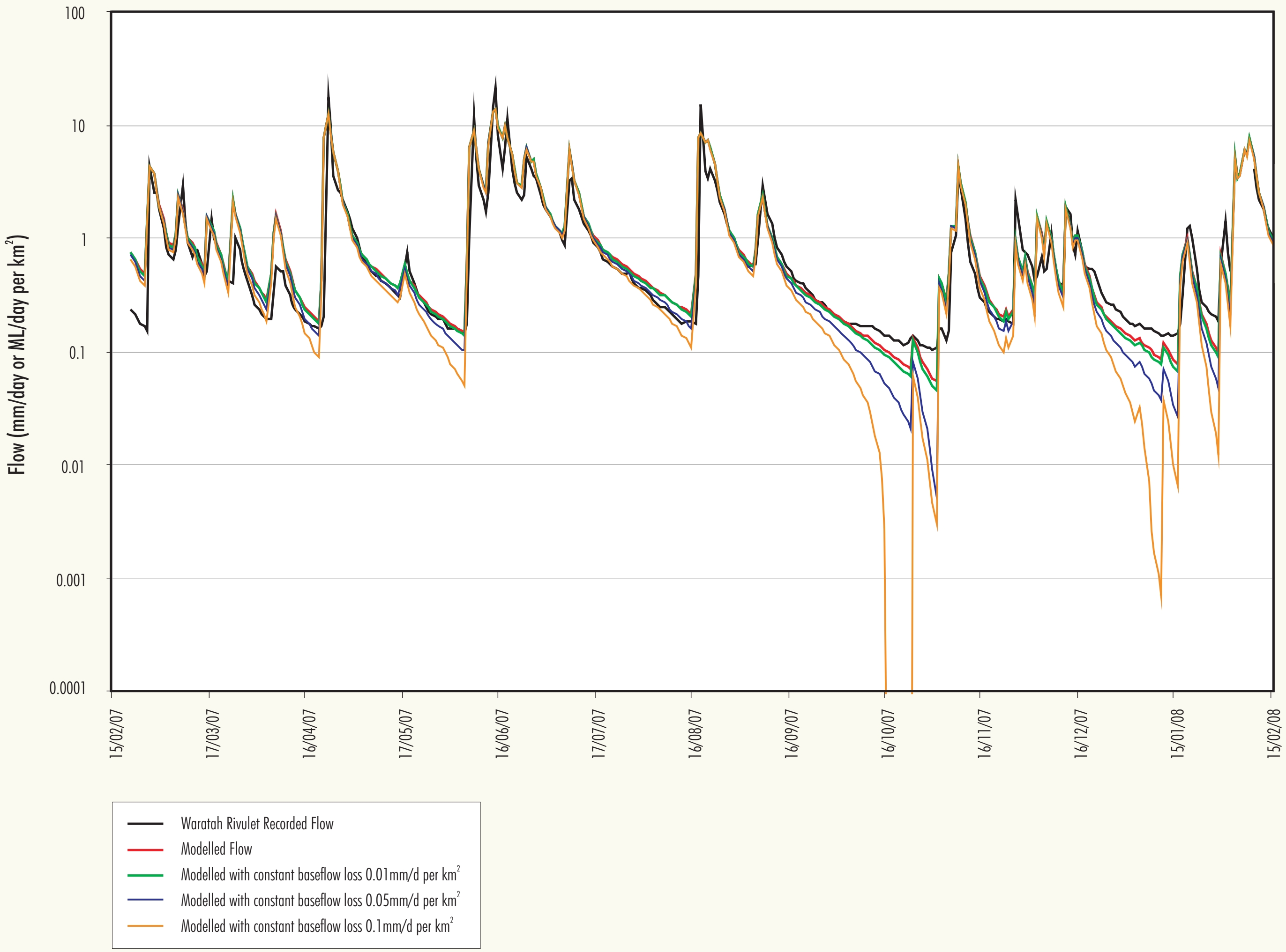

Source: Gilbert and Associates (2008)

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FIGURE 4-8

Recorded Streamflow Hydrograph - Waratah Rivulet and Comparison of Modelled Flow Losses

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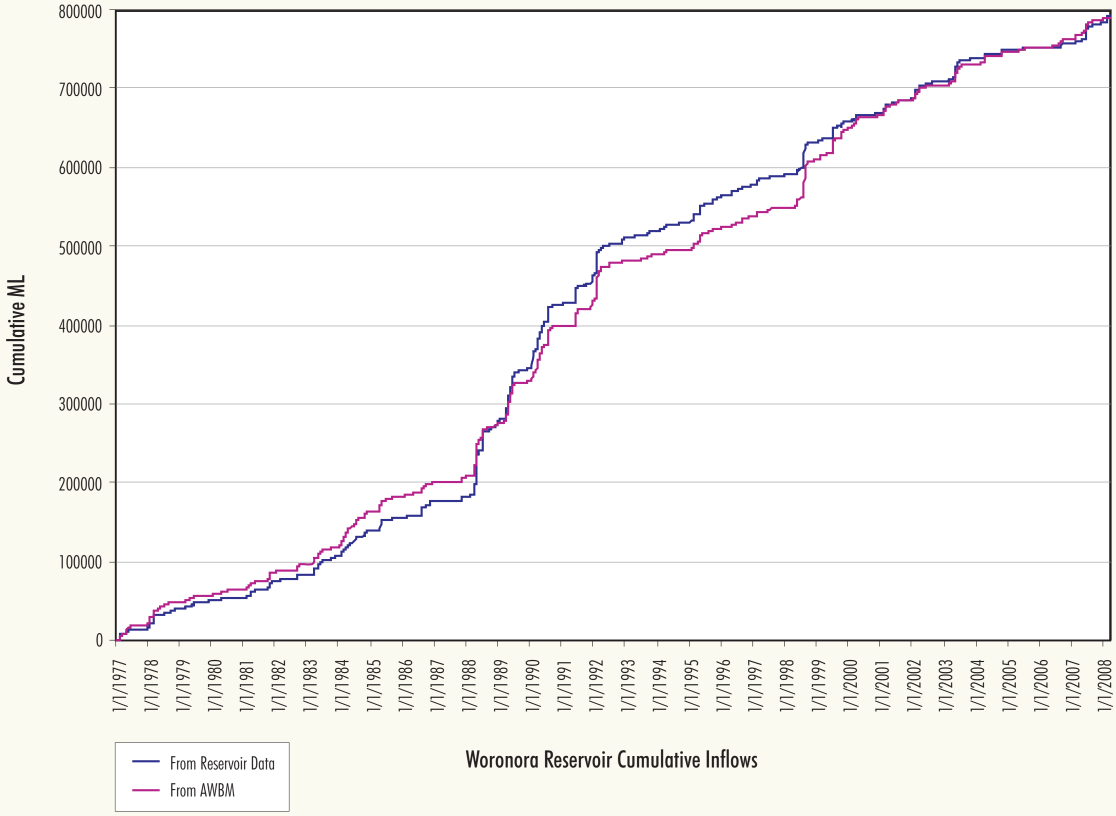
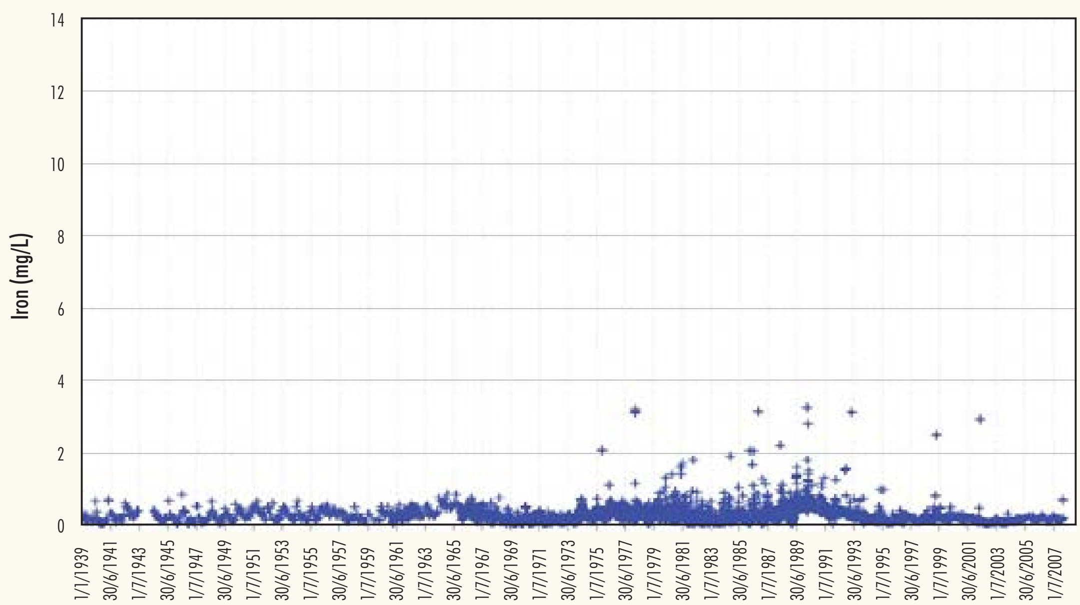


Woronora Reservoir Cumulative Inflows



Recorded Iron Concentrations - Woronora Reservoir 1939-2007

Source: Gilbert and Associates (2008)

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FIGURE 4-9
Woronora Reservoir
Cumulative Inflows and
Recorded Iron Concentrations

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Fracturing of rock strata has been observed in streams that overlie the Completed and Current Underground Mining Areas at the Metropolitan Colliery. Fracturing of rock strata in watercourses can result in the conveyance of a portion of natural surface flows via the fracture network (Appendix C). Figure 4-2 provides diagrammatic representations of flow diversion as a result of mine subsidence effects.

The observed effects of subsidence on Waratah Rivulet are well documented. It is known from extensive field tests that the fracture system below the bed of the Waratah Rivulet comprises a series of large open cracks up to 15 m in depth, which have a horizontal or sub-horizontal orientation (Appendix C). Observations of mine subsidence effects on Waratah Rivulet indicate the fracture network can convey significant flows below the surface (Appendix C). However, when flow exceeds the hydraulic capacity of the network, surface flow occurs in these areas. Observations also indicate that the hydraulic capacity of the network is not constant along the affected reach (Appendix C).

Analysis of estimated flow rates in Waratah Rivulet since 2002 indicate that there have been two recent periods of abnormally persistent low flows, namely from March to May 2006 and late December 2006 to February 2007 (Appendix C). During these extended periods of low flow, surface flows were diverted to the subsurface fracture network and declining pool water levels resulted.

Pool Water Levels and In-stream Connectivity

Waratah Rivulet contains a series of in-stream pools that have formed in natural depressions in the bedrock and behind locally elevated rock bars. A number of pools have been identified within the Project Underground Mining Area in the reach of Waratah Rivulet between Flat Rock Crossing and the full supply level of the Woronora Reservoir (Appendix C).

The distance between the end of one pool and the start of another varies, however it is generally similar to the lengths of the pools. The average distance between the pools is approximately 60 m (Appendix C). Tributary streams also contain numerous in-stream pools. The pools in tributaries of the Waratah Rivulet are generally much smaller in plan area, depth and volume relative to runoff flow rates, than those on the Waratah Rivulet (Appendix C).

Pool water level monitoring has been undertaken by HCPL at mined and unmined locations including Waratah Rivulet (as shown on Figure 4-6).

The results of pool water level monitoring and field observations by Gilbert and Associates (Appendix C) provide an indication of mine subsidence effects on pools in Waratah Rivulet and tributaries, as described below. A more detailed description is provided in Appendix C.

Monitoring data indicates that subsidence has had a larger effect on water levels in the pool immediately upstream of the WRS3 rock bar (Pool A) than other pools on the Waratah Rivulet that overlie the Completed Underground Mining Area. However, water balance analysis of Pool A supports the view that there has been a significant reduction of underflow through the Pool A rock bar since a large runoff event occurred in February 2007, indicating a process by which fractures are being closed or "clogged" by silt and sediment infilling over time (i.e. some degree of natural healing) (Appendix C). It is also noted that water levels in some pools unaffected by mine subsidence periodically fall below their "cease to flow" level (i.e. stop overflowing) if the combined effects of evaporation from the pool surface and slow natural leakage through the downstream rock is greater than the inflow rate (Appendix C).

During periods of significant rainfall and runoff in Waratah Rivulet, the water level in subsidence impacted pools is similar to pools unaffected by subsidence. Under these flow conditions pools and their downstream rock bars 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 in some cases recedes faster than is the case in unaffected pools (Appendix C).

During periods of low flow, sections of Waratah Rivulet in the Completed Underground Mining Area have been observed to "dry out" with surface flows being conveyed via the sub-surface fracture network to downstream sections. This behaviour has also been observed in some sections of the Eastern Tributary downstream of any mine subsidence effects. That is, it is a natural phenomenon, albeit less extensive than that observed in the subsidence affected reaches of Waratah Rivulet (Appendix C).

As described above, the hydraulic capacity of the fracture network is not constant along the affected reach. Observations of flows along different reaches of Waratah Rivulet confirm that flows are sufficient to provide a continuous connection between some pools at times when there is not continuous flow connecting other pools.

There are also some inter-pool reaches with “micro-pools” and shallow depressions in the bed rock which hold water during dry periods. During prolonged dry periods when flows recede to low levels, the number of instances where loss of flow continuity between pools increases with a greater proportion of these lower flows being conveyed entirely in the subsurface fracture network. However, during these prolonged dry periods, some inter-pool reaches with “micro-pools” and shallow depressions in the bedrock that hold water have been observed (Appendix C).

Water levels have also been monitored in a number of pools in tributary streams at the Metropolitan Colliery. 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. This response is consistent with the capture and underflow of small flows.

Observations of the subsidence affected upper reaches of the Eastern Tributary by Gilbert and Associates (2008) also provide an indication of mine subsidence effects on pools in tributaries. 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. The Eastern Tributary was undermined by Metropolitan Colliery Longwall 2 in 1996. 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, a portion of the pools subject to mine subsidence effects hold some water during prolonged dry periods. These latter pools remain full during most typical wetting and drying cycles (Appendix C).

Surface Water Quality

Surface water quality monitoring has been conducted on Waratah Rivulet and other local streams. Extensive surface water quality sampling has been conducted by HCPL and SCA on Waratah Rivulet and the sampling locations are shown on Figure 4-6.

The sampling locations on Waratah Rivulet have been grouped into eight reaches according to their location for the purpose of water quality characterisation (Table 4-5 and Figure 4-6).

Reach 1 represents the most upstream water quality sampling sites, while Reach 8 represents the most downstream water quality sampling sites (i.e. near the full supply level of the Woronora Reservoir). Figure 4-6 also shows the location of the sampling sites relative to the Completed and Current Underground Mining Areas and the Project Underground Mining Area.

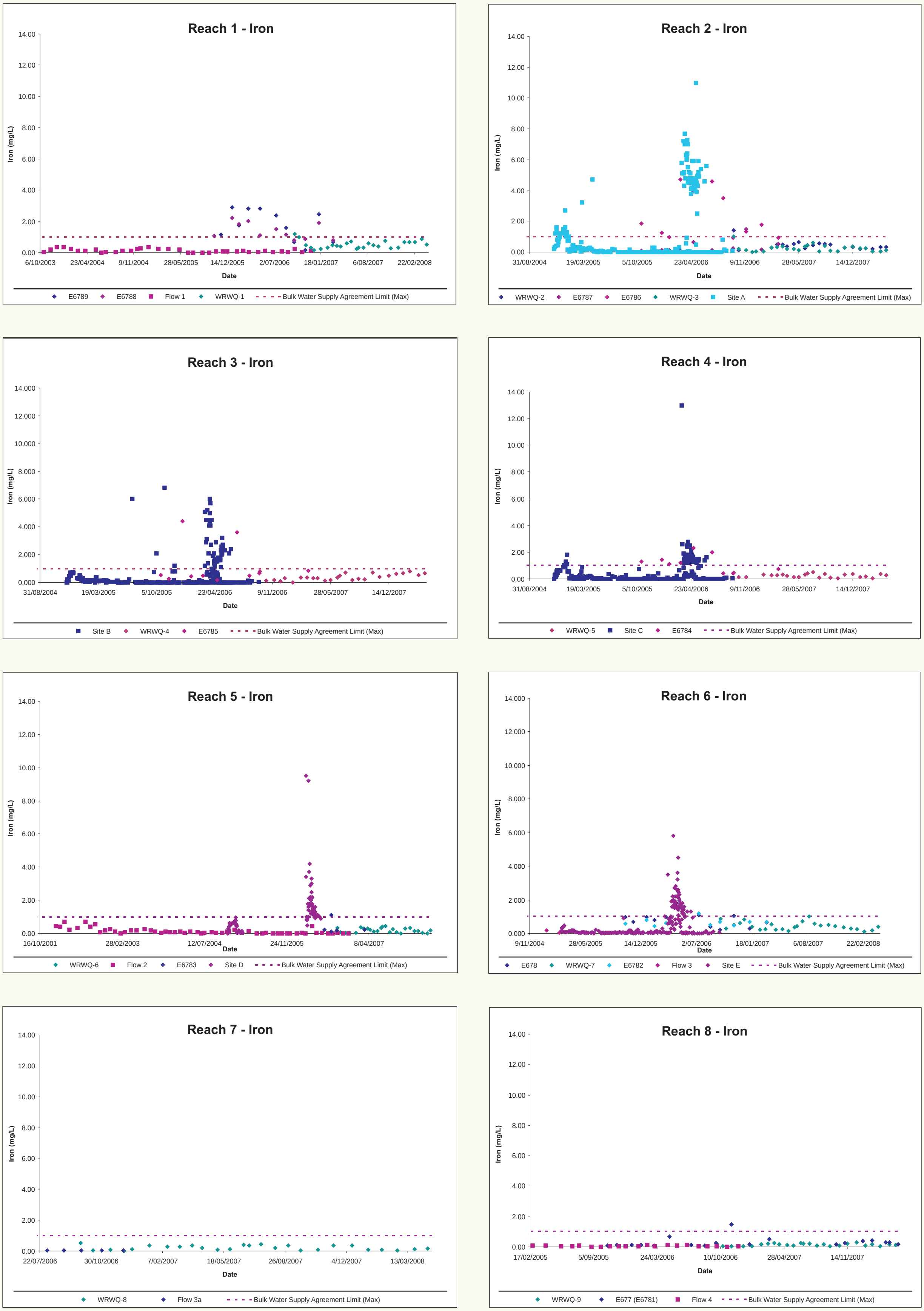
Table 4-5
Summary of Water Quality Monitoring Sites – Waratah Rivulet

Reach Number	Sampling Site Numbers
1	WRWQ1, Flow 1, E6788, E6789
2	WRWQ2, Site A, E6787, E6786, WRWQ3
3	WRWQ4, Site B, E6785
4	WRWQ5, Site C, E6784
5	WRWQ6, Flow 2, Site D, E6783
6	WRWQ7, Flow 3, Site E, E6782, E678
7	WRWQ8, Flow 3a
8	WRWQ9, Flow 4, E6781 (E667)

Water samples collected at these sites have been analysed for general indicators (e.g. pH, electrical conductivity, oxidation/reduction potential, turbidity and dissolved oxygen), metals (e.g. aluminium, barium, cobalt, iron, manganese, strontium and zinc), common anions and cations (e.g. calcium, chloride, magnesium, nitrate, sodium, potassium and sulphate) and nutrient indicators (e.g. total nitrogen and total phosphorous).

A summary table of the extensive water quality results is provided in Appendix C. In general, water quality at all sites has been good with concentrations of most indicators low relative to the Woronora Reservoir Bulk Water Supply Agreement Limits and the recommended Australian and New Zealand Environment and Conservation Council (ANZECC) (2000) guidelines for the protection of aquatic ecosystems in upland rivers (Appendix C).

The overall water quality of most indicator parameters has not been noticeably affected by mining at the Metropolitan Colliery. Mine subsidence effects on water quality in the Waratah Rivulet have resulted in localised and transient changes (spikes or pulses) in iron (Figure 4-10), manganese (Figure 4-11) and to a lesser extent aluminium (Appendix C) and minor associated increases in electrical conductivity (Figure 4-12).



Note: Woronora Reservoir Bulk Water Supply Agreement maximum limit 1 mg/L

Source: Gilbert and Associates (2008)

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FIGURE 4-10

Observed Iron Concentrations
Waratah Rivulet

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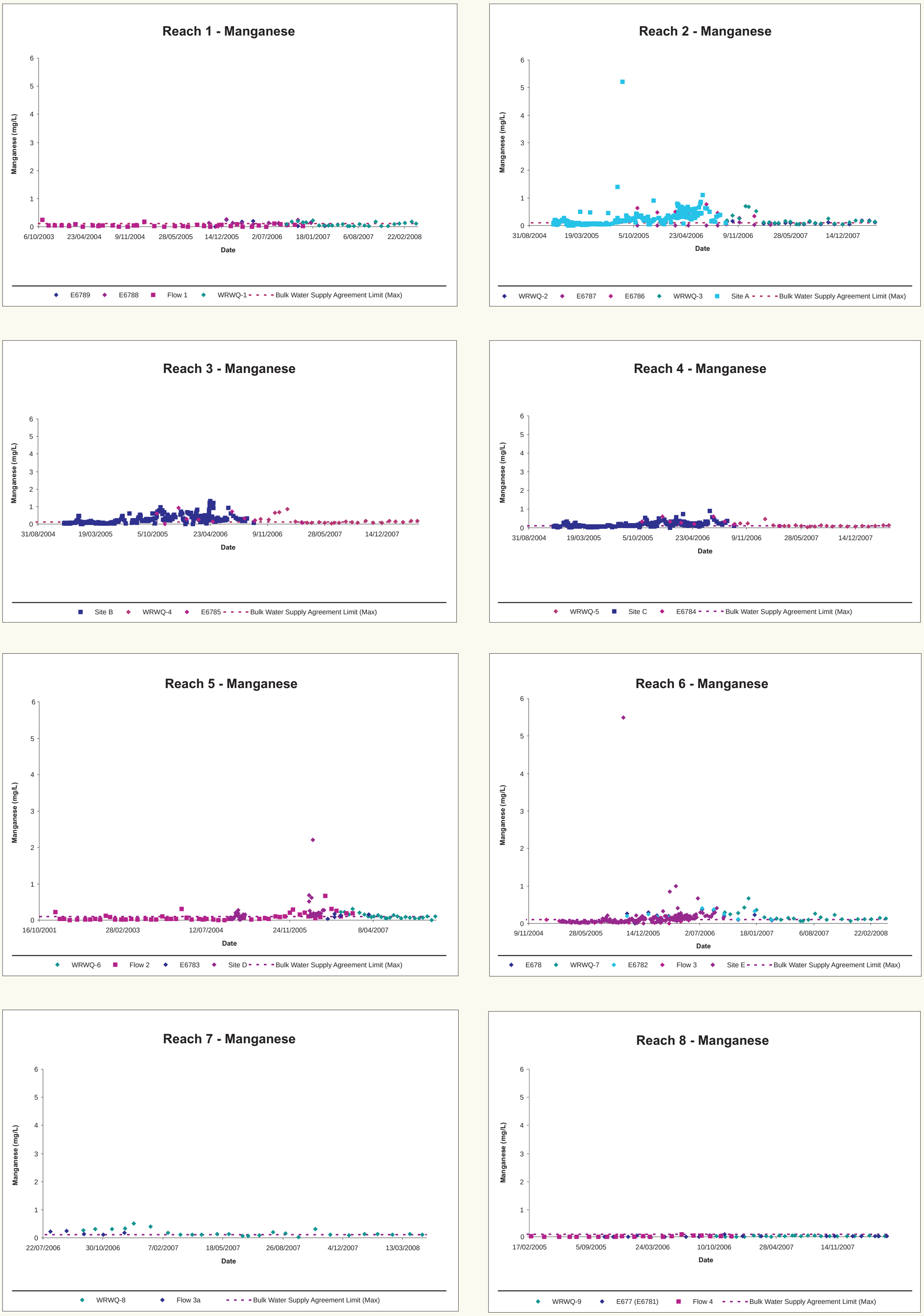

Note: Woronora Reservoir Bulk Water Supply Agreement maximum limit 0.1 mg/L

Source: Gilbert and Associates (2008)

METROPOLITAN COAL PROJECT

FIGURE 4-11

Observed Manganese Concentrations
Waratah Rivulet

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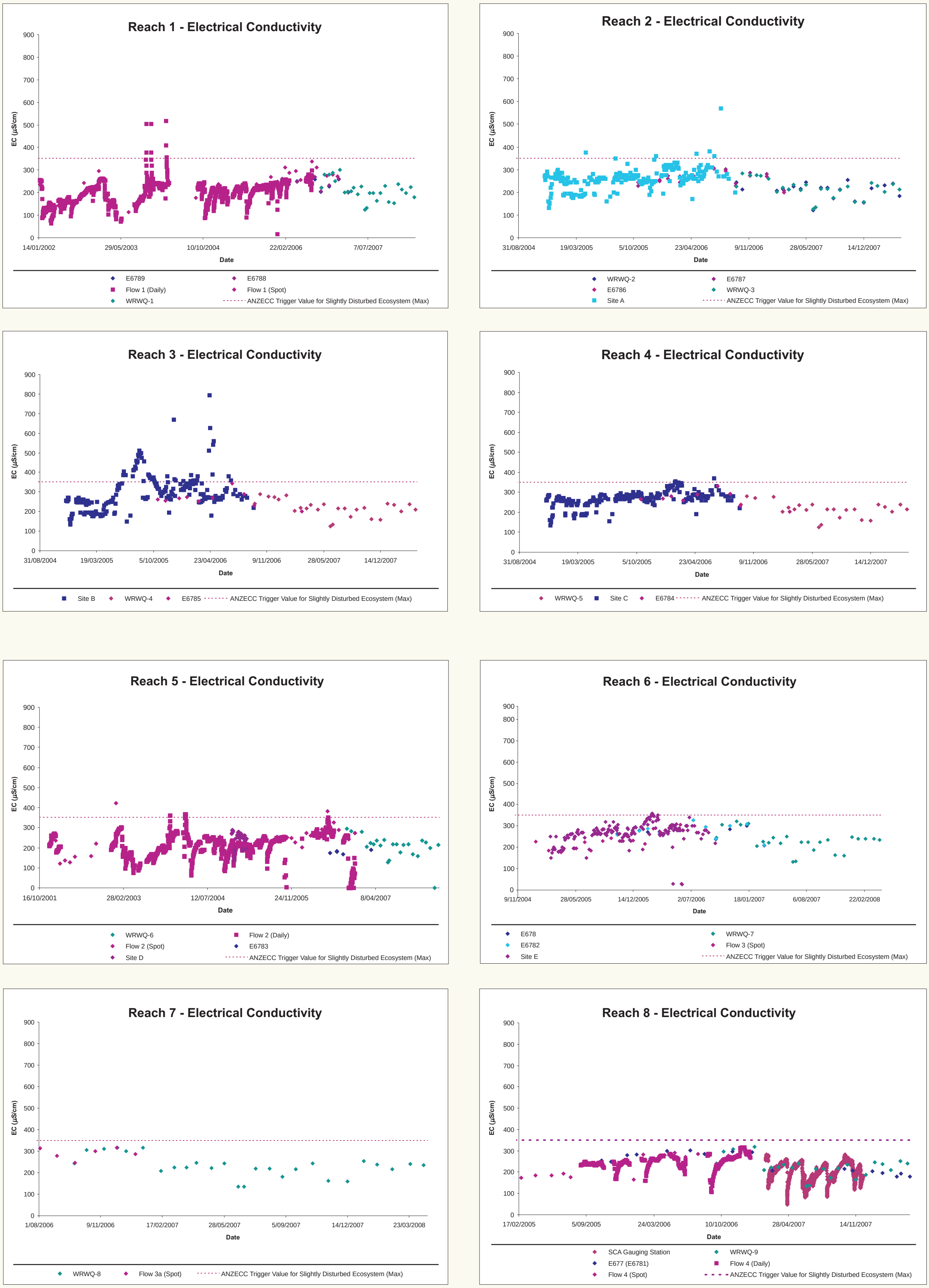

Note: ANZECC (2000) Trigger value (maximum) for the protection of aquatic ecosystems in upland rivers, 350 μS/cm

Source: Gilbert and Associates (2008)

METROPOLITAN COAL PROJECT

FIGURE 4-12

Observed Electrical Conductivities
Waratah Rivulet

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MET-06-02 Section 4_033B

The most likely mechanism for this appears to be flushing of minerals from freshly exposed fractures created by upsidence and valley closure. By nature the pulses are isolated and non persistent (Appendix C). Iron can also be seen to form orange coloured flocculent material which 'precipitate' out. There does not appear to be any noticeable link between subsidence effects and dissolved oxygen or the pH of water (Appendix C).

The pulses described above have not had any measurable effect on water quality in Woronora Reservoir downstream (Appendix C). This is evidenced by the recorded iron concentrations in the Woronora Reservoir in the period 1939 to 2007 (Figure 4-9). Recorded iron concentrations in Woronora Reservoir have not changed (increased) in the period since longwall mining commenced (1995) and in particular they have not been affected by the observed pulses seen in some upstream reaches in 2006 (Appendix C). The trends in manganese concentrations in Woronora Reservoir mirror the trends in iron concentration (Appendix C).

No gas emissions have previously been observed during mining at the Metropolitan Colliery (Appendix A). Gas emissions in the bases of streams have been encountered elsewhere in the Southern Coalfield (i.e. Cataract, Georges and Nepean Rivers) and have tended to be short-lived temporary events (Appendix C).

Metropolitan Colliery Stream Restoration Trial

HCPL has conducted a restoration trial using PUR at a rock bar known as WRS4 on the Waratah Rivulet (approximately 200 m upstream of Flat Rock Crossing) in consultation with the SCA. The restoration trial commenced in March 2008 and was completed in May 2008. The objective of the trial was to investigate the effectiveness of PUR grouting products and associated injection methods in reducing the hydraulic conductivity of the fractured rock mass. Successful restoration of the WRS4 rock bar was confirmed through measurement of the decrease in hydraulic conductivity and further evidenced by the return of water flowing over the rock bar (HCPL, 2008b).

A graph illustrating the comparative behaviour of three pools on Waratah Rivulet, comprising Pool A (affected by mining), Pool F (affected by mining) and Pool H (unaffected by mining and of similar size and morphology to Pool F) over the period 15 September 2005 to 21 August 2008 is provided on Figure 4-13a. The location of the pools is shown on Figure 4-6. Figure 4-13b shows the last six months of the recorded data.

There is a clear difference in water level response in Pool F prior to 18 April 2008 and after this date. Water levels in Pool F have mirrored those in Pool H after 18 April 2008, while water levels in Pool A continued to show the effects of subsidence related underflows.

Figure 4-13b clearly shows water level responses in Pool F in this period have mirrored those in Pool H (i.e. have been similar to natural pool behaviour). It can therefore be concluded that water level responses in Pool F have changed markedly as a result of the PUR restoration trial (Appendix C).

Key outcomes of the restoration trial reported include (HCPL, 2008b):

- PUR injection can be conducted without environmental harm.
- Fracture spaces can be successfully filled from <1 mm fine cracks to larger (>100 mm) voids.
- The hydraulic conductivity of the overall rock mass was decreased to the extent that the rock bar once again acted as a natural weir to maintain the persistence of its upstream pool.
- The injection products and method of injection could be applied to other rock bars along Waratah Rivulet.

Local Hydrology - Major Surface Facilities Area

The Major Surface Facilities Area is located above Helensburgh Gully and adjacent to Camp Gully (Figure 1-3). Camp Gully has a catchment area of approximately 3.8 km^2 and drains directly into the Hacking River to the north-east (Figure 2-1). Runoff from most of the catchment is diverted around the Major Surface Facilities Area and either into Helensburgh Gully or Camp Gully. Runoff from the Major Surface Facilities Area is collected in the site water management system. As described in Section 2.9.1, HCPL releases excess treated water from the Major Surface facilities Area to Camp Gully in accordance with EPL No. 767 conditions.

Metropolitan Colliery Pollution Reduction Programmes

The Metropolitan Colliery is regulated by EPL No. 767 issued by the DECC (Section 3). The DECC has initiated a number of pollution reduction programmes (PRPs) for the Major Surface Facilities Area via EPL No. 767, including PRPs that relate to the management of surface water. The PRPs that have been implemented in relation to surface water are summarised in Table 4-6.

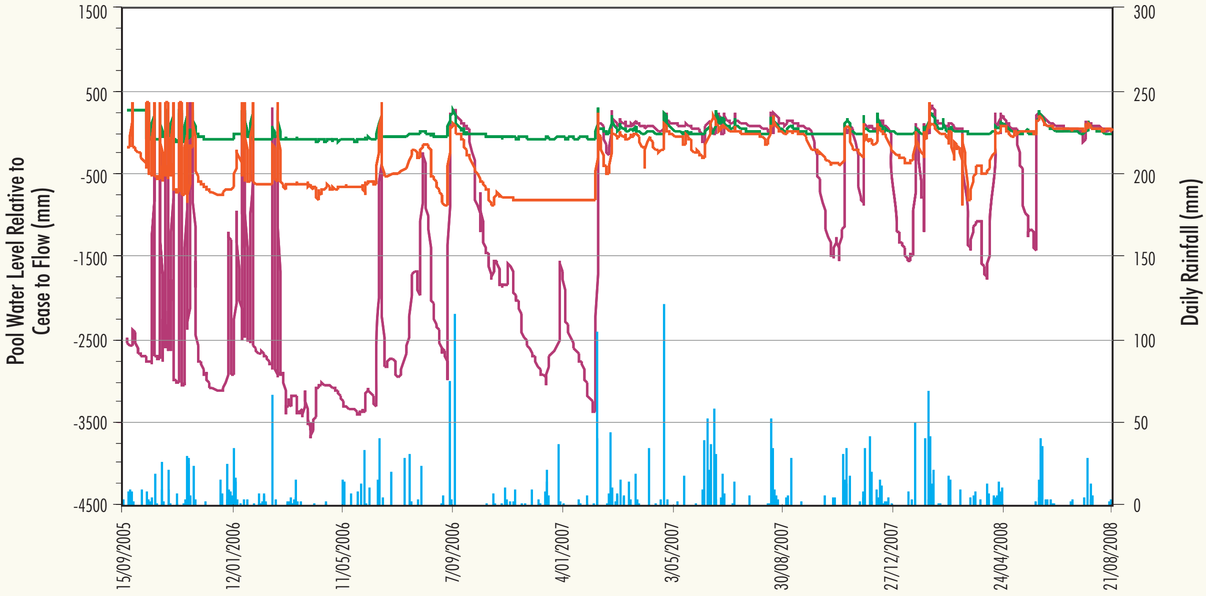

Figure 4-13a Pool Water Levels (2005 - 2008)

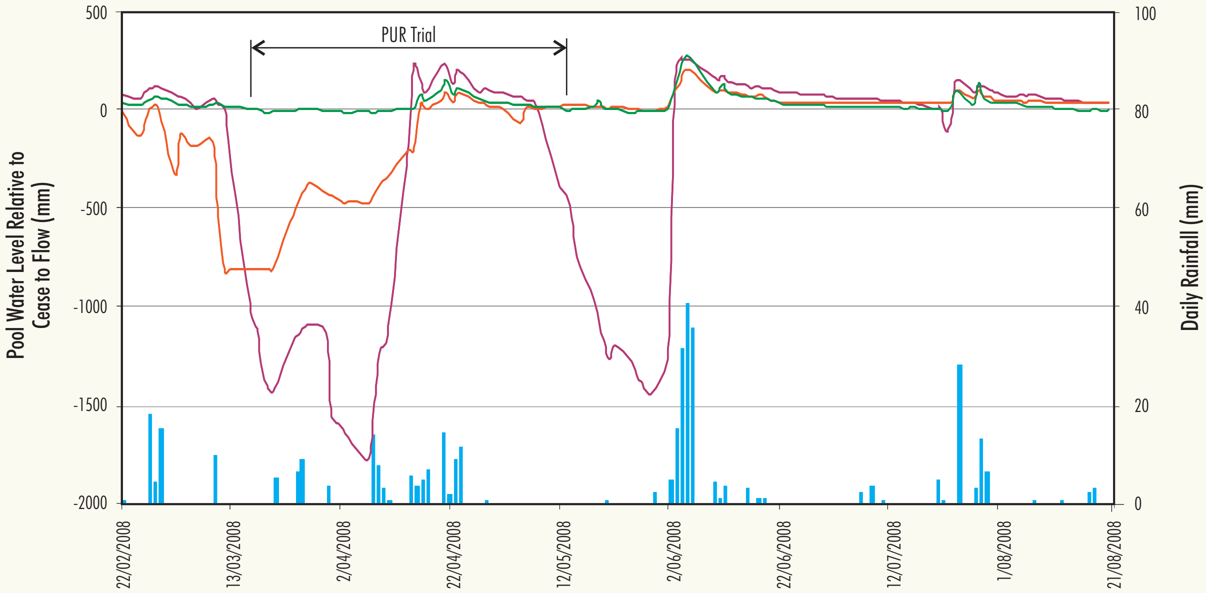

Figure 4-13b Pool Water Levels (2008)

- Rainfall
- Pool A (Pool Upstream of WRS3)
- Pool F (Pool Upstream of WRS4 Restored)
- Pool H (Downstream Control Site)

Source: Gilbert and Associates (2008)

METROPOLITAN COAL PROJECT

FIGURE 4-13
PUR Restoration Graphs -
Pools A, F and H

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Table 4-6
Pollution Reduction Programmes Related to Surface Water Management

PRP Name	Aim and Description of PRP
PRP 1	*The aim of this PRP was to prevent the discharge of stormwater from the site up to and including a 1 in 25 year ARI, 72 hour storm event by installing and operating a wastewater collection and treatment system.*
PRP 2 – Turkeys Nest Pond and Pumping System Upgrade	*The aim of this PRP was to protect Camp Creek, the Hacking River and the Royal National Park by providing adequate storage and pumping capacity for Turkeys Nest Dam to ensure there will be no overflow of contaminated runoff into Camp Creek.*
PRP 3 – Settlement Pond Upgrade	*The aim of this PRP was to improve the collection and treatment of contaminated stormwater from the upper catchment of the premises by increasing the size of the sand filtration pond.*
PRP 4 – Taj Mahal Upgrade	*The aim of this PRP was to facilitate the use of stormwater for operational purposes and to provide a means of underground disposal of excess contaminated stormwater from significant rainfall events by constructing a second concrete pit adjacent to the Taj Mahal.*
PRP 7 – Surface Water Assessment	*The aim of this PRP was for the licensee to protect the Hacking River Catchment by preparing a surface water management plan which determines the capacity of the site to capture and treat polluted stormwater runoff.*

The upgrades that HCPL has made to surface water management at the Major Surface Facilities Area in accordance with the PRPs listed in Table 4-6 form part of the existing surface water environment for the Project. Surface water management measures for the Project Major Surface Facilities Area are described in Section 2.9.

Coal Reject Geochemical/Physical Characteristics

An analysis of the physical properties of Metropolitan Colliery coal reject was undertaken by SCL Environmental Services Pty Ltd (2007) as a component of investigations into coal reject management options (Section 3.9.2). In summary the testwork indicated:

- The coarse coal reject was generally less than 90 mm in size and the majority of the material (some 70%) was between approximately 6 mm and 50 mm in size. The ash content of the coarse reject samples was approximately 71%.
- The fine coal reject was generally less than 1 mm in size and the majority of the fine reject (some 72%) was less than 0.038 mm in size. The sampled ash content of the fine reject was approximately 44%.

An analysis of the geochemical nature of Metropolitan Colliery coarse and fine coal rejects was conducted in 2007 by EGi. Four samples each of ROM coarse and fine coal reject material were collected in September and October 2007.

Analysis of the eight coal reject samples indicated they had relatively low total sulphur content (0.16 to 0.38%) and the acid neutralising capacity of the samples ranged from 9 to 62 kilograms of sulphuric acid per tonne (kg H_2SO_4/t) (EGi, 2008).

EGi's (2008) analysis of the coal reject sample pH and acid producing potential indicated that the four fine reject samples and two of the coarse reject samples were non-acid forming (NAF).

Two of the coarse coal reject samples were not classified, but may have some limited acid generating potential (2 to 3 kg H_2SO_4/t), however, EGi (2008) concluded that the results suggested that the materials were low risk.

The EGi geochemical testwork correlated with the findings of other investigations into the nature of coal reject from the washing of coal from the Bulli Seam which indicate that the material is generally inert as summarised by the following:

- The Bulli Seam consists of coal and carbonaceous claystone and usually contains few, if any, non-coal bands or splits (DMR, 2000). Investigations conducted for the Camp Gully coal reject emplacement at Metropolitan Colliery indicated that the coal reject material generated by the Metropolitan Colliery was inherently inert and unreactive and the potential for acid discharges to be produced from the coal reject over time was minimal (Sinclair Knight and Partners, 1990).

