Environmental Assessment

# Cadia East Project

## SECTION 4

# TABLE OF CONTENTS



## LIST OF TABLES

## TABLE OF CONTENTS (continued)

### LIST OF TABLES (Continued)



### LIST OF FIGURES

## TABLE OF CONTENTS (continued)

## LIST OF FIGURES (Continued)

# 4 ENVIRONMENTAL ASSESSMENT

The following section presents the environmental assessment for the Project. In accordance with the EARs, this section includes a description of the existing environment (including the existing Cadia Valley 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. This section provides an environmental assessment of the following:

- land resources, climate and bushfire regime;
- groundwater;
- surface water;
- flora;
- fauna;
- air quality;
- noise;
- Aboriginal heritage;
- European heritage;
- road transport;
- regional economy;
- employment, population and community infrastructure;
- visual character; and
- hazard and risk.

## 4.1 LAND RESOURCES, CLIMATE AND BUSHFIRE REGIME

### 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, bushfire regime and geochemistry in the vicinity of the Project is also provided.

***Landuse***

The dominant landuse in the Orange region is agriculture, principally grazing (sheep and cattle), cropping and orchards. Other agricultural activities include honey production, viticulture and softwood production (predominantly Monterey Pine [*Pinus radiata*]).

Landuse in the vicinity of the Cadia Valley is dominated by sheep and cattle grazing on the flatter areas, and state forestry operations on poorer soil and steeper slopes in the Canobolas State Forest to the east and north (Figure 2-1).

Project disturbance areas that are not currently disturbed by Cadia Valley Operations activities (e.g. the Cadia East subsidence zone and associated zone of influence, expanded inundation areas of the NTSF and STSF) are currently used for forestry operations, grazing or are areas annexed from existing mining operations. The site of the CVO Dewatering Facility is currently used for grazing (Figure 1-3).

***Landforms and Topography***

The Orange region is located on the western side of the Great Dividing Range. Areas of higher elevation in the region include Mount Canobolas (1,396 m AHD) and Mount Towac (1,136 m AHD) located to the north of the Cadia Valley. In the Cadia Valley elevations generally range from approximately 600 m AHD to 1,000 m AHD.

The region is predominantly characterised by gently undulating hills, cleared open grassland and vegetation consisting mainly of scattered paddock trees, with isolated patches of remnant woodland and shelterbelts. State Forests situated in the area include the Glenwood and Canobolas State Forests to the south-west of Orange, and Mullion Range State Forest to the north of Orange.

The dominant topographic feature of the Project area is the Cadia Valley, which is characterised by undulating hills, cleared open grassland and scattered native vegetation remnants. The Cadia Valley is bounded by a series of rolling hills which form ridgelines to the east and west of Cadiangullong Creek (Figure 2-1).
Mount Canobolas and Mount Towac form the topographic features to the north of the Cadia Valley. To the south, the Cadia Valley opens out to generally gently undulating land extending to the Belubula River, with occasional steeply sided gullies in the lower portion of the catchment.

Cadiangullong Creek is the major watercourse in the valley, rising within Canobolas State Forest, extending through ML 1405 in a generally southerly direction and then discharging into the Belubula River (Figure 2-1). Tributaries of Cadiangullong Creek within the Cadia Valley include Rodds Creek, Cadia Creek, Copper Gully and Hoares Creek. All of these creeks have been affected to some degree by development of the Cadia Valley Operations.

These streams flow in a generally south-west direction and drain the land to the east of Cadiangullong Creek. Surface water features are discussed further in Section 4.3.

The following existing Cadia Valley Operations components have modified the topography of the Cadia Valley:

- Cadiangullong Dam;
- Rodds Creek Water Holding Dam;
- Cadia Hill open pit;
- Ridgeway subsidence zone;
- North and South Waste Rock Dumps;
- STSF;
- NTSF; and
- various water management structures and storages.

Elevations within the planned Project disturbance areas that are not currently disturbed by Cadia Valley Operations activities range from approximately 930 m AHD (on Sharpe's Ridge to the east of the Cadia Hill open pit) to approximately 750 m AHD at Copper Gully (Figure 2-1).

The North Waste Rock Dump has a height of approximately 890 m AHD. The South Waste Rock Dump has a currently approved maximum height of 880 m AHD. The planned final pit floor of the Cadia Hill open pit will be at approximately 235 m AHD which will be approximately 480 m below the bed of Cadiangullong Creek.

Elevations at Rodds Creek range from approximately 930 m AHD at the head of Rodds Creek to approximately 640 m AHD at the confluence between Rodds Creek with Cadiangullong Creek (Figure 2-1). The existing NTSF and STSF are situated along Rodds Creek and have approved embankment heights of 741 m AHD and 682 m AHD, respectively.

The topography of the CVO Dewatering Facility site is generally flat with an elevation of approximately 875 m AHD.

***Soils***

The soils of the Cadia Valley have been classified and mapped at a general scale of 1:15,000 by Resource Strategies (2000a) in accordance with the descriptions of soil landscapes by Kovac *et al*. (1990) and the Australian Soil Classification (Isbell, 1996).

Soil types encountered in the Project disturbance areas that are not currently disturbed by Cadia Valley Operations activities are generally representative of those previously encountered in the existing Cadia Valley Operations areas.

The following soil types based on Kovac *et al.* (1990) were identified in the Cadia Valley (Resource Strategies, 2000a; Soil Conservation of NSW, 1994):

- alluvial soil;
- yellow podzolic;
- red podzolic;
- krasnozem;
- red earth;
- yellow earth;
- euchrozem;
- lithosol; and
- yellow solodic soil.

The following soil landscapes based on Kovac *et al.* (1990) were identified in the Cadia Valley (Resource Strategies, 2000a):

- Barenore-Lyndhurst;
- Panuara;
- Quarry;
- Canobolas;
- Vittoria-Blayney; and
- Towac.

***Agricultural Suitability***

An agricultural suitability assessment of the Cadia Valley area was conducted in accordance with the five class system (Riddler, 1996) which allows for assessment and identification of land based on suitability for agricultural purposes. Regional agricultural suitability mapping (DPI, pers. comm., 30 January 2009) was used to augment existing mapping and to determine