- Investigations conducted for the Glenlee Redevelopment at the Glenlee Washery indicated that reject produced from the Bulli Seam was known to be non-hazardous and chemically inert (International Environmental Consultants Pty Ltd, 2006). Results from the sampling of coal reject produced at Metropolitan Colliery and emplaced at Glenlee Washery show that the reject materials are non saline, low in total and soluble heavy metals and have a low potential to produce acids or other hazardous leachate over time (*ibid*.).
- BHP Billiton - Illawarra Coal (BHPB-IC) has supplied coal reject (coal wash) material for use as engineered fill to a number of users in the Illawarra including residential developments and commercial applications (BHPB-IC, 2006). Testwork conducted on coal wash material by Illawarra Coal has indicated that the trace element composition of coal reject material poses little or no contamination risk to the environment or public health, and that coal wash material is not pyritic and has a low potential to produce acidity (*ibid.*).

Water quality sampling results indicate the pH of water released from the Major Surface Facilities Area to Camp Gully in accordance with EPL No. 767 conditions is slightly alkaline (7.3 to 8.9 pH) which supports the above findings (HCPL, 2008c).

4.4.2 Potential Impacts

The potential impacts of the Project on surface water resources are described in Appendix C and summarised below.

Woronora Reservoir Inflows

Based on the analysis of the effects of mining at the Metropolitan Colliery on inflows to the Woronora Reservoir summarised in Section 4.4.1, Gilbert and Associates (2008) concluded that:

- On the basis of recorded data from streamflow gauging stations in the area, streamflow patterns and magnitudes in the region are consistent.
- Recorded streamflow data from Waratah Rivulet indicates that there is no evidence of flow loss at low flows in periods of prolonged dry weather and flow recession as might be expected if flow were being affected by mining activity.
- The observed behaviour is consistent with no losses occurring from the catchment.
- There has been no discernable departure of streamflow model-predicted inflows to the Woronora Reservoir from those calculated using recorded reservoir data following commencement of mining.

These conclusions are consistent with the findings of the Groundwater Assessment. Detailed groundwater investigations have shown that the geological and hydrogeological regimes in the Metropolitan Colliery area are such that there is no mechanism by which the Project could result in a detectable loss of groundwater contribution to reservoir yield (Appendix B).

All the investigations undertaken to date show that subsidence induced underflow re-emerges downstream of the subsidence area with no evidence of flow loss to Woronora Reservoir. As described in Section 4.4.1, this finding is supported by the SCPR (DoP, 2008).

Based on the above and the Subsidence Assessment undertaken by MSEC (Appendix A), the Project is not expected to have an effect on catchment inflows to the Woronora Reservoir (Appendices B and C).

Stream Flows

Subsidence predictions for the Project indicate that the maximum valley closure and upsidence movements at watercourses within the Project Underground Mining Area are within the range where fracturing of bedrock (and the consequent diversion of a portion of the total stream flow as underflow) could occur (Appendix A).

However, subsidence movements associated with the Cawley's Creek and Wilson's Creek catchments would be relatively small, to the extent that fracturing of bedrock in these creeks is not expected (Appendix A).

In Waratah Rivulet the amount of potential underflow as a result of the development of a fracture network has been conservatively estimated to increase the average frequency of no flow days as a result of the Project from 2% to 15% and increase the average frequency of low flows (less than 2 ML/day) from 36% to 40% of days (Appendix C). Mine subsidence associated with the Project would have a negligible effect (less than 0.5%) on moderate (approximately 10 ML/day) and larger flows.

During prolonged dry periods when flows recede to low levels, a greater proportion and in some areas, all 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 summary, in the Project Underground Mining Area the effects of underflow would be most noticeable during periods of low flow and on the frequency of no flow, while the effects on the frequency and magnitude of high flows would be negligible (Appendix C).

Pool Water Levels and In-stream Connectivity

Underflow has been observed to result in lower water levels in pools as they become hydraulically connected with the fracture network.

During periods of significant rainfall and runoff in Waratah Rivulet, the water level in subsidence affected 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 in some cases recede faster than is the case in unaffected pools. As described in Section 4.4.1, water balance analysis of Pool A on Waratah Rivulet supports the view that there has been a significant reduction of underflow through the Pool A rock bar since a large runoff event occurred in February 2007 indicating a process by which fractures are being closed or "clogged" by silt and sediment infilling over time (i.e. some degree of natural healing) (Appendix C).

Previous observations of pools in tributaries subject to mine subsidence 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 Project mine subsidence effects would hold some water during prolonged dry periods (Appendix C). These latter pools would remain full during most typical wetting and drying cycles.

Water Quality

As described in Section 4.4.1, the overall water quality of most indicator parameters has not been noticeably affected by mine subsidence and water quality at all sites has been good with concentrations of most parameters being low relative to the Woronora Reservoir Bulk Water Supply Agreement Limits and ANZECC (2000) guidelines for the protection of aquatic ecosystems in upland rivers.

The effect of subsidence on water quality is expected to be similar to that already observed and described in Section 4.4.1 (i.e. transient pulses of iron, and to a lesser extent, manganese, aluminium and conductivity increases which would likely occur following any instances of fresh cracking of the creek bed) (Appendix C).

There is no evidence or reason to expect upward trends in water quality parameters or persistent change to water quality as a result of subsidence effects (Appendix C).

Gas releases are considered unlikely to occur at Metropolitan Colliery (MSEC, 2008) and adverse water quality effects are not expected (Appendix C).

Project activities (e.g. on-going surface exploration activities, the upgrade and extension of surface infrastructure, access tracks, environmental monitoring and management activities, stream restoration activities and other minor Project-related surface activities) have the potential to increase soil erosion/sedimentation or result in water contamination (e.g. fuel leakages from equipment or uncontrolled spills). Appropriate management measures to minimise this risk are presented in Section 4.4.3 below.

Water draining from coal reject stockpiled on-site at the Major Surface Facilities Area could result in the mobilisation of salt and sediments or the mobilisation of metals if the material was acid generating. As described in Section 4.4.1, analysis of Metropolitan Colliery coal reject and at other mines in the Southern Coalfield indicates that coal reject is generally inert.

As water releases from the Major Surface Facilities Area to Camp Gully, which flows to the Hacking River would continue to be constrained by the existing EPL No. 767, it is expected there would be no material effect to downstream water quality (Appendix C).

Stream Gradients and Alignments

The anticipated changes in channel gradients predicted by MSEC (2008) would cause localised increases and decreases in flow energy/velocities (Appendix C). Increases in flow energy in steeper sections may in turn result in bed, or more likely, bank erosion. The extent of any erosion effects would depend principally on the strength of bank materials and the integrity of the riparian vegetation.

Based on observation of similar streams that have been affected by subsidence at the Metropolitan Colliery, 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 (Appendix C).

The potential for changes in stream alignment due to mine subsidence is considered to be low (Appendix A). The steep and incised nature of the local watercourses is such that alignment change is not a real possibility and it has not occurred in any subsided areas at the Metropolitan Colliery to date (Appendix C).

Upland Swamp Hydrology

As described in Section 4.3.1, the dominant hydrological processes 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. As the swamps are essentially rainfall-fed, water levels within upland swamps fluctuate in response to significant rainfall events and also seasonally with climatic conditions (Appendix B). Potential impacts on upland swamps resulting from mine induced surface cracking are described in Section 4.3.2. In summary, 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 (Appendix B).

Whilst swamp grades vary naturally, the predicted maximum mining-induced tilts are generally orders of magnitude lower than the existing natural grades within the swamps (Appendix C). The predicted tilts would not have any significant effect on the localised or overall gradient of the swamps or the flow of water.

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 (Appendix C).

There is one in-valley swamp situated in the Completed Underground Mining Area that is predicted to be marginally further affected by subsidence movements during mining of Longwalls 20 to 24. The magnitude of the additional movements are predicted to be small in comparison to the movements that have already occurred and it is considered highly unlikely that there will be any change to swamp hydrology as a result of Project mining (Appendix C).

Slope and Ridgetop Hydrology

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 real effect on the soil moisture regime (Appendix C).

Climate Change and Surface Water

Climate change and greenhouse gas emissions associated with the Project are discussed in Section 3.8. Consideration of the potential surface water impacts of the Project in the context of global climate change is provided in Appendix C and Section 3.8.

4.4.3 Mitigation Measures, Management and Monitoring

Adaptive Management Approach for Waratah Rivulet

The Project incorporates significant adaptive management measures (Section 5) that would allow for the monitoring of impacts on the Waratah Rivulet, and if monitoring indicates the environmental impacts are greater than is considered acceptable, then adaptive management measures including modification of mining geometry would be implemented, as required.

Stream Restoration at Key Rock Bars

As described in Section 4.4.1, successful restoration of the WRS4 rock bar was confirmed through measurement of the decrease in hydraulic conductivity and further evidenced by the recovery of Pool F that overtopped the rock bar (HCPL, 2008b). On the basis of the WRS4 restoration trial, PUR injection is considered a technically feasible method of restoring pool characteristics at the larger rock bars along Waratah Rivulet, where future assessment indicates the need (HCPL, 2008b).

HCPL plans to undertake restoration activities at the WRS3 rock bar in 2008. In addition, HCPL is committed to undertaking restoration activities at rock bars WRS5, 6, 7 and/or 8, where future assessment indicates the need (Section 5).

Water Quality Management Measures

Construction Activities

Temporary erosion and sediment controls (e.g. silt fences and sediment control structures) would be installed prior to the commencement of construction activities. Erosion and sediment control measures would be designed in accordance with applicable water management principles and guidelines (e.g. *Managing Urban Stormwater: Soils and Construction* [Landcom, 2004]).

The primary objectives of these erosion control measures would be to:

- control soil erosion and sediment generation from areas disturbed by construction activities; and
- maintain water quality (primarily in terms of total suspended solids content) in watercourses.

Specific mitigation measures to control soil erosion and sediment migration would include:

- minimising surface disturbance and restricting access to disturbed areas;
- rehabilitation and revegetation of mine infrastructure areas if no longer required;
- minimising compaction during soil excavation and movement;
- use of erosion control features (e.g. silt fences and temporary sediment traps, diversion banks, channels and rip-rap structures) to minimise sediment migration, divert surface water around disturbed areas and to control runoff velocity; and
- use of sediment retention storages to contain runoff from disturbed areas (e.g. at the Major Surface Facilities Area).

Site Water Balance

The Project (i.e. Major Surface Facilities Area) site water balance would be reviewed annually to optimise performance and validate predictions.

Spills and Water Contamination Controls

Land contamination control measures of relevance to the management of potential impacts on surface water resources are described in Section 4.1.3.

Surface Water Monitoring

The current Metropolitan Colliery surface water monitoring programme in the Completed and Current Underground Mining Areas has been developed by HCPL in consultation with the SCA. HCPL has already commenced some pre-mining data collection in the Project Underground Mining Area, however additional surface water monitoring would be conducted to assess localised impacts of the Project on surface water resources.

A surface water monitoring programme would be developed for the Project and detailed in the EMP (Section 6). The frequency, parameters and locations monitored as part of the surface water quality monitoring programme would be described in the EMP, however it is anticipated that the following would be incorporated in the EMP:

- the existing pluviometer (rainfall measurement) network would be maintained over the life of the Project;
- an evaporation pan would be re-established at or near the Woronora Reservoir;
- stream flow gauging stations on Waratah Rivulet, Woronora River and O'Hares Creek would be maintained over the life of the Project;
- the existing water quality monitoring regime conducted by HCPL on Waratah Rivulet would continue and would be supplemented by on-going monitoring in the Eastern Tributary, Woronora River, Honeysuckle Creek and Bee Creek;
- water quality sampling in Woronora Reservoir would continue;
- water level monitoring of major pools on Waratah Rivulet would continue for the life of the Project;
- water levels in two representative pools on Woronora River and in the main pools that occur in the lower reaches of the Eastern Tributary would be monitored using continuous water level monitoring devices; and
- storage characteristics (volume versus level) and cease to flow levels of all monitored pools would be determined by survey.

The SWMP would also include any applicable water quality monitoring at the Major Surface Facilities Area.

HCPL's adaptive management approach for Waratah Rivulet and Woronora Reservoir monitoring is provided in Sections 5 and 6, respectively.

Coal Reject Geochemical Testwork

Periodically over the life of the Project, HCPL would test coal reject material that is produced to confirm that the coal reject geochemistry is generally consistent with that observed to date and does not require the implementation of any specific management measures with respect to reject disposal or surface water management.

Water Releases – Camp Gully

Water releases from the major Surface Facilities Area to Camp Gully would continue to be undertaken in accordance with the requirements of EPL No. 767. Any upgrades to release systems or water treatment that are undertaken in accordance with the requirements of EPL No. 767 would be reported in the AEMR (Section 6).

4.5 AQUATIC ECOLOGY

The Aquatic Ecology Assessment report prepared by BIO-ANALYSIS Pty Ltd is provided in Appendix D. Peer review was undertaken by Dr David Goldney of the Western Research Institute (Attachment 3). A description of the aquatic ecology in the vicinity of the Project is provided in Section 4.5.1. Section 4.5.2 describes the potential impacts of the Project on aquatic ecology, while Section 4.5.3 outlines Project aquatic ecology mitigation measures, management and monitoring. Section 4.5.4 describes compensatory measures and ecological initiatives.

Matters of national environmental significance of relevance to aquatic ecology are discussed in Section 3.4.1.

4.5.1 Existing Environment

Setting

A description of the local hydrology of the Project Underground Mining Area and surrounds is provided in Section 4.4. As described in Section 4.4, a number of streams occur in the Project Underground Mining Area and surrounds including Waratah Rivulet and its tributaries and other tributaries that drain directly to the Woronora Reservoir.

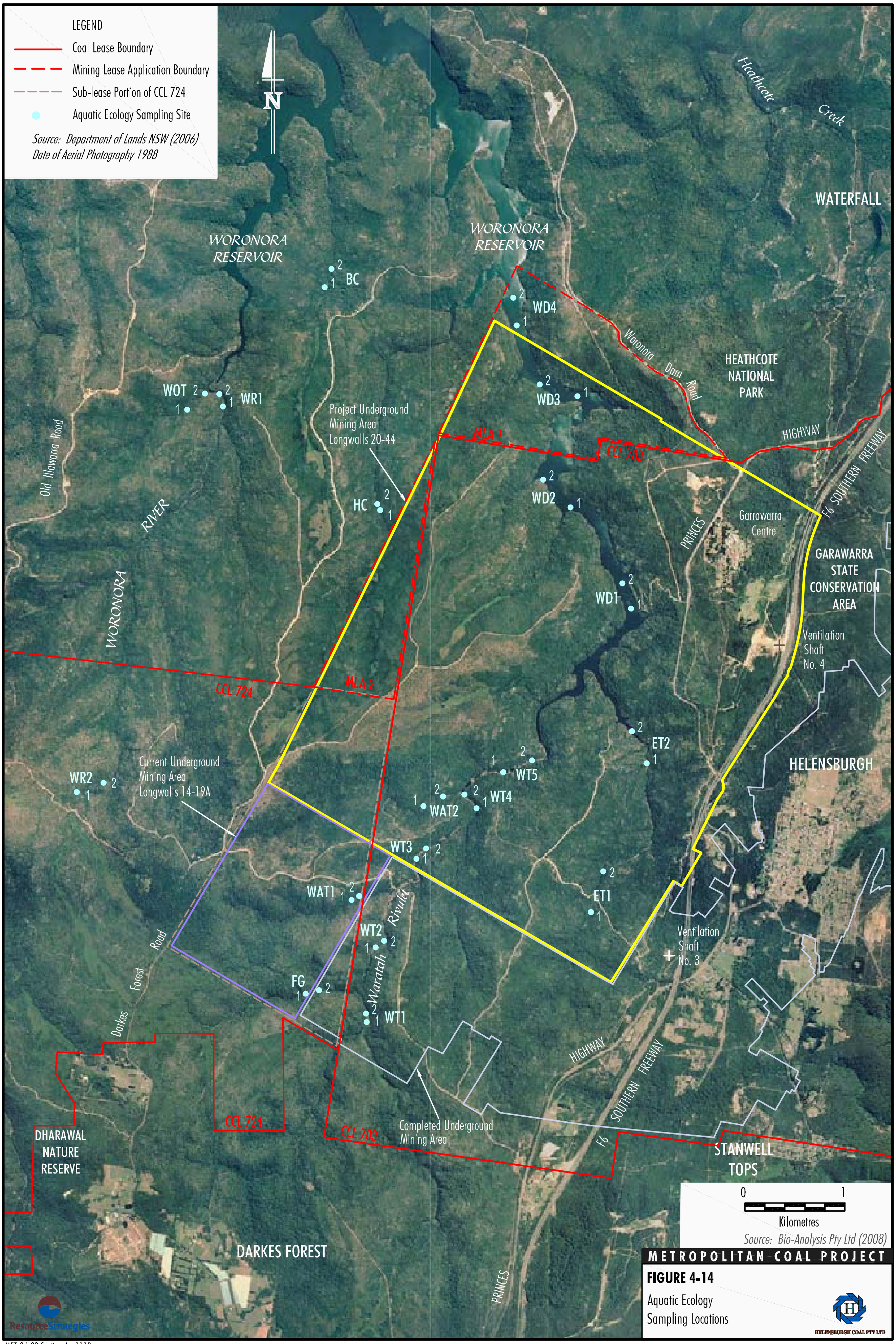
The upper reaches of the Woronora Reservoir are also situated within the Project Underground Mining Area and provide habitat for aquatic biota. The north-eastern portion of the Project Underground Mining Area, the Major Surface Facilities Area and surrounds are situated in the Hacking River catchment.

Baseline Aquatic Ecology Surveys

Baseline aquatic ecology surveys were conducted during spring 2006 (streams) and summer 2007 (Woronora Reservoir) (Appendix D). Field survey methods included descriptions of sampling site habitat characteristics, water quality measurements at the time of sampling, and sampling of assemblages of macrophytes (cover class estimates and quantitative assessment of relative abundance), macroinvertebrates (quantitative sweep net sampling) and fish (electrofishing methods).

Targeted surveys were conducted for threatened aquatic biota listed under the TSC Act, *Fisheries Management Act, 1994* and EPBC Act considered possible occurrences in the Project Underground Mining Area or surrounds. The aquatic ecology sampling sites are shown on Figure 4-14. Sampling was conducted at sites on Waratah Rivulet (sites WT1 to WT5), tributaries of Waratah Rivulet (sites FG, WAT1 and WAT2), Woronora River (sites WR1 and WR2), a tributary of the Woronora River (site WOT), Honeysuckle Creek (site HC), Bee Creek (site BC), a tributary of the Woronora Reservoir in the east (sites ET1 and ET2), and in the upper reaches of the Woronora Reservoir (sites WD1 to WD4) (Figure 4-14).

As a component of the aquatic ecology surveys and assessment, a number of reference sources containing the results of local or regional aquatic surveys, database records and other scientific studies and literature were reviewed, and where appropriate included in the assessment of aquatic ecology (e.g. Bruce *et al.*, 2001; Ecowise Environmental, 2005a; 2005b; 2006). A number of aquatic ecology surveys have previously been undertaken on behalf of HCPL on Waratah Rivulet and its tributaries including those by Marine Pollution Research (2003 to 2005), The Ecology Lab (2005 to 2006) and BIO-ANALYSIS Pty Ltd (2007 to 2008).



METROPOLITAN COAL PROJECT

FIGURE 4-14

Aquatic Ecology Sampling Locations

MET-06-02 Section 4 _111B

Aquatic Habitats

A detailed description of streams in the Project Underground Mining Area and surrounds and of the baseline aquatic ecology sampling sites is provided in Appendix D. A general overview of the aquatic habitat characteristics is provided below.

Waratah Rivulet and Woronora River flow through relatively steep valleys. Stream substrates are predominantly comprised of bedrock, with some areas of sandy substrate. Macrophytes are present in areas with a sandy substratum.

Trees and branches have fallen across many of the smaller streams sampled (e.g. Waratah Rivulet tributaries and Honeysuckle Creek). Deposits of iron oxide were observed at a number of sampling sites. At sites in the upper reaches of the Woronora Reservoir, there was evidence of stream bank degradation due to clearing of vegetation along the banks of the reservoir and erosion due to a falling water level.

Water quality measurements recorded at the time of sampling are provided in Appendix D. The mean pH was below the recommended ANZECC (2000) guideline for the protection of aquatic ecosystems in upland rivers (i.e. pH 6.5 to 8.0) at a number of sampling sites including streams not previously subject to mine subsidence. While mean conductivity values were within the recommended ANZECC (2000) guidelines for the protection of aquatic ecosystems (i.e. 30 to 350 µS/cm) at the majority of sites sampled, all mean dissolved oxygen values were below the recommended ANZECC (2000) guidelines of 90 to 110% Saturation. Mean turbidity values at the sampling sites were within the recommended ANZECC (2000) guidelines for the protection of aquatic ecosystems (i.e. 2 to 25 Neophelometric Turbidity Units [NTU]).

Macrophytes

Thirty-eight aquatic macrophyte species were recorded in quadrats. An additional 16 species were recorded during cover class estimates. Macrophytes were generally present at sampling sites in low species numbers and low population densities. Aquatic macrophytes are not naturally abundant in either Waratah Rivulet or the tributaries of Waratah Rivulet or Woronora Reservoir. The streams are naturally rocky with very little sediment habitat available for aquatic plants to establish. The steep nature of the tributaries also means that when there is significant flow, both sediments and aquatic plants can be scoured and dislodged/washed downstream.

Introduced macrophyte species were recorded at sites sampled on Waratah Rivulet, a tributary of the Woronora Reservoir in the east, and in the Woronora Reservoir.

Macroinvertebrates

A total of 2,308 individuals from 52 macroinvertebrate taxa were collected from sites using the quantitative sampling technique. The taxon classification and abundance of macroinvertebrates collected from each site is provided in Appendix D. The most abundant macroinvertebrate taxa were Atyidae, Leptophlebiidae, Cenidae, Leptoceridae and Dytiscidae in the streams and Atyidae, Dytiscidae, Libellulidae and Physidae in the Woronora Reservoir. Mean macroinvertebrate diversity varied significantly across location. The most important taxon to contribute to structure of assemblages varied amongst locations. Little submerged vegetation and rock substratum were recorded during sampling. Lack of sufficient in-stream habitat appears to account for the relatively low macroinvertebrate species abundance.

Fish

The richness and abundance of assemblages of fish recorded by the baseline aquatic ecology surveys was low. Only two native species were recorded, *viz.* the Long-finned Eel (*Anguilla reinhardtii*) in the Waratah Rivulet and Woronora River and Australian Smelt (*Retropinna semoni*) in the Woronora Reservoir. The dam wall of the Woronora Reservoir is likely to be a major barrier to migration of fish.

The very low fish species richness and abundance upstream of the Woronora Reservoir can be best explained by the inability of particular species to negotiate this barrier, rather than loss of habitat. Fish species recorded in the Woronora River downstream of the Woronora Dam (in Sutherland) include the Common Jollytail (*Galaxias maculatus*), Flathead Gudgeon (*Philypnodon grandiceps*), Dwarf Flathead Gudgeon (*Philypnodon* sp.), Firetail Gudgeon (*Hypseleotris galii*), Striped Gudgeon (*Gobiomorphus australis*), Empire Gudgeon (*Hypseleotris compressa*), Cox's Gudgeon (*Gobiomorphus coxii*), Australian Smelt (*Retropinna semoni*), Long-finned Eel (*Anguilla reinhardtii*), Short-finned Eel (*Anguilla australis*), Mosquito Fish (*Gambusia holbrooki*) and Goldfish (*Carassius auratus*) (Harris and Gehrke, 1997).

The introduced Mosquito Fish (*Gambusia holbrooki*) was recorded in the Woronora Reservoir, Waratah Rivulet and Woronora River. The Mosquito Fish is a major pest species in the freshwaters of eastern NSW. Alien species, particularly Mosquito Fish, commonly thrive in still waters (McDowall, 1996), especially when the pre-existing assemblages are depauperate (Ross, 1991; Stanford *et al*., 1996). Recent studies have found assemblages of fish in highly-regulated rivers have a greater proportional abundance of alien to native fish compared to unregulated rivers (Gehrke *et al*., 1995; Gehrke and Harris, 2001).

Threatened Aquatic Biota

Review of relevant literature and databases prior to the baseline aquatic ecology surveys identified four threatened aquatic species or their habitats that have the potential to occur in the Project Underground Mining Area or surrounds, as follows:

- Adams Emerald Dragonfly (*Archaeophya adamsi*) – listed as Vulnerable under the *Fisheries Management Act, 1994*;
- Sydney Hawk Dragonfly (*Austrocordulia leonardi*) – listed as Endangered under the *Fisheries Management Act, 1994*;
- Macquarie Perch (*Macquaria australasica*) – listed as Vulnerable under the *Fisheries Management Act, 1994* and listed as Endangered under the EPBC Act; and
- Australian Grayling (*Prototroctes maraena*) – listed as Vulnerable under the EPBC Act.

However, none of these species were recorded during the baseline surveys, nor have the Adams Emerald Dragonfly or Sydney Hawk Dragonfly been recorded by the numerous aquatic macroinvertebrate surveys conducted in streams in the Project Underground Mining Area and surrounds for the Metropolitan Colliery (Marine Pollution Research, 2003 to 2005; The Ecology Lab, 2005 to 2006; BIO-ANALYSIS Pty Ltd, 2007 to 2008).

The Adams Emerald Dragonfly is one of Australia's rarest dragonflies, with only five adults ever collected from a few sites in the greater Sydney region (NSW Fisheries, 2002). Larvae of the Adams Emerald Dragonfly have been found in small creeks with gravel or sandy bottoms, in narrow, shaded riffle zones with moss and rich riparian vegetation (NSW Fisheries, 2002).

The Sydney Hawk Dragonfly was discovered in 1968 from Woronora River and Kangaroo Creek, south of Sydney and later recorded from the Nepean River at the Maldon Bridge near Wilton (NSW Fisheries, 2007). Intensive surveys over recent years have failed to detect the presence of any of the life stages of the Sydney Hawk Dragonfly along Woronora River and Kangaroo Creek. The species has not been collected from the locality since the removal of the weir in the Woronora River at Heathcote (Hawking and Theischinger, 2004).

The Macquarie Perch has been found in the Georges River drainage basin, several kilometres downstream of the Project Underground Mining Area (near Holsworthy), but not since the early 1980s (Harris and Gehrke, 1997; NSW Government BioNet database). The Woronora River system was sampled at 20 sites in 2001 by NSW Fisheries to determine whether the Macquarie Perch existed within the catchment. The survey found no Macquarie Perch upstream or downstream of Woronora Dam (Bruce *et al.*, 2001).

The Australian Grayling has not been found in the Georges River basin or in the Hacking River catchment (Pease and Herbert, 2002; NSW Government BioNet database).

No threatened aquatic biota listed under the TSC Act, *Fisheries Management Act, 1994* or EPBC Act have been recorded within the Project Underground Mining Area or in the Woronora Reservoir.

4.5.2 Potential Impacts

Potential impacts of the Project on aquatic ecology were considered in terms of habitat alteration (e.g. potential mine subsidence impacts on hydrology, pool habitat, in-stream connectivity and water quality), potential mine subsidence impacts on biodiversity (aquatic macrophytes, macroinvertebrates, fish, threatened aquatic biota and riparian vegetation), and other potential direct, indirect and cumulative impacts, as described below. Alteration of habitat following subsidence due to longwall mining is listed as a key threatening process under the TSC Act.

Subsidence Effects on Hydrology

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* (NSW Scientific Committee, 2005).

The effects of mine subsidence on surface water flows are described in detail in Section 4.4 and Appendix C. In summary, in the Project Underground Mining Area the effects of underflow would be most noticeable during periods of low flow and on the frequency of no flow, while the effects on the frequency and magnitude of high flows would be negligible (Appendix C).

The Groundwater (Appendix B) and Surface Water (Appendix C) Assessments for the Project indicate that mine subsidence would not result in a loss of water to the Woronora Reservoir (Sections 4.3 and 4.4).

Subsidence Effects on Pools

Fracturing of rock strata in watercourses can also result in a reduction in water level in pools due to the conveyance of a portion of natural surface flows via the fracture network (Appendix C). The effects of mine subsidence on pools are described in detail in Section 4.4 and Appendix C, including observations on the effects of previous mining at the Metropolitan Colliery on Waratah Rivulet pools and on tributary pools.

In summary, during dry periods when flows are in a low, recessionary regime, the water level in pools affected by subsidence would in some cases recede faster than is the case in unaffected pools. 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 in some cases decline below the “cease to flow” level at a rate faster than it did prior to being undermined.

It is likely that a portion of the pools subject to mine subsidence effects would hold some water during prolonged dry periods (Appendix C). These latter pools would remain full during most typical wetting and drying cycles.

Subsidence Effects on In-Stream Connectivity

As described in Section 4.4, the hydraulic capacity of the fracture network is not constant along the affected stream reach. Observations of flows along different reaches of Waratah Rivulet that have been subject to mine subsidence confirm that flows are sufficient to provide a continuous connection between some pools at times when there is not continuous flow connecting other pools (Appendix C).

During prolonged dry periods when flows recede to low levels, the number of instances where loss of flow continuity between pools occurs increases with a greater proportion of these lower flows being conveyed entirely in the subsurface fracture network. However, during these prolonged dry periods, some inter-pool reaches with “micro-pools” and shallow depressions in the bedrock that hold water have been observed and would provide refugia for some aquatic biota.

Subsidence Effects on Water Quality

Mine subsidence has the potential to impact on stream water quality that can reduce the quality of habitat for aquatic biota. Subsidence effects on water quality are described in detail in Appendix C and are summarised in Section 4.4.

Subsidence in Waratah Rivulet has resulted in localised and transient changes (spikes or pulses) in some metals (e.g. iron, manganese and to a lesser extent aluminium) and minor associated increases in electrical conductivity, which likely occur following fresh cracking of the streambed. The pulses have not had any measurable effect on water quality in the Woronora Reservoir downstream. Further, subsidence effects to Waratah Rivulet have not resulted in any significant changes or trends in dissolved oxygen or pH levels. In the Waratah Rivulet, areas of the substratum have been observed on some occasions to be covered by iron flocculent material for several hundred metres downstream of mine subsidence fractures. Potential ecological effects of such flocculent material include smothering of benthic habitat and biota and reduced light available for aquatic plants (Sammut *et al*., 1996). The bacterially catalysed oxidation of iron also consumes dissolved oxygen (Sammut *et al*., 1996).

Subsidence Effects on Biodiversity - Aquatic Macrophytes

Aquatic macrophytes are important dynamic biological components of streams. They can modify physicochemical conditions, form structural habitats for epiphytes and fauna, trap detritus, provide shelter, compete with algae and provide detritus to food chains (Carpenter and Lodge, 1986). As described above, fracturing of the stream channel can result in conveyance of a portion of surface water flows via the fracture network and a reduction in pool water levels. Changes in hydrology as a result of mine subsidence have the potential to impact on aquatic plants through exposure and desiccation.

As described above, aquatic macrophytes are not naturally abundant in either Waratah Rivulet or the tributaries of Waratah Rivulet or Woronora Reservoir.

Obligate water plants generally require permanent water, however they can recolonise once water becomes available again. Aquatic macrophytes have evolved reproductive strategies to cope with the variable nature of flow in streams and wetlands within Australia. In the past, the conveyance of surface flows and reduced pool water levels in Waratah Rivulet (i.e. upstream of the WRS3 rock bar) resulted in the exposure and desiccation of some beds of an aquatic macrophyte (i.e. Water Ribbons, *Triglochin procerum*) (The Ecology Lab, 2005 to 2006; Gingra Ecological Surveys, 2007). More recent surveys indicate that Water Ribbons have re-established in the pool following rain (Gingra Ecological Surveys, 2007).

The Project is unlikely to have a significant impact on the composition or distribution of aquatic macrophytes. This is supported by the monitoring of aquatic macrophytes at Metropolitan Colliery to date.

Subsidence Effects on Biodiversity - Macroinvertebrates

The composition and abundance of macroinvertebrates within coastal streams is controlled by flow regime, food supply, water quality, biotic interactions and habitat structure (Cummins *et al.*, 1997; Growns and Growns, 1997).

Localised impacts on assemblages of aquatic macroinvertebrates may occur as a result of changes in aquatic habitat. No significant long-term impacts on assemblages of macroinvertebrates have been found as a result of mine subsidence at the Metropolitan Colliery. Examination of taxa collected from local streams at different times, both before and after mining, indicated that there had been no changes or loss in taxa. Small changes in composition and abundance are considered likely to be due to natural variability in these assemblages through time. Furthermore, there were no significant differences detected in assemblages of macroinvertebrates (richness and abundance) in areas where mining has occurred, compared with reference locations sampled at the same time.

Subsidence, cracking and the consequent diversion of a portion of stream flow may impact on aquatic macroinvertebrates at small scales, for short periods of time and the assemblages would recover quickly. Data collected from reference locations without mine subsidence effects also show similar patterns in richness and abundance of assemblages through time. Natural variability in the richness and abundance of assemblages of macroinvertebrates can be related to the type of habitat, macroinvertebrate reproductive strategies and the variable flow regimes.

Short-term disturbance would include drying associated with reduced availability of water habitat and the effects of iron precipitate smothering benthic habitats and/or organisms. If however, adverse impacts on macroinvertebrates were to occur at pool specific locations, the significant remaining intact pools (acting concurrently as refugia pools), would likely rapidly seed macroinvertebrate re-establishment within the impacted pool, as and when water flow again occurred following the onset of a fresh or minor flood event, events predicted to occur relatively frequently within the wider catchment. The temporal extent of any effects would also be mitigated by natural healing mechanisms observed in the Completed Underground Mining Area (Section 4.4.1) and through the implementation of HCPL's stream restoration commitments (Section 5).

The Project is unlikely to have any significant long-term impacts on assemblages of macroinvertebrates in the Waratah Rivulet or in tributaries of Waratah Rivulet or Woronora Reservoir.

Subsidence Effects on Biodiversity - Fish

The conveyance of surface water flows to sub-surface fractures in the area affected by subsidence has the potential to reduce available habitat for fish (e.g. aquatic macrophytes, pools) and connectivity among sections of the stream channel, impeding fish passage. Other mine-related activities (e.g. bypass pumping during stream restoration activities) also has the potential to temporarily affect stream connectivity and fish passage.

The dam wall of the Woronora Reservoir acts as a major barrier to fish migration upstream. Given the depauperate fish fauna assemblage and the presence of the Woronora Reservoir, it is unlikely that the Project would further significantly impact on fish fauna within the Project Underground Mining Area or surrounds.

Subsidence Effects on Biodiversity - Threatened Species

No threatened aquatic biota listed under the TSC Act, *Fisheries Management Act, 1994* or EPBC Act are known to occur in streams within the Project Underground Mining Area or in the Woronora Reservoir. It is unlikely that any threatened aquatic biota would occur given the location of the Woronora Dam, which is a barrier to fish migration upstream, the habitat requirements of species that could potentially occur and the absence of records to date.

Subsidence Effects on Biodiversity - Riparian Vegetation

Riparian and streambank vegetation has several primary physical and biological functions, which are important in maintaining the health of aquatic systems (Turak and Bickel, 1994; Pusey and Arthington, 2003). The degradation of native riparian vegetation along NSW watercourses is listed as a key threatening process under the *Fisheries Management Act, 1994*.

Riparian vegetation has the potential to be impacted by subsidence, primarily as a result of changes in stream water levels. Monitoring of riparian vegetation along the Waratah Rivulet indicates that impacts of subsidence have been localised and limited in extent (Gingra Ecological Surveys, 2007; 2008).

It is unlikely that stream water level changes as a result of mine subsidence would disturb riparian vegetation to the extent that its role would be adversely impacted.

Other Direct or Indirect Impacts

Project activities (e.g. on-going surface exploration activities, the upgrade and extension of surface infrastructure, access tracks, environmental monitoring and management activities, stream restoration activities and other minor Project-related surface activities) have the potential to increase soil erosion/sedimentation or result in water contamination (e.g. fuel leakages from equipment or uncontrolled spills). However, appropriate management measures to minimise these risks are presented in Sections 4.1.3, 4.4.3 and 4.5.3.

Project activities may also require the diversion/ pumping of stream flow around surface activities (e.g. during stream restoration activities) that have the potential to obstruct fish movement. However, the diversion/pumping of stream flow around surface activities would be temporary in nature.

The potential effects of climate change on the nature and extent of the Project potential impacts has been considered including those relating to groundwater and surface water, as described in Section 3.8. The Project has the potential to increase slightly the vulnerability of the aquatic ecosystem to climate change. However, such impacts are likely to be relatively small.

Cumulative Impacts

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 aquatic and terrestrial ecology is provided in Appendices D and G and summarised below.

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 Underground Mining Area and surrounds 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 sire, etc.) appears to be very high.

The following aspects have been considered in assessing cumulative impacts (Appendices D and G):

- 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 aquatic and 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 to 2 years), take many year to fully express themselves (e.g. 10 years or more), or continue to develop over much longer periods of time.

When the cumulative impacts of the past and present actions described have peaked within the footprint area under consideration, the following outcomes are predicted (Appendices D and G):

- The impacts on aquatic and terrestrial ecology 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.

Supplementary Consideration of SCPR Recommendations

Following the substantial completion of the aquatic ecology impact assessment, the SCPR was released (DoP, 2008). As described in Sections 1 and 3.7, the Director-General's EARs for the Project require an assessment of the potential impacts of the Project, taking into consideration the findings and recommendations of the SCI. One of the recommendations of the SCPR is for environmental assessments to include *identification and assessment of significance for all natural features located within 600 m of the edge of secondary extraction*.

The following information is provided in relation to the assessment of aquatic ecology located within 600 m of the edge of Project secondary extraction:

- The baseline aquatic ecology surveys included the use of systematic sampling sites and techniques to survey aquatic biota in the Project Underground Mining Area and surrounds (Figure 4-14).
- Aquatic ecology within the 600 m buffer area has been considered in the assessment of the Project's potential impacts on aquatic biota and their habitats.
- No significant impacts on aquatic ecology were identified for the Project within the Project Underground Mining Area or surrounds.

General consideration of the recommendations of the SCPR is provided in Section 3.7.

4.5.3 Mitigation Measures, Management and Monitoring

In accordance with the NSW Fisheries (1999) *Policy and Guidelines for Aquatic Habitat Management and Fish Conservation*, HCPL has considered ways to mitigate the potential impacts of the Project on aquatic ecology. Measures have been developed to minimise impacts on aquatic biota and their habitats and would be detailed in a FFMP to be developed for the Project (Sections 5.2 and 6). The aquatic ecology components of the FFMP would be developed in consultation with the NSW Fisheries and other relevant authorities and to the satisfaction of the DoP. The FFMP would include the aquatic ecology management measures described below. The FFMP would be prepared prior to the extraction of Longwall 20.

As described in Section 4.4, surface water quality monitoring would be conducted to monitor subsidence-related impacts on surface water quality. The surface water quality monitoring programme would include parameters of relevance to aquatic ecology including dissolved oxygen, pH, conductivity and turbidity.

Monitoring and management of subsidence effects on riparian vegetation are described in Section 4.6.3.

In addition to the above, HCPL has committed to undertake restoration works at four key rock bars on Waratah Rivulet (Section 5.2).

Other Direct or Indirect Impacts

As described in Section 4.6.3, the FFMP would outline management measures to be implemented at sites where vegetation clearance is necessary to limit soil and vegetation disturbance and the potential for sedimentation in streams. For example, surface water management structures would be utilised to control erosion and sediment during works involving surface disturbance to minimise the potential for Project activities to adversely affect water quality. The FFMP would also include management measures for the containment of drill cuttings and to minimise the risk of water contamination (e.g. fuels and oils). Measures that would be implemented to minimise potential impacts of surface activities on surface water quality are described in Section 4.4.3.

HCPL would operate at the Major Surface Facilities Area in accordance with the requirements of EPL No. 767 which regulates the controlled discharge of treated water to Camp Gully. It is anticipated that upgrade of the Major Surface Facilities Area for the Project would improve water management at the site and minimise potential surface water quality impacts in the Hacking River catchment.

Flat Rock Crossing is an existing stream crossing on Fire Road 9H that provides access for vehicular traffic across Waratah Rivulet. The NSW Fisheries (2003) *Policy and Guidelines for Fish Friendly Waterway Crossings* provides a summary of the specific legislation and policy requirements for those intending to plan, design and construct waterway crossings in NSW. No stream crossings would be constructed for the Project.

In regard to greenhouse gas emissions and climate change effects, measures to minimise greenhouse gas emissions would include improvements to maximise efficiency of the use of fuels and minimise electricity consumption and are described in Section 3.8.

Monitoring

Consistent with the recommendations of the SCPR (DoP, 2008), the aquatic ecology monitoring programme would be designed to:

(i) monitor subsidence-induced impacts on aquatic ecology; and

(ii) monitor the response of aquatic ecosystems to the implementation of stream restoration works.

The aquatic ecology monitoring programme would be described in detail in the FFMP to be developed for the Project.

The aquatic ecology monitoring programme would:

- include monitoring at an appropriate frequency and scale for a period prior to, during, and following the completion of mining;
- include monitoring at an appropriate frequency and scale prior to, during, and following the implementation of stream restoration activities;
- take into account the seasonality and inter-annual variability of the systems under study;
- target the collection of a minimum of two years pre-mining data, where practicable;
- include sites situated within the Project Underground Mining Area, as well as control sites situated in comparable unmined locations (the location of sampling sites would be determined in consideration of the aquatic habitat characteristics, their location relevant to the mine plan and access constraints);
- include the use of quantitative sampling techniques;
- be designed to comprise appropriate sampling replication;
- be designed consistent with best practice impact monitoring (e.g. the use of an experimental design that allows advanced statistical analyses techniques to be employed such as Before, After, Control, Impact [BACI] designed studies);
- be co-ordinated with other monitoring programmes as practicable to assist with determinations of causal relationships (e.g. monitoring of pool water levels, stream flow, groundwater levels and subsidence);
- be developed in consideration of their potential contribution to regional and cumulative data sets on aquatic ecosystems consistent with Recommendation 21 of the SCPR (Section 3.7.4); and
- be peer reviewed by an appropriately qualified specialist.

The approach to monitoring described above is consistent with the NSW Fisheries (1999) *Policy and Guidelines for Aquatic Habitat Management and Fish Conservation* which supports the use of a scientifically rigorous monitoring programme to assess impacts on aquatic ecology and the effectiveness of environmental mitigation, and to facilitate the implementation of adaptive management.

Riparian vegetation would also be monitored as described in Section 4.6.3.

Cumulative Impacts

The mitigation measures, management and monitoring described above are relevant to minimising potential cumulative impacts on aquatic ecology.

4.5.4 Compensatory Measures and Ecological Initiatives

Compensatory measures and ecological initiatives for the Project are outlined in Sections 3.9.3 and 5.6.

4.6 TERRESTRIAL FLORA

Baseline terrestrial flora surveys were conducted for the Project by Bangalay Botanical Surveys and the report is provided in Appendix E. The potential impacts of the Project on terrestrial flora and their habitats have been assessed by FloraSearch and the assessment is provided in Appendix G. Peer review was undertaken by Dr David Goldney of the Western Research Institute (Attachment 3).

A description of the flora in the vicinity of the Project is provided in Section 4.6.1. Section 4.6.2 describes the potential impacts of the Project on flora, while Section 4.6.3 outlines flora mitigation measures, management and monitoring, in response to the potential impacts that have been identified. Section 4.6.4 describes compensatory measures and ecological initiatives.

Matters of national environmental significance of relevance to flora are discussed in Section 3.4.1.

4.6.1 Existing Environment

Setting

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

Baseline Flora Surveys

Seasonal field surveys were conducted during spring 2006, summer 2006/2007, autumn 2007 and spring/summer 2007/2008 (Appendix E). The vegetation was systematically surveyed using random meanders, quadrats and spot sampling sites. The spot and quadrat sampling sites are shown in Appendix E.

Targeted searches for threatened flora species and other plant species of conservation significance were also conducted in areas of potential or suitable habitat. Mapping of the vegetation, including EECs, was also conducted. The baseline flora surveys were conducted in accordance with DEC (2004b) *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities, Working Draft.*

As a component of the baseline flora surveys, a number of reference sources containing the results of local or regional flora surveys, database records and other scientific studies and literature were reviewed, and where appropriate included in the assessment of existing vegetation. In particular, the NSW National Parks and Wildlife Service (NPWS) (2003) *Native Vegetation of the Woronora, O'Hares and Metropolitan Catchments* provided information on vegetation communities (including EECs), floristic data, threatened species and their habitats and the regional conservation status of flora.

The description and mapping of vegetation communities by the baseline flora survey are broadly consistent with the classification described in NPWS (2003) (Table 4-7). The baseline flora survey however refines the vegetation mapping and floristic data in the vicinity of the Project Underground Mining Area. NPWS Atlas of NSW Wildlife and Sydney Royal Botanic Gardens database records were also utilised to inform the baseline flora survey. Previous vegetation monitoring or assessment reports for the Metropolitan Colliery were also considered. For example, Bangalay Botanical Surveys (2007) conducted surveys in the Longwalls 18-19A area in spring 2006, summer 2006 and autumn 2007.

Table 4-7
Vegetation Communities Identified within the Project Underground Mining Area and Surrounds

Vegetation Communities Identified within the Project Underground Mining Area and Surrounds		NPWS (2003) Vegetation Mapping	
Map Unit	**Vegetation Community**	**Map Unit**	**Vegetation Community**
Woodlands on Sandstone or Lateritic Soils			
1a	Exposed Sandstone Scribbly Gum Woodland	29	Exposed Sandstone Scribbly Gum Woodland
1b	Sandstone Heath-Woodland	34	Sandstone Heath-Woodland
1c	Silvertop Ash Ironstone Woodland	33	Silvertop Ash Ironstone Woodland
1r	Disturbed and/or Regenerating Sandstone or Lateritic Communities	-	-
Heaths and Mallee Heaths			
2a	Rock Pavement Heath	38	Rock Pavement Heath
2b	Rock Plate Heath-Mallee	39	Rock Plate Heath-Mallee
2c	Woronora Tall Mallee-heath	40	Woronora Tall Mallee-heath
2r	Regenerating Mallee-heath	-	-
Upland Swamps			
3a	Upland Swamp: Banksia Thicket	42	Upland Swamp: Banksia Thicket
3b	Upland Swamp: Tea Tree Thicket	43	Upland Swamp: Tea Tree Thicket
3c	Upland Swamp: Sedgeland-heath Complex	44	Upland Swamp: Sedgeland-heath Complex
3d	Upland Swamp: Fringing Eucalypt Woodland	45	Upland Swamp: Fringing Eucalypt Woodland
Riparian Scrub			
4a	Sandstone Riparian Scrub	4	Sandstone Riparian Scrub
Tall Open Forests			
5a	Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion	16	Tall Blackbutt-Apple Shale Forest
5b	O'Hares Creek Shale Forest	17	O'Hares Creek Shale Forest
5r	Regenerating O'Hares Creek Shale Forest	50	Regenerating Vegetation
Sandstone Forests			
6a	Sandstone Gully Apple-Peppermint Forest	25	Sandstone Gully Apple-Peppermint Forest
6r	Disturbed and/or Regenerating Sandstone Gully Apple-Peppermint Forest	-	-
Disturbed Land			
7a	*Acacia* Regeneration	49A	-
7b	Introduced – Weeds and Exotics	50	Weeds and Exotics

Source: After Appendix E.

Upland Swamp Investigation

An investigation of upland swamps and impacts of underground mining was conducted by FloraSearch to inform the assessment of upland swamps situated within the Project Underground Mining Area (Longwalls 20 to 44) and within the potential extent of mine subsidence effects (Appendix G). Site inspections of thirteen swamps that had experienced mine subsidence and twelve that had not experienced mine subsidence on the Woronora Plateau were conducted by FloraSearch in January and February 2008. Information recorded at each swamp location included swamp health, soil disturbance or erosion and the vegetation communities present. A literature review was also conducted by FloraSearch in regard to underground mining and upland swamps in the Southern Coalfield (Appendix G).

Vegetation Communities

Vegetation communities mapped by Bangalay Botanical Surveys (2008) are shown on Figure 4-15 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 listed in Table 4-7 and are broadly consistent with the classification described in NPWS (2003).

Upland swamps on the Woronora Plateau occur in small headwater valleys that are characteristically sediment choked and swampy (Young, 1986). The presence of the upland swamps is related to their topographic position, the lithology of the bedrock and the hydrological balance on the plateau (*ibid*.). 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. Six swamp communities have been identified on the Woronora Plateau, namely: I. Fringing Eucalypt Woodland; II. Banksia Thicket; III. Restioid Heath; IV. Sedgeland; V. Cyperoid Heath and VI. Tea Tree Thicket (Keith and Myerscough, 1993; Keith, 1994; NPWS, 2003). Communities 1 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 (Appendix G). 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).

The swamps within the Project Underground Mining Area are classified as headwater upland swamps (Figure 4-5). One in-valley upland swamp is situated outside of the Project Underground Mining Area, but within the potential extent of mine subsidence effects (Figure 4-5). This swamp overlies Metropolitan Colliery Longwalls 7 and 8 and consequently has already experienced mine subsidence from completed mining operations.

Flora Species Composition

The majority of plant species occurring within the Woronora Special Area and recorded during the baseline flora surveys are native (Appendix E). A total of 601 plant species were recorded during the baseline flora surveys, including 528 native and 73 introduced species. 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).

A list of plant species recorded during the baseline flora surveys is provided in Appendix E.

Introduced Flora Species and Noxious Weeds

In general, introduced plant species were found during the baseline flora surveys to be limited to areas subject to prior and/or current disturbance (Appendix E). Introduced species occurred infrequently along fire roads and generally included widespread and common species in low densities. Introduced species diversity and abundance increased within vegetation along major roads (e.g. the F6 Freeway and Old Princes Highway) and larger areas of disturbed landscapes that occur in the north-east and east.

A number of weeds recorded during 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) (Appendix E).

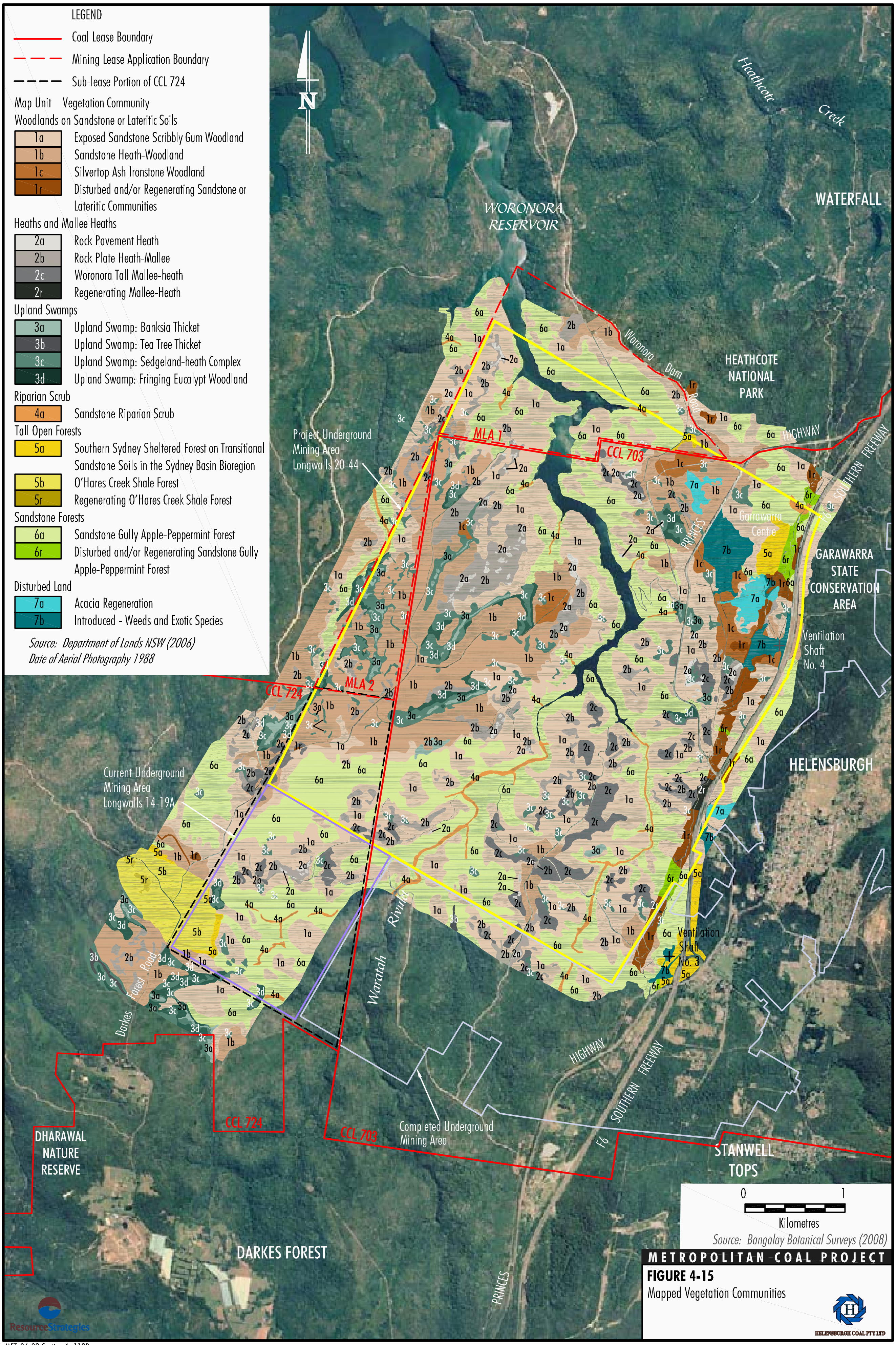


FIGURE 4-15
Mapped Vegetation Communities

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Threatened Flora Species

Four threatened flora species have been recorded in the Project Underground Mining Area (Longwalls 20 to 44) and/or surrounds, *viz*. Bynoe's Wattle (*Acacia bynoeana*), Thick-leaf Star-hair (*Astrotricha crassifolia*), Prickly Bush-pea (*Pultenaea aristata*) and Deane's Paperbark (*Melaleuca deanei*).

Possible occurrences of a further two threatened species, namely, *Leucopogon exolasius* and *Epacris purpurascens* var. *purpurascens* were also recorded during the baseline flora surveys, however the identification of these species could not be confirmed due to the lack of fertile fruiting or flowering parts required for positive identifications (Appendix E). These threatened flora species and their status are summarised in Table 4-8. Locations of identified threatened flora species in the vicinity of the Project Underground Mining Area are shown on Figure 4-16.

Rare or Threatened Australian Plants (RoTAP)

Ten species listed as rare in Rare or Threatened Australian Plants (RoTAP) (Briggs and Leigh, 1996) were recorded during the baseline flora surveys, *viz. Hibbertia nitida, Lissanthe sapida, Darwinia diminuta, Monotoca ledifolia, Darwinia grandiflora, Eucalyptus apiculata, Eucalyptus luehmanniana, Grevillea longifolia, Boronia serrulata* and *Lomandra fluviatilis* (Appendix E).

Endangered Flora Populations

No endangered flora populations listed under the TSC Act are located in the Project Underground Mining Area or are known to occur in the immediate surrounds (Appendix E).

Endangered Ecological Communities

One EEC listed under the TSC Act was recorded in the Project Underground Mining Area and surrounds, *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 Longwalls 20 to 44 in the vicinity of Longwalls 18 to 19A (Current Underground Mining Area).

The Southern Sydney Sheltered Forest on Transitional Sandstone Soils EEC 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 the Southern Sydney Sheltered Forest on Transitional Sandstone Soils EEC 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*.).

Table 4-8
Threatened Flora Species Recorded during Baseline Flora Surveys

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: After Appendix E.
[1] Threatened species status current as at 1 August 2008.
E – Endangered
V – Vulnerable

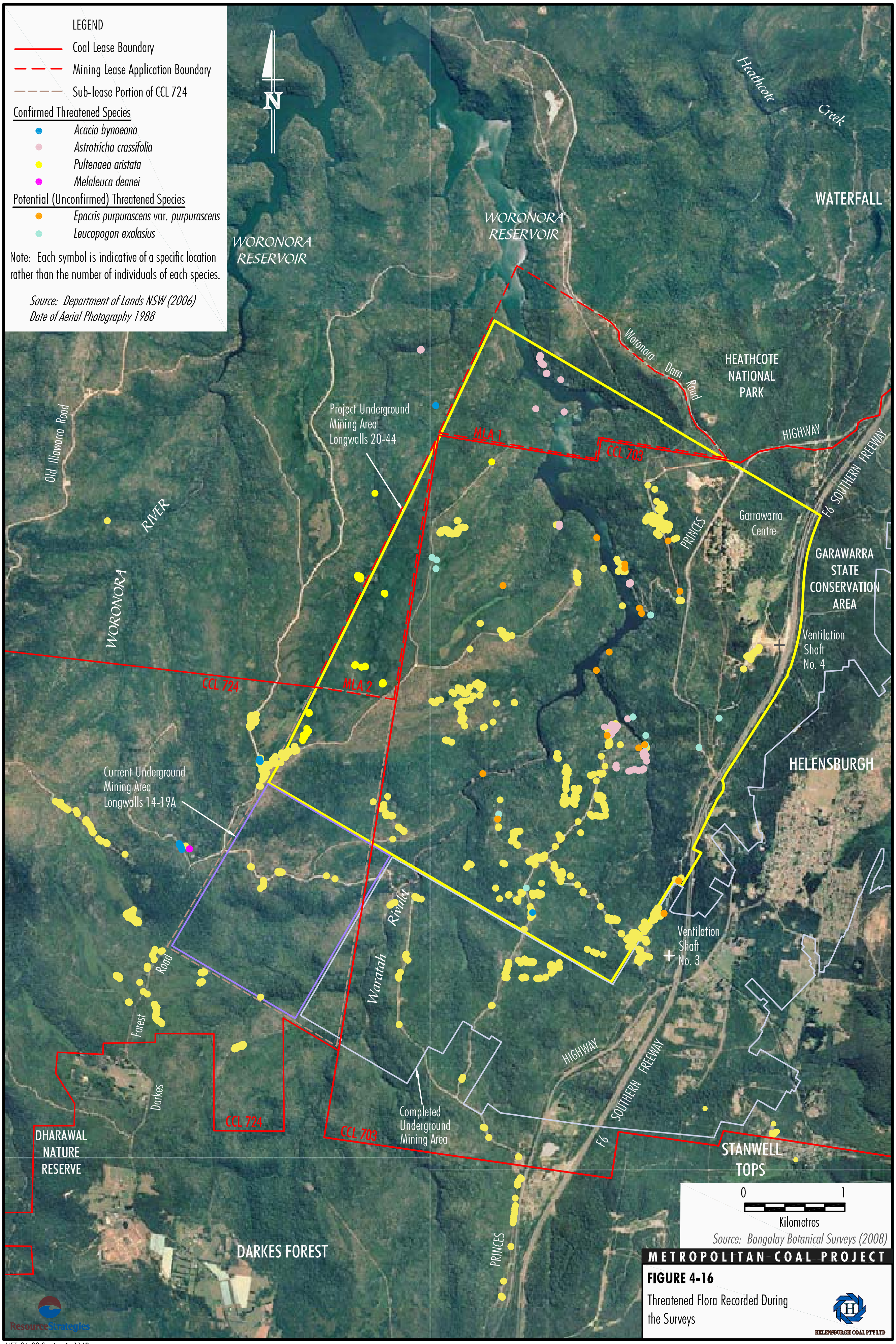


FIGURE 4-16

Threatened Flora Recorded During the Surveys

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, 1998).

The community occurs on flat ridgetops and adjacent slopes (NSW Scientific Committee, 1998) 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 (DECC, 2008d). 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 comprising 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 locations of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils EEC (Map Unit 5a) and O'Hares Creek Shale Forest EEC (Map Units 5b and 5r) mapped in the vicinity of the Project Underground Mining Area are shown on Figure 4-15.

4.6.2 Potential Impacts

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) and other direct, indirect or cumulative impacts, as described below. Alteration of habitat following subsidence due to longwall mining is listed as a key threatening process under the TSC Act.

Subsidence Effects and Riparian Vegetation

As described in Section 4.4, 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. These subsidence effects 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 have the potential to alter the availability of water to riparian vegetation and affect the condition of some plants close to the stream channel.

As has been observed at Metropolitan Colliery previously, potential mine subsidence impacts on riparian vegetation are expected to be relatively minor (i.e. localised area of dieback), with effects to vegetation condition predominantly being temporary (i.e. recovery has subsequently occurred) and limited in extent. Gingra Ecological Surveys (2008) states that *In overall terms the condition of the riparian vegetation along Waratah Rivulet had improved to be similar to the pre-mining condition along the length of the rivulet, indicating significant recovery of riparian vegetation*.

There is one known case (along the Cataract River at Tower Colliery) where releases of gas through the soil profile close to river banks have adversely affected vegetation (Appendix A). 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 (Appendix A).

While no gas emissions have previously been observed at the Metropolitan Colliery, gas emissions could potentially occur at the surface as a result of Project mine subsidence and has the potential to result in some areas of dieback of riparian vegetation. However, any such effects would have a limited areal extent (i.e. proximal to the point of release) and would be temporary in nature. It is expected that natural revegetation of such an impact would occur relatively rapidly.

Subsidence Effects and Slope and Ridgetop Vegetation

Mine subsidence has the potential to cause shallow surface cracking near the tops of slopes. To date, this type of surface tension crack has only been identified at Metropolitan Colliery on one occasion (namely, adjacent to Fire Road 9H). As described in Section 4.2, the size and extent of surface cracking on slopes and ridgetops as a result of the Project is expected to be minor (Appendix A).

Shallow surface cracking has the potential to effect the movement of water (e.g. may become a preferred flow path for surface flow). However, as described in Section 4.4 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 (Appendix C). There have been no reported observations of changes to ridgetop and slope vegetation at Metropolitan Colliery that have been attributed to mine subsidence.

Mine subsidence also has the potential to cause rock fall, however given the predicted low incidence of rock fall (Appendix A), the potential impacts on flora as a result of rock fall are likely to be minor.

Assessment of the maximum potential subsidence on the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC is provided in Appendix A. Surface cracking as a 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 Underground Mining Area and surrounds is expected to be isolated and of a minor nature due to the relatively low magnitudes of the predicted strains and due to the relatively high depths of cover (Appendix A). Further, the maximum predicted systematic tilt is small when compared to the existing natural surface gradients.

The magnitude of the predicted subsidence effects is considered too small to influence the hydrological processes in this area including the soil moisture regime that sustains the EEC in this area (Appendix C). As a result, it is unlikely that the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC would be adversely affected by mine subsidence (Appendix G).

Subsidence Effects and Upland Swamp Vegetation

The upland swamps within the Project Underground Mining Area and immediate surrounds are not situated in the four key clusters of swamps identified by the DECC (2007a) as being of particular conservation significance in the Southern Coalfield. However, it is recognised that upland swamps are of particular ecological significance.

There is concern 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.

As described in Section 4.6.1, upland swamps within the Project Underground Mining Area are classified as headwater upland swamps (Figure 4-5). One in-valley upland swamp is situated outside of the Project Underground Mining Area, but within the potential extent of mine subsidence effects (Figure 4-5).

The in-valley swamp overlies Metropolitan Colliery Longwalls 7 and 8 and consequently has already experienced mine subsidence from completed underground mining. Site inspections of this in-valley swamp by FloraSearch indicate that the previous mine subsidence has not had a detrimental effect on vegetation health, vegetation community composition or abundance in the swamp and the swamp is considered to be in a healthy condition (Appendix G).

As described in Section 4.3, surface cracking resulting from mine subsidence within the upland swamps in the Project Underground Mining Area or within the extent of mine subsidence effects is not expected to result in an increase in the vertical movement of water from the perched water table into the regional aquifer (Appendix B).

The predicted tilts would not have any significant effect on the localised or overall gradient of the upland swamps (Appendix A) or the flow of water (Appendix C). 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 other components in the swamp water balance (Appendix C). Given the above, no change to the fundamental surface hydrological processes (Appendix C) and vegetation are expected within the upland swamps.

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.

The Project Underground Mining Area and surrounds is greater than 2,000 hectares (ha) in area. It is estimated that the Project would involve less than 10 ha of proposed vegetation clearance. Vegetation clearance activities would primarily be associated with on-going surface exploration activities, the upgrade and extension of surface infrastructure (e.g. Ventilation Shaft No. 4, access tracks, environmental monitoring and management activities, stream restoration activities and other minor Project-related surface activities).

Project vegetation clearance would occur progressively 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.

A network of fire trails managed by the SCA already exists and no further roads would be required, with the exception of some short temporary access tracks from the main fire trails to surface infrastructure. Such access tracks would involve minimal disturbance to vegetation, would be closed when no longer needed, and allowed to regenerate from the soil seed bank to minimise impacts on native vegetation.

Given the localised nature of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils EEC and O'Hares Creek Shale Forest 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 these EECs.

Further, vegetation clearance for surface infrastructure would not take place in upland swamps except for environmental monitoring purposes. Establishment of environmental monitoring sites would involve minimal vegetation clearance for equipment and access.

The Project also has the potential to increase the frequency of fire trail maintenance measures due to an increase in vehicular traffic in the Woronora Special Area. However, road/track maintenance measures are not expected to require additional vegetation clearance as a result of the Project.

Weeds

Many weed species are effective competitors for resources and have the potential to reduce the floristic structure and diversity of native plant communities. In general, introduced species are absent from areas of undisturbed natural habitat in the Woronora Special Area (Appendix E).

Introduced plant species in the Project Underground Mining Area and surrounds are largely confined to disturbed sites, including fire trails, cleared areas in the east and north-east and along the verges of the F6 Freeway and Princes Highway. There is potential for weed species to invade areas of disturbed soils. However, it is unlikely that introduced species would invade intact natural habitats in the absence of soil disturbance (Appendix G).

Infection of Native Plants by <u>Phytophthora cinnamomi</u>

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. *P. 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, 2002). 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, 2002). 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.* However, appropriate management measures to minimise this risk are presented in Section 4.6.3 below.

Fire

High frequency fire is listed as a key threatening process under the TSC Act. The frequent occurrence of fires has the potential to impact flora through disruption to lifecycle processes and habitat. 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.

However, given the range of management measures proposed to be in place to manage the behaviour of people in the Project Underground Mining Area, it is unlikely that there would be an increase in fire frequency resulting from the Project. Management measures to minimise the potential for bushfire are described in Section 4.6.3.

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 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 (Section 4.1). Regular rainfall reduces dust generation potential and dust build-up on foliage.

Project-related vehicle traffic in the Woronora Special Area has the potential to increase dust generation. However, the potential for dust generation in the Woronora Special Area is expected to be low. Vehicle-generated dust would be concentrated close to the road verge and is unlikely to be a sufficient amount for the effect to be noticeable (Appendix G). Consequently, no significant effect to vegetation condition is expected.

Greenhouse Gas Emissions and Climate Change Effects

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.

Climate change and greenhouse gas emissions associated with the Project are discussed in Section 3.8 including the potential ecological impacts of the Project in the context of global climate change.

Threatened Flora

Evaluations have been conducted to assess the potential impacts of the Project 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. The evaluations are documented in Appendix G.

On the basis of these evaluations, it is considered that the Project would be unlikely to have a significant effect on threatened flora, including:

- the lifecycle of a threatened species and/or population;
- the habitat of a threatened species, population or ecological community;
- threatened species or populations that are at the limit of their known distribution;
- current disturbance regimes;
- habitat connectivity; and
- any critical habitat of threatened flora.

Cumulative Impacts

As described in Section 4.5.2, 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 and their habitats is provided in Appendix G and are summarised in Section 4.5.2.

Supplementary Consideration of SCPR Recommendations

Following the substantial completion of the flora impact assessment, the SCPR (DoP, 2008) was released. As described in Sections 1 and 3.7, the Director-General's EARs for the Project require an assessment of the potential impacts of the Project, taking into consideration the findings and recommendations of the SCI.

< TOC Home >

One of the recommendations of the SCPR is for environmental assessments to include *identification and assessment of significance for all natural features located within 600 m of the edge of secondary extraction*.

The following information is provided in relation to the assessment of terrestrial flora located within 600 m of the edge of Project secondary extraction:

- Vegetation mapping by NPWS (2003) and Tozer *et al*. (2006) provides information on vegetation within the 600 m buffer area.
- The baseline flora surveys for the Project mapped vegetation communities within an area approximately 200 to 400 m beyond the edge of secondary extraction (Figure 4-15 and Appendix E).
- The baseline flora surveys for the Project included targeted surveys for threatened flora (Figure 4-16) up to 600 m beyond the edge of secondary extraction.
- Terrestrial flora within the 600 m buffer area has been considered in the assessment of the Project's potential impacts on terrestrial flora, including the assessment of significant natural features such as upland swamps.
- Threatened species evaluations have been conducted for threatened flora species, populations, ecological communities and their habitats that are known to occur or could possibly occur in the Project Underground Mining Area and wider surrounds (i.e. in consideration of the wider Woronora Plateau).
- No significant impacts on terrestrial flora were identified for the Project within the Project Underground Mining Area and surrounds.

4.6.3 Mitigation Measures, Management and Monitoring

Although the Project would avoid or minimise impacts on native vegetation where practicable, several measures have been developed to mitigate unavoidable impacts of the Project on flora. A FFMP would be developed for the Project. The FFMP would be developed in consultation with the DECC and the SCA and to the satisfaction of the DoP and would include the flora management measures described below.

Subsidence Impacts on Vegetation

The management of subsidence impacts on vegetation would be closely linked to vegetation monitoring, as described below. Measures that would be implemented in the event monitoring detects significant incidents or variations to the predicted subsidence impacts in this EA would be included in the FFMP. Under such circumstances, an investigation would be initiated and the need for additional ameliorative/ management measures would be determined. If required, these ameliorative/management measures would be developed by HCPL in consultation with the relevant authorities based on the results of the investigation.

Potential ameliorative/management measures for impacts on vegetation include the planting of endemic plant species. Any active planting would utilise flora species characteristic of the particular vegetation community in that area and would utilise seed collected from the Woronora Special Area.

Vegetation Clearance

As described in Section 4.6.2, vegetation clearance associated with the Project would primarily be associated with on-going surface exploration activities, the upgrade and extension of surface infrastructure, access tracks, environmental monitoring and management activities, stream restoration activities and other minor Project-related surface activities.

The FFMP would outline management measures to be implemented at sites where vegetation clearance is necessary. The environmental management of vegetation clearance sites would include:

- Detailed site inspections to identify the specific flora characteristics of the areas proposed to be disturbed.
- Identification of areas in which specific surface works involving vegetation clearance would be avoided or limited (e.g. within swamps, EECs and areas where threatened flora species are present).
- Final site selection and works design so as to minimise the amount of vegetation clearance required.
- Identification of management measures to minimise impacts on flora, prior to, during and/or following the completion of the surface works including natural regeneration and/or rehabilitation measures.

These management measures are described below.

The FFMP would identify areas in which specific surface works involving vegetation clearance would be avoided or limited. Given the localised nature of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils EEC and O'Hares Creek Shale Forest 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 these EECs.

Further, vegetation clearance for surface infrastructure would not take place in upland swamps except for environmental monitoring purposes. Establishment of the environmental monitoring sites would involve minimal vegetation clearance for equipment and access.

Surveys for threatened flora species would be conducted prior to disturbance and works would be relocated, where feasible, to avoid or minimise impacts on any threatened species population. In the event field inspections identify individuals of a threatened flora 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 flora 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.

Consistent with HCPL's existing approach, where practicable surface works would be sited to minimise the amount of vegetation clearance required (e.g. the positioning of sites to avoid the removal of trees or the siting of infrastructure in previously disturbed areas such as the slashed verges of existing SCA roads/tracks). The ventilation shaft would be located in an existing disturbed area.

Inspections of proposed disturbance areas would also be conducted to identify management measures to be implemented to minimise impacts on flora, prior to, during and/or following the completion of the surface works. Potential management measures include:

- Restricting vegetation clearance to the slashing of vegetation (i.e. leaving the lower stem and roots *in-situ* to maximise the potential for natural regrowth).
- Lopping of branches, rather than the removal of trees.
- The use of existing fire trails to access sites to minimise the disturbance of soils.
- Limiting the amount of soil disturbance to the minimum required for the mobilisation, placement and operation of equipment and for maintaining access to equipment.
- The use of rubber lattice matting or other measures to delineate work areas and to minimise disturbance to soils and vegetation.
- Measures to encourage natural regeneration (e.g. placing stockpiled vegetative material over cleared areas).
- Rehabilitation measures (e.g. the implementation of weed control measures, or active planting in the event natural regeneration is not considered to be progressing).

Weeds

Weed management measures for surface activities in the Woronora Special Area would be developed in consultation with the SCA. Potential weed management measures include the mechanical removal of weeds and application of approved herbicides and the inspection of all vehicles and mechanical equipment brought to site to avoid importation of foreign soil and organic matter.

Follow-up inspections would be conducted to assess the effectiveness of weed management measures and to determine the requirement for any supplementary management measures.

Infection of Native Plants by Phytophthora cinnamomi

Measures for the management of *P. cinnamomi* would be developed in consideration of DEH (2006c) *Management of Phytophthora cinnamomi for Biodiversity Conservation in Australia.* Management measures to minimise the potential for the introduction or spread of *P. cinnamomi* include:

- Restricting the movement of vehicles to formed tracks and pre-existing roads, where practicable.
- Limiting activities that cause soil disturbance.
- Encouraging natural regeneration in areas requiring revegetation.
- Potential measures in the event any infestation areas are identified include:
  - limiting access to infestation areas;
  - limiting access to uninfested areas following entry to infested sites;
  - implementation of hygiene protocols (e.g. clean footwear, equipment, vehicles and/or hygiene stations) when accessing and/or exiting known infestation areas; and
  - the inclusion of *P. cinnamomi* general awareness and procedure information in HCPL staff and contractor inductions, particularly for those requiring access to identified infestation areas.

Fire

A range of management measures would be implemented for the Project to minimise the risk of bushfire. HCPL's existing Bushfire Preparedness Plan for activities in the Woronora Special Area would be reviewed and where appropriate revised for the Project (Section 4.1.3).

Dust and Vegetation

As described in Section 4.11, a range of dust control measures would be employed at the Major Surface Facilities Area (e.g. watering of potential dust generating surfaces).

Vehicle access in the Woronora Special Area would be via formed tracks and existing fire trails. HCPL staff and contractors would be required to observe speed limits (current speed limit of 40 kilometres per hour [km/hr]) when using the fire trails, which would limit the amount of dust generated.

Greenhouse Gas Emissions and Climate Change Effects

Measures to minimise greenhouse gas emissions would include improvements to maximise efficiency of the use of fuels and minimise electricity consumption, as described in Section 3.8.

Threatened Flora

The mitigation measures, management and monitoring described above are relevant to the minimisation of potential impacts on threatened flora.

Monitoring

Vegetation monitoring would be described in detail in the FFMP to be developed for the Project and would include monitoring of riparian, upland swamp and slope/ridgetop vegetation.

The vegetation monitoring components would be co-ordinated with other monitoring programmes where practicable to assist with determinations of causal relationships (e.g. monitoring of pool water levels in streams, groundwater levels, swamp gradients, visual monitoring [e.g. of scour pools and erosion features in upland swamps] and subsidence monitoring).

Riparian, upland swamp and slope/ridgetop vegetation would be monitored at an appropriate frequency and scale for a period prior to, during, and following the completion of mining. The monitoring programmes would target the collection of a minimum of two years pre-mining data, where practicable. The monitoring programmes would include sites situated within the Project Underground Mining Area, as well as control sites situated in comparable unmined locations and would be designed to comprise appropriate sampling replication.

The FFMP would describe the riparian, upland swamp and slope/ridgetop vegetation monitoring. The location of sampling sites would be determined in consideration of the riparian, upland swamp and slope/ridgetop vegetation characteristics, their location relevant to the Project Underground Mining Area, access and site inspection.

Monitoring of upland swamp vegetation would target the monitoring of the Sedgeland-Heath complex, as well as monitoring of the Cyperoid Heath/Tea Tree Thicket vegetation. Upland swamp vegetation would be monitored using transects and/or quadrats to obtain quantitative data on flora. Riparian and slope/ridgetop vegetation would be monitored by visual observations, as well as quantitative sampling.

Cumulative Impacts

The mitigation measures, management and monitoring described above are relevant to minimising potential cumulative impacts on terrestrial flora.

4.6.4 Compensatory Measures and Ecological Initiatives

Compensatory measures and ecological initiatives for the Project are detailed in Sections 3.9.3 and 5.6, and include offsets and initiatives that relate to terrestrial flora.

4.7 TERRESTRIAL FAUNA

Baseline terrestrial fauna surveys were conducted for the Project by Western Research Institute and Biosphere Environmental Consultants and the report is provided in Appendix F. The potential impacts of the Project on terrestrial fauna and their habitats have been assessed by Western Research Institute and the assessment is provided in Appendix G.

A description of the terrestrial fauna in the vicinity of the Project is provided in Section 4.7.1. Section 4.7.2 describes the potential impacts of the Project on terrestrial fauna, while Section 4.7.3 outlines terrestrial fauna mitigation measures, management and monitoring. Section 4.7.4 describes compensatory measures and ecological initiatives.

Matters of national environmental significance of relevance to terrestrial fauna are discussed in Section 3.4.1.

4.7.1 Existing Environment

Setting

The Project is situated in the Sydney Basin IBRA bioregion (Thackway and Cresswell, 1995) and the Bassian zoogeographic region (Schodde, 1994).

Baseline Terrestrial Fauna Surveys

Baseline terrestrial vertebrate fauna surveys were conducted in spring/early summer 2006 and autumn 2007. 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. The fauna sampling sites are shown in Appendix F. Targeted surveys were conducted for threatened fauna species listed under the TSC Act and EPBC Act considered possible occurrences in the Project Underground Mining Area or surrounds.

As a component of the baseline terrestrial vertebrate fauna surveys, a number of reference sources containing the results of local or regional fauna surveys, database records and other scientific studies and literature were reviewed, and where appropriate included in the assessment of terrestrial fauna.

In particular, the DECC (2007c) *Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region* provided information on terrestrial fauna habitats (including priority fauna habitats), vertebrate fauna species (including known records, lifecycle components, regional conservation status and priority native fauna), threatened species and their habitats, and management recommendations. NPWS Atlas of NSW Wildlife, Australian Museum and Birds Australia database records were also utilised by the baseline fauna survey. Previous terrestrial fauna surveys at the Metropolitan Colliery were also considered. For example, amphibian surveys conducted in the Longwalls 14 to 17 area by Biosphere Environmental Consultants (2007).

Major Habitat Types

Five broad habitat types were identified in the Project Underground Mining Area and surrounds, namely, forest, woodland, heath and mallee, riparian (and associated watercourse) and upland swamp, as described below and in Appendix F.

The habitats in the Project Underground Mining Area and surrounds are variable and of high quality although the majority of vegetation communities are in early to mid-successional stage following the 2001 bushfire (Appendix F). Habitat connectivity within all habitat types is generally high.

Of the four priority fauna habitats mapped by the DECC (2007c) in the Greater Southern Sydney Region, upland swamps are located in the Project Underground Mining Area and surrounds. The Project Underground Mining Area and 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 by the DECC (2007c).

Woodland and Forest Habitat

Forest habitat is generally confined to slopes of gullies, valley floors and upland areas where soil has accumulated and can support larger trees. 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).

Woodland and forest habitat in the Project Underground Mining Area and surrounds 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 for terrestrial fauna. Many sites offering potential roosting or resting locations for a range of vertebrate species are located throughout the Project Underground Mining Area and surrounds. Some on ground logs are also present in this habitat type. The woodland and forest habitats may also contain drainage lines or ephemeral streams that contain water during and for a period following rain.

Vegetation communities representative of the woodland and forest habitats 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 4-15). The variety of canopy, mid-storey and understory flora species found in the woodland and forest habitats 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.

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 include Rock Pavement Heath (Map Unit 2a), Rock Plate Heath-Mallee (Map Unit 2b) and Woronora Tall Mallee-heath (Map Unit 2c) (Figure 4-15). 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*). 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.

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 upstream areas, the riparian vegetation gives way to swamps or gully forest vegetation. The Woronora Reservoir also provides habitat resources for terrestrial fauna.

Upland Swamp Habitat

Upland swamps occur on ridgetops 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. Fringing eucalypt woodland (up to 15 m in height) is also present in some areas of upland swamp.

Native Fauna Species

The number of native terrestrial fauna species identified during the Project baseline terrestrial fauna surveys is provided per fauna type in Table 4-9. 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 (Appendix F).

Table 4-9
Native Terrestrial Fauna Species

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

Source: Appendix F.

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

Introduced Fauna Species

Five introduced species were recorded during the Project baseline fauna surveys, namely the House Mouse (*Mus musculus*), Dog (*Canis lupis familiaris*), Red Fox (*Vulpes vulpes*), Rusa Deer (*Cervus timorensis*) and Rabbit (*Oryctolagus cuniculus*).

Threatened Fauna Species

Thirteen threatened species were recorded in the Project Underground Mining Area (i.e. Longwalls 20 to 44) and/or surrounds during the baseline fauna 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.

The threatened fauna species are summarised in Table 4-10 and the locations where they were identified are shown on Figure 4-17.

The Eastern Ground Parrot, Southern Brown Bandicoot and Long-nosed Potoroo are considered to be species of the highest conservation priority in the Greater Southern Sydney Region (DECC, 2007c).

High priority species in the Greater Southern Sydney Region include the Broad-headed Snake, Squirrel Glider and Large-footed Myotis, while the Turquoise Parrot and Grey-headed Flying Fox are species of moderate to high priority (DECC, 2007c).

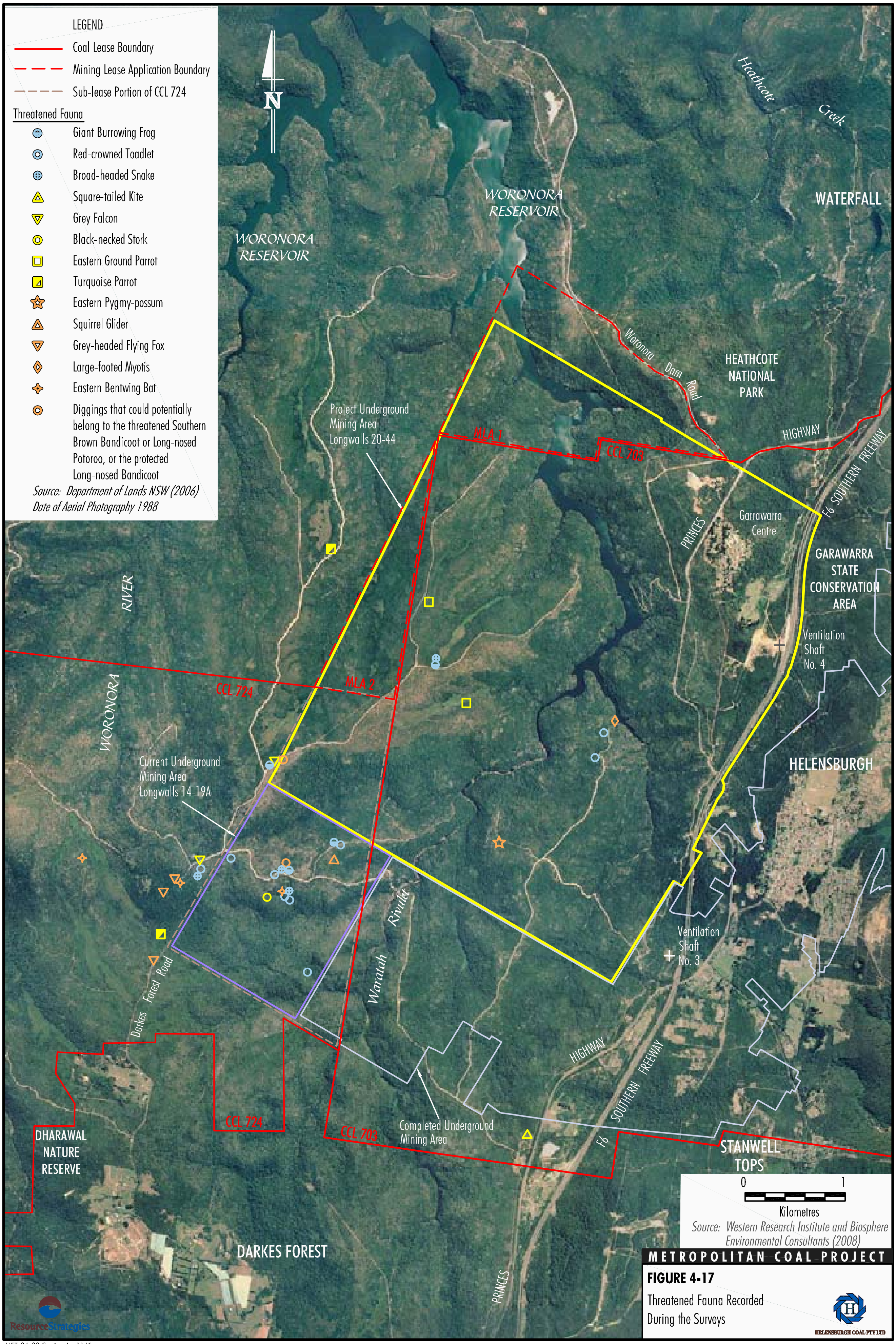
Table 4-10
Threatened Terrestrial Fauna Species Recorded during Baseline Fauna Surveys

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: After Appendix F.

[1] Threatened species status current as at 1 August 2008.

E – Endangered V – Vulnerable



METROPOLITAN COAL PROJECT
FIGURE 4-17
Threatened Fauna Recorded During the Surveys

The Giant Burrowing Frog, Red-crowned Toadlet, Square-tailed Kite and Eastern Pygmy-possum are species of moderate priority, and the Black-necked Stork and Eastern Bentwing Bat, species of lower priority (DECC, 2007c).

The Black-necked Stork and Grey Falcon were recorded flying overhead and are known only as vagrants in the area (DECC, 2007c; Pizzey and Knight, 1999).

4.7.2 Potential Impacts

Potential impacts of the Project on terrestrial fauna 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) and other direct, indirect or cumulative impacts, as described below. As described in Section 4.6.2, alteration of habitat following subsidence due to longwall mining is listed as a key threatening process under the TSC Act.

Subsidence Effects and Woodland/Forest Habitat – Heath and Mallee Habitat

The woodland/forest habitats generally occur on slopes and ridgetops. The heath and mallee habitats typically occur on ridges, upper slope and plateau areas.

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.

As described in Section 4.6.2, the only surface tension crack reported at Metropolitan Colliery to date is adjacent to Fire Road 9H which is near the top of a steep slope. 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 (Appendix A).

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.

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. Given the predicted low incidence of rock falls (Appendix A), it is considered unlikely that mine subsidence would result in a significant impact on any fauna species utilising these habitat types. In particular, 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.

Mine subsidence also 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 either the soil moisture regime that sustains the existing vegetation or the availability of water to terrestrial fauna (Appendix C).

Subsidence Effects and Riparian (and associated watercourse) Habitat

Section 4.6.2 describes the potential subsidence effects on streams and riparian zones and the associated potential impacts on riparian vegetation. Mine 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.

As described in Section 4.4, mine subsidence 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 (Appendix C). During prolonged dry periods when flows recede to low levels, a greater proportion of the lower flows would be conveyed via the fracture network.

Mine subsidence also has the potential to result in changes in stream water quality as localised and transient changes (spikes or pulses) in iron, manganese and to a lesser extent aluminium and minor associated increases in electrical conductivity (Appendix C). By nature, these pulses are isolated and non-persistent (Appendix C).

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 and the lifecycle components of terrestrial vertebrate fauna that may utilise the riparian/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.

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 would hold some water during prolonged dry periods (Appendix C). These latter pools would remain full during most typical wetting and drying cycles.

The Platypus was recorded during the Project surveys in the Woronora River and 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, 2008e). 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*.).

As described above, mine subsidence has the potential to alter stream flows 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 pools in response to water flow being redirected into the dilated strata. However, there is no net loss of water within the system as it resurfaces further downstream (Appendix C).

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 (Appendix G).

It is possible, given the relatively small size of pools along the rivulet that a single breeding female Platypus could be potentially adversely impacted and recruitment affected. However such an impact would be very unlikely to impact adversely on the viability of the Platypus population within the Waratah Rivulet (Appendix G). 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 local Platypus population (Appendix G).

Some threatened fauna species are also known to utilise riparian/watercourse habitat. For example, the Large-footed Myotis was recorded by Anabat detection flying above water in the eastern arm of the Woronora Reservoir. The threatened fauna species evaluations discussed below and provided in Appendix G consider the potential impacts of the Project's alteration of natural flow regimes on threatened fauna species.

Subsidence Effects and Upland Swamp Habitat

Potential impacts on upland swamp vegetation are described in Section 4.6.2. No change to the fundamental surface hydrological processes (Appendix C) and upland swamp vegetation (Appendix G) 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 (Appendix G).

Habitat Disturbance

The nature and extent of vegetation clearance associated with the Project is described in Section 4.6.2. Vegetation within the Project Underground Mining Area and surrounds 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. Management measures to minimise impacts on terrestrial fauna habitats are described in Sections 4.6.3 and 4.7.3.

Fire

High frequency fire is listed as a key threatening process under the TSC Act. High frequency fire has the potential to result in a reduction in vegetation structure and a corresponding loss of animal species (NSW Scientific Committee, 2000b). 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. However, given the range of management measures proposed to be in place to manage the behaviour of people in the Project Underground Mining Area (described in Section 4.6.3), it is unlikely that there would be an increase in fire frequency resulting from the Project.

Fauna Traps

The excavation of holes in the ground for the Project (e.g. drill holes associated with groundwater monitoring bores, stream restoration activities or exploration activities) has the potential to trap native fauna.

Fauna and Road Traffic

The movement of vehicles associated with the Project activities within the Woronora Special Area has the potential to increase the incidence of fauna mortality via vehicular strike.

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. Project noise emissions are assessed in Appendix J.

The Project would not increase the existing level of noise at the Major Surface Facilities Area (Section 4.10.4), however, noise has the potential to disrupt the routine activities of vertebrate fauna. Potential sources of noise in the Project Underground Mining Area and surrounds include the ventilation shafts, vehicle movements and the operation of equipment (e.g. drill rig, compressors and other equipment). The potential for noise generation in the Project 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, 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 (Section 4.16).

Introduced Pest Species

Many animal pests pose a threat to native fauna through competition for habitat resources and direct predation. Predation by the Red Fox and the Feral Cat, competition, grazing and habitat degradation by the European Rabbit, competition and habitat degradation by Feral Goats, herbivory and environmental degradation by Feral Deer, and predation, habitat degradation, competition and disease transmission by Feral Pigs, are listed as key threatened processes under the TSC Act and/or EPBC Act. The House Mouse, Dog, Red Fox, Rusa Deer and Rabbit were recorded during the baseline fauna surveys.

Vegetation clearance associated with the Project, particularly for access tracks has the potential to increase the occurrence of vertebrate pest species. The provision of refuge or scavenging areas (e.g. discarded food scraps and other rubbish) also has the potential to increase populations of introduced pest species in the Project Underground Mining Area and surrounds.

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 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, 2001). Collection and handling of frogs and inadvertent transport of infected material between frog habitats may also promote the disease's spread (NSW Scientific Committee, 2003). Access to amphibian habitats and the handling of frogs have the potential to introduce or spread the Chytrid fungus. However, appropriate management measures to minimise this risk are presented in Section 4.7.3 below.

SEPP 44 – Koala Habitat Protection

In response to a state-wide decline of Koala populations, the SEPP 44 was gazetted in January 2005 (Section 3.2.5). The applicability of SEPP 44 has been assessed in consideration of the potential Koala habitat available and the presence of core Koala habitat (Appendix F). 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 Underground Mining Area and surrounds (Appendix E), it does not fall within the definition of core Koala habitat (Appendix F). There was no evidence of the presence of Koalas within the Project Underground Mining Area and surrounds during the baseline fauna 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 (Appendix F).

Greenhouse Gas Emissions and Climate Change Effects

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.

Climate change and greenhouse gas emissions associated with the Project are discussed in Section 3.8 including the potential ecological impacts of the Project in the context of global climate change.

Threatened Fauna

Evaluations have been conducted to assess the potential impacts of the Project 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 for development applications assessed under Part 3A of the EP&A Act. The evaluations are documented in Appendix G.

On the basis of these evaluations, it is considered that the Project would be unlikely to have a significant effect on threatened fauna and:

- the lifecycle of a threatened species and/or population;
- the habitat of a threatened species, population or ecological community;
- threatened species or populations that are at the limit of their known distribution;
- current disturbance regimes;
- habitat connectivity; and
- any critical habitat of threatened fauna.

Cumulative Impacts

As described in Section 4.5.2, 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 fauna and their habitats is provided in Appendix G and summarised in Section 4.5.2.

Supplementary Consideration of SCPR Recommendations

As described in Section 4.6, the SCPR (DoP, 2008) was released following the substantial completion of the terrestrial fauna impact assessment.

The following information is provided in relation to the assessment of terrestrial fauna located within 600 m of the edge of secondary extraction:

- The baseline fauna surveys included the use of systematic terrestrial fauna sites to sample terrestrial fauna in major habitat types identified in the Project Underground Mining Area and surrounds. Additional information on the terrestrial fauna of the Woronora Plateau was available in the DECC (2007c) *Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region* and was utilised by the terrestrial fauna surveys and assessment.
- Terrestrial fauna within the 600 m expanded area has been considered in the assessment of the Project's potential impacts on terrestrial fauna, including the assessment of potential impacts on key terrestrial fauna habitats such as upland swamps.
- Threatened species evaluations have been conducted for threatened fauna species and their habitats that are known to occur or could possibly occur in the Project Underground Mining Area and surrounds.
- No significant impacts on terrestrial fauna and/or their habitats were identified for the Project within the Project Underground Mining Area or within the area potentially affected by mine subsidence.

4.7.3 Mitigation Measures, Management and Monitoring

Although the Project would avoid or minimise impacts on terrestrial fauna and their habitats wherever practicable, several measures have been developed to mitigate unavoidable impacts of the Project on terrestrial fauna. A FFMP would be developed for the Project and would include measures to minimise impacts on terrestrial fauna. The FFMP would be developed in consultation with the DECC and the SCA and would include the fauna management measures described below.

Subsidence Impacts on Terrestrial Fauna and their Habitats

Similar to the management of terrestrial flora, the management of subsidence impacts on terrestrial fauna and their habitats would be closely linked to monitoring, as described below. The monitoring results would initiate an investigation in the event terrestrial fauna and/or their habitats are considered to be potentially experiencing impacts inconsistent with those predicted in this EA in a similar manner to that described for terrestrial flora in Section 4.6.3.

Habitat Disturbance

As described in Section 4.7.2, vegetation clearance associated with the Project would primarily be associated with on-going surface exploration activities, the upgrade and extension of surface infrastructure, access tracks, environmental monitoring and management activities, stream restoration activities and other minor Project-related surface activities. The measures described in Section 4.6.3 for vegetation clearance are relevant to the minimisation of potential impacts on terrestrial fauna and their habitats.

In addition to the measures described in Section 4.6.3, inspections of proposed disturbance areas would be conducted to identify management measures to be implemented to minimise impacts on terrestrial fauna and their habitats.

Fire

As described in Section 4.6.3, a range of management measures would be implemented for the Project to manage the behaviour of people in the Project area and to minimise the risk of bushfire.

Fauna Traps

To minimise the potential for native fauna to become trapped, excavated holes in the ground (e.g. drill holes associated with groundwater monitoring bores, stream restoration activities or exploration activities) would be filled, capped and/or covered, where practicable in the Woronora Special Area.

Fauna and Road Traffic

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

As described in Section 4.7.2, studies indicate that many species are well adapted to human activities and noise. Notwithstanding, noise mitigation and management measures would be implemented at the Project major surface facilities in accordance with the *NSW Industrial Noise Policy* (INP) (NSW Environment Protection Authority [EPA], 2000) (Section 4.10.5).

Introduced Pest Species

Vegetation clearance associated with the Project (e.g. for access tracks) has the potential to increase the occurrence of vertebrate pest species. As described in Section 4.7.2, Project infrastructure would occupy only small areas of the surface, would involve minimal clearance and disturbed areas would be allowed to naturally regenerate from the soil seed bank when no longer needed. Active planting may be undertaken in areas where natural regeneration is not considered to be progressing.

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 permitted to take domestic pets into the Woronora Special Area.

The FFMP would describe management measures to be implemented to minimise the occurrence of pest fauna species and would be developed in consultation with the SCA for activities in the Woronora Special Area. In addition to the measures described above, other management measures would include (DECC, 2007c):

- Reporting sightings of vertebrate pest species to the SCA, and the DECC for inclusion in the Atlas of NSW Wildlife in order for the distribution and abundance of the vertebrate pests to be better understood. This is particularly relevant to Feral Deer.
- Subject to the SCA's approval, implementation of systematic measures to aid in the control of Feral Cats and Foxes in habitats of particular threatened species (e.g. Eastern Ground Parrot) where this species is known to occur.
- Destruction of rabbit burrows.
- The inclusion of general vertebrate pest awareness in HCPL inductions, particularly for staff and contractors accessing the Woronora Special Area.
- On-going consultation with the SCA and the DECC in relation to the management of vertebrate pest species.

Amphibian Chytrid Fungus

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 (2001) *Hygiene Protocols for the Control of Disease in Frogs*.

Hygiene protocols would be established for activities conducted in the Waratah Rivulet and Woronora River catchments and movement between these two catchments. Potential management measures include (NPWS, 2001):

- The thorough cleaning and disinfecting of footwear.
- The thorough cleaning and disinfecting of equipment (such as nets, callipers, headlamps and waders).
- Restricting the movement of vehicles to formed tracks and pre-existing roads, where practicable.
- In the event the frog Chytrid fungus is known to be present at a site, that site would be the last site surveyed/sampled, where practicable.

Monitoring

The assessment of terrestrial fauna indicates that the impacts of the Project on terrestrial fauna, protected or threatened, are likely to be very limited in nature and are unlikely to impact on the viability of any species population in the short or long-term (Appendix G). In all cases, the impacts have been demonstrated to likely occur at point scale rather than at landscape scale (Appendix G).

Wildfire is known to reduce populations of vertebrate species, particularly those associated with the fire-prone habitats of the Sydney sandstone. Hence, populations disappear, re-establish, wax and wane in response to fire.

In consideration of the background ecological noise caused by recent wildfire in the Woronora Special Area, the monitoring of terrestrial fauna and their habitats would target specific Project potential impacts, namely, mine subsidence impacts on rocky habitats (e.g. rock fall) and the alteration of water availability.

Similar to the monitoring programmes for terrestrial flora, the terrestrial fauna monitoring programmes would be co-ordinated with other monitoring programmes as practicable to assist with determinations of causal relationships (e.g. monitoring of pool water levels in streams and subsidence monitoring).

The terrestrial fauna monitoring programmes would be conducted at an appropriate frequency and scale for a period prior to, during, and following the completion of mining. The monitoring programmes would target the collection of a minimum of two years pre-mining data, where practicable, and would include sites situated within the Project Underground Mining Area, as well as control sites situated in comparable unmined locations. The programmes would also be designed to comprise appropriate sampling replication. The location of sampling sites would be determined in consideration of site characteristics, their location relevant to the mine plan, access and site inspection.

The terrestrial fauna monitoring programmes proposed to be implemented include:

- Monitoring of sandstone habitats – monitoring of cliff faces and other sandstone habitats for terrestrial vertebrate fauna to assess the impact of subsidence on rocky habitats and usage by terrestrial vertebrate fauna.
- Monitoring of amphibian species – surveys for amphibians, including threatened species, with a focus on habitats of the Giant Burrowing Frog and Red-crowned Toadlet associated with tributaries.

The FFMP would describe the terrestrial fauna monitoring programmes.

Cumulative Impacts

The mitigation measures, management and monitoring described above are relevant to minimising potential cumulative impacts on terrestrial fauna.

4.7.4 Compensatory Measures and Ecological Initiatives

Compensatory measures and other ecological initiatives for the Project are detailed in Sections 3.9.3 and 5.6, and include offsets and initiatives that relate to terrestrial fauna.

4.8 ABORIGINAL HERITAGE

An Aboriginal Cultural Heritage Assessment was prepared for the Project by Kayandel Archaeological Services (Appendix H) and was peer reviewed by R.G. Gunn (Attachment 3). A description of Aboriginal heritage in the vicinity of the Project is provided in Section 4.8.1. Section 4.8.2 describes the potential impacts of the Project on Aboriginal heritage, while Section 4.8.3 outlines mitigation measures, management and monitoring.

4.8.1 Existing Environment

Aboriginal History

The Project Underground Mining Area is located within the Illawarra Local Aboriginal Land Council boundary (the Aboriginal heritage study area also extended into the Tharawal Local Aboriginal Land Council area to the west of the Current Underground Mining Area). While the tribal boundaries of pre-contact Aboriginal groups are not certain, both Norman Tindale's and David Horton's maps indicate that the Project is located within the area inhabited by the Tharawal language group (Appendix H). Depending on the source, the language groups immediately adjacent to the Tharawal included the Eora to the north, Daruk (or Dharug) to the north-west, Gandangara (or Gundungurra) to the west and the Wodi Wodi (or Yuin) to the south (Tindale, 1974; Horton, 1996).

The Tharawal people were broadly defined into two groups (i.e. the Sweet [Fresh] Water Tharawal, and the Salt Water Tharawal) with the Helensburgh area inhabited by the Salt Water Tharawal (Spackman and Mossop, 2000). According to oral tradition, the Tharawal people arrived in the Illawarra by sea (Organ and Speechley, 1997). This is reflected in a Dreaming story, as told to R H Matthews by a Shoalhaven man, about the Gang-man-gang or Billen-Billen (Windang Island) (*ibid*).

According to that story, the Tharawal people came from a land at a great distance from Australia, and got here by a canoe that was stolen from a whale (*ibid*). They brought with them the Dharawal, or Cabbage Tree Palm, after which they are named (Wesson, 2005).

Whilst Cubbitch Barta do not appear on Tindale's map, they are a clan of the Dharawal and were known to colonists as the Cowpastures Tribe (Cubbitch Barta, letter dated 12 June 2008), and currently have a registered Native Title claim for a portion of land in the township of Helensburgh (Commonwealth of Australia, 2006a).

Although the actual size of the Aboriginal population in the Illawarra Region prior to white settlement is unknown, some researchers believe there may have been between 2,000 and 3,000 Aboriginal people living in the Illawarra Region at the time of European contact (Butlin in Organ and Speechley, 1997). The density of archaeological evidence of Aboriginal occupation across the Illawarra Region supports that the region was well populated for a long period of time. It has been suggested that the wealth of natural resources, pleasant and stable climate as well as the topography of the land itself is largely responsible for the high population density of the region during inhabitation by Aboriginal people (Appendix H).

Natural Resources

While semi-permanent water sources were available to Aboriginal groups within the area, variable climatic conditions may have affected the availability of water and in turn may have subsequently influenced the way Aboriginal people moved through and used the landscape over time.

A description of the topography and soils present in the vicinity of the Project is provided in Section 4.1. The extensive outcropping of Hawkesbury Sandstone on steep slopes proximal to semi-permanent water provides ample opportunities for Aboriginal habitation sites. As discussed in Appendix H, these sandstone outcrops provide shelter and while subject to on-going natural weathering processes, retain evidence of Aboriginal occupation. Local topographic features, such as ridgetops and plateau areas may have been used as access routes and vantage points by Aboriginal inhabitants.

Literature reviewed as part of the Aboriginal Cultural Heritage Assessment and comments received from the Aboriginal community suggest that many plants and animals on the Woronora Plateau were known to be exploited by Aboriginal people, including:

- macropods such as the red wallaby and the swamp wallaby used for food, skin cloaks and binding;
- birds such as hawks, emus, quails, currawongs, wood ducks, doves, crows, magpies and the wedge-tailed eagle;
- smaller marsupials such as the echidna, sugar glider, platypus and koala;
- reptiles such as the brown snake, red-bellied black snakes, death adders and heath monitors; and
- plants such as *Podolepsis jaceoides* (yam daisy), *Exocarpus* sp. (native cherry/currant), *Santalum obtusifolium*, *Lambertia formosa* (red devil), *Xanthorrhaea* sp. (grass tree), *Solanum aviculare* (contraceptive apple), and *Thysanotus virgatus* (fringed violet).

Sections 4.5, 4.6 and 4.7 and Appendices D, E and F provide comprehensive information on the aquatic and terrestrial flora and fauna attributes of the Project Underground Mining Area and surrounds.

Previous Archaeological Investigations

Numerous Aboriginal heritage surveys, assessments, monitoring, site inspections and baseline recordings have been undertaken within the Project Underground Mining Area and surrounds over the past 37 years. A summary of these archaeological investigations is provided below.

Between 1971 and 1983, the Illawarra Prehistory Group and Caryll Sefton conducted numerous archaeological surveys across the Woronora Plateau (including the majority of the Project Underground Mining Area and surrounds). As evidenced by the original recording dates on the Aboriginal Heritage Information Management System (AHIMS) site cards, these early surveys recorded the majority of currently known Aboriginal heritage sites within the Project Underground Mining Area and surrounds.

In 1994, C.E. Sefton Pty Ltd conducted an archaeological survey and assessment of Longwalls 1 to 8 (Completed Underground Mining Area, Figure 2-1) in consultation with representatives of the Aboriginal community (C.E. Sefton Pty Ltd, 1994a, 1994b).

In 2001, C.E. Sefton Pty Ltd conducted an archaeological survey and assessment of Longwalls 8 to 13 (Completed Underground Mining Area, Figure 2-1) in consultation with representatives of the Aboriginal community (C.E. Sefton Pty Ltd, 2001).

In 2004, C.E. Sefton Pty Ltd conducted an archaeological survey and assessment for Longwalls 13 to 17 and 20 to 22 in consultation with representatives of the Aboriginal community (C.E. Sefton Pty Ltd, 2004).

Between 2004 and 2007, the Illawarra Prehistory Group (original recorders of a large proportion of Aboriginal heritage sites on the Woronora Plateau, see above) re-conducted the archaeological survey of the majority of the Project Underground Mining Area and surrounds (Illawarra Prehistory Group, 2007 [unpublished data]). The aims of this survey were to identify and record previously unrecorded Aboriginal heritage sites and to re-record previously recorded and registered Aboriginal heritage sites on the Woronora Plateau. The survey was undertaken by up to six people over more than 50 survey days and identified 186 Aboriginal heritage sites within the Project Underground Mining Area and surrounds.

In 2006, an Aboriginal Cultural Heritage Assessment was undertaken by Kayandel Archaeological Services for Longwalls 14 to 17 as part of an SMP Application (Kayandel Archaeological Services, 2006). Fieldwork for this assessment covered a portion of the Project Underground Mining Area and surrounds and was undertaken in consultation with the Aboriginal community and included both archaeological and cultural assessments.

In 2006, rock art specialist R.G. Gunn, in association with Kayandel Archaeological Services, undertook a comprehensive baseline recording of Aboriginal cultural heritage sites in the Longwall 14 to 17 area in consultation with the Aboriginal community (Gunn and Kayandel Archaeological Services, 2007).

Various DECC AHIMS data requests have been completed across the Project Underground Mining Area and surrounds, with the most recent data provided in May 2008.

In 2007, an Aboriginal cultural heritage assessment was undertaken by Kayandel Archaeological Services as part of HCPL's SMP Application for Longwalls 18 to 19A (Kayandel Archaeological Services, 2007). This assessment was undertaken in consultation with the Aboriginal community and included both archaeological and cultural assessments along with proposed management and monitoring measures.

In accordance with recommendations in C.E. Sefton Pty Ltd (1994a, 1994b, 2001, 2004) and Kayandel Archaeological Services (2006), approximately 41 Aboriginal heritage sites at the Metropolitan Colliery have been systematically monitored for the effects of mine subsidence in consultation with representatives of the Aboriginal community (C.E. Sefton Pty Limited, 2006a, 2006b; Kayandel Archaeological Services, unpublished).

Monitoring of Aboriginal heritage sites has been undertaken in 1994, 1995, 1996, 1998, 2000, 2002, 2004, 2006 and 2008 (*ibid.*). Management measures recommended by C.E. Sefton Pty Ltd (2006a, 2006b) as a result of this monitoring have been undertaken (e.g. installation of a silicone drip line at site FRC 10 to minimise impact to art from water seepage).

Cultural Heritage Assessment

Assessment Programme

The Aboriginal Cultural Heritage Assessment (Appendix H) utilised the results of the extensive fieldwork and information base (described above) and the results of Project supplementary survey and inspections conducted by archaeologists and representatives of the Aboriginal community in December 2007. The aim of the Project supplementary survey and inspections was to provide the contemporary Aboriginal community the opportunity to inspect the area and Aboriginal heritage sites within the Project Underground Mining Area and surrounds in order to provide more informed comment on cultural significance and proposed management recommendations.

Assistance with surveys and cultural heritage advice was provided by 10 Aboriginal community groups, including:

- Cubbitch Barta;
- Illawarra Aboriginal Corporation[1];
- Illawarra Local Aboriginal Land Council;
- KEJ Tribal Elders Corporation;
- La Perouse Botany Bay Aboriginal Corporation (through the Northern Illawarra Aboriginal Collective);
- Mr Gary Caines;
- Tharawal Local Aboriginal Land Council;
- Wadi Wadi Coomaditchie Aboriginal Corporation (through the Northern Illawarra Aboriginal Collective);
- Wodi Wodi Elder's Corporation; and
- Woronora Plateau Gundungara Elders Council (through the Northern Illawarra Aboriginal Collective).

1 The Illawarra Aboriginal Corporation was invited to be included in this assessment however declined and indicated their support of the views/involvement of the Illawarra Local Aboriginal Land Council.

Table 4-11 summarises the main stages of the consultation/survey programme previously undertaken at Metropolitan Colliery and the main stages of the consultation/survey programme undertaken as part of the Project. As described in Section 3.5.8, the Project Aboriginal Cultural Heritage Assessment has been undertaken in accordance with the *Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* (DEC, 2005a) and *National Parks and Wildlife Act 1974: Part 6 Approvals Interim Community Consultation Requirements for Applicants* (DEC, 2004a).

Archaeological Findings

A total of 188 Aboriginal heritage sites were identified within the Project Underground Mining Area and surrounds, consisting of:

- sandstone overhangs with art[2] and/or artefacts and/or deposit and/or grinding grooves and/or engravings and/or potential archaeological deposit (PAD); and
- open sites with artefact scatters and/or engravings and/or grinding grooves and/or art[2] and/or PAD.

Each of the 188 Aboriginal heritage sites are described in detail in Appendix H (including photos and site cards) and summarised in Table 4-12 below. The locations of Aboriginal heritage sites within the Project Underground Mining Area and surrounds is provided on Figure 4-18.

In addition to the above, three other potential Aboriginal heritage sites were identified by the Northern Illawarra Aboriginal Collective in their comments on the ACHA (Appendix H). These include two trees that are reported to bear "*likely birth-marks*" and a "*possible cairn*" (arrangement of stones). Potential impacts to the two trees are considered to be within the range of impacts described in Section 4.6.2. Potential impacts to the "*possible cairn*" are considered to be within the range of the impacts predicted for the 188 known Aboriginal sites described in Section 4.8.2.

The SCPR (DoP, 2008) was published after finalisation of the ACHA (including receipt of comments from each of the Aboriginal community groups/parties and incorporation/ consideration of these comments). The SCPR recommends that environmental assessments for Part 3A projects include identification and assessment of all natural features located within 600 m of the edge of proposed longwalls (*ibid*.). To this end, an additional 61 Aboriginal heritage sites were identified outside the initial study area, assessed for their archaeological significance and assessed for potential impacts resulting from the Project (Appendix H).

These sites are located outside the 35 degree angle of draw/20 mm subsidence contour and as such the potential for subsidence induced impacts at these sites is considered to be very low to negligible (Appendix A).

Condition of Archaeological Findings

It was noted during field surveys that many Aboriginal heritage sites are subject to on-going natural deteriorating processes unrelated to mining, including:

- Impacts from Tree Roots – Site FRC 91 was noted to have tree roots growing through the roof of the shelter forcing the sandstone shelf to crack. This may reduce the structural integrity of the overhang or have a direct physical effect on the site.
- Natural Weathering – Substantial deterioration (e.g. rock fall, fading of motifs, cracking of the shelter surface [sometimes through artwork[3]], granulation of the surface, water seepage across motifs and fungal growth across motifs) of some sandstone overhangs and open sites including FRC 32, FRC 97, FRC 185, FRC 117, FRC 340, FRC 31, FRC 28, FRC 199, FRC 29, FRC 113, FRC 198, NT33, NEW 9, NT 18, FRC 127 FRC 28 and FRC 113.

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2 For the purpose of the Aboriginal Cultural Heritage Assessment and this EA, "rock art" refers only to pictograms (i.e. drawings/paintings). Whilst petroglyphs (i.e. engravings) are also a form of rock art, they are separated from pictograms in this assessment to maintain consistency with the extensive recordings and re-recordings undertaken across the study area over the past 37 years.

3 This crack through Aboriginal artwork is attributed to natural processes rather than mining as it is located approximately 3 km from any current or previous longwall mining activities.

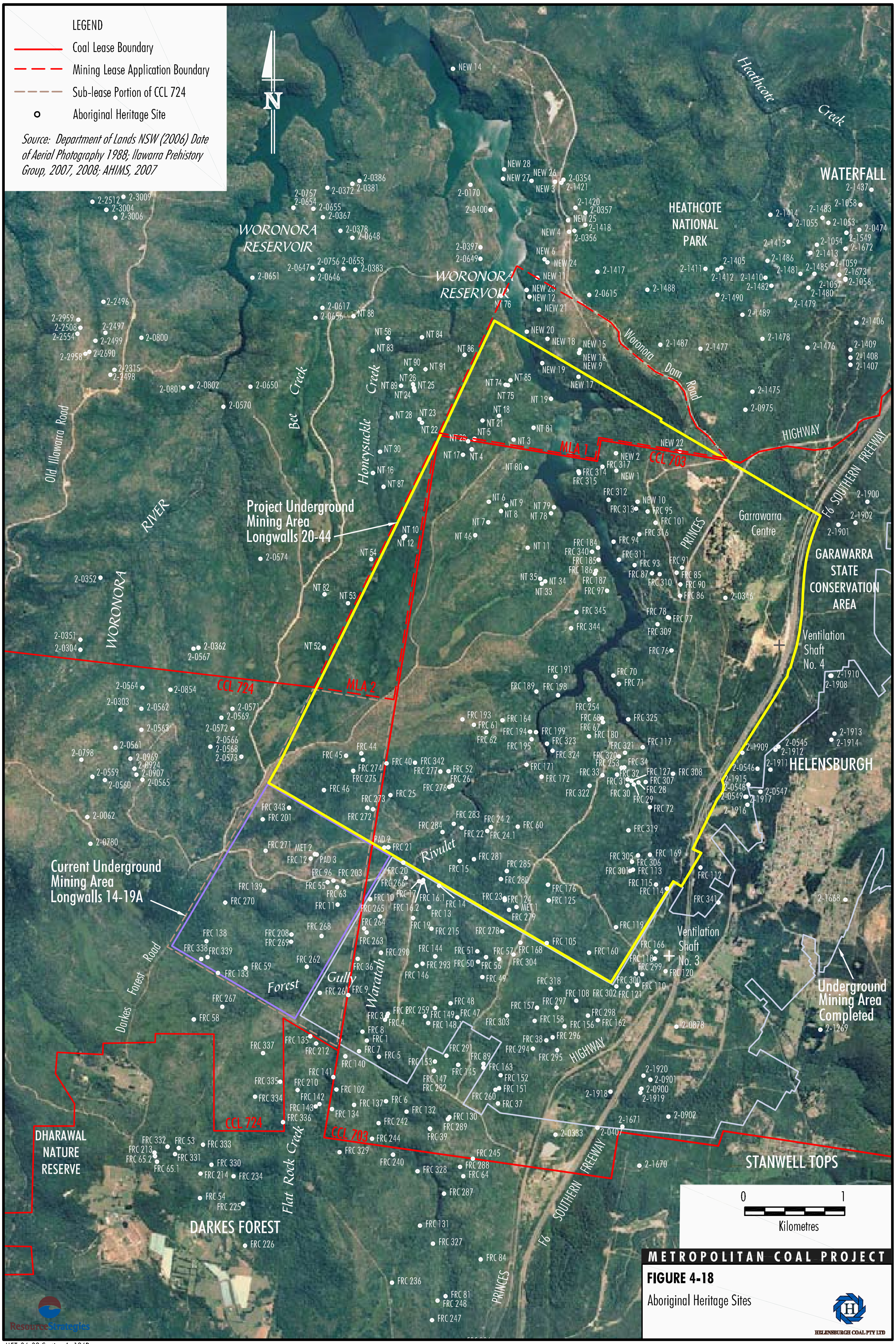
Table 4-11
Summary of the Previous and Project Aboriginal Heritage Consultation/Survey Programme

Date	Consultation/Survey Conducted
Previous Consultation/Survey	
1990 to 2008	The Aboriginal community has been involved in archaeological surveys, Aboriginal cultural significance assessments, monitoring of Aboriginal heritage and the implementation of management and mitigation measures at the Metropolitan Colliery, including: • Archaeological survey and assessment of Camp Gully (Elizabeth Rich, 1990). • Archaeological survey and assessment for Longwalls 1 to 8 (C.E. Sefton Pty Ltd, 1994a, 1994b). • Archaeological survey and assessment for Longwalls 8 to 13 (C.E. Sefton Pty Ltd, 1994a, 1994b). • Archaeological survey and assessment for Longwalls 14 to 17 (including similar consultation steps to those outlined below for the Project) (Kayandel Archaeological Services, 2006). • Archaeological survey and assessment for Longwalls 18 to 19A (including similar consultation steps to those outlined below for the Project) (Kayandel Archaeological Services, 2007). • Monitoring of Aboriginal heritage sites in 1995, 1996, 1998, 2000, 2002, 2004, 2006 and 2008 (C.E. Sefton Pty Ltd, 2006a, 2006b; Kayandel Archaeological Services, unpublished). • Development of a comprehensive baseline record of Aboriginal heritage sites within the Longwall 14 to 17 area (Gunn and Kayandel Archaeological Services, 2007).
Project Consultation/Survey	
April/May 2007	**Identification** of local Aboriginal community groups with an interest in being consulted in regard to Aboriginal heritage at Metropolitan Colliery. Identification made via: public advertisement; direct consultation with Aboriginal groups previously consulted in regard to Metropolitan Colliery; consultation with the DECC, the WCC, Native Title Services, Registrar of Aboriginal Owners and the Illawarra and Tharawal Local Aboriginal Land Councils.
October 2007	**Provision** to Aboriginal community groups of a proposed methodology for undertaking the Project Aboriginal Cultural Heritage Assessment. The proposed methodology contained a hard copy of detailed information (including sites cards, photos and relevant baseline recordings) on each of the known Aboriginal heritage sites within the Project Underground Mining Area and surrounds.
October/November 2007	**Feedback** from the Aboriginal community groups in regard to the proposed methodology. Consideration of all comments received on the proposed site inspection programme.
December 2007	**Cultural Heritage Survey** – representative survey of areas not subject to recent systematic survey with on-going consultation and input from the Aboriginal survey participants. Cultural significance of the area and Aboriginal heritage sites discussed with the Aboriginal participants.
December 2007	**Cultural Heritage Site Inspections** – site inspection of: the Project Underground Mining Area and surrounds, all known Aboriginal heritage sites of moderate archaeological significance; all known Aboriginal heritage sites of high archaeological significance; and a representative selection of known Aboriginal heritage sites of low archaeological significance. Additional specific Aboriginal heritage sites inspected to accommodate requests from the Aboriginal participants. Cultural significance of the area and Aboriginal heritage sites discussed with the Aboriginal participants.
May 2008	**Draft Report** – issued to Aboriginal community groups for review. Included the provision of survey results, results of archaeological and cultural significance discussions (based on feedback received during previous consultation and fieldwork), potential impacts and proposed management and mitigation measures.
May/June 2008	**Meetings and Further Consultation** – meetings and consultation with the Aboriginal community groups to discuss the draft report, proposed management and mitigation measures and future Project involvement.
May/June 2008	**Written Feedback and Advice** – additional written feedback received from each Aboriginal community group involved in the Aboriginal Cultural Heritage Assessment (including comment on the consultation, survey, assessment and proposed management and mitigation measures).

Table 4-12
Known Aboriginal Heritage Sites within the Project Underground Mining Area and Surrounds

Site Type	Site
Sandstone Overhangs	
Sandstone overhang with art and PAD	FRC 11, FRC 29, FRC 117, FRC 186, FRC 208, NT 9, NT 85
Sandstone overhang with art only	FRC 13, FRC 14, FRC 20, FRC 23, FRC 26, FRC 44, FRC 52, FRC 71, FRC 76, FRC 78, FRC 86, FRC 93, FRC 94, FRC 97, FRC 115, FRC 127, FRC 172, FRC 180, FRC 187, FRC 89, FRC 191, FRC 194, FRC 195, FRC 98, FRC 199, FRC 269, FRC 275, FRC 83, FRC 306, FRC 308, FRC 310, FRC 19, FRC 325, FRC 340, NEW 9, NEW 10, NEW 15, NEW 20, NT 11, NT 19, NT 78, NT 79
Sandstone overhang with PAD only	FRC 60, FRC 160, FRC 201, PAD 2, PAD 3
Sandstone overhang with artefacts, grinding grooves and deposit	FRC 105, NEW 2
Sandstone overhang with art, artefacts and deposit	FRC 16.1 FRC 16.2, FRC 21, FRC 22, FRC 24.2, FRC 25, FRC 31, FRC 34, FRC 40, FRC 45, FRC 46, FRC 68, FRC 70, FRC 77, FRC 85, FRC 87, FRC 91, FRC 124, FRC 125, FRC 171, FRC 176, FRC 185, FRC 266, FRC 272, FRC 274, FRC 277, FRC 281, FRC 305, FRC 314, FRC 317, FRC 321, MET 1, NEW 17, NEW 19, NT 3, NT 4, NT 5, NT 6, NT 10, NT 18, NT 23, NT 33, NT 54
Sandstone overhang with art, grinding grooves and engravings	FRC 17
Sandstone overhang with art, artefacts, deposit and/or grinding grooves	FRC 24.1, FRC 28, FRC 62, FRC 72, FRC 113, NT 34, NT 35
Sandstone overhang with art and artefacts	FRC 30, 2-0346
Sandstone overhang with artefacts only	FRC 61
Sandstone overhang with artefact and deposit	FRC 343
Sandstone overhang with artefacts and deposit	FRC 15, FRC 67, FRC 90, FRC 119, FRC 184, FRC 254, FRC 276, FRC 279, FRC 284, FRC 285, FRC 302, FRC 309, FRC 311, FRC 312, FRC 313, FRC 315, FRC 316, FRC 320, FRC 323, FRC 324, FRC 344, FRC 345, NEW 16, NEW 22, NT 22, NT 74, NT 75, NT 76, NT 80, NT 81, NT 86
Open Sites	
Open site with grinding grooves and engravings	FRC 12, FRC 57, FRC 63, FRC 139, NT 8, NT 7, NT 46, NT 52
Open site with grinding grooves and artefacts	FRC 169
Open site with grinding grooves only	FRC 32, FRC 33, FRC 55, FRC 59, FRC 95, FRC 96, FRC 101, FRC 114, FRC 133, FRC 138, FRC 164, FRC 168, FRC 193, FRC 203, FRC 253, FRC 267, FRC 268, FRC 270, FRC 271, FRC 273, FRC 278, FRC 280, FRC 301, FRC 304, FRC 307, FRC 338, FRC 339, MET 2, NEW 1, NEW 18, NT 7, NT 12, NT 21, NT 29, NT 53
Open site with engravings only	FRC 322
Open site with artefact scatter	FRC 342

Source: After Appendix H.



METROPOLITAN COAL PROJECT

FIGURE 4-18

Aboriginal Heritage Sites

- Inappropriate Visitor Behavior – Litter and evidence of recent campfires in sandstone overhang sites, touching of the rock surface in rock art shelters (which can chemically alter the surface of a shelter and result in increased deterioration of rock art) and presence of graffiti at sandstone overhang sites previously recorded with a moderate to high archaeological significance.

Archaeological and Cultural Heritage Values

As part of the Aboriginal Cultural Heritage Assessment, the existing information (e.g. site cards, photos, site plans, detailed baseline recordings, previous archaeological reports) was reviewed for each of the known Aboriginal heritage sites. Based on this review and the site inspections undertaken in August and December 2007, each site was assigned an archaeological significance ranking of low, moderate or high.

The archaeological significance rankings for each of the 188 Aboriginal heritage sites within the Project Underground Mining Area and surrounds are presented in Table 4-13. As indicated in Appendix H, all Aboriginal heritage site types recorded within the Project Underground Mining Area and surrounds are represented elsewhere on the Woronora Plateau.

Five Aboriginal heritage sites within the Project Underground Mining Area and surrounds, *viz.* FRC 12, FRC 24.1, FRC 24.2, FRC 31 and NT 8 are listed on the Register of the National Estate. Nine Aboriginal heritage sites are deemed to be of high archaeological significance (i.e. FRC 12, FRC 32, FRC 62, FRC 68, FRC 185, FRC 191, FRC 195, FRC 322 and NEW 2) with 22 and 157 Aboriginal heritage sites deemed to be of moderate and low archaeological significance, respectively (Table 4-13).

Numerous Aboriginal heritage sites/places are located in areas surrounding the study area. Proximal Aboriginal heritage sites/places of particular note include nine that are listed on the Register of the National Estate with five of these located within protected areas (i.e. the Royal National Park and Dharawal State Conservation Area). These nine sites/places include Place ID 13675 (Dharawal State Conservation Area), Place ID 100633, Place ID 3333 (Royal National Park), Place ID 13686, Place ID 13702, Place ID 13676 (Dharawal State Conservation Area), Place ID 13673 (Dharawal State Conservation Area), Place ID 13671 (Royal National Park) and Place ID 13670 (DEWHA, 2008f).

Aboriginal heritage sites within or surrounding the Project Underground Mining Area have been identified as being of specific cultural interest to the Aboriginal community. These sites and comments received from the Aboriginal community are detailed in Appendix H. The Aboriginal community has also previously indicated that all Aboriginal heritage sites (both known and unknown), when considered collectively as a ‘bundle’, are culturally significant.

4.8.2 Potential Impacts

Project Surface Development

As part of the Project detailed design phase, the final location of some of the ancillary infrastructure (ventilation systems and groundwater monitoring bores) and surface works (exploration works, construction and/or management of access tracks, subsidence monitoring, subsidence restoration works and surface rehabilitation works) would be determined. Project surface development works are further described in Section 2 and have the potential to directly impact Aboriginal heritage sites.

Underground Mining Operations

Potential subsidence effects from underground mining operations are summarised in Section 4.2 and discussed in detail in Appendix A. The potential impact of these effects on Aboriginal heritage is summarised below and described further in Appendix H.

Potential impacts from underground mining on Aboriginal heritage sites include the cracking of sandstone and (where cracking coincides with a sandstone overhang) isolated rock fall.

Maximum predicted tensile strains greater than 0.5 mm/m may result in the cracking of sandstone at open sites (i.e. grinding grooves and engraving sites) and closed sites (i.e. sandstone overhang sites). Maximum predicted compressive strains greater than 2 mm/m may result in the cracking of sandstone at open sites (i.e. grinding grooves and engraving sites) (Appendix A).

Sixty-eight of the 188 Aboriginal heritage sites are predicted to experience tensile strains greater than 0.5 mm/m, including five sites of high archaeological significance (i.e. FRC 12, FRC 185, FRC 191, FRC 195 and NEW 2). No open sites have a maximum predicted compressive strain greater than 2.0 mm/m. Appendix A 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.

Table 4-13
Archaeological Significance of Aboriginal Heritage Sites within the Project Underground Mining Area and Surrounds

Archaeological Significance Ranking	Aboriginal Heritage Site	Number of Sites
High	FRC 12, FRC 32, FRC 62, FRC 68, FRC 185, FRC 191, FRC 195, FRC 322, NEW 2	9
Moderate	FRC 13, FRC 22, FRC 24.1, FRC 24.2, FRC 28, FRC 31, FRC 57, FRC 70, FRC 72, FRC 85, FRC 97, FRC 113, FRC 139, FRC 272, FRC 305, NEW 10, NEW 17, NT 5, NT 8, NT 11, NT 17, NT 34, NT 52	23
Low	FRC 11, FRC 14, FRC 15, FRC 16.1, FRC 16.2, FRC 17, FRC 20, FRC 21, FRC 23, FRC 25, FRC 26, FRC 29, FRC 30, FRC 33, FRC 34, FRC 40, FRC 44, FRC 45, FRC 46, FRC 52, FRC 55, FRC 59, FRC 60, FRC 61, FRC 63, FRC 67, FRC 71, FRC 76, FRC 77, FRC 78, FRC 86, FRC 87, FRC 90, FRC 91, FRC 93, FRC 94, FRC 95, FRC 96, FRC 101, FRC 105, FRC 114, FRC 115, FRC 117, FRC 119, FRC 124, FRC 125, FRC 127, FRC 133, FRC 138, FRC 160, FRC 164, FRC 168, FRC 169, FRC 171, FRC 172, FRC 176, FRC 180, FRC 184, FRC 186, FRC 187, FRC 189, FRC 193, FRC 194, FRC 198, FRC 199, FRC 201, FRC 203, FRC 208, FRC 253, FRC 254, FRC 266, FRC 267, FRC 268, FRC 269, FRC 270, FRC 271, FRC 273, FRC 274, FRC 275, FRC 276, FRC 277, FRC 278, FRC 279, FRC 280, FRC 281, FRC 283, FRC 284, FRC 285, FRC 301, FRC 302, FRC 304, FRC 306, FRC 307, FRC 308, FRC 309, FRC 310, FRC 311, FRC 312, FRC 313, FRC 314, FRC 315, FRC 316, FRC 317, FRC 319, FRC 320, FRC 321, FRC 323, FRC 324, FRC 325, FRC 338, FRC 339, FRC 340, FRC 342, FRC 343, FRC 344, FRC 345, MET 1, MET 2, NEW 1, NEW 9, NEW 15, NEW 16, NEW 18, NEW 19, NEW 20, NEW 22, NT 3, NT 4, NT 6, NT 7, NT 9, NT 10, NT 12, NT 18, NT 19, NT 21, NT 22, NT 23, NT 29, NT 33, NT 35, NT 46, NT 53, NT 54, NT 74, NT 75, NT 76, NT 78, NT 79, NT 80, NT 81, NT 85, NT 86, PAD 2, PAD 3, 2-0346	156

Source: Appendix H.

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). Therefore, it is likely that subsidence effects would be less than the maximum predicted. Appendix A states that:

> *Potential fracturing of the exposed sandstone 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. The potential for fracturing to occur at the grinding grooves would, therefore, be considered low*.

Appendix A also notes that although impact is possible, based on experience in the Southern Coalfield, the likelihood of significant impact on sandstone overhang sites as a result of mine subsidence is also low.

Previous Aboriginal heritage monitoring programmes at the Metropolitan Colliery have been designed to focus monitoring effort on those sites with a greater potential to be impacted. As noted in C.E Sefton Pty Ltd (2006b), *prior to the extraction of Longwalls 8-13 a report was prepared … which gauged the potential side effects of the proposed Longwall mining on archaeological sites. On the basis of this assessment it was recommended that sites in Category A and Category B (most probable and probable respectively) and some in Category C (unlikely) be monitored*.

Monitoring of approximately 41 Aboriginal heritage sites (subject to mine subsidence) has been undertaken between 1995 and 2008 at the Metropolitan Colliery. Of the 41 sites monitored, 21 had maximum predicted tensile or compressive strains greater than 0.5 mm/m and/or 2 mm/m respectively.

The majority of sites monitored had no observable change following mine subsidence, with observable change identified in six Aboriginal heritage sites. Changes noted during monitoring include: potential natural weathering; cracks noted in sandstone platforms away from engravings/grinding grooves; cracking along existing bedding planes; and rear wall blockfall (Appendix H).

Previous risk assessments of the potential impact on Aboriginal heritage sites from mine subsidence have indicated that the risk to Aboriginal heritage sites varies depending on the nature and location of the site. Monitoring of Aboriginal heritage sites over previously mined areas in the Illawarra Region has shown that larger overhangs are at greater risk, particularly where water seepage is present (C. E. Sefton Pty Ltd, 1996a; 1996b; 2004). The extent to which Aboriginal heritage sites may be affected is influenced by several factors such as overhang shape and size, seepage through bedding planes, the location of the Aboriginal heritage site in the landscape and its location with respect to the longwall and direction of mining (*ibid*.).

Whilst not part of a specific monitoring programme, Caryll Sefton reports that she has observed the collapse of two wet overhangs (with one being an Aboriginal heritage site [FRC 149] with artefacts and archaeological deposit, although no artwork) located in drainage lines above previous longwalls at Metropolitan Colliery (C. E. Sefton Pty Ltd, 2004).

As detailed above, subsidence related impacts that have been recorded at the Metropolitan Colliery primarily relate to damage of the rear wall (e.g. cracking), however, this has not always resulted in impacts to associated features (e.g. Aboriginal artwork) (C. E. Sefton Pty Ltd, 2004; 2006b; Kayandel Archaeological Services, unpublished).

Based on the above, it is expected that the majority of identified Aboriginal heritage sites would experience no significant change, particularly when compared to natural deteriorating processes unrelated to mining and given the conservative nature of the subsidence predictions.

4.8.3 Mitigation Measures, Management and Monitoring

The mitigation measures, management and monitoring detailed below have been developed in consultation with Cubbitch Barta, Illawarra Local Aboriginal Land Council, KEJ Tribal Elders Corporation, Mr Gary Caines, Northern Illawarra Aboriginal Collective (including representatives from Woronora Plateau Gundungara Elders Council, Wadi Wadi Coomaditchie Aboriginal Corporation, and La Perouse Botany Bay Aboriginal Corporation), Tharawal Local Aboriginal Land Council and Wodi Wodi Elder's Corporation during the Aboriginal cultural heritage surveys, in subsequent meetings and in formal correspondence. Input from the consultation process to the below mitigation measures, management and monitoring is described in Appendix H.

An Aboriginal Cultural Heritage Management Plan (ACHMP) would be developed for the Project in consultation with the Aboriginal community. The ACHMP would be active throughout the life of the Project and be flexible to incorporate on-going outcomes as a result of monitoring, survey and fieldwork, analysis and consultation.

The ACHMP would include:

- A protocol for consultation with the Aboriginal community over the life of the Project and the participation of Aboriginal community representatives in cultural heritage monitoring, management and mitigation works.
- Details of statutory requirements to be met throughout the life of the Project regarding the management of Aboriginal heritage.
- A protocol/programme for HCPL to sponsor existing or new Aboriginal community projects which benefit the wider Aboriginal community. These may include (for example): Aboriginal community field days; restoration of culturally significant buildings; rehabilitation/protection of areas with high cultural values; and/or potential employment/skill development opportunities. Any such sponsorship would be made available to the wider Aboriginal community with submissions presented to HCPL and projects selected by HCPL based on their individual merit and benefit to the wider Aboriginal community.

- A programme and scope for undertaking additional supplementary Aboriginal heritage fieldwork, on a progressive basis, across the longwall mining area as part of future SMP applications. The fieldwork would be designed to identify additional sites, to inform the detailed design of management measures, to monitor the effects of subsidence and to validate subsidence predictions and/or inform adaptive management.
- A programme for further investigation (via additional site inspection and Aboriginal community consultation) of the two trees (one located near FRC 279 and one located at FRC 265) identified by the Northern Illawarra Aboriginal Collective as bearing *likely birth-marks* (i.e. to identify if it is an Aboriginal heritage site or not).
- A programme for further investigation (via additional site inspection and Aboriginal community consultation) of the stone arrangement identified by the Northern Illawarra Aboriginal Collective as a *possible cairn* (i.e. to identify if it is an Aboriginal heritage site or not).
- A programme for developing updated site cards and plans for Aboriginal heritage sites that were observed to have been subject to natural deterioration since their original recording up to 37 years ago (including FRC 28, FRC 29, FRC 31, FRC 32, FRC 57, FRC 62, FRC 63, FRC 117, FRC 194, FRC 253, FRC 276, NT 8, NT 46, and NEW 17).
- Consideration[4] of undertaking further recording of information from known Aboriginal heritage sites throughout the Project Underground Mining Area and surrounds, including:
  - brushing the floors of sandstone overhangs to locate artefacts;
  - further investigating the drip zone at the edges of select sandstone overhangs to locate artefacts;
  - undertaking test pits within select sandstone overhangs to locate deposited artefactual material; and
  - draining small natural water holes (located on open sandstone platforms adjacent to grinding grooves) to locate artefacts.
- A programme for undertaking pre-clearance surveys in areas above the proposed mining domain to identify the most appropriate location for required Project surface infrastructure.
- A protocol for managing Aboriginal heritage sites in areas above the mining domain located proximal to required surface disturbance works (e.g. exploration works, installation/operation/maintenance of surface infrastructure, construction/maintenance of access tracks, monitoring and stream restoration), including:
  - avoidance of impacts to Aboriginal heritage sites where practicable;
  - demarcation of Aboriginal heritage sites where proximal surface works are required; and
  - developing a comprehensive baseline record in consultation with representatives of the Aboriginal community prior to disturbance where avoidance is not practicable.
- A programme for further investigation (via additional site inspection and Aboriginal community consultation) of the artwork in sites FRC 93 and FRC 198 against the description of art provided on the AHIMS site card (i.e. whether the art depicts a kangaroo).
- A monitoring programme (developed in consultation with the Aboriginal community through the SMP process) for sites of moderate or high archaeological significance to identify if subsidence has impacted Aboriginal heritage sites and to validate the predicted subsidence movements, including;
  - proposed monitoring team (including Aboriginal representation);
  - particulars of any further recording of information prior to sites being subject to subsidence;

[4] Due to the disturbance that would result from such investigations and current opposition from various Aboriginal community groups, such investigations would not be included in the ACHMP unless consultation undertaken during development of the ACHMP indicates consensus between the Aboriginal community and the DECC.

  - tasks to be undertaken during each monitoring round, including:
    - comparison of the baseline record against the status of the site at the time of monitoring;
    - inspections of rock surfaces for cracking and/or exfoliation and/or blockfall;
    - inspection of art motifs for damage or deterioration;
    - subsidence monitoring within and around each site;
    - identification of natural deterioration process (such as fire, vegetation growth and water seepage);
    - detail and describe (including photos) any changes noted;
  - proposed monitoring schedule;
  - proposed reporting requirements; and
  - a strategy to undertake on-going consultation with the Aboriginal community.

- A protocol for the development and implementation of management measure(s) at sites of moderate or high archaeological significance and/or mitigation measure(s) at sites of high archaeological significance. These measures would be site specific and dependant on the nature and extent of the observed/predicted subsidence effect. Potential measures include:
  - installing standing supports in sandstone overhangs (e.g. timber props, timber cogs, sandbags, and metal [hydraulic] props);
  - installing a stress relief slot or stress focus notch adjacent to an open site;
  - installing an artificial dripline to direct increased moisture/water seepage away from art panels; and
  - implementation of general reinforcement techniques (e.g. rock bolts, cement sprays [shotcrete] and injection [with PUR or similar]).

  Development of these measures should acknowledge that while the measures may reduce the risk of further decrease in integrity, they also have a potential to cause damage to a particular Aboriginal site or its setting.

- A protocol for determining the most appropriate management measure(s) at sites of moderate or high archaeological significance and/or mitigation measure(s) at sites of high archaeological significance and for presenting guiding principles for managing Aboriginal heritage, for example:
  - Avoidance

    According to Article 15.1 of the Burra Charter, "Change may be necessary to retain cultural significance, but is undesirable where it reduces cultural significance" (Marquis-Kyle and Walker, 2004). Avoidance of impact should be the first consideration (e.g. selecting the location for surface infrastructure and monitoring equipment to avoid interaction with known Aboriginal sites).
  - Temporary Changes

    In line with Article 15.2 and 15.3 of the Burra Charter, any change that does reduce cultural significance should aim to be reversible and be reversed when circumstances allow (Marquis-Kyle and Walker, 2004). For example, a measure that may involve temporary changes includes supporting a highly significant overhang site whilst subsidence effects are experienced in an area and the removal of the supports once subsidence movements have ceased.
  - Stabilisation

    Stabilisation is considered a preservation technique appropriate to the conservation and management of Aboriginal indigenous places (Marquis-Kyle and Walker, 2004). Stabilisation, in the case of rock art sites, may involve changing the hydrology of the shelter. For example, cracking of the shelter surface at FRC 10 (sandstone overhang with art) had the potential to impact on the art by allowing seepage to flow over the art. In accordance with recommendations, an artificial dripline was installed to divert water away from the art. The method allowed for the retention of the primary aspect of cultural significance (i.e. the rock art pigments).

- An access protocol so that Aboriginal people can access sites in the Project Underground Mining Area and surrounds in accordance with HCPL and SCA occupational health and safety requirements.

- A cultural awareness programme for staff and contractors to assist in minimising impact to Aboriginal heritage (e.g. through augmentation of existing induction programmes).
- A protocol for registering (with the DECC) any new sites identified at the Project as well as updating and maintaining the existing record of Aboriginal heritage sites.
- A protocol that defines actions to be followed in the event that human skeletal material is encountered within the Project Underground Mining Area and surrounds (e.g. stop works in the immediate area, notification of relevant authorities and the Aboriginal community and the development of appropriate management systems).

4.9 NON-ABORIGINAL HERITAGE

A Non-Aboriginal Heritage Assessment for the Project was conducted by Dr Michael Pearson of Heritage Management Consultants Pty Ltd (Appendix I). As the Project would involve upgrades at the Major Surface Facilities Area as well as the extension of mining into the Project Underground Mining Area (Figure 2-1), the Non-Aboriginal Heritage Assessment included assessment of both these areas.

There are a range of listed heritage items in the township of Helensburgh, including the Helensburgh Railway Station (listed on the State Heritage Register), a range of residential and public buildings and historical railway buildings and structures. While these are documented in Appendix I, no potential impacts from the Project are anticipated on listed non-Aboriginal heritage items in the township of Helensburgh (Appendix I), and hence the focus of the following discussion is on the existing Metropolitan Colliery surface facilities and items located above or in close proximity to the Project Underground Mining Area (Figure 2-1).

A description of non-Aboriginal heritage at the Major Surfaces Facilities Area and in the vicinity of the Project Underground Mining Area is provided in Sections 4.9.1 and 4.9.2. Section 4.9.3 describes the potential impacts of the Project on non-Aboriginal heritage, while Section 4.9.4 outlines mitigation measures, management and monitoring.

Matters of national environmental significance of relevance to non-Aboriginal heritage are discussed in Section 3.4.

4.9.1 Background

Helensburgh and Metropolitan Colliery

Prospecting operations by the Cumberland Coal and Iron Mining Company commenced in 1884 with a bore on Camp Creek, which intersected 3.6 m of the Bulli Seam approximately 258 m below the surface. The Metropolitan Coal Company of Sydney was floated in 1887 to develop the seam, a decision that coincided with the construction of the Illawarra Railway linking Sydney and Wollongong (completed in 1888).

Helensburgh (originally known as 'Camp Creek') began as a tent town for workers constructing the Illawarra Railway between 1884 and 1888, and for exploration workers looking for coal deposits in roughly the same period. Permanent settlement began once exploration in the area confirmed a mineable coal deposit. After the Metropolitan Colliery had commenced production in 1888, the town of Helensburgh grew around the Metropolitan Colliery.

Metropolitan Colliery was at full production by 1890 and by 1893 the Metropolitan Colliery was the highest producer in the Southern Coalfield. By 1895 approximately 300 men worked underground, with horses providing haulage power.

After Metropolitan Colliery was in full production, a reduction of the ruling grade of the Illawarra Railway (to 1:80) to facilitate better movement of trains resulted in a deviation and relocation of the railway, including an almost complete relocation of the line between Waterfall and Coalcliff. The No. 4 and No. 5 tunnels located north and south of the Metropolitan Colliery were abandoned, as was the original railway station north of the Metropolitan Tunnel in Helensburgh. The new railway ran adjacent to Metropolitan Colliery, and a spur line was built into the Metropolitan Colliery Major Surface Facilities Area for the transport of coal.

The Metropolitan Colliery powerhouse was established by 1910 to provide electricity both underground and on the surface, and to power one ventilation fan. By 1915 the powerhouse at the Metropolitan Colliery was also being used to service Helensburgh village.

Some mechanical loading was introduced at the Metropolitan Colliery in 1940, however substantial mechanisation did not occur until 1951 when cutters, loaders, shuttle cars and belt conveyors were introduced to facilitate bord and pillar mining. Horses remained in use for underground haulage until 1955 and underground pit pony stables still exist near the bottom of Ventilation Shaft No. 2 (Appendix I).

A conveyor decline was established in 1954 for coal haulage, and a new CHPP was constructed in 1959. Further upgrades to the Major Surface Facilities Area occurred after the Metropolitan Colliery was purchased by Australian Iron and Steel in 1965. Mechanisation of operations was completed the following year.

Bord and pillar mining continued at the Metropolitan Colliery until longwall mining was introduced in 1995.

Garrawarra Centre

The Garrawarra Centre is located in the north of the Project Underground Mining Area (Figure 2-1) and was established in 1909 as the first (and only) government controlled institution constructed specifically for the treatment of tuberculosis in NSW. When it opened, it was known as the Waterfall State Sanatorium and throughout the first half of the 20th Century the Sanatorium was the primary tuberculosis treatment facility in NSW.

It continued as a tuberculosis facility until 1957 when patient numbers had reduced to an extent that it was no longer required. After extensive remodelling it reopened in 1958 as the Garrawarra Hospital, for the chronically ill and the aged. It has operated as an aged care facility since this time, with additional infrastructure and modifications to existing buildings occurring periodically (Howard Tanner and Associates Pty Ltd, 1993).

4.9.2 Existing Environment

Metropolitan Colliery Surface Facilities

The location of the Major Surface Facilities Area is shown on Figure 2-1. An aerial photograph of the Major Surface Facilities Area is provided on Figure 2-2. The Metropolitan Colliery heritage complex has been identified as a site of regional significance (Appendix I). Identified places and items of heritage significance at the Metropolitan Colliery are provided in Table 4-14. The location of each of these items is described in Appendix I.

Project Underground Mining Area

The Non-Aboriginal Heritage Assessment also reviewed the non-Aboriginal heritage items that are located above or in close proximity to the Project Underground Mining Area (Appendix I). Identified areas are shown on Figure 4-19 and major components are detailed in Table 4-15.

4.9.3 Potential Impacts

Major Surface Facilities Area

Potential impacts to non-Aboriginal heritage items within the Major Surface Facilities Area include impacts associated with:

- upgrades/extensions to the CHPP, material handling (conveyor) systems, water management systems and electrical reticulation and control systems; and
- construction of additional infrastructure such as a demountable bathhouse, coal reject paste plant and associated coal reject stockpile, pumping, pipeline and underground delivery systems.

The specifics of these works would be determined by detailed engineering design. Notwithstanding, potential impacts to the listed heritage items within the Major Surface Facilities Area are summarised in Table 4-16.

Appendix I provides further detail of the general potential for impact on identified sites of heritage significance within the Major Surface Facilities Area.

Project Underground Mining Area

MSEC (2008) (Appendix A) provided preliminary subsidence predictions for the Garrawarra Centre based on an east-west, full extraction, longwall layout. All buildings within the Garrawarra Centre were predicted to experience negligible tilt impacts, and, with the exception of the longer buildings (i.e. 40 m to 100 m in length) that have higher heritage significance, were predicted to experience strain impacts that would result in no more than hairline cracks or fine cracks which would not require repair.

Table 4-14
Identified Items of Heritage Significance at Metropolitan Colliery Surface Facilities

Place Name	Description
No. 4 Tunnel (Illawarra Railway)[1]	The southern portal of the Metropolitan Tunnel (No. 4) lies within the colliery lease area, the northern end being adjacent to the old Helensburgh railway station in Vera Street.
No. 5 Tunnel (Illawarra Railway)[1]	A short tunnel across the valley south of the coal stockpiles. Ovoid single-track tunnel fully brick lined, abandoned 1914.
Power Pylon[1]	A pylon located up slope of the power station, built of angle-iron lattice sections with three cross-trees of angle-iron.
Shaft No. 1 Headframe[1]	The No. 1 headframe appears in early photographs of the colliery. It is a large steel headframe with circular bracing panels and decorative wrought iron hand rails. The bracing legs have been cut off, and the winding engine site is now occupied by conveyor belt towers.
Shaft No. 2 and Koepe Winder[1]	The No. 2 headframe is a concrete tower with internal steel framework inside, on top of the original No. 2 shaft, currently used as man-access. The cages are lowered by the Koepe winder of about 1900, modernized in 1985.
Shaft No. 2 Fan Evase[1]	The fan evase is a concrete tube angled upward from the fan position adjacent to the shaft, with an octagonal outer form. The fan is still in position adjacent to the shaft. The current fan evase appears to be of the same vintage as the No. 2 shaft headframe, probably dating to the 1950s.
Tunnel Opening, Portal and Winder House[1]	Referred to as the drift portal and winder and built in 1954, the drift is currently 1,164 m long, angled at 1:3. The British Thomson Houston Co. Ltd winding engine and cab is still in operation.
Coal Storage and Washery[1]	The coal storage and washery building is a building developed and altered over time commencing in 1959, with many components of different ages.
Office and Bathhouse[1]	The office is a single-storey brick building, and the Bathhouse two storeys with large rooms with hoists for miner's clothing and personal possessions, a shower block, lamp room and ancillary rooms. A major part of the bathhouse was built in the late 19th or very early 20th Century, and the office is a mid-20th Century structure.
No. 3 Ventilation Shaft[1]	A concrete brick engine house with two steel trunking fan evases leading from shaft top. Built 1976, located west of the F6 Southern Freeway south west of Helensburgh.
Pit Pony Stables Underground[1]	Series of brick-floored, railed stalls along drives from bottom of No. 2 shaft, skip rails alongside. Pit horses were last used at Metropolitan in 1955.
Powerhouse[1]	Brick two-storey structure. Power generation equipment all removed. Houses a switch room and a workshop.
Railway Viaduct*	An arched brick structure is located at the eastern end of the southern conveyor, east of the bush 'island', half-way between railway tunnels 4 and 5. The structure is partially buried in material from the coal storage mounds, but is clearly a substantial structure, 1.8 m height of the arch being visible.
Camp Creek Culvert*	A brick-lined culvert or tunnel, approximately 65 m long and approximately 6 m high and wide, built beneath a large earth bank that carried the main Illawarra rail line over Camp Creek. The line was abandoned in 1915.
Weir on Camp Creek*	A mass-concrete weir wall extending across Camp Creek immediately upstream of the now-infilled side valley on which much of the post 1950s colliery infrastructure sits. The dam still provides water for mine operations.
Reduction Pond Base*	Mass concrete footings on hill behind the bath house. Shown on approximately 1950s plan in Manager's office as 'reduction pond'.
Manager's Residence*	A mid-20th Century brick cottage with tiled roof and adjacent tennis court, located at the top of the gully immediately above the mine site and opposite Lukin Street.

Source: After Appendix I.

1 Listed on the Wollongong LEP and/or Illawarra REP and/or *Strategic Management Plan for Historic Coal Mining Sites of the Illawarra* (OHM Consultants, 2006).

* Not currently listed on the Wollongong LEP or *Strategic Management Plan for Historic Coal Mining Sites of the Illawarra* (OHM Consultants, 2006).

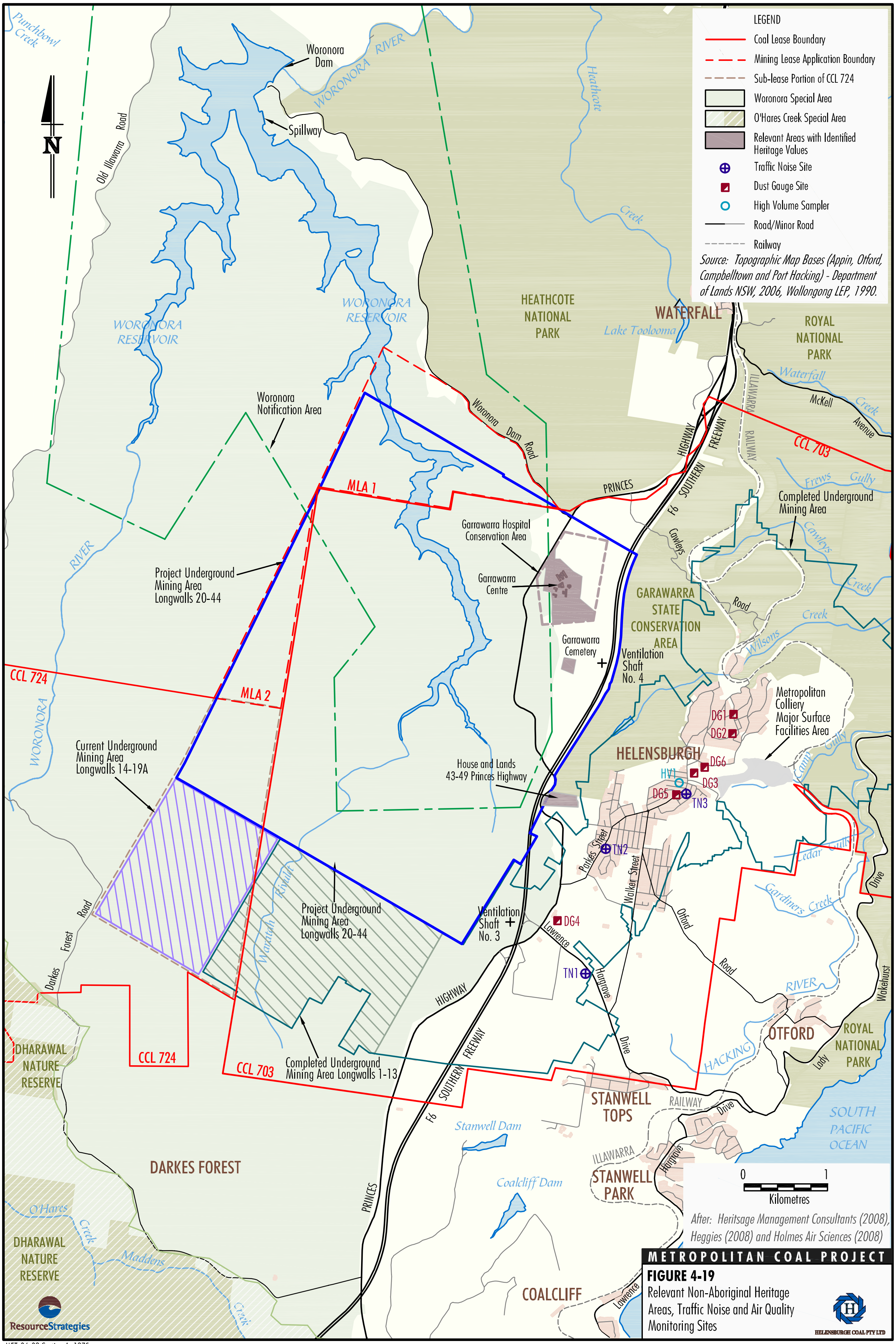


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Table 4-15
Identified Items of Heritage Significance Located in Close Proximity to the Project Underground Mining Area

Place Name		Description
Garrawarra Centre (Wollongong LEP listing)	Heritage Conservation Area	Large group of Federation hospital buildings built 1906-1913 of brick, stucco and timber, with many later buildings in the complex. The significant buildings are from the office of Walter Liberty Vernon, Government Architect. All are altered from their original function, but remain remarkably intact externally and internally, and have new functions within an aged care facility.
	Gates and Gatehouse	Group of structures comprising two sections of curved iron palisade fencing set into stone bases, a stone Gatehouse and gate piers, and decorative wrought iron vehicle and pedestrian gates.
	Administration Building	Picturesquely massed building on steeply sloping site. Face brick at ground and lower ground level, pebble dash render to walls, and steeply pitched tile roof with exposed rafter ends.
	Kitchen and Store Block	Large two storey service block with face brick base and boarded upper level, tile roof.
	Staff Cafeteria, Nurses Hostel	Two storey building with hipped roof and corrugated fibro roofing, mottled face brickwork to ground floor, roughcast render to first floor. Wide verandah at main entry on north side with trafficable terrace over, projecting bays with splayed walls to north and east sides, trafficable roofs over.
	Residential Houses	A significant part of a row of houses for hospital uses at varying times. Federation Arts and Crafts style buildings are of greatest significance. The contextual values of the site are group value, landmark value, representative value and integrity.
	Cemetery	The Cemetery is located South of the hospital. Little remains to identify the Cemetery from the surrounding bushland. Mounds in the ground and some broken pieces of marble.
House and associated lands, 43-49 Princes Highway[1] (Wollongong LEP listing)		A simple building with a rusticated stone lower walls and fibro sheet upper walls, in a large rural paddock setting.
Royal National Park and Garawarra State Conservation Area (National Heritage List)		Royal National Park and Garawarra State Conservation Area constitute a major centre of temperate plant species richness, having one of the richest concentrations of plant species in temperate Australia. The historical values of this item are specific to the Royal National Park, over 3 km from the proposed Project Underground Mining Area (Section 3.4.1).

Source: After Appendix I.

[1] Wollongong LEP currently lists the heritage item as 10 Princes Highway, however the Wollongong City Council Heritage Department has advised that the correct address for the listed item is 43-49 Princes Highway.

Table 4-16
Potential Impacts on Listed Items of Heritage Significance within the Major Surface Facilities Area

Place Name	Potential Impact
Shaft No. 1 Headframe	May be affected by upgrade proposals for the immediately adjacent CHPP and related infrastructure.
Coal Storage and Washery	May be affected by the upgrade of the CHPP over time.
Pit Pony Stables (underground)	Access may no longer be available in the future.
Powerhouse	May be affected by the upgrade of electrical reticulation and control systems.

Source: After Appendix I.

For the longer buildings of higher significance, MSEC (2008) has provided conservative performance criteria that would result in predicted strain impacts of similar magnitude to that described above (i.e. resulting in no more than hairline cracks or fine cracks which would not require repair). HCPL has committed to these performance criteria in the Project Statement of Commitments (Section 6), and detailed future mine design in the vicinity of the Garrawarra Centre would be constrained by these criteria.

Accordingly, all of the buildings within the Garrawarra Centre would experience negligible tilt impacts and strain impacts no greater than hairline cracks or fine cracks which would not require repair (Appendix I).

MSEC (2008) has also provided subsidence predictions for the part-stone cottage at 43-49 Princes Highway, and has assessed that it would be expected to experience negligible tilt impacts, and strain impacts resulting in no more than hairline cracks. Given the small predicted values of ground movement, it is unlikely that any preventative measures would be required (Appendix I).

No potential impacts on the heritage values associated with the Royal National Park have been identified as it is located over 3 km from the proposed Project Underground Mining Area (Figure 4-19).

Heritage Management Consultants (Appendix I) concluded that there would be negligible impact on heritage values (historic, scientific, cultural, social, archaeological, architectural, natural or aesthetic significance) of the sites in the vicinity of the Project Underground Mining Area (or their settings) as a result of the Project.

4.9.4 Mitigation Measures and Management

Metropolitan Colliery Surface Facilities

A CMP would be developed for the Metropolitan Colliery. The CMP would provide guidance for management of heritage items during the detailed design, construction and operational phases of the Project. The CMP process would include:

1. Further detailed inspection of all items of heritage significance or potentially of heritage significance within the Major Surface Facilities Area and recording of these items. Further literature and archival review to inform the CMP, where relevant.
2. Consultation with relevant agencies including the DoP (Heritage Office) regarding the detailed design of any heritage controls.
3. Consideration of heritage-related requirements of relevant planning instruments (e.g. the Wollongong LEP and Illawarra REP) (Section 3).
4. Consideration of contingency measures to address future (i.e. unforeseen) potential effects to heritage.

Project Underground Mining Area

The expected Project impacts to the heritage values of the house and associated lands at 43-49 Princes Highway, and at the Royal National Park have been assessed as negligible to nil, and as such, no specific management measures are considered necessary (Appendix I).

As described in Section 3.3.1, the resolution of particular management issues pertaining to individual longwall panels or mining domains would be undertaken in SMPs that would be prepared progressively over the life of the Project. Specific monitoring measures for non-Aboriginal heritage sites potentially impacted by the Project underground mining (e.g. the Garrawarra Centre) would be included in these SMPs as required.

A conservation plan was commissioned by the Southern Sydney Area Health Service in 1993 to establish a Statement of Cultural Significance and Conservation Policy for the Garrawarra Centre (The *Conservation Plan for Garrawarra Centre for Aged Care* [Howard Tanner and Associates, 1993]).

Howard Tanner and Associates (1993) provides conservation processes for the Garrawarra Centre. It is considered that the potential impacts on the Garrawarra Centre resulting from the Project would be significantly less than the impacts associated with the refurbishment works described by Howard Tanner and Associates (1993) (Appendix I). The Non-Aboriginal Heritage Assessment concluded that the *Conservation Plan for Garrawarra Centre for Aged Care* (Howard Tanner and Associates, 1993) is a suitable reference document for the management of heritage items at the Garrawarra Centre during the life of the Project (if required) (Appendix I).

4.10 NOISE

A Noise Impact Assessment for the Project has been undertaken by Heggies Pty Ltd (Heggies) in accordance with the requirements of the INP (EPA, 2000), *Environmental Noise Control Manual* (ENCM) (EPA, 2004) and *Environmental Criteria for Road Traffic Noise* (ECRTN) (EPA, 1999), and is presented in Appendix J.

A description of the existing noise environment in the vicinity of the Major Surface Facilities Area, including previous noise control measures are provided in Sections 4.10.1 and 4.10.2. Section 4.10.3 describes operational noise, overpressure and vibration criteria that are applicable to the Project. Section 4.10.4 describes the potential impacts of the Project with respect to operational noise, transport noise, blasting and vibration, and Section 4.10.5 outlines mitigation measures, management and monitoring.

4.10.1 Background

Setting

The Metropolitan Colliery has been operating since the 1880s and the township of Helensburgh originally developed around the Major Surface Facilities Area in order to accommodate the mine workforce. As a result, suburban residential areas of Helensburgh are located in close proximity to the Major Surface Facilities Area (Figure 2-2).

Some residences in Helensburgh are therefore exposed to industrial noise associated with the operation of the Major Surface Facilities Area, and some residences and businesses are also exposed to transport noise associated with deliveries to the site and off-site road and rail transport of coal product and coal reject.

Previous Noise Investigations and Noise Reduction Programmes

As described in Section 3, the Metropolitan Colliery is regulated via EPL No. 767 issued by the DECC.

In recognition of the existing industrial noise generation of the Metropolitan Colliery and the close proximity of neighbouring residential areas, the DECC has initiated a number of PRPs for the Major Surface Facilities Area via EPL No. 767, including the following PRPs that relate to on-site operational noise reduction:

- PRP 9 Noise Assessment Report – *The aim of this PRP is for the licensee to assess noise for the premises in accordance with the NSW EPA Industrial Noise Policy, and to determine if the premises can meet the requirements of the Policy. The primary aim is to eliminate public concern caused by machinery operations at night.*
- PRP 11 Noise Reduction Programme - *The aim of this PRP was to identify measures to reduce noise emissions from the premises.*

PRP 11 outlined noise goals for the Metropolitan Colliery as follows:

> *The licensee must investigate measures to reduce noise emissions from the premises with the aim of meeting the noise criteria listed in the table below. The licensee must outline the proposed reduction measures in a Noise Emission Reduction Program Report prepared for EPA approval.*
>
> *Noise Criteria*

Location	*Day ($L_{Aeq(15minute)}$)*	*Evening $L_{Aeq(15minute)}$)*	*Night $L_{Aeq(15minute)}$)*	*Maximum $L_{A1(1minute)}$)*
Oxley Place	*45*	*40*	*40*	*50*
Park[es] *Street*	*45*	*40*	*40*	*50*

HCPL undertook a number of noise investigations and studies to address the requirements of PRPs 9 and 11. As a result of these investigations, HCPL has implemented a range of noise management and operational on-site noise reduction measures to reduce noise emissions of the Metropolitan Colliery, including:

- the implementation of regular maintenance inspections for the identification and repair of muffler and exhaust systems, worn conveyor idlers and other machinery not operating in accordance with design requirements and hence potentially increasing noise emissions;
- the retrofitting of broadband reversing alarms to FEL and other surface mobile equipment (less intrusive than beeper alarms);

- the replacement of worn or cracked ceramic lining tiles and installation of rubber impact plates to reduce noise generation associated with coal flow through material transfer chutes;
- the implementation of a truck transport curfew, with no off-site trucking of coal product or coal reject between 5.00 pm and 7.00 am;
- specific implementation of noise mitigation measures on the crusher building, including cladding of the western face of the building and crusher chute with sheeting and noise insulation material; and
- fitting of compressor silencers on vacuum pumps at the lower levels of the washery building.

Following the implementation of these Stage 1 noise controls, Heggies was commissioned to undertake a review of the works undertaken, as detailed in *PRP 11 Noise Reduction Programme Peer Review Metropolitan Colliery* (Heggies, 2007). Heggies (2007) concluded that the noise goals were not being met after the implementation of the Stage 1 works and recommended that additional investigation and assessment be undertaken in order to examine in further detail the practicality of reducing noise emissions from the Metropolitan Colliery.

The DECC subsequently issued a revision of EPL No. 767, which included:

> PRP 12 Stage 2 Noise Investigation and Mitigation Program - *Previous noise investigations have established noise assessment criteria for the premises and identified works which have been undertaken to reduce noise from some sources on the premises. The aim of this Pollution Reduction Program is to build on these investigations/works via detailed monitoring and computer modelling to assess noise impacts and identify reasonable and feasible noise controls and management measures for the premises.*

In accordance with the requirements of PRP 12, HCPL commissioned Heggies to complete a Stage 2 Noise Mitigation Investigation.

Key assessment components of *PRP 12 Noise Reduction Programme – Stage 2 Noise Mitigation Investigation* (the PRP 12 Study) (Heggies, 2008) comprised:

- an audit of the sound power level of all major equipment at the Metropolitan Colliery;
- investigation and ranking of the current highest noise sources at far field receptors based on operator attended surveys;
- development and calibration of a computer based noise model of the Metropolitan Colliery noise sources to iteratively model the relative effectiveness of implementing various noise controls and/or combinations of noise controls for calculating emission levels at receptors;
- researching potential source mitigation for the major noise sources based on technically achievable noise controls for industrial and mining infrastructure;
- ranking of the noise controls based on potential noise reduction, cost effectiveness and operational limitations following iterative computer modelling;
- assessment of the reasonableness and feasibility of achieving the noise goals for the site; and
- a recommended programme of works, operating practices or other measures for noise reduction to meet the noise criteria for the site.

The findings of the PRP 12 investigations were described in the PRP 12 Study.

The PRP 12 Study major findings included (Heggies, 2008):

> - *The Metropolitan Colliery's existing noise emissions are well above the DECC's PRP 12 noise goals and it is not reasonable and feasible to achieve the nominated goals in the absence of some major change such as complete replacement and relocation of the CHPP building and associated materials handling plant and equipment.*

The PRP 12 Study report was prepared independently of HCPL's plans for the Project, however, the PRP 12 Study major findings and recommendations for noise reductions have been incorporated into the Noise Impact Assessment (Appendix J) and noise mitigation measures, where relevant.

4.10.2 Existing Environment

Noise Measurement and Description

Recorded and assessed noise levels presented in Appendix J and summarised below are expressed in A-weighted decibels (dBA). The logarithmic dBA scale simulates the response to the human ear, which is more sensitive to mid to high frequency sounds and less sensitive to lower frequency sounds. Table 4-17 provides information on common noise sources in dBA for comparative reference.

Hearing "nuisance" for most people begins at noise levels of about 70 dBA, while sustained (i.e. eight hours) noise levels of 85 dBA can cause hearing damage.

Measured and predicted noise levels are expressed as the equivalent continuous sound pressure level (L_{Aeq}), which is a constant sound level that is equal in energy to the fluctuating levels recorded during the monitoring period.

Noise Monitoring

Background noise surveys were conducted in December 2006 coinciding with the Christmas/New Year Metropolitan Colliery shutdown to characterise and quantify the acoustic environment (i.e. in the absence of operations at the existing Metropolitan Colliery) at four representative residential locations proximal to the Major Surface Facilities Area and surrounds. Results of this survey are provided in Table 4-18.

Ambient noise surveys were also conducted in November 2007 and March 2008 to coincide with normal Metropolitan Colliery operations to quantify noise levels (i.e. all noise sources) and to estimate the noise contribution of the existing Metropolitan Colliery operations at locations proximal to the Major Surface Facilities Area and at locations more remote from the Major Surface Facilities Area.

These measurements indicated existing mine noise levels at the nearest residences located in Oxley Place and Parkes Street (Figure 1-3) are up to 56 dBA during normal Metropolitan Colliery operations (Appendix J). These measurements also indicated the existing noise emissions of the Metropolitan Colliery decrease with distance from the Major Surface Facilities Area due to the topographic effects and the built environment.

Road Traffic Noise Monitoring

Traffic noise measurements were also undertaken at three representative residential locations along the existing off-site haulage route including at one location on Lawrence Hargrave Drive and at two locations on Parkes Street (Figure 4-19). Data recorded at these sites was processed in accordance with the requirements of the ECRTN (EPA, 1999).

Existing traffic noise levels at these locations are detailed in Table 4-19.

Metropolitan Colliery Noise Complaints Record

HCPL maintains a complaints register as part of its environmental management and community relations protocol. Noise related complaints from January 2003 to May 2008 are summarised as follows:

- 2003 - one complaint (operational noise);
- 2004 - seven complaints (mostly operational noise, two relating to train or truck noise);
- 2005 - three complaints (operational noise);
- 2006 - six complaints (operational noise);
- 2007 - two complaints (off-site truck noise); and
- 2008 (to 31 May) - one complaint (operational noise).

Given the existing Metropolitan Colliery operational noise emissions and close proximity of the nearby residential areas, this level of community complaints is considered to be modest.

4.10.3 Applicable Noise, Overpressure and Vibration Criteria

Project Operational Noise Criteria

In accordance with INP objectives, background noise levels for the Major Surface Facilities Area and surrounds have been characterised (Table 4-18). Project specific noise assessment criteria, which form the basis for impact assessment and determining mitigation requirements, have been derived for the Project based on these measured background levels and the noise criteria provided in EPL No. 767 (i.e. the PRP 12 noise goals) for residences that are located in close proximity to the Major Surface Facilities Area.

Table 4-17
Relative Scale of Various Noise Sources

Noise Level (dBA)	Relative Loudness	Common Indoor Noise Levels	Common Outdoor Noise Levels
110-130	Extremely noisy	Rock band	Jet flyover at 1,000 m
100	Very noisy	Internal demolition work (jackhammer)	Petrol engine lawn mower at 1 m
90	Very noisy	Food blender at 1 m	Diesel truck at 15 m
80	Loud	Garbage disposal at 1 m, shouting at 1 m	Urban daytime noise
70	Loud	Vacuum cleaner at 3 m, normal speech at 1 m	Commercial area heavy traffic at 100 m
60	Moderate to quiet	Large business office	-
50	Moderate to quiet	Dishwasher next room, wind in trees	Quiet urban daytime
40	Quiet to very quiet	Small theatre, large conference room (background), library	Quiet urban night-time
30	Quiet to very quiet	Bedroom at night, concert hall (background)	Quiet rural night-time
20	Almost silent	Broadcast and recording studio	-
0-10	Silent	Threshold of hearing	-

Source: After US Department of Interior, Robinson Project EA (1994) and Richard Heggie Associates (1995).

Table 4-18
Noise Environment for Project Assessment Purposes

INP Noise Amenity Zone	Receiver Area	Background $L_{A90(15minute)}$ All Noise Sources (dBA)			Estimated $L_{Aeq(period)}$ Industrial Noise Only (dBA)		
		Day	Evening	Night	Day	Evening	Night
Near Project Boundary							
Suburban	Indicative for Receiver Area	42	36	34	<49	<39	<34
North and Beyond Project Boundary							
Suburban	Indicative for Receiver Area	37	33	30	<49	<39	<34

Source: Afer Appendix J.
Daytime 7.00 am to 6.00 pm, Evening 6.00 pm to 10.00 pm, Night-time 10.00 pm to 7.00 am.

Table 4-19
Unattended Traffic Noise Logger Results

ID*	Location	Offset Distance from Road	Daytime $L_{Aeq(15hour)}$ (dBA)	Night $L_{Aeq(9hour)}$ (dBA)	Night-time Peak $L_{Aeq(1hour)}$ (dBA)	Morning Peak $L_{Aeq(1hour)}$ (dBA)	Afternoon Peak $L_{Aeq(1hour)}$ (dBA)
TN1	171 Lawrence Hargrave Drive	30 m	66	59	63	66	66
TN2	170 Parkes Street	15 m	64	59	63	66	64
TN3	83 Parkes Street	15 m	65	57	64	67	65

Source: After Appendix J.
Note: Daytime 7.00 am to 10.00 pm, Night-time 10.00 pm to 7.00 am.
* TN1 = L171; TN2 = P170; TN3 = P83 in Appendix J.

Tables 4-20 and 4-21 provide Project specific intrusive criteria, and applicable amenity criteria for non-residential landuses.

Noise Management and Noise Affectation Zones

Where an exceedance of the Project specific criteria outlined in Tables 4-20 and 4-21 is predicted to occur, depending on the degree of the exceedance, such exceedances can be classified as falling into a Noise Management Zone or Noise Affectation Zone.

Receptors are generally classified as being within a Noise Management Zone when the predicted noise levels are 1 dBA to 5 dBA above the criteria, and as being within a Noise Affectation Zone when the predicted noise levels are greater than 5 dBA above the criteria.

However, it does not necessarily follow that all people exposed to Project noise above the criteria would find the noise noticeable, or unacceptable.

In subjective terms, an increase or decrease (variation) in noise can be generally described as follows:

- negligible noise level variation (less than 1 dBA) (not noticeable by all people);
- marginal noise level variation (between 1 dBA and 2 dBA) (not noticeable by most people);
- moderate noise level variation (between 3 dBA and 5 dBA) (not noticeable by some people but may be noticeable by others); and
- appreciable noise level variation (greater than 5 dBA) (noticeable by most people).

As described in Section 4.10.4, modelling of existing Metropolitan Colliery and Project operational noise emissions indicates that no privately owned residences would experience an increase in operational noise as a result of the Project.

Table 4-20
Project Specific Intrusive Noise Assessment Criteria

Street No.	Location Area	Intrusive $L_{Aeq(15minute)}$ Acceptable (dBA)		
		Day	Evening	Night
Near Project Boundary				
1-9, 2-18	Oxley Place	45	40	40
1-7	Wills Place			
40-46, 48-54, 53-59, 56-74, 65-69, 86-88	Parkes Street			
34, 36	Old Station Road			
48-54, 53	Hume Drive			
2A, 2B, 2	Robertson Street			
4	McMillan Street			
North and Beyond Project Boundary				
Any, except as noted above	All other residential	42	38	35

Source: After Appendix J.
Note: Daytime 7.00 am to 6.00 pm, Evening 6.00 pm to 10.00 pm, Night-time 10.00 pm to 7.00 am.

Table 4-21
Project Specific Amenity Noise Assessment Criteria - Non-Residential Landuses

Non Residential Landuses	Amenity $L_{Aeq(period)}$ Acceptable to Maximum(dBA)		
	Day	Evening	Night
Church	External 50-55 when in use		
School	External 45-50 when in use		
Hospital	External 50-55 when in use		
Active Recreation Area	External 55-60 when in use		

Source: After Appendix J.
Note: Daytime 7.00 am to 6.00 pm, Evening 6.00 pm to 10.00 pm, Night-time 10.00 pm to 7.00 am.

At the majority of private residences that are located in close proximity to the Major Surface Facilities Area, the Project is predicted to provide significant operational noise reductions in comparison to the existing noise emissions of the Metropolitan Colliery. Hence there would be some locations that would continue to exceed the Project specific criteria, but would likely perceive a significant decrease in operational noise emissions in comparison to the existing Metropolitan Colliery noise emissions.

Road Traffic Noise Criteria

Based on the ECRTN, Lawrence Hargrave Drive is classified as a "sub-arterial road" and Parkes Street as a "collector road". The applicable traffic noise criteria for these road types are presented in Table 4-22.

As is typically the case in suburban and urban areas in NSW, comparison of the criteria outlined in Table 4-22 and the traffic noise monitoring results in Table 4-19 indicates the traffic noise goals are already exceeded at residences located in close proximity to the local roads.

For the Project, the ECRTN establishes that in cases where the nominated traffic noise goals are already exceeded, traffic associated with the development should not lead to an increase in the existing traffic noise of more than 2 dBA.

Rail Traffic Noise Criteria

RailCorp operates the South Coast rail network in NSW, of which the Illawarra Railway is a component. Noise emissions from the railway are regulated via the RailCorp's EPL No. 12208.

EPL No. 12208 provides railway operating noise objectives as follows:

> *It is an objective of this licence to progressively reduce noise levels to the goals of 60 dB(A) Leq, (24hr) and 85 dB(A) max pass by noise, at one metre from the facade of the nearest affected residential property through the implementation of the Pollution Reduction Programs.*
>
> *In the development of new works, the licensee is required to work towards the planning goals of 55 dB(A) Leq, (24hr) and 80 dB(A) max pass by noise, at one metre from the facade of the nearest affected residential property.*

The goals do not represent unobtrusive noise levels. Rather, the objectives recognise that rail operations are inherently noisy and represent a compromise between what may be desirable from a community point of view (i.e. maintaining amenity) and what is necessary to enable trains to operate (Appendix J).

The stated objectives of the RailCorp EPL provide guidance for noise regulation for the South Coast rail network, including rail movements associated with the Project (Appendix J).

Blasting Noise and Vibration Criteria

The DECC has recommended the adoption of the ANZECC (1990) *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* for assessing potential annoyance from blast emissions (including blasting vibration) during daytime hours (Appendix J).

The assessment of blast emission impacts outside the hours advocated by ANZECC (1990) are described by the ENCM in *Chapter 154 Noise Control Guidelines – Blasting* (EPA, 1994) (Appendix J).

Blasting noise limits for human comfort and structural damage are also specified in *Explosive – Storage and use Part 2: Use of Explosives – Appendix J* (AS 2187.2) (Appendix J).

Road and Rail Vibration Criteria

The DECC (2006) *Assessing Vibration: A Technical Guideline* provides guideline building vibration levels associated with a low probability of annoyance to occupants arising from continuous and impulsive vibration sources.

Table 4-22
Applicable Road Traffic Noise Goals

Receiver Area (Road)[1]	Policy	Descriptor	Traffic Noise Goal (dBA)
Helensburgh (Lawrence Hargrave Drive)	Landuse developments with the potential to create additional traffic existing on sub-arterials	Daytime[2] $L_{Aeq(15hour)}$	60
		Night-time[3] $L_{Aeq(9hour)}$	55
Helensburgh (Parkes Street)	Landuse developments with the potential to create additional traffic existing on collector roads	Daytime[2] $L_{Aeq(1hour)}$	60
		Night-time[3] $L_{Aeq(1hour)}$	55

Source: After Appendix J.
[1] Refer to Figure 4-19. [2] 7.00 am to 10.00 pm. [3] 10.00 pm to 7.00 am.

In addition, the German Standard DIN 4150-3 1999 *Structural Vibration Part 3: Effects of Vibration on Structures* provides guideline criteria for evaluating the short-term and long-term effects of vibration on structures (i.e. with respect to damage risk to structures). On the basis of these guidelines, Heggies identified key damage and annoyance criteria for residential dwellings as described in Table 4-23.

Table 4-23
Relevant Rail and Road Damage and Annoyance Vibration Criteria

Receiver Area	Damage Risk	Annoyance Risk	
	Long-Term[1]	Continuous (horizontal)	Continuous (vertical)
Residential Dwellings	5.0 mm/s	1.2 mm/s (0.6 mm/s)[2]	0.5 mm/s (0.2 mm/s)[2]

Source: Appendix J.

[1] Conservatively assumed to be long-term for the purposes of damage risk assessment.

[2] Night-time criterion applicable only to residential dwellings.

4.10.4 Potential Impacts

Operational Project Noise Modelling

An acoustic model was developed for the Major Surface Facilities Area that simulates Project components and noise source information (i.e. sound power levels and locations).

The key sources of noise identified for the Project included:

- construction activities;
- train loading activities;
- on-site coal reject haulage;
- on-site coking coal trucking;
- operation of the CHPP (e.g. conveyors, pumps/compressor units, etc.);
- operation of mobile plant;
- the coal reject paste plant; and
- coal handling.

The model also considers meteorological effects, surrounding terrain, aspects of the built environment (i.e. existing buildings) and distance from source to receiver.

Meteorological effects included in the modelling are those characterised as prevailing in accordance with INP assessment methodologies. The definition of prevailing conditions included statistical analysis of meteorological data (including consideration of wind speed and direction, as well as temperature lapses and inversions).

Noise mitigation measures from the PRP 12 Study report have, where relevant, been incorporated into the Project noise model. The incorporation of noise mitigation measures into the model has been undertaken progressively to reflect the staged implementation of noise reduction measures on-site (Appendix J).

In order to establish the Metropolitan Colliery noise model, on-site noise measurements were conducted during November 2007 to determine fixed and mobile plant sound power levels for inclusion in the Project Noise Model, where appropriate (Appendix J).

Operational Noise Emission Scenarios

Predictive noise emission modelling has been undertaken for three representative periods, based on the planned Project development including:

- the existing Metropolitan Colliery operations;
- Project Year 3 (combined operational and construction noise); and
- Project Year 15 (peak operational production period).

The modelling of an existing operational noise scenario for the Metropolitan Colliery has been undertaken as part of the Project modelling for two key purposes:

- to provide an estimate of the current noise contribution of the Major Surface Facilities Area to nearby residences; and
- to allow quantification of the significant noise reductions that the Project noise mitigation measures would provide at most private receptors adjacent to the Major Surface Facilities Area.

As described in Section 2, operational activities would be undertaken 24 hours per day and seven days per week. Day/night noise would be generated by a number of sources including the CHPP, coal reject paste plant, coal handling and train loading operations. Operational activities that would be undertaken during the daytime only would include coal reject and product coal road haulage off-site.

Existing Operations

Modelling of the existing Major Surface Facilities Area operations represents a higher noise generating period (i.e. the worst-case scenario with respect to noise emissions that could occur prior to the implementation of any significant Project noise mitigation measures).

Year 3

Project Year 3 activities would include construction activity associated with the CHPP upgrade and establishment of the coal reject paste plant, as well as increased ROM coal production and coal train loading operations. Year 3 would also have continued off-site coal reject and product coal road haulage.

In Year 3, a range of Project noise mitigation measures would have been progressively implemented (e.g. CHPP coarse washery building cladding and sound insulation) and these measures have been incorporated in the Year 3 noise modelling to estimate the noise reductions that would occur.

Year 15

Project Year 15 would present the scenario with peak ROM coal production, CHPP production and coal train loading and product coal road haulage.

The Year 15 noise modelling incorporates the noise mitigation measures identified in Appendix J to simulate the noise reductions that are expected in the peak year of Project production.

Predicted Intrusive Operational Noise Emissions

The modelling of existing Metropolitan Colliery and Project noise emissions indicates that no privately owned residences would experience an increase in operational noise as a result of the Project (Appendix J).

At the majority of private residences that are located in close proximity to the Major Surface Facilities Area, the Project is predicted to provide significant operational noise reductions in comparison to the existing noise emissions of the Metropolitan Colliery (Appendix J).

Operational noise levels at receivers near the Project boundary to the north are generally predicted to remain unchanged by the Project (or be slightly reduced) due to the contribution of train loading activities which are in close proximity and dominate noise emissions at these locations (Appendix J).

Predicted intrusive noise emissions exceed the relevant assessment criteria for some receivers nearest the Project boundary during all three noise emission scenarios. However, significant operational noise reductions would be achieved as the Project progresses, with the number of private residences in the Noise Affectation Zone falling from 29 to 14, as shown in Table 4-24.

Table 4-24
Predicted Number of Dwellings in the Noise Affectation and Noise Management Zones
Existing Metropolitan Colliery and Project Years 3 and 15

Noise Exceedance Zone	Noise Exceedance[1]	Predicted Number of Residences		
		Existing	Year 3	Year 15
Noise Affectation Zone	>5 dBA above Project specific criteria	29	20	14
Moderate Noise Management Zone	3-5 dBA above Project specific criteria	5	9	6
Marginal Noise Management Zone	1-2 dBA above Project specific criteria	1	2	8

Source: Appendix J.
[1] Any noise period (i.e. in the Daytime, Evening or Night-time).

The number of dwellings predicted to fall within the Noise Management Zone for the existing Metropolitan Colliery and the Project Year 3 and Year 15 is detailed in Table 4-24. The number of residences in the marginal noise management category increases, as Project noise emissions fall and dwellings move out of the Noise Affectation Zone into the Noise Management Zone (Table 4-24) with the progressive implementation of Project noise mitigation measures.

Figures 4-20 and 4-21 show the predicted intrusive night-time noise emissions for Year 3 of the Project during calm conditions and north winds.

Predicted Amenity Operational Noise Emissions

Predicted Project amenity noise emissions are below the relevant assessment criteria (Table 4-21) for all non-residential receptors (i.e. Holy Cross Catholic Church, Holy Cross Primary School and nearby public recreation areas) surrounding the Major Surface Facilities Area during all noise emission scenarios (Appendix J).

Comparison of Project noise emissions to applicable residential amenity noise criteria indicates that the Project would reduce the number of residences with exceedances of the criteria from 14 (existing Metropolitan Colliery) to three residences in Year 3, and no exceedances of the applicable amenity criteria are predicted in Project Year 15 (Appendix J).

Predicted Noise Emissions Associated with Ventilation Shaft No. 4

The Noise Impact Assessment (Appendix J) included consideration of the potential impacts of the development of Ventilation Shaft No. 4, later in the Project life (Section 2.5.4). The nearest residential receivers are located more than 1 km to the east of Ventilation Shaft No 4, and the night-time noise contribution at this distance is calculated to be below applicable noise criteria (Appendix J).

The Garrawarra Centre is located over 800 m to the north-west of Ventilation Shaft No. 4 and compliance with applicable amenity noise criteria (50 dBA external) is also predicted at the Garrawarra Centre with the operation of Ventilation Shaft No. 4 (Appendix J).

Road Transport Noise

As described in Section 4.10.3, the existing measured traffic noise is above the ECRTN goals at the three traffic noise monitoring locations (Table 4-19). As described above, the ECRTN establishes that in cases where the nominated traffic noise goals are already exceeded, traffic associated with a development should not lead to an increase in the existing traffic noise of more than 2 dBA.

The existing delivery routes and key coal and coal reject haulage routes would not be altered by the Project and Metropolitan Colliery employee and consumable traffic along public roads would not be significantly increased by the Project (Section 4.12). As stated in Sections 2.6 and 2.7, the Project would not increase existing annual maximum haulage movements for the transport of product coal to the Coalcliff and Corrimal Coke Works, or for the transport of coal reject to the Glenlee Washery, for disposal by SADA.

The potential for Project traffic to increase traffic noise has been quantified. The predicted results fall well below the 2 dBA increase limit that is advocated by the ECRTN (Appendix J).

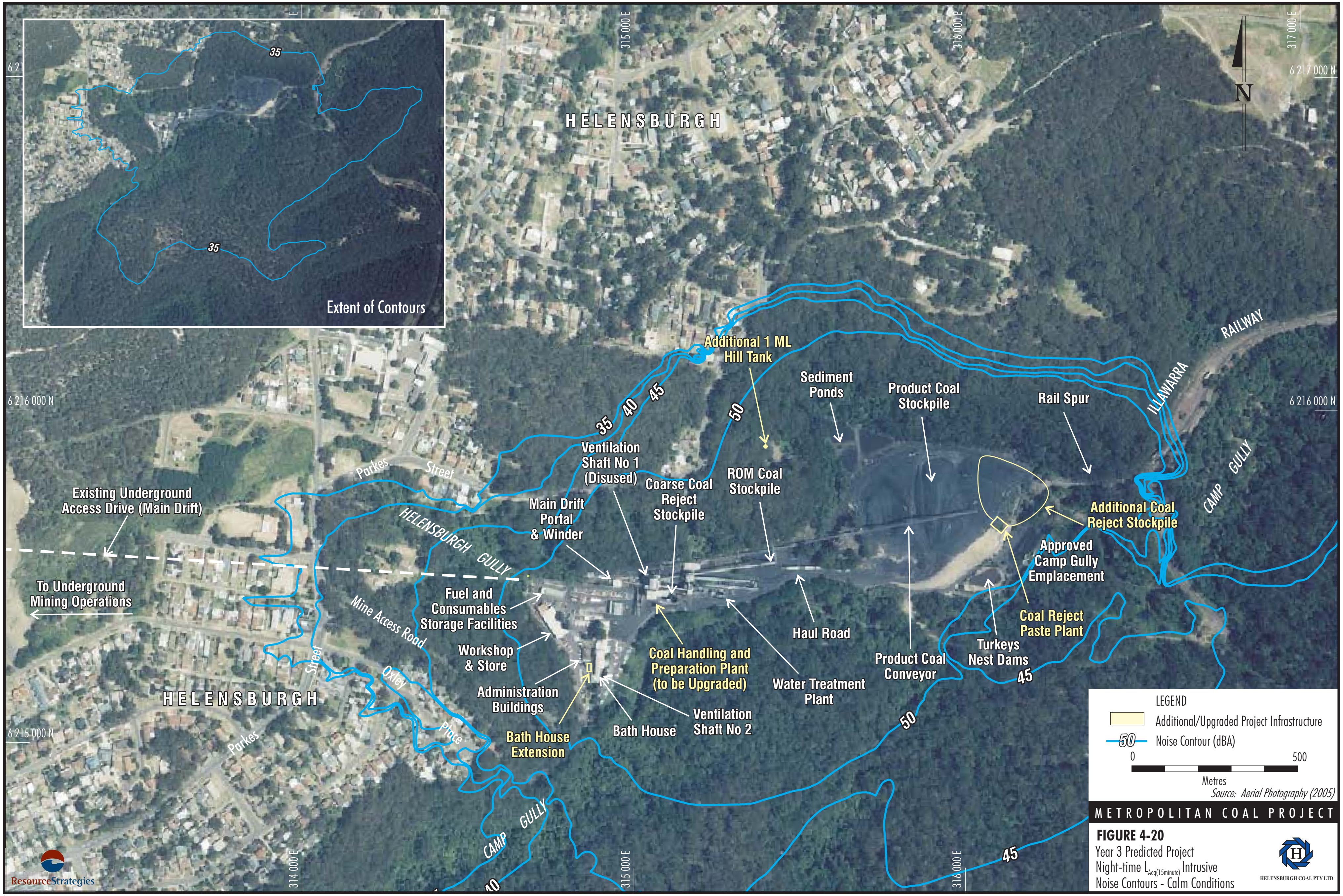
Rail Transport Noise

The midweek and weekend (average and peak) existing train movements and associated rail noise levels have been determined for the South Coast line between Helensburgh and Otford in the vicinity of the Project (Appendix J).

A comparison of the existing rail noise levels with the future cumulative train noise including additional Project train movements (Section 2.7.2) indicates only a negligible noise increase (i.e. < 1 dBA) due to the increased Project train movements at the nearest residential receivers to the rail line, as there is only a small number of additional train movements arising from the Project (Appendix J). Predicted existing and cumulative Project rail transport noise emissions at various offset distances from the railway are described in Appendix J.

Blasting Noise and Vibration

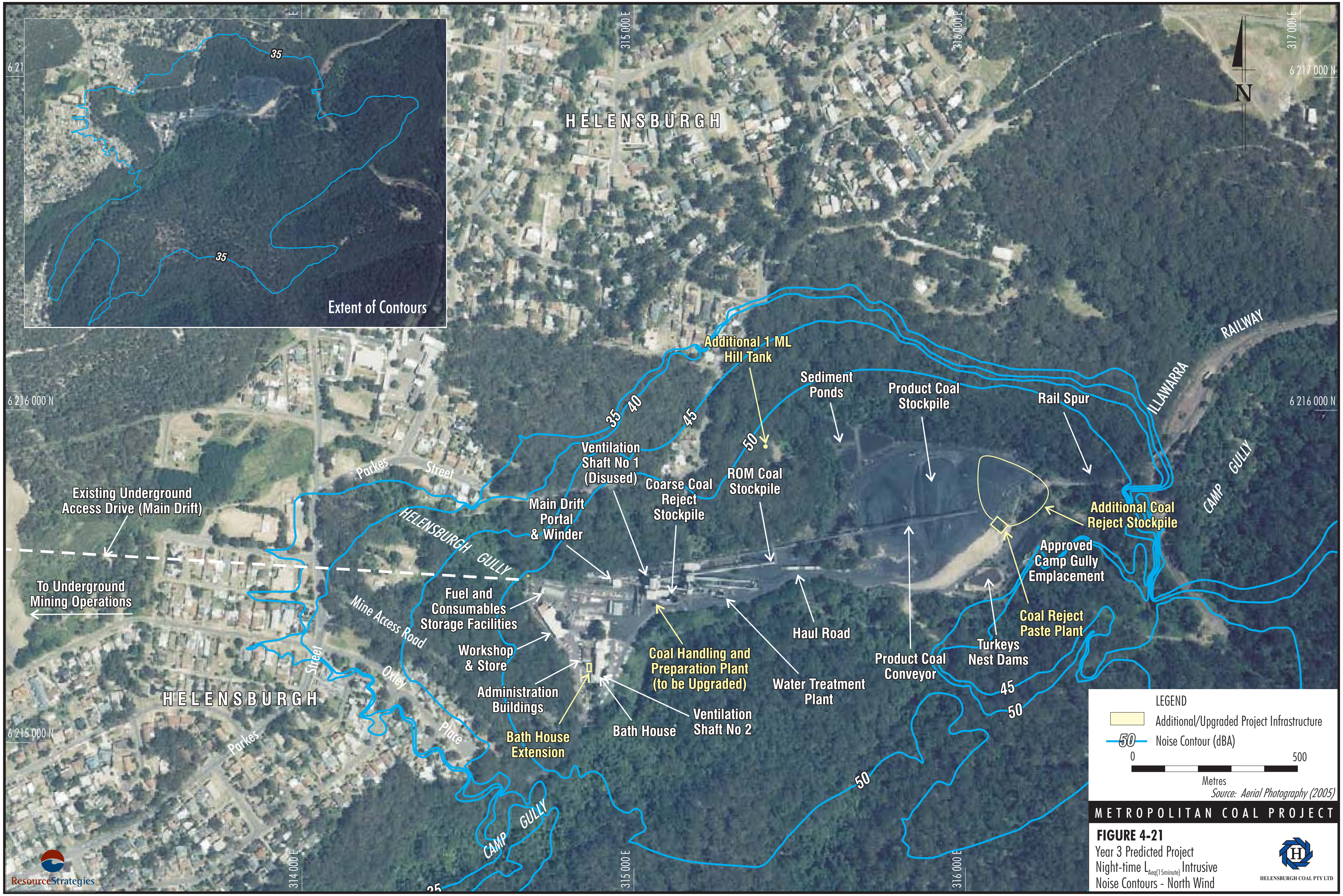
Overpressure (or airblast) is measured in linear decibels (dBL) and is the peak air pressure pulse caused by the blast including generated energy that is below the limit of human hearing. The velocity of ground vibration caused by the blast is measured in mm/s (Appendix J).



METROPOLITAN COAL PROJECT

FIGURE 4-20
Year 3 Predicted Project Night-time $L_{Aeq(15minute)}$ Intrusive Noise Contours - Calm Conditions

MET-06-02 Section 4_029C



METROPOLITAN COAL PROJECT

FIGURE 4-21
Year 3 Predicted Project Night-time $L_{Aeq(15minute)}$ Intrusive Noise Contours - North Wind

MET-06-02 Section 4_030C

Occasionally, geological structures (e.g. dykes) may be encountered underground that have to be broken up using explosives. This blasting would be undertaken at significant depth (e.g. 400 m below the surface). Airblast emissions arising from underground blasting (when undertaken) would propagate from the excavation site and release to the surface via the nearest ventilation shafts. However, before reaching the surface, airblast noise is reduced significantly due to underground confinement (Appendix J).

Potential airblast and vibration effects arising from the occasional application of underground blasting at the Project have been assessed in Appendix J. Airblast emissions arising from underground blasting are predicted to meet the most stringent night-time criteria at the nearest residential dwellings (Appendix J). Similarly, blast induced ground vibration levels are predicted to meet the most stringent night-time criteria at the nearest residential dwellings (Appendix J).

Rail and Road Transport Vibration

Ground vibration is also caused by heavy vehicle and train movements on the public road and rail networks. Road and rail vibration effects of the movement of heavy vehicles on the public road network and trains on the South Coast rail network have been assessed and are detailed in Appendix J.

As the Project would not result in significant increases in the total number of heavy vehicle movements on the public road network or total rail movements on the South Coast rail network, the existing road vibration effects of heavy vehicle movements on the public road network and rail vibration effects of trains on the South Coast rail network would be generally unchanged by the Project (Appendix J).

4.10.5 Mitigation Measures, Management and Monitoring

Project Operational Noise

As described in Appendix J and Sections 4.10.1 to 4.10.4, during the previous studies and Noise Impact Assessment (Appendix J), a number of iterative steps were undertaken to identify the key existing operational noise sources and to identify and rank potential noise mitigation measures that could be incorporated in the Project, including:

- detailed sound power level and received noise measurement and noise modelling of the effectiveness of various noise control measures in the PRP 12 Study;
- noise modelling of the existing Metropolitan Colliery noise emissions to identify existing areas of affectation to direct where mitigation may be usefully applied; and
- modelling of the implementation of Project additional noise mitigation measures progressively over the life of the Project.

The predictive noise modelling included key noise mitigation and management measures recommended by the PRP 12 Study and additional noise mitigation measures that have been identified as a component of Project upgrades of the Major Surface Facilities Area, including (Appendix J):

- enclosure of the coarse washery building (HCPL underway with this work);
- CHPP upgrade to include the installation of modern low-noise equipment where practicable, and/or additional sound insulation, or specific mitigation of key noise sources (e.g. drives);
- replacing existing exhaust silencers on pumps and compressors with high performance mufflers;
- relocating or enclosing the MD1 conveyor drive fan as a component of Project conveyor upgrades;
- partial enclosure or construction of a barrier to the south/west of MD1 conveyor drive as part of Project conveyor upgrades;
- implementation of a low noise conveyor idler replacement system on surface transfer conveyors as a component of Project conveyor upgrades;
- enclosure of the new coal reject paste plant;
- use of modern low-noise 30 t off-road trucks and FEL for on-site coal reject handling (between the CHPP and the temporary coal reject stockpile or coal reject paste plant);
- project surface construction activities to be restricted to daytime hours;
- no off-site road haulage of product coal or coal reject during the evening or night-time periods (continuation of an existing Metropolitan Colliery operational noise control measure);
- no haulage of coal reject between the CHPP and the temporary stockpile or between the CHPP and the coal reject paste plant to be undertaken in the evening and night-time periods; and

- continued use of broadband noise alarms on existing and future equipment adjusted to meet Occupational Health and Safety (OHS) requirements.

PRPs under the existing EPL No. 767 provide an effective mechanism for progressive improvement of operational noise performance at the Metropolitan Colliery. The Project Noise Impact Assessment (Appendix J) indicates significant operational noise reductions would occur as a result of the Project. If the Project is approved, it is anticipated that the PRP process would continue to provide the mechanism to identify and implement further operational noise management or improvement measures that may be practicable over the life of the Project.

In addition, HCPL would over the life of the Project implement a noise improvement programme under the PRP that would involve, where practicable, the implementation of:

- the best available technology for Project upgrades including considering acoustical specifications for new Project equipment;
- desktop design validation and supplier shop acoustical testing;
- *in-situ* acoustic testing of new equipment;
- acoustical field testing during plant commissioning (e.g. coal reject paste plant);
- refitting and/or replacement in the event of non-compliance with acoustic specifications;
- computer-based acoustical modeling of installed plant using achieved sound power levels; and
- measuring acoustical compliance of Project upgrades via on-site and off-site operator-attended noise measurements of acoustically significant plant.

Project Operational Noise Compliance Programme

The existing and future PRPs would inform the noise management measures for the Project. These include (Section 6):

- applicable noise criteria from the Project Approval;
- noise monitoring to be undertaken for the Project (i.e. monitoring locations, frequencies, parameters and specifications);
- a description of the Project noise mitigation measures;
- a protocol for the on-going management of noise at the Metropolitan Colliery, including the PRP process;
- procedures to be followed in the event of an exceedance of Project Approval noise criteria, should they occur; and
- complaint response protocols.

The PRPs and associated noise monitoring would be used to optimise noise controls, validate the noise modelling predictions and results would be reported to relevant authorities via the AEMR (Section 3.3.1).

Exceedances of Project Approval Operational Noise Criteria

In the event of an exceedance of Project operational noise criteria as defined in the Project Approval, and depending on the degree of exceedance, additional noise management measures that could be employed include:

- prompt response to any community issues of concern (e.g. implementation of additional noise monitoring);
- refinement of on-site noise operating procedures, where practicable; and
- consideration of additional acoustical controls at key noise sources, or at particular exposed receivers.

Road Transport Noise and Vibration

Notwithstanding the fact the Project is not predicted to significantly alter existing off-site road transport noise or road transport vibration effects on the public road network, HCPL would implement the following mitigation measures as a component of a Transport Management Plan to be prepared for the Project (Section 6):

- cap the Project public road haulage of coal reject at the existing Metropolitan Colliery maximum annual haulage levels;
- maintenance of the existing level of product coal haulage;
- maintain the existing Metropolitan Colliery heavy vehicle night-time curfew (i.e. large vehicle access to the site is restricted during night-time hours);
- where practicable, work with HCPL suppliers to minimise the use of heavy vehicles to deliver small items to the Major Surface Facilities Area that could be delivered via a light vehicle or van; and

- encourage the mine operational workforce and Project construction workforce to car-pool and minimise workforce related light vehicles movements to the site.

Rail Transport Noise and Vibration

Notwithstanding the fact the Project is not predicted to significantly alter existing rail noise or rail transport vibration effects on the South Coast rail network, HCPL would implement the following mitigation measures as a component of the Transport Management Plan (Section 6):

- liaise with RailCorp to minimise Project night-time train movements as far as practicable within train scheduling restraints; and
- liaise with the Metropolitan Colliery CRG and RailCorp to facilitate the resolution of any particular rail noise or vibration issues (e.g. on-site train whistle noise) that may arise with respect to on-site or off-site rail haulage noise or vibration over the life of the Project, as required.

Blasting Noise and Vibration

Blasting would not generally be required at the Project. Notwithstanding, when blasting is required for the management of particular geological structures underground, HCPL would design blast parameters to meet the applicable DECC overpressure and vibration criteria with a high margin of conservatism at the nearest private receptors.

4.11 AIR QUALITY

A description of the existing air quality environment in the vicinity of the Major Surface Facilities Area, including dust control measures are provided in Sections 4.11.1 and 4.11.2. Section 4.11.3 describes the potential impacts of the Project with respect to air quality, while Section 4.11.4 outlines mitigation measures, management and monitoring.

4.11.1 Background

Setting

Suburban residential areas of Helensburgh are located in close proximity to the existing Major Surface Facilities Area.

Some residences in Helensburgh are therefore exposed to dust emissions associated with the operation of the Major Surface Facilities Area and associated road and rail transport of coal products and coal reject.

Previous Dust Investigations and Dust Reduction Programmes

In recognition of the existing dust generation of the Metropolitan Colliery and the close proximity of neighbouring residential areas, the DECC has initiated a number of PRPs for the Major Surface Facilities Area via EPL No. 767, including the following PRPs that relate to on-site dust monitoring and dust reduction:

- PRP 5 Dust Monitoring Programme - *The aim of this PRP was to assess the impacts of dust on the surrounding community by establishing a dust monitoring program in accordance with AS 3580.10.1-1991.*
- PRP 6 Development and Implementation of a Surface Dust Management Plan - *The aim of this PRP was to provide a structured approach towards minimizing the impacts of airborne dust on residents near Metropolitan Colliery by documenting the current dust suppression systems and identify areas of further investigations and improvements.*
- PRP 8 Improvements to Dust Suppression Systems (Investigation) - The aim of this PRP was for the licensee to undertake investigations and make recommendations to improve the effectiveness of dust suppression strategies at the Metropolitan Colliery's clean coal stockpile area.
- PRP 10 Improvements to Dust Suppression Systems (Implementation) - *The aim of this PRP was to implement the recommendations of PRP 8 and install an additional six stockpile sprays along the rail line for improved dust suppression.*

As a result of these investigations, HCPL established a dust monitoring network in the vicinity of the Major Surface Facilities Area (Section 4.11.2) and a number of additional air quality management measures have been implemented at the Metropolitan Colliery over the last five years in accordance with the Airborne Dust Management Plan (HCPL, 2007a).

Current dust management measures include:

- watering of unsealed haul roads and hardstand areas;
- enclosure of crushing and screening processes;
- enclosure of transfer conveyors;
- fixed water sprays located on conveyors and stockpiles (sprays can be operated manually or automatically by wind speed and direction sensor);
- truck wash for all heavy vehicles travelling off-site; and
- HCPL has been undertaking progressive sealing of car parks and yard areas.

Project Air Impact Quality Assessment

An Air Quality Impact Assessment for the Project has been undertaken by Holmes Air Sciences and is presented in Appendix K. As a component of this assessment, background air quality data collected by HCPL in the vicinity of the Major Surface Facilities Area was collated and reviewed.

The assessment was conducted in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005b).

4.11.2 Existing Environment

The current air quality environment in Helensburgh includes the existing dust contributions associated with the operations at the Major Surface Facilities Area.

As a component of the Air Quality Impact Assessment, background air quality data was collected and reviewed. Background air quality data was collected from the current dust monitoring network which includes one high volume sampler, and six dust deposition gauges. The following section provides an overview of existing air quality for the relevant parameters.

The locations of the existing monitoring sites are shown on Figure 4-19. In addition, odour and total suspended particulate (TSP) measurements were undertaken at the existing ventilation upcast shaft (Ventilation Shaft No. 3) located to the west of the F6 Southern Freeway (Figure 4-19).

Air Quality Criteria

Dust Deposition

The DECC amenity criteria for dust deposition seek to limit the maximum increase in the mean annual rate of dust deposition from a new development to 2 grams per square metre per month (g/m^2/month) and total dust deposition (i.e. including background air quality) to 4 g/m^2/month.

Concentrations of Suspended Particulate Matter

Exposure to suspended particulate matter can be associated with health and amenity impacts. The likely risk of these impacts depends on a range of factors including the size, chemical make-up and level of the particulate matter and the general health of the person (NSW Health and NSW Minerals Council, 2006).

Such particles (TSP) are typically less than 50 micrometers (µm) in size and can be as small as 0.1 µm. Fine particles less than 10 µm are referred to as PM_{10}. Suspended particulate matter criteria, standards and goals used in the assessment include:

- DECC 24-hour PM_{10} assessment criterion of 50 micrograms per cubic metre (µg/m^3) (for concentrations due to the Project alone).
- The DECC annual assessment criterion for PM_{10} of 30 µg/m^3 as a concentration that should be met within the region (concentrations due to the Project and background air quality).
- The National Health and Medical Research Council's (NHMRC) annual goal for TSP of 90 µg/m^3 (as the assessment criterion for TSP concentrations due to the Project and background air quality).

Details of the air quality criteria for concentrations of particulate matter are provided in Table 4-25.

Table 4-25
Air Quality Standards/Assessment Criteria for Particulate Matter Concentrations

Pollutant	Standard/Goal/Criterion	Agency
Total Suspended Particulate Matter	90 μg/m^3 (annual mean)	NHMRC
Particulate Matter < 10 μm	50 μg/m^3 (24-hour average – maximum)*	DECC assessment criterion
	30 μg/m^3 (annual mean)	DECC assessment criterion
	50 μg/m^3 (24-hour average, 5 exceedances permitted per year)	NEPM reporting standard

Source: After Appendix K.
* Project only emissions.

Dust Deposition

Monthly dust deposition rates have been measured at four sites (DG1, DG2, DG3 and DG4) since December 2002, and at two additional sites (DG5 and DG6) since November 2006 (Figure 4-19).

Annual dust deposition results for these six sites are presented in Table 4-26. Annual average dust deposition rates for all sites have been in the range of 1.1 to 2.9 g/m^2/month. In 2007 the dust deposition rate averaged across all sites was 1.8 g/m^2/month. The average monthly dust deposition rate for all sites was well below the DECC goal of 4 g/m^2/month (Appendix K).

Suspended Particulates

Particulate Matter Less than Ten Microns in Size

PM_{10} data were obtained from the high volume air sampler (HVAS) (HV1) at Helensburgh (Figure 4-19). The monitor measures the contribution from a range of particulate matter sources, including local traffic, nearby residences, as well as local industry and dust sources associated with the existing Metropolitan Colliery operations. Data have been collected on every sixth day since 5 May 2007.

The estimated annual average PM_{10} concentration at HV1 is 14 μg/m^3, which is well below the DECC air quality goal of 30 μg/m^3 (Appendix K).

The PM_{10} monitoring at HV1 indicates that 24-hour average concentrations have generally been well below the DECC's 24-hour assessment criterion of 50 μg/m^3. The highest 24-hour PM_{10} concentration recorded to date was 36 μg/m^3, measured on 20 October 2007 (Appendix K).

Total Suspended Particulates

TSP levels can be inferred from the PM_{10} monitoring data (Appendix K). The annual average inferred TSP background concentration based on the annual average PM_{10} concentration (14 μg/m^3) is 35 μg/m^3, which is well below the DECC assessment criterion of 90 μg/m^3 (Appendix K).

Table 4-26
Average Dust Deposition Rates (g/m^2/month)

Year	Dust Monitoring Site					
	DG1	DG2	DG3	DG4	DG5	DG6
2003	2.4	1.4	2.1	2.1	-	-
2004	2.6	1.1	2.2	2.5	-	-
2005	1.9	1.6	2.1	2.4	-	-
2006	2.9	1.7	2.2	2.0	-	-
2007	2.8	1.3	1.2	2.6	1.3	1.4

Source: After Appendix K.
DECC criterion = 4 g/m^2/month

Dust Complaints

In accordance with the requirements of EPL No. 767, a log of complaints has been kept by HCPL and covers the period 2003 to present (Appendix K). Most of the complaints relating to air quality suggested that dust or coal dust was settling on nearby resident's property. This is most likely due to an accumulation of dust over long periods of time which may be visible, but still complies with the DECC's assessment criteria for dust deposition (Appendix K).

There has been a marked decrease in the number of dust related complaints between 2003 (11 complaints) and 2007 (four complaints) (Appendix K). This may correspond to HCPL implementing additional on-site dust controls under the PRPs (Section 4.11.1) since 2003.

Ventilation Shaft Emissions Testing

Sampling of dust and odour from the existing Ventilation Shaft No. 3 (upcast shaft) at the Metropolitan Colliery was undertaken in March 2007 (Appendix K). Data collected have been used to determine dust and odour emissions from the existing and proposed additional Ventilation Shaft No. 4 (Section 2.5.4). The ventilation air testing was carried out in accordance with the procedures identified in the DECC (2007d) *Approved Methods for the Sampling and Analysis of Air Pollutants in NSW*.

4.11.3 Potential Impacts

The majority of potential air quality related impacts due to the Project are related to the development/expansion of materials handling at the Major Surface Facilities Area rather than the extension of the underground mining of coal.

The Air Quality Impact Assessment has considered the air quality emissions likely to be generated by the Project and the predicted impact of these emissions in combination with existing background air quality in the vicinity of the Project. As the measured background air quality includes the existing air quality contributions of the Metropolitan Colliery, this is inherently conservative, as an element of double counting of emissions would occur (Appendix K).

Emissions associated with operation of the Project would be primarily derived from coal dust emissions from transfer points, from plant shaping coal stockpiles, loading/unloading and wind blown emissions (particularly from the surface of coal stockpiles) as well as hauling product/coal reject off-site. The majority of emission sources are located at the Major Surface Facilities Area. Ventilation shafts (Figure 2-1) comprise the only emission source from the underground workings (Appendix K).

A full description of the dispersion model and the emissions inventory (including the locations of dust sources) is provided in Appendix K. The results of dispersion modelling are presented graphically as isopleths in Appendix K.

Project impacts were modelled for Years 3 and 15. Year 3 was selected as it includes Project construction activities and a marginal increase in production.

Year 15 represents the anticipated peak year for Project production and materials handling and hence potential maximum air quality emissions. An additional upcast ventilation shaft (Ventilation Shaft No. 4) would have been installed by Year 15 (Figure 2-1). The provisional Project production schedule is presented in Table 2-2.

Dust Deposition

In accordance with the DECC's dust deposition criteria, dust deposition impacts from the Project in isolation and the Project including background air quality were assessed for Years 3 and 15.

Year 3

Project-only increases in dust deposition at the nearest residential areas during Year 3 are predicted to be 1 g/m^2/month or less. Incremental increases in annual average dust deposition due to the Project only are not predicted to be above the applicable 2 g/m^2/month DECC amenity criterion at any receiver.

Annual average dust deposition due to the Project plus background was not predicted to be above the applicable 4 g/m^2/month DECC amenity criterion at any receiver in the vicinity of the Project in Year 3 (Appendix K).

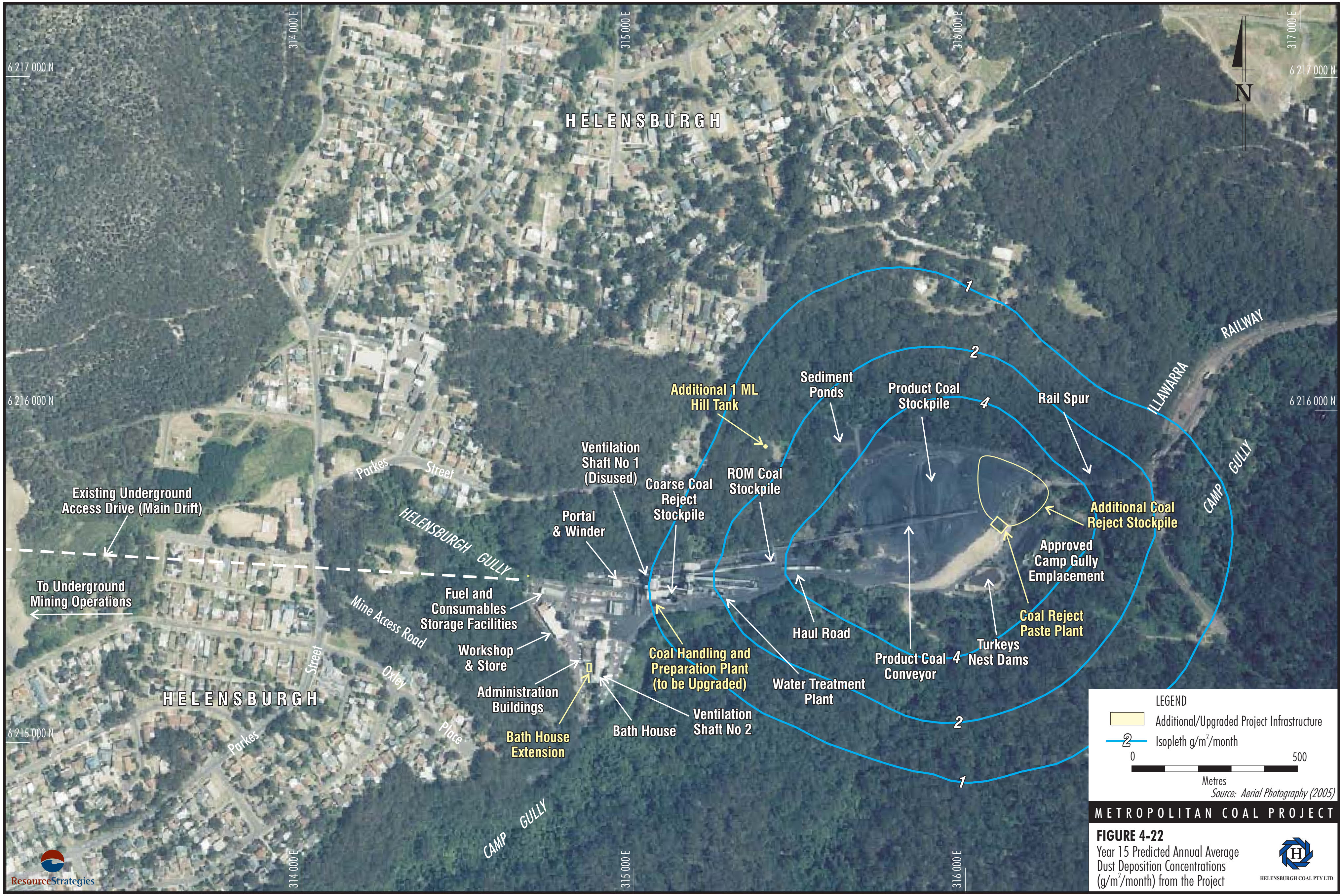


FIGURE 4-22
Year 15 Predicted Annual Average Dust Deposition Concentrations (g/m²/month) from the Project

Year 15

Project-only increases in dust deposition at the nearest residential areas during Year 15 are predicted to be 1 g/m^2/month or less. Figure 4-22 shows the predicted annual average dust deposition rates resulting from the Project in Year 15.

Incremental increases in annual average dust deposition due to the Project only are not predicted to be above the applicable 2 g/m^2/month DECC amenity criterion at any receiver.

Annual average dust deposition due to the Project plus background was not predicted to be above the applicable 4 g/m^2/month DECC amenity criterion at any receiver in the vicinity of the Project in Year 15 (Appendix K).

Suspended Particulate Matter

Concentrations of suspended particulate matter were calculated as 24-hour average and annual average PM_{10} concentrations and annual average TSP concentrations for comparison against the applicable criteria (Table 4-25). The maximum 24-hour average PM_{10} criteria is assessed for the Project alone, whilst the annual average PM_{10} and TSP assessment criterion/standards relate to Project emissions in addition to background concentration levels (Appendix K).

On the basis of baseline air quality monitoring data, the background annual average PM_{10} concentration for the Project site is 14 µg/m^3 (Section 4.11.2). The inferred annual average TSP background level is 35 µg/m^3 (Section 4.11.2).

Maximum 24-hour average PM_{10}

Maximum 24-hour average PM_{10} concentrations modelled for Years 3 and 15 were not predicted to exceed the DECC assessment criterion (Project only) of 50 µg/m^3 at any receiver (Appendix K). Residences located in close proximity to the Major Surface Facilities Area on Parkes Street (i.e. 48, 50 and 52/54 Parkes Street) were predicted to experience maximum 24 hr PM_{10} concentrations close to the DECC criteria (i.e. 49 µg/m^3) in Year 15 due to their close proximity to the coal stockpiles and train loading activities.

Figure 4-23 shows the predicted maximum 24-hour average PM_{10} concentrations resulting from the Project in Year 15.

Annual Average PM_{10}

Predicted annual average PM_{10} (Project plus background) concentrations modelled for Years 3 and 15 were not predicted to be above the 30 µg/m^3 DECC assessment criterion at any receiver (Appendix K).

Figure 4-24 shows the predicted annual average PM_{10} (Project only) concentrations resulting from the Project in Year 15.

Annual Average TSP

Annual average TSP (Project plus background) concentrations modelled for Years 3 and 15 were not predicted to be above the NHMRC goal of 90 µg/m^3 at any receiver (Appendix K).

Greenhouse Gases

An assessment of Project greenhouse gas emissions is provided in Appendix K. The Project greenhouse assessment is provided in Section 3.8.

Odour

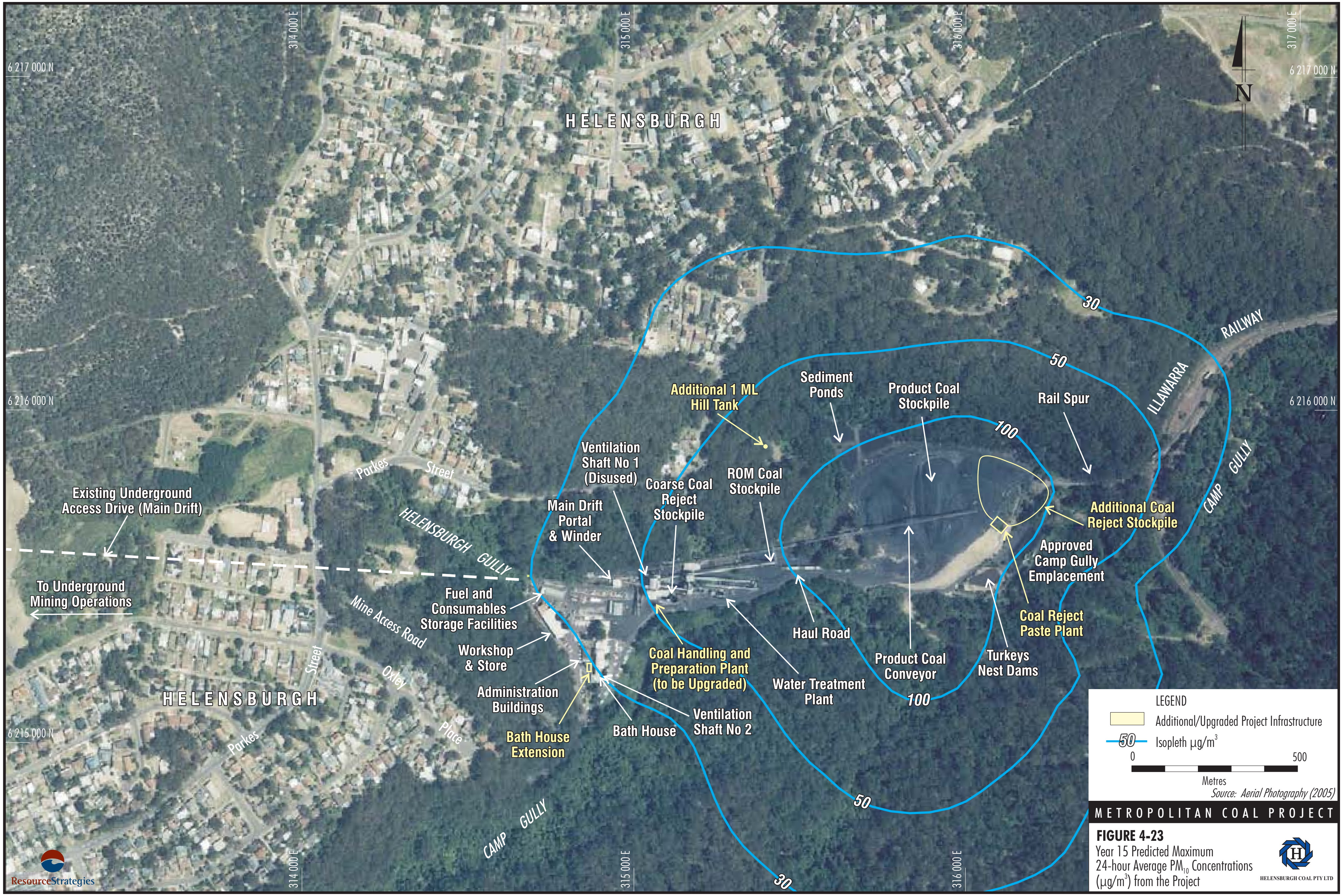
An assessment of Project odour emissions is provided in Appendix K. Odour modelling was carried out in accordance with *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005b). The outcomes of this assessment are summarised below.

The DECC odour criteria is 2 odour units (ou) at the 99th percentile, for populations of 2,000 or more (Appendix K).

The main potential sources of odour emissions from the Project would include:

- coal seam gas from the existing Ventilation Shaft No. 3 and proposed Ventilation Shaft No. 4 (Figure 2-1); and
- odour resulting from spontaneous coal combustion.

Existing odour levels at Ventilation Shaft No. 3 were measured and are very low (Appendix K). Predicted odour levels for when Ventilation Shaft No. 3 only would be operating and when both ventilation shafts would be operating were not predicted to be above the DECC odour assessment criterion at any receiver (Appendix K).



METROPOLITAN COAL PROJECT

FIGURE 4-23
Year 15 Predicted Maximum 24-hour Average PM_{10} Concentrations ($\mu g/m^3$) from the Project

MET-06-02 Section 4_003F

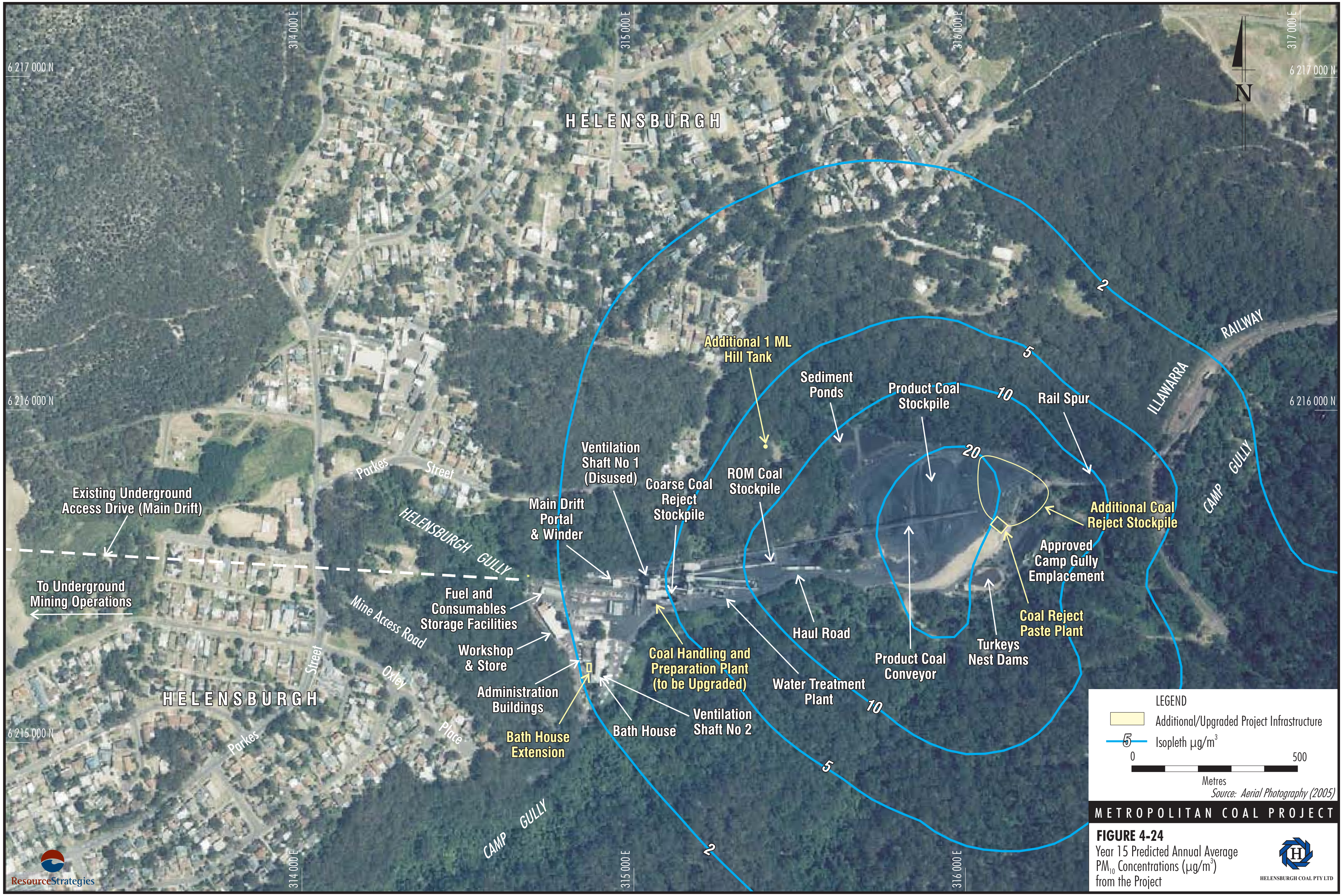


FIGURE 4-24
Year 15 Predicted Annual Average PM_{10} Concentrations (µg/m³) from the Project

MET-06-02 Section 4_004D

Self-heating of coal can give rise to smouldering fires in stockpiles, which can lead to odorous emissions. The Bulli Seam at the Metropolitan Colliery is not susceptible to spontaneous combustion and there have been no reported self heating incidents (e.g. within coal or reject stockpiles) at the Metropolitan Colliery (HCPL, 2007a).

4.11.4 Mitigation Measures, Management and Monitoring

During the development of the dispersion modelling undertaken by Holmes Air Sciences, a number of air quality mitigation measures were incorporated for Project air quality modelling.

A range of controls would continue to be employed by HCPL to reduce air quality emissions from the Major Surface Facilities Area. The dust controls that would be implemented for the Project can be summarised in two broad categories:

- engineering controls; and
- operational controls which vary operations when adverse meteorological conditions occur.

Engineering controls involve measures such as covering/enclosing conveyors and enclosing transfer points (Appendix K).

The specific air quality control measures that are currently used and would continue to be used at the Project are listed in Section 4.11.1.

Stockpile and conveyor sprays at the Major Surface Facilities Area can be operated manually or automatically by wind speed and direction sensors.

Air Quality Monitoring

An Airborne Dust Management Plan has been prepared for the Metropolitan Colliery as part of an existing PRP. The existing and future PRPs for air quality would describe the following elements:

- air quality monitoring to be undertaken for the Project;
- Project mitigation measures with respect to air quality;
- a protocol for the on-going management of air quality;
- procedures to be followed in the event of an exceedance of criteria should they occur; and
- complaint response protocols.

Air quality monitoring would also incorporate a real-time dust monitoring system, which would enable site operators to modify activities, as required to minimise dust emissions and off-site impacts during adverse conditions.

The results of the air quality monitoring would be used to optimise air quality controls, validate the air quality modelling predictions and would be reported to relevant authorities via the AEMR (Section 3.3.1).

An additional dust gauge has recently been installed at Old Station Road.

Greenhouse Gas

Project measures for energy efficiency are described in Section 3.8.3.

Odour

While no odour impacts are predicted from the Project ventilation shafts (Appendix K), in the event of an issue or complaint arising with respect odour, suitable complaint response and monitoring measures would be developed.

On-site stockpiles would continue to be managed to reduce the potential for the development of spontaneous combustion in accordance with the existing Stockpile Management Plan.

4.12 TRANSPORT

A Traffic Assessment for the Project was prepared by Masson Wilson Twiney and is presented in Appendix L. Sections 2.7 and 2.8 describe Project product coal and coal reject transport on the public road network and rail transport of product coal on the rail network.

A description of the existing traffic environment in the vicinity of the Major Surface Facilities Area and key transport routes is provided in Section 4.12.1, and Section 4.12.2 describes the potential impacts of the Project on traffic. Section 4.12.3 outlines applicable mitigation, monitoring and management measures.

4.12.1 Existing Environment

Access to the Major Surface Facilities Area is via the mine access road, off Parkes Street, Helensburgh (Figure 1-3).

The existing road system and traffic flows in the vicinity of the Project are described in detail in Appendix L and are summarised below.

As described in Section 2.1.5 and 2.1.6, the existing Metropolitan Colliery haulage of coal reject to the Glenlee Washery located to the west of Campbelltown and product coal haulage to the Corrimal and Coalcliff Coke Works south-east of Helensburgh (Figure 1-1) contributes to existing heavy vehicle movements on the public road network. These existing Metropolitan Colliery heavy vehicle movements would not be increased above the current maximum annual movements.

Road Hierarchy

The major regional roads and roads of relevance to the Project include the those described below (Figures 1-1, 1-2 and 1-3).

Arterial Roads

The F6 Southern Freeway runs in a north-south direction, providing access between Sydney and Wollongong and is located between Helensburgh and the Woronora Special Area (Figure 2-1).

The Princes Highway (State Highway No. 1) provides a major link between Sydney and Wollongong (Figure 1-1). The F6 Southern Freeway replaces Princes Highway along much of its length, and the Old Princes Highway roughly runs parallel to the freeway route. The Princes Highway overlies a portion of the Project Underground Mining Area (Figure 2-1).

The Old Princes Highway also provides part of the existing haulage route between the Metropolitan Colliery and the Glenlee Washery (for transport of coal reject) and the coking works at Coalcliff and Corrimal (for transport of product coal) (Figure 1-1).

Narellan Road (partly State Route 69) forms part of Metroad 9 connecting Campbelltown to Windsor. Narellan Road connects Campbelltown and Narellan, with a major interchange at the South Western Freeway/Hume Highway. The Camden Bypass links Narellan Road at Narellan with the Old Hume Highway at Camden South and functions as an arterial road. Narellan Road is part of the existing coal reject haulage route to the Glenlee Washery.

Sub-Arterial Roads

Appin Road (Main Road 177, State Route 69) provides a transport link between the Princes Highway at Bulli Tops and Narellan Road near Campbelltown. It provides the main vehicular access for the township of Appin. To the north of Appin, it is also known as Narellan Appin Road. Appin Road is part of the existing coal reject haulage route to the Glenlee Washery (Figure 1-1).

Lawrence Hargrave Drive performs a sub-arterial function in the road network as it provides a secondary regional link along the coast, extending between the Old Princes Highway at Helensburgh and the Princes Highway at Bulli (Figure 1-1).

Lawrence Hargrave Drive provides the only vehicular access to numerous localities along the coast, including Stanwell Park, Coalcliff and Wombarra. Lawrence Hargrave Drive is part of the existing coal haulage route to the Corrimal and Coalcliff Coke Works (Figure 1-1).

Local Roads

Parkes Street forms the primary access road through Helensburgh and functions as a collector road for the Helensburgh township. Parkes Street provides access to local streets in the Helensburgh area and to the local shopping area around the Walker Street intersection (Figure 2-1).

The mine access road is a private road which provides access to the Major Surface Facilities Area from Parkes Street (Figure 2-2).

Springs Road is a rural road which extends eastwards from Macarthur Road through Spring Farm. Springs Road currently functions as a local road, however with planned development of the Spring Farm release area, it will function as a collector road. Springs Road is of relevance to the Project as it is part of the haulage route to the Glenlee Washery (Figure 1-1).

Rail System

The South Coast Rail network provides a passenger and freight rail link along the coast between Kiama and Sydney via Wollongong. Metropolitan Colliery is connected to the main line via a siding on the Illawarra Railway (between Helensburgh Station and Otford Station) (Figure 1-3).

Existing Road and Traffic Conditions

The following sections summarise existing road and traffic flow conditions in the general Project area and on key existing Metropolitan Colliery heavy vehicle haulage routes.

Existing Road Conditions

F6 Southern Freeway

The F6 Southern Freeway has a 110 km/hr speed limit with two lanes in each direction in the general Project area. Ramps located at Helensburgh allow both northbound and southbound traffic to enter and exit.

The southbound on/off ramps form the fourth leg of the roundabout intersection with Lawrence Hargrave Drive and Old Princes Highway. The northbound on/off ramps are located further south, forming the stem of a tee intersection with Old Princes Highway.

Narellan Road

Narellan Road is generally a high quality urban road, with a minimum of two lanes in each direction plus additional turning lanes at major intersections. The major intersections are controlled with traffic signals and the speed limit is 80 km/hr to the west of Blaxland Road, and 60km/hr to the east.

Camden Bypass

Ramps provide access for northbound and southbound traffic to enter and exit Camden Bypass to and from Macarthur Road. Camden Bypass is a high standard divided road, with two lanes in each direction and a 100 km/hr speed limit.

Appin Road

In the Campbelltown area, Appin Road is a divided road, with two or three lanes in each direction and additional turning lanes at major intersections, which are signal controlled. It has a speed limit of 80 km/hr. Beyond the urban area, the speed limit is 70 km/hr, and the carriageway reduces to an undivided road with a single lane in each direction. In the rural area between Campbelltown and Appin, Appin Road has a speed limit of 80 km/hr with a single lane in each direction. The road is undulating, with no particularly steep grades or sharp bends. In the township of Appin, the speed limit is 60 km/hr, with a 40 km/hr school zone. Some kerbside parking is permitted.

To the east of Appin, Appin Road is also known as Bulli Appin Road, and between Appin and Bulli Tops, Appin Road has one or two lanes in each direction, with a 100 km/hr speed limit. This section is undulating, with no particularly steep grades or sharp bends.

Lawrence Hargrave Drive

Lawrence Hargrave Drive typically has a single lane in each direction and has priority over side streets. Its intersection with Old Princes Highway at Helensburgh is controlled with a roundabout.

At the intersection of Lawrence Hargrave Drive with Otford Road/Lady Wakehurst Drive, Lawrence Hargrave Drive has a hairpin bend. Priority is given to northbound traffic on Lawrence Hargrave Drive, with “Stop” controls for vehicles approaching on Lawrence Hargrave Drive from the west and on Lady Wakehurst Drive from the east. Lawrence Hargrave Drive follows a steep grade down southbound to Stanwell Park. It has a 60 km/hr speed limit, and has double centre lines along most of its length. Kerbside parking is not permitted.

Parkes Street

Parkes Street extends eastwards from Old Princes Highway (Figure 2-1) and has a single lane in each direction. It has double centre lines and kerbside parking is generally permitted along both kerbs. At intersections, Parkes Street has priority over side street traffic, with the exception of the Walker Street intersection, which is controlled with a roundabout. Parkes Street forms the stem of the tee intersection with Old Princes Highway and Old Princes Highway has priority.

Metropolitan Colliery Site Access Road

The Metropolitan Colliery site access road has a wide carriageway with little or no linemarking. It has some steep sections and tight bends, but accommodates the large trucks used by the haulage contractor. It intersects with Parkes Street at a tee intersection.

Springs Road

Springs Road is a two lane road with a straight alignment with minor grades. It intersects with Richardson Road at a tee intersection, where Springs Road traffic has priority. Springs Road intersects with Macarthur Road at a tee intersection, where Macarthur Road traffic has priority.

Existing Traffic Volumes

Appendix L summarises historical and recent RTA annual average daily traffic (AADT) data for major roads of relevance to the Project, which range from approximately 5,500 movements per day at Lawrence Hargrave Drive to approximately 55,000 movements per day on Narellan Road.

Project traffic surveys were conducted along the key routes used by the Metropolitan Colliery haulage contractor including the mine access road and Parkes Street between 21 and 27 October 2007 and 15 and 21 November 2007 (Appendix L).

The traffic assessment analysis of existing traffic flows indicates that the Metropolitan Colliery makes only a minor contribution to total traffic volumes on the existing coal and coal reject haulage routes (Table 4-27). With the exception of Parkes Street (6.5%) and Lawrence Hargrave Drive (3.4%), the Metropolitan Colliery traffic contributes less than 3% of the existing daily traffic on the routes surveyed (Appendix L).

Measured traffic growth rate in the area surrounding the Project between 1994 and 2003 is presented in Table 4-28.

It is expected that background traffic growth in Helensburgh would be low and for the purposes of the Traffic Assessment a 1% growth rate was assumed (Appendix L).

Intersection Performance

Intersection traffic flow data was collected at six relevant intersections (refer Appendix L) on 24 October 2007 between 7.00 am and 9.00 am, and 4.00 pm and 6.00 pm. The performance of these intersections was assessed using the intersection analysis computer programme SIDRA (Signalised and Unsignalised Intersection Design and Research Aid) (Appendix L) (Table 4-29).

The results of the intersection turning movement surveys indicate that the peak traffic activity periods in the morning and evening on the surrounding road system occurred between 8.00 am and 9.00 am, and 5.00 pm and 6.00 pm and the existing levels of service were good and with spare capacity (Table 4-29) (Appendix L).

Traffic Safety

A review of accident data in the Helensburgh area has been undertaken. Analysis of the accident data identified no particular accident patterns or causation factors (Appendix L).

Future Traffic Improvements

The RTA has developed a preferred option for the reconstruction of the intersection of Lawrence Hargrave Drive and Princes Highway at the bottom of Bulli Pass. The selected proposal consists of a single northbound lane from Georges Avenue that is aligned west of the existing Princes Highway and spans Bulli Pass to provide a seamless connection with Lawrence Hargrave Drive. This work would remove the existing right turn from the Princes Highway to Lawrence Hargrave Drive.

It is anticipated that over the life of the Project, a number of road improvements would be made on the regional road system.

4.12.2 Potential Impacts

Potential traffic impacts of the Project on road traffic movements and key intersection operation are assessed in Appendix L and summarised below. The potential impacts of additional rail transport associated with increased product coal trains on the South Coast Rail network are also considered below.

Project Traffic Generation

Project surface construction works would be undertaken intermittently over a period of up to five years and would be undertaken generally during daytime hours up to seven days per week. Predicted traffic generation during construction would comprise both light vehicles and small truck/heavy vehicle movements associated with employee transport and deliveries/services, respectively.

Post-construction, Project employment would return to existing levels and there would be less light vehicle traffic movements compared to the Project construction period.

Table 4-27
Average Weekday Daily Traffic Volumes by Haulage Route (veh/day)

Site (refer Appendix L)	Road Name/Location	Total Vehicles*	Metropolitan Colliery Construction to Existing Traffic Flows
Through Helensburgh (All Routes)			
1	Mine Access Road	829	100%
2	Parkes Street	7,486	6.5%
Route to/from Coalcliff			
3	Lawrence Hargrave Drive at Stanwell Tops	5,870	3.4%
Route to/from Corrimal			
4	Old Princes Highway at Bulli Pass	10,516	0.9%
5	Princes Highway at Russell Vale	25,780	0.2%
Route to/from Glenlee Washery			
6	Bulli-Appin Road at Kings Fall Bridge	8,174	1.0%
7	Narellan-Appin Road at Appin	9,916	0.8%
8	Appin Road at Bradbury	29,729	0.3%
9	Narellan Road at Narellan Vale	55,613	0.1%
10	Camden Bypass at Elderslie	19,292	0.4%
11	Springs Road at Spring Farm	2,924	2.8%

Source: After Appendix L.
* Average two way daily traffic (flow in both directions) - Monday to Friday.

Table 4-28
Average Annual Traffic Growth Rates (1994 to 2003)

Road	Total Growth (%)	Average Annual Growth (%)
Lawrence Hargrave Drive	45.2	5.02
Princes Highway, Bulli Pass	24.5	2.72
Princes Highway, Russell Vale	8.8	0.98
Bulli-Appin Road	8.6	0.95
Narellan-Appin Road	6.8	0.76

Source: After Appendix L.

Table 4-29
Relevant Intersection Performance – Surveyed Traffic Flows 2007

Site (refer Appendix L)	Intersection	Level of Service*	
		AM Peak	PM Peak
A	Parkes Street and Colliery Road	A	A
B	Parkes Street and Walker Street	A	A
C	Parkes Street and Old Princes Highway	A	B
D	Old Princes Highway and Lawrence Hargrave Drive	B	B
E	Lawrence Hargrave Drive and Walker Street	A	B
F	Railway Street and Corrimal and Coke Works	A	-

Source: After Appendix L.
* Level of Service as determined by SIDRA.
A - Good operation.
B - Good with acceptable delays and spare capacity.
Note: - No turning vehicles in PM peak at Corrimal Coke Works intersection.

Two traffic scenarios were investigated to determine the potential impact of Project traffic flows on the local road network during peak Project construction and operations. These scenarios were:

- Year 2014 – end of Project construction period, combining operational traffic, peak estimated construction traffic and predicted growth in background traffic.
- Year 2032 – end of the Project, combining operational traffic and predicted growth in background traffic.

Table 4-30 summarises the predicted peak daily vehicle movements (traffic in both directions) for these scenarios on the local road network, in comparison to existing (2007) traffic levels. During non-peak times, it is anticipated that Project traffic flows would be lower.

As stated in Section 2.7.1, the Project would not involve any significant changes to the annual tonnage of product coal trucked to the Corrimal Coke Works and Coalcliff Coke Works or coal reject to Glenlee Washery, or the hours of trucking. Although the haulage of coal rejects to the Glenlee Washery is expected to cease once the existing capacity of the facility is utilised, the Traffic Assessment (Appendix L) has conservatively considered maximum coal reject haulage movements would continue for the life of the Project.

Project construction would (at peak) increase traffic flows to the Metropolitan Colliery by approximately 10%, and outside of Helensburgh the contribution to total traffic would be negligible (Appendix L). Post-construction, the Project contribution to traffic on the majority of the key routes would fall (Table 4-30).

The Traffic Assessment concluded that with the additional Project traffic, the Metropolitan Colliery would continue to make only a small contribution to total traffic volumes on the existing haulage routes (Appendix L).

Intersection Performance

The peak hour performance with predicted background traffic growth was assessed for the six key intersections (Table 4-29) using the intersection analysis computer programme SIDRA (Appendix L).

The key intersections in the Helensburgh area would be expected to continue to operate at good levels of service with the forecast growth in background traffic. Potential average delay encountered by each vehicle was also considered. The assessment found that delays would remain at acceptable levels, and the intersections would have spare capacity during the peak hours (Appendix L).

The additional traffic expected to be generated by the Project during the on-street peak hours would be sufficiently low that potential impacts on the operation of the surrounding intersections are considered to be negligible (Appendix L).

Car Parking

The existing Metropolitan Colliery car park is located adjacent to the administration and workshop buildings located at the Major Surface Facilities Area. HCPL would review the existing car parking facilities and upgrade these facilities as necessary during construction and/or operation of the Project in accordance with WCC requirements.

Road Safety

The traffic assessment did not identify any particular accident patterns or causation factors in the Helensburgh area (Section 4.12.1). As the Project would not significantly alter traffic flows, or the type of vehicles on the key haulage routes, the Project is considered unlikely to have any adverse affects on road safety.

Cumulative Traffic Increases

Other developments in the vicinity of the Project site have the potential to add additional traffic flows that may result in cumulative impacts on the local road network. General traffic growth expected to be generated over the life of the Project was included in the traffic assessment (Appendix L).

Woronora Special Area

The Project would result in a continued requirement for HCPL staff and contractors to access the Woronora Special Area for environmental management, monitoring, stream restoration works and other limited surface activities.

Table 4-30
Predicted Average Weekday Traffic Flows on the Local Road Network

Site (refer Appendix L)	Road and Location	Year 2007			Year 2014			Year 2032		
		Total	Colliery	Colliery % of Total	Total	Project	Project % of Total	Total	Project	Project % of Total
Through Helensburgh (All Routes)										
1	Mine Access Road	829	829	100	923	923	100	841	841	100
2	Parkes Street	7,486	488	6.5	8,058	570	7.1	9,248	500	5.4
Route to/from Coalcliff										
3	Lawrence Hargrave Drive at Stanwell Tops	5,871	198	3.4	7,878	210	2.7	12,997	198	1.5
Route to/from Corrimal										
4	Old Princes Highway at Bulli Pass	10,516	94	0.9	12,519	110	0.9	17,614	96	0.5
5	Princes Highway at Russell Vale	25,780	60	0.2	27,557	72	0.3	32,085	62	0.2
Route to/from Glenlee Washery										
6	Bulli-Appin Road at Kings Fall Bridge	8,174	84	1.0	8,727	98	1.1	10,102	86	0.9
7	Narellan-Appin Road at Appin	9,916	82	0.8	10,445	88	0.8	11,783	82	0.7
8	Appin Road at Bradbury	29,729	82	0.3	31,184	86	0.3	31,042	82	0.3
9	Narellan Road at Narellan Vale	55,613	82	0.1	75,311	82	0.1	82,475	82	0.1
10	Camden Bypass at Elderslie	19,292	82	0.4	33,066	82	0.2	35,397	82	0.2
11	Springs Road at Spring Farm	2,924	82	2.8	7,982	82	1.0	7,982	82	1.0

Source: After Appendix L.

Rail Transport

As stated in Section 2.1.4, the majority of product coal is transported by train to the Port Kembla Coal Terminal. The increase in coal production and the requirements of train scheduling indicate that the Project would require 24 hour train loading up to seven days per week.

Trains are restricted to 45 wagon trains (due to the length of the Metropolitan Colliery rail spur) with a capacity of some 75 t per wagon, or approximately 3,375 t per train. It is anticipated that the number of trains would increase from 1.5 trains per day to three trains per day on average over the year. This increase corresponds to an average net rail traffic increase of approximately 2.6% to 3.8% during mid-week and weekend periods respectively (Appendix J), and is considered to be minor.

4.12.3 Mitigation Measures, Management and Monitoring

HCPL recognises that off-site traffic movements associated with the Metropolitan Colliery are a concern for a number of residents and businesses located on Parkes Street in Helensburgh and rail movements are also potentially of concern to residents located in close proximity to the Illawarra Railway.

Notwithstanding the fact the Project is not predicted to significantly alter existing off-site road transport on the public road network or off-site rail movements on the South Coast Rail network, HCPL would implement the following mitigation measures as a component of a Transport Management Plan to be prepared for the Project (Section 6):

- maintain the current public road haulage of product coal and coal reject at the existing Metropolitan Colliery maximum annual haulage levels;
- maintain the existing Metropolitan Colliery heavy vehicle night-time curfew (i.e. large vehicle access to the site is restricted during night-time hours);

- work with suppliers to minimise the use of heavy vehicles to deliver small items to the Major Surface Facilities Area that could be delivered via a light vehicle or van, where practicable;
- encourage the mine operational workforce and Project construction workforce to car-pool and minimise workforce related light vehicle movements to the site;
- liaise with RailCorp to minimise Project night-time train movements as far as practicable within train scheduling restraints; and
- liaise with the Metropolitan Colliery CRG, WCC and RailCorp to facilitate the resolution of any particular transport issues that may arise.

The volumes of traffic associated with activities in the Woronora Special Area would be low and access to the Woronora Special Area would be in accordance with SCA requirements (e.g. conditions of entry, speed limits etc). Hence no additional specific traffic management measures are considered to be required.

4.13 REGIONAL ECONOMY

A Socio-Economic Assessment (including a regional economic assessment) was prepared for the Project by Gillespie Economics and is presented in Appendix M. The Metropolitan Colliery is located within the Illawarra Statistical Division (SD) of NSW. The Illawarra SD comprises the Statistical Local Areas (SLAs) of Wollongong, Wingecarribee, Shellharbour, Kiama and Shoalhaven.

The regional economic assessment was conducted at two different scales to assess the potential impact of the Project at a regional scale and at the NSW level. A summary of the existing regional and NSW economy (including the influence of the existing Metropolitan Colliery) is provided in Section 4.13.1.

The potential impacts of the Project on the regional and NSW economies are described in Section 4.13.2.

4.13.1 Existing Environment

The regional economic assessment is based on a 2005-2006 input-output analysis for the Illawarra SD and NSW economies.

The Gross Regional Product (GRP) for the regional economy is estimated at $13,062M, comprising $8,060M to households as wages and salaries and $5,002M in other value added contributions.

The comparative distribution of various industry sectors to employment, the GRP and output earnings for the region and for the state of NSW are presented in Table 4-31.

The manufacturing and mining sectors are of greater relative importance to the regional economy than they are to the NSW economy. The agriculture/forestry/fishing sector, services sector (GRP and output) and building sector (output) are of less relative importance to the regional economy than they are to the NSW economy.

The services sector is the most significant sector, with manufacturing being the second most significant sector, in terms of total employment and contribution to both GRP and output for the region and in NSW (Table 4-31).

Table 4-31
Contributions to Gross Regional Product, Employment and Output by Industry Sector – Illawarra SD and NSW (2005 to 2006)

Sector	Total Employment (%)		Contribution to GRP (%)		Contribution to Output (%)	
	Illawarra	NSW	Illawarra	NSW	Illawarra	NSW
Agriculture, Forestry and Fishing	1	3	1	2	1	2
Mining	1	1	4	2	2	2
Manufacturing	13	11	13	11	23	19
Utilities	1	1	2	2	3	3
Building	7	7	6	6	8	9
Services	77	77	69	71	62	65

Source: After Appendix M.

In terms of gross regional output, the metal manufacturing sector is the most significant sector of the regional economy followed by the business services sector, retail trade and building/construction (Appendix M).

The retail trade sector is the greatest employer in the region followed by the services sectors (predominantly education, business services, health and personal/other services). However, in terms of income paid to employment, the business services sectors is the most significant, reflecting the high wages in this sector. Metal manufacturing is the major sector responsible for exports from the region and imports to the region (Appendix M).

4.13.2 Potential Impacts

Regional economic impact assessment is primarily concerned with the effect of an impacting agent on an economy in terms of specific indicators, such as employment, income, GRP and gross regional output. The assessment in Appendix M includes consideration of the regional economic impacts of the existing Metropolitan Colliery and the impacts of the Project on both the Illawarra SD and NSW.

Existing Metropolitan Colliery Operations

Using input-output analysis, it was estimated that the existing operation of the Metropolitan Colliery contributes the following to the regional economy (Appendix M):

Illawarra SD – Existing Operations

- $253M in annual direct and indirect regional output or business turnover;
- $110M in annual direct and indirect regional value added;
- $46M in annual household income; and
- 549 direct and indirect jobs.

Project Operations

The Project is predicted to have the following impacts on the Illawarra SD and NSW economies, respectively (Appendix M):

Illawarra SD

- $372M in annual direct and indirect regional output or business turnover;
- $136M in annual direct and indirect regional value added;
- $56M in annual household income; and
- 700 direct and indirect jobs.

NSW Economy

- $687M in annual direct and indirect regional output or business turnover;
- $301M in annual direct and indirect regional value added;
- $154M in annual household income; and
- 1,951 direct and indirect jobs.

The main sectors of the Illawarra economy that would be affected by the output, value-added and income flow-on impacts from the Project are likely to be the rail, pipeline and other transport sector; services to transport sector (Port); services to mining sector; scientific research, technical and computer services sector; retail trade sector; agriculture, mining and construction equipment sector and wholesale mechanical repairs sector.

The Project would provide continued direct employment in the region for 320 people (HCPL staff and on-site contractors). Eighty-nine percent of these are estimated to reside in the region. Approximately 11% are estimated to reside outside the Illawarra Region. Production-induced employment impacts would mainly occur in the transport, services and manufacturing sectors. Consumption-induced employment flow-ons would mainly occur in the services, wholesale/retail and accommodation/cafes/restaurants sectors.

The potential impacts of the Project on the NSW economy are substantially greater than for the Illawarra Region alone, as more mine expenditure is captured and there is a greater level of inter-sectoral linkages in the larger NSW economy (Appendix M).

End of Project Life

The Project would stimulate demand in the Illawarra and NSW economies leading to increased business turnover in a range of sectors and increased employment opportunities. Cessation of the Project would, however, lead to a reduction in regional economic activity.

The magnitude of the regional economic impacts of cessation of the Project would depend on a number of interrelated factors, including: movements of workers and their families; alternative development opportunities; and economic structure and trends in the regional economy at the time.

If it is assumed that some or all of the workers remain in the region, the impacts of Project cessation would be less severe than if a greater number left the region. This is because the consumption-induced flow-ons of the decline would be reduced through the continued consumption expenditure of those who stay.

To the extent that alternative development opportunities arise in the regional economy, the regional economic impacts associated with mine closure that arise through reduced production and employment expenditure can be substantially ameliorated and absorbed by the growth of the region.

The Illawarra Region is highly prospective, with considerable coal resources (Appendix M). It is therefore likely that over time new mining developments would occur, offering potential to strengthen and broaden the economic base of the region and hence buffer against impacts of the cessation of individual activities.

HCPL would develop a Mine Closure Plan (MCP) before Project closure. The plan would be prepared in consultation with WCC, DoP and the Helensburgh community and would include consideration of amelioration of potential adverse socio-economic effects due to the reduction in employment at Project closure.

4.14 EMPLOYMENT, POPULATION AND COMMUNITY INFRASTRUCTURE

For the purposes of the employment, population and community infrastructure component of the Socio-Economic Assessment (Appendix M), the Illawarra SD was used as the local region.

A summary in relation to background demographics, employment and community infrastructure is provided in Section 4.14.1. The potential impacts of the Project on the existing community infrastructure as a result of employment and population change associated with the Project is provided in Section 4.14.2. Relevant mitigation measures are described in Section 4.14.3.

4.14.1 Existing Environment

Population Profile

Table 4-32 compares population growth experienced in the Illawarra SD and NSW as a whole and provides estimates of the population growth for the period 2011 to 2031. As shown in Table 4-32 the total population of the Illawarra SD increased from 337,478 in 1991 to 381,898 in 2001 at a rate greater than that for NSW (Table 4-32). However, population growth has slowed between 2001 and 2006 to a rate less than that for NSW (Table 4-32).

The Illawarra SD population is expected to continue to grow but at a declining rate of 0.97% per annum after 2011 then 0.86% per annum after 2016 (Appendix M) (Table 4-32).

Demographics

Table 4-33 provides a summary of the age distribution of the Illawarra SD population for the years 1996 to 2006 and the age distribution for NSW in 2006.

Table 4-33 indicates that the proportion of people under the age of 14 and between the ages of 15 to 44 has declined slightly over time in the Illawarra SD and the proportion of the population in the older age brackets has slightly increased, reflecting the general aging of the Australian population (Appendix M). Compared to NSW, however, the Illawarra SD has a slightly lower proportion of 15 to 44 year olds and slightly greater proportion of younger people and older people.

The proportion of males (49%) and females (51%) in the Illawarra SD was relatively even at the 2006 Census and the proportion of people born overseas in the Illawarra SD (18%) is lower than NSW as a whole (24%) (Appendix M).

Employment Profile

The unemployment rate in the Illawarra SD has been declining over time. However, the unemployment rate has been consistently higher than that for NSW (Table 4-34). The unemployment rate for men has been consistently higher than the unemployment rate for women (Appendix M).

Average individual taxable income in the Illawarra Region was in the order of $40,000 in 2003 compared to $43,649 for NSW (Appendix M).

Table 4-32
Illawarra and NSW Observed and Predicted Population Growth Rate

Year	1991	1996	2001	2006	2011	2016	2021	2026	2031
Illawarra SD									
Population	337,478	360,298	381,898	390,616	438,400	457,200	475,300	492,300	507,800
Population Growth Rate (per annum)	-	1.35%	1.20%	0.46%	0.97%	0.86%	0.79%	0.72%	0.63%
NSW									
Population	5,732,032	6,038,696	6,371,745	6,585,732	7,145,200	7,437,300	7,725,200	8,002,500	8,259,200
Population Growth Rate(per annum)	-	1.07%	1.10%	0.67%	0.88%	0.82%	0.77%	0.72%	0.64%

Source: After Appendix M.

Table 4-33
Distribution of the Illawarra Population by Age Group

Proportion of Total Population	Illawarra SD			NSW
	1996	2001	2006	2006
Aged 14 years and younger	22.5%	21.5%	20.1%	19.8%
Aged 15 years to 44 years	42.5%	40.3%	37.9%	41.7%
Aged 45 years to 64 years	21.3%	23.2%	25.4%	24.7%
Aged 65 years and over	13.8%	15.0%	16.6%	13.8%

Source: Appendix M.
Note: Percentages may not add to 100% due to rounding.

Table 4-34
Unemployment in the Illawarra Region

Year	1991	1996	2001	2006
Total No. in Labour Force	147,949	154,008	162,947	170,670
As % of People over 15 Years	57.0%	55.1%	54.7%	55.0%
Total Employment	127,626	135,966	148,402	158,028
Total Unemployment	20,323	18,042	14,545	12,642
Unemployment Rate	13.7%	11.7%	8.9%	7.4%
NSW Unemployment Rate	**11.2%**	**8.8%**	**7.2%**	**5.9%**

Source: Appendix M.

Housing

There were approximately 151,616 private dwellings in the Illawarra SD in 2006 and there is a higher proportion of separate houses than in NSW (80% compared with 70%, respectively). The Illawarra SD has a lower proportion of townhouses/units/ flats/apartments than NSW (19% compared with 29%, respectively) (Appendix M). Table 4-35 provides a summary of the housing in the Illawarra SD and comparative totals for NSW.

The average number of rental listings has generally increased from March quarter 2001 to June 2006 and has since declined (Appendix M).

There is considerable short stay tourism accommodation available in the Illawarra Region (Table 4-36), including in the order of 89 hotels/motels as well as serviced apartments (Appendix M).

Table 4-35
Housing Stock in the Illawarra Region (Occupied Dwellings Only)

	Illawarra			NSW
	1996	**2001**	**2006**	**2006**
Total Private Dwellings	132,418	144,201	151,616	2,470,452
% Separate Houses	79.8%	79.8%	79.6%	69.7%
% Townhouse, Flat, Unit, Apartment	16.7%	17.4%	18.8%	28.8%
% Other	2.1%	2.1%	1.6%	1.4%
% Not Stated	1.4%	0.6%	0.05%	0.08%

Source: Appendix M.

Table 4-36
Illawarra Region Hotels and Motels

Hotels/Motels	2002/2003	2003/2004	2004/2005	2005/2006
Establishments with Facilities	83	84	85	89
Room Occupancy Rates	49.8	50.1	50.1	50.4
Guest Nights	793,556	824,773	822,576	940,442
Bed Occupancy Rate	28.7	30.3	30.5	32.4
Accommodation Gross Takings $000	51,616	55,715	57,329	64,157

Source: Appendix M.

Education

The Illawarra SD is well equipped with education facilities. The NSW Department of Education and Training (DET) is the main provider of primary and secondary education in the Illawarra SD, providing 130 of the 180 schools. The Illawarra SD has 131 infant and primary schools, 35 secondary schools and 14 combined schools (Table 4-37) (Appendix M). It is reasonable to assume that schools in the region have excess capacity, as Table 4-37 demonstrates that total enrolments in these schools have been decreasing in the period 2003 to 2006, however enrolments at secondary and private schools have increased over this time (Appendix M). There has been a slight increase the level of private schooling in this period.

Health

The South East Sydney and Illawarra Area Health Service (SESIAHS) administers the following health and community services in the Illawarra Region (Appendix M):

- 1 principal hospital – Wollongong Hospital;
- 2 major district hospitals – Shoalhaven Hospital and Shellharbour Hospital;
- 2 small district hospitals – Bulli Hospital and Milton-Ulladulla Hospital;
- 4 sub-acute facilities – Coledale Hospital, Port Kembla Hospital, Kiama Hospital, David Berry Hospital and Garrawarra Centre;
- 12 community health centres;
- 8 dental clinics;
- 22 early childhood centres; and
- 10 mental health centres.

According to the 2006 population census there were 16,598 people employed in the health and community services industries in the Illawarra SD (Table 4-38).

Health and community services are a relatively large sector in the Illawarra economy, accounting for 13% of all employment in 2006, compared to a figure of 11% for NSW.

4.14.2 Potential Impacts

The primary potential impact of the Project on community infrastructure relates to population growth and related effects on housing and community facilities.

Table 4-37
Education in the Illawarra Region

Year	2003	2004	2005	2006
Schools	**178**	**179**	**178**	**180**
Primary	132	132	132	131
Secondary	36	36	34	35
Combined	10	11	12	14
Public	129	129	130	130
Private	49	50	48	50
Student Enrolment	**69,549**	**69,329**	**68,905**	**68,589**
Primary	57.4%	57.0%	56.7%	55.9%
Secondary	42.6%	43.0%	43.3%	44.1%
Public	73.6%	73.0%	72.4%	72.0%
Private	26.4%	27.0%	27.6%	28.0%
TAFE				
College Enrolments	38,845	38,705	34,268	36,331
University				
Full Time	11,163	11,360	11,798	11,488
Part Time	7,957	7,408	7,931	7,203

Source: After Appendix M.

Table 4-38
Employment in Health and Community Services in the Illawarra SD

ANZSIC Code	Industry	2006	%
861	Hospitals and Nursing Homes	7,396	45%
862	Medical and Dental Services	2,122	13%
863	Other Health Services (including optometry, pathology, physiotherapy etc)	2,631	16%
864	Veterinary Services*	244	1%
86	**Total Health Services**	**12,393**	**75%**
870	Community Services (undefined)	348	2%
871	Child Care Services	1,179	7%
872	Community Care Services (including accommodation for the aged, residential and non-residential care, etc,)	2,227	13%
87	**Total Community Services**	**3,754**	**23%**
O000	Health and Community Services (undefined)	451	3%
O	**Total Health and Community Services**	**16,598**	**100%**

Source: After Appendix M.
* Veterinary Services are included in Health Services by the Australian Bureau of Statistics (ABS).

Project Construction

Workforce

As described in Section 2.12, 320 staff and on-site contractors are employed at the Metropolitan Colliery. During construction of the Project, an additional workforce of up to 50 people would be required during peak periods of construction. The various construction activities would be spread over a period of approximately five years and construction employment would average about five people.

Population Effects

Little if any population change as a result of the additional construction workforce is envisaged.

Community Infrastructure Effects

The current levels of employment at the Project would continue and Project construction would involve a modest level of temporary employment that is likely to be sourced from within the Illawarra Region or would commute from Sydney, therefore no community infrastructure impacts are envisaged as a result of the Project.

Project Operation

Workforce

The existing Metropolitan Colliery workforce would be maintained by the Project with increases in efficiency allowing for the proposed increases in coal production. Therefore compared to current levels, no additional direct workforce or population is predicted as a consequence of the Project.

Some additional flow-on workforce is expected as a result of greater flow-on employment associated with the Project compared to the current operation. This greater flow-on employment arises because the Project involves greater levels of operational expenditure in the region than the current operation.

Population Effects

Assuming the average Illawarra household size of 2.5, the population associated with additional flow-on employment would be in the order of 378 (Appendix M). However, this represents a maximum population change associated with the operation phase of the Project as some or all of the indirect workforce change may be sourced from within the Illawarra Region, either directly or indirectly, particularly as the Illawarra Region has generally had a higher unemployment rate than NSW.

Community Infrastructure Effects

A maximum population influx to the region of 378 is small in the context of annual population growth of the region, representing in the order of three months average population growth between 2001 and 2006 and one month average population growth between 1996 and 2001 (Appendix M).

As such the demand this maximum population influx would create for housing is also modest. It represents 0.1% of total occupied housing stock in 2006, 0.6% of unoccupied residential properties in 2001[5] and 8% of new dwelling approvals in 2006 to 2007. *The Illawarra Regional Strategy* (DoP, 2007) provides a strategy to accommodate a population increase of 47,600 over the next 25 years (Appendix M).

During operation of the Project, any incoming flow-on workers would be expected to exhibit average family structures and hence would be associated with some children creating some increased demand for education facilities within the region. In the context of declining enrolments in schools within the Illawarra SD, the increased demand for schooling is considered to be insignificant (Appendix M).

There is potential for the Project to increase the demand for public health facilities in the region such as for hospitals, general practitioner medical services, dental, physiotherapy, chiropractors and optometrists via the potential increase in population as a result of increased flow-on employment associated with the Project. However, the potential indirect population increase during operation of the Project is very small compared to the total population of the region (Appendix M).

Demand for additional investment in community services such as child care, aged care and community care services, by Local, State and Commonwealth Governments can arise from increases in the population. However, the expected increases in population are very small and no additional investment in community services and facilities infrastructure would be anticipated (Appendix M).

5 This data is no longer available in the 2006 Census.

Social Considerations

Employment

The Project would create direct jobs during construction and indirect employment across a range of sectors. Even the generation of temporary employment for the unskilled during construction may provide enough experience to help secure future permanent employment.

Community Structure

In terms of community structure, the Illawarra Region is a relatively close-knit area with a traditional industrial base in coal mining and steel production. The Project reinforces and expands this historical focus of the region. Since most of the initial construction workforce would be drawn from the existing population, it is not expected that the Project would negatively impact on the existing community structure (Appendix M).

Amenity

The development of the Project has some potential to adversely affect amenity (e.g. via dust, traffic, visual impacts, etc.). However the Major Surface Facilities Area is an existing industrial facility and the Project would include the implementation of mitigation and management measures where practicable to minimise potential impacts on amenity (Sections 4.10 to 4.12 and 4.16).

End of Mine Life

Potential socio-economic impacts associated with the end of mine life are described in Section 4.13.2.

4.14.3 Mitigation Measures and Management

As described in Section 4.14.2, little or no impacts to the local population or community infrastructure are predicted as a result of the Project.

HCPL would continue to consult with the local community through the Metropolitan Colliery CRG which provides a forum for discussion between representatives of the mine and the local community on issues directly relating to the mine's operations, environmental performance and community relations, and to keep the community informed on these matters.

If during the Project life social or community infrastructure issues arise, these would be managed in consultation with the CRG, WCC and/or the relevant State Government department.

HCPL would develop a MCP before Project closure in consultation with regulatory agencies and the CRG and would include consideration of amelioration of potential adverse socio-economic effects due to the reduction in employment at Project closure.

4.15 HAZARD AND RISK

A PHA was conducted to evaluate the hazards associated with the Project (Appendix N). The PHA is a requirement of SEPP 33 (Section 3.2.5) and was conducted in accordance with the general principles of risk evaluation and assessment provided in the DUAP *Multi-Level Risk Assessment Guidelines* (1999).

4.15.1 Hazard Identification and Risk Assessment

Potentially hazardous materials required for the Project include diesel, petrol, hydrocarbons (oils, greases, degreaser and kerosene), conventional explosives and gas cylinders. The incremental risks posed by the usage of these materials for the Project would include increases in their transport, handling and consumption.

For the purposes of risk identification, the Project was subdivided into a number of operational areas (Appendix N) and potential incidents were identified and divided into generic classes for each operational area including:

- leaks/spills;
- fire;
- explosion; and
- theft.

Other classes of incidents identified included:

- release of noxious gases to atmosphere;
- subsidence in excess of predictions and safety factors; and
- equipment malfunction.

The potential risks identified in the PHA related to the following Project elements/activities:

- transport to site;
- on-site storage;
- construction/development (Major Surface Facilities Area);

- construction/development (Project Underground Mining Area surface works);
- underground mining operations;
- coal handling and preparation (stockpiles);
- product coal transport (road);
- coal reject transport;
- product coal transport (rail);
- water management;
- exploration/monitoring activities;
- rehabilitation and restoration works (underground mining); and
- other infrastructure and supporting systems.

Following identification of the potential hazards associated with the Project, a qualitative assessment of the risks to the public, property and the environment associated with the development and operation of the Project was undertaken (Appendix N). Incremental risks were also assessed by comparing the Project risks with those at the existing Metropolitan Colliery.

Given the in-place or proposed mitigation measures outlined below, no incremental risks posing significant off-site impacts were identified.

4.15.2 Mitigation Measures and Management

A number of hazard prevention and mitigation measures are currently in-place for the existing Metropolitan Colliery. These measures are documented in existing Metropolitan Colliery management plans (e.g. Underground Emergency Management Plan, Surface Emergency Management Plan, Contractor Management Plan, Underground Transport Management Plan, Stockpile Management Plan, and Fire and Explosion Control Management Plan).

The above occupational health and safety plans would be revised or replaced where necessary to address the Project requirements.

A number of hazard treatment and mitigation measures would also be described in other management plans for the Project, including the following:

- SMP(s).
- SWMP.

The following hazard mitigation and/or preventative measures would be adopted by HCPL to reduce the likelihood and/or consequences of potentially hazardous incidents associated with the Project:

- **Maintenance** – On-going and timely maintenance of mobile and fixed plant and equipment in accordance with the manufacturer's recommended maintenance schedule, and consistent with the maintenance schemes required by relevant standards. Only vehicles permitted to carry dangerous goods would be used for transport of hazardous materials.
- **Staff Training** – Operators and drivers would be trained and (where appropriate) licensed for their job descriptions. Only those personnel licensed to undertake skilled and potentially hazardous work would be permitted to do so.
- **Engineering Structures** – Civil engineering structures would be constructed in accordance with applicable codes, guidelines and Australian Standards.
- **Contractor Management** – All contractors employed by HCPL would be required to operate in accordance with the relevant Australian Standards, NSW Legislation and HCPL's Contractor Management Plan.
- **Storage Facilities** – Storage and usage procedures for potentially hazardous materials (i.e. fuels and lubricants) would be developed in accordance with Australian Standards and relevant legislation.

4.16 VISUAL CHARACTER

The Project is located within three main visual landscape settings, comprising (Figure 1-2):

- the Major Surface Facilities Area and immediate surrounds;
- the wider Completed and Current Underground Mining Areas, which include a variety of landforms and landuses; and
- the Project Underground Mining Area, primarily in the Woronora Special Area.

The Project would not involve any additional surface development within the majority of the Completed or Current Underground Mining Areas, hence the discussion below focuses on the Major Surface Facilities Area and surrounds and the Project Underground Mining Area and surrounds (Figure 1-2).

4.16.1 Existing Environment

The Major Surface Facilities Area is located in a densely vegetated valley in close proximity to suburban areas of Helensburgh (Figure 2-2). Due to the steepness of the valley and presence of tall dense vegetation, restricted views of the Major Surface Facilities Area are available only from a limited number of immediately surrounding dwellings and publicly accessible locations.

Local landuses in Helensburgh proximal to the Major Surface Facilities Area include:

- local private residences located to the north, west and south-west (Figure 2-2);
- public recreational areas located to the west and north-west (Figure 3-1);
- environmental protection areas to the south (Figure 3-1); and
- the Illawarra Railway and Garawarra State Conservation Area, located to the east (Figure 2-1).

The Major Surface Facilities Area is generally lit 24 hours per day for operational and safety requirements of the existing Metropolitan Colliery. The night-time visual landscape in Helensburgh in close proximity to the Major Surface Facilities Area reflects the influence of this existing lighting, including visible light glow over the existing facilities.

As discussed in Section 4.1.1, landuse in the Woronora Special Area is primarily restricted to water supply catchment and nature conservation.

Due to its long-term restriction from public access, industrial development and agricultural development, the Woronora Special Area is largely undeveloped and covered by bushland. Fire trails, linear infrastructure (e.g. electricity transmission lines) and the Metropolitan Colliery Ventilation Shaft No. 3 and associated electrical switchyard are also located within the Woronora Special Area.

Existing developments in the Project Underground Mining Area that are located outside of the Woronora Special Area and contribute to the existing visual setting include the F6 Southern Freeway, Princes Highway and the Garrawarra Centre (Figure 1-2).

4.16.2 Potential Impacts

Major Surface Facilities Area

Potential impacts to the visual character of the Major Surface Facilities Area include the construction and operation of additional infrastructure items including an additional demountable bath house, an additional short-term coal reject stockpile, coal reject paste plant and upgrades of the CHPP and associated materials handling systems (Figure 2-2).

Given the existing mass and scale of the Major Surface Facilities Area buildings, structures (e.g. conveyors) and stockpiles, the Project alterations are considered minor.

As shown on Figure 2-2, the temporary coal reject stockpile and coal reject paste plant would be constructed in the east of the Major Surface Facilities Area near the existing product coal stockpiles. Any residences with existing views of the eastern portion of the Major Surface Facilities Area may have views of the new coal reject paste plant and associated coal reject stockpile however, these views would be limited at a number of locations by the intervening distance and the thick vegetation that surrounds the Major Surface Facilities Area (Figure 2-2).

Upgrade of existing infrastructure and construction of additional infrastructure as part of the Project is expected to have negligible impact on the visual character of the Major Surface Facilities Area and surrounds.

Potential impacts of the Project on night-lighting include the extension of lighting to the additional infrastructure items described above to meet suitable operational and safety requirements. The scale and nature of night lighting for the Project would be similar in intensity to the existing Metropolitan Colliery night lighting.

Project Underground Mining Area

Potential impacts on the visual character of the Project Underground Mining Area include the construction of Ventilation Shaft No. 4 (and associated electrical infrastructure), on-going minor surface works (e.g. exploration and environmental monitoring) and the aesthetic effects of subsidence related impacts on surface features (e.g. streams and clifflines) located above the Project longwalls.

These are discussed further below.

Ventilation Shaft No. 4

As shown on Figure 4-18, Ventilation Shaft No. 4 would be located in an existing disturbed area to the west of the F6 Southern Freeway. As described in Sections 2.4.4 and 2.5.4, the facility would include a range of infrastructure including the ventilation fans, electricity supply and distribution systems such as a transformer for the ventilation fan supply and to supply the electrical demand of the underground mine operations via cables down surface-to-seam boreholes.

Rock material from the construction of Ventilation Shaft No. 4 would be used to build a site pad and/or bunding around the ventilation shaft and supporting infrastructure. Depending on the final design of the ventilation infrastructure, it is likely that the ventilation fans and other aspects of the facility or the surrounding bunding/fencing would be visible from a short section of the F6 Southern Freeway to northbound and/or southbound traffic. Distant views may also be available from the Princes Highway to the west of the facility in limited locations.

At the cessation of the Project, the Ventilation Shaft No. 4 surface infrastructure would be removed, the shaft would be capped in accordance with the DPI requirements and the site would be rehabilitated.

Methane Flare Unit

HCPL would install a methane flare unit adjacent to Ventilation Shaft No. 3 during the early years of the Project if gas compositions within the Project Underground Mining Area are considered amenable (Section 2.5.5) and subject to obtaining necessary permits and approvals.

The methane flare unit would be located to the west of the existing ventilation installation (Figure 2-1). The top of the flare stacks would be approximately 8.5 m high and would potentially be visible from some locations within the Woronora Special Area and/or portions of the public road network. However the design of the methane flare unit would be such that the flames would be enclosed within the flare stacks and it is not anticipated that the operation of the flare stacks would generate any significant night-lighting issues from any public vantage points.

At the cessation of viable flaring operations (i.e. after the first few years) the methane flare unit would be removed and the area would be rehabilitated. Any potential visual amenity impacts associated with views of the top of the flare stacks from public roads and elevated vantage points in the Woronora Special Area would therefore be temporary in nature.

Exploration Works and other Short-term Surface Activities

As described in Section 4.1, access to the Woronora Special Area is restricted and hence views of activities in the Woronora Special Area are restricted to areas that are readily visible from the public road network (e.g. the F6 Southern Freeway and the Princes Highway) or adjoining landuses. Exploration works, environmental monitoring and other short-term surface activities may be visible at times from public viewpoints and any minor land disturbance associated with these activities may be visible if located close to these vantage points.

Any disturbance associated with short-term surface activities in the Woronora Special Area would be rehabilitated and any visual impacts would therefore be minor, limited in extent and temporary in nature.

Subsidence Related Impacts on Streams

As described in Sections 4.3 to 4.5, subsidence related impacts on streams in the Woronora Special Area above the Completed Underground Mining Area at the Metropolitan Colliery have been extensively documented in the Surface Water, Groundwater and Aquatic Ecology assessments conducted for the Project (Appendices B, C and D).

While these impacts are not visible to the public (as access to the Woronora Special Area is restricted), a range of comments received from the public and government agencies during the development of this EA (Section 3.5) indicate that there are concerns regarding potential aesthetic impacts on the Waratah Rivulet.

As described in Sections 4.2, 4.3 and 4.4, Project longwall mining is predicted to result in surface and sub-surface cracking in streams, including visible surface cracking of the exposed sandstone streambeds and at some rock bars.

The cracking of streambeds and rock bars can lead to alteration of the local hydrological processes as described in Section 4.4 and shown on Figure 4-2. These alterations of local hydrological processes can result in aesthetic impacts such as reduced water levels in pools, drying out of sections of some streams during times of low flow and an increase in the precipitation of iron.

Subsidence effects may accelerate localised iron precipitation and may cause the discolouration of stream waters and stream beds to an orange/brown colour.

The development of the existing Woronora Reservoir (Figure 4-18), which has resulted in the clearing of a large area of bushland and the periodic inundation of the lower sections of the Waratah Rivulet, Woronora River and associated tributaries has also created aesthetic impacts.

Subsidence Related Impacts on Cliffs, Overhangs and Steep Slopes

As described in Appendix A and Section 4.2.4, the incidence of rock falls from Project subsidence is expected to be low. Notwithstanding, visible exposure of fresh rock faces and debris around the base of cliffs may occur in isolated locations if rock falls do occur. Significant slope failures have not been observed in the Southern Coalfield (Appendix A).

4.16.3 Mitigation Measures and Management

Major Surface Facilities Area

New buildings (e.g. the coal reject paste plant and the demountable bath house extension) would be designed to complement existing building structures and/or colours, where practicable. CHPP upgrades and other modifications to features of heritage significance at the Major Surface Facilities Area would be undertaken in accordance with the requirements of the CMP (Section 4.9.4).

Additional night-lighting for the Project upgrades would be restricted to the minimum required for operational and safety requirements and would be directed away from public receptors, where practicable.

Project Underground Mining Area

Ventilation Shaft No. 4

As a component of the detailed design of the Ventilation Shaft No. 4 installation, consideration of the visibility of the site and the potential to incorporate visual vegetation screening or bunding to reduce potential views from the surrounding public road network would be conducted. The larger components of the facility such as the ventilation fans would be painted a suitable colour to blend in within surrounding vegetation, where practicable.

Methane Flare Unit

As a component of the detailed design of the methane flare unit, consideration of the visibility of the site and the potential to incorporate colouring or screening to reduce the visibility of the flare stacks from the surrounding public road network would be conducted.

Exploration Works and other Short-term Surface Activities

No visual impact mitigation measures are considered warranted for short-term surface works that would be required above the Project Underground Mining Area and in the surrounds. As described in Section 5, once such activities are completed, any associated disturbance areas would be rehabilitated.

Subsidence Related Aesthetic Impacts on Streams

As described in Section 4.4, HCPL has completed a stream restoration trial at the WRS4 rock bar which indicates that restoration of some of the impacts of subsidence related impacts on streams (e.g. underflow and pool persistence) can be successfully ameliorated. On the basis of the WRS4 trial, PUR injection is considered a technically feasible method of restoring some aesthetic values along any section of Waratah Rivulet, where future assessment indicates the need (HCPL, 2008b).

Consistent with the recommendations of the SCPR (DoP, 2008), HCPL is currently investigating the potential use of cosmetic treatments (in the form of coloured grout or similar) to restore aesthetic values along Waratah Rivulet. HCPL intends to trial cosmetic repair techniques at the WRS4 rock bar and its applicability to other rock bars along Waratah Rivulet would be determined in consultation with the relevant authorities.

Stream restoration activities would be reported annually in the AEMR (Sections 5 and 6).

Subsidence Related Impacts on Cliffs, Overhangs and Steep Slopes

No specific visual mitigation measures are proposed for isolated rock falls that may occur in the Project Underground Mining Area as a result of the Project. Such rock falls occur naturally in the Hawkesbury Sandstone landscapes of the Woronora Plateau, and exposed rock surfaces weather over time and vegetation re-establishes naturally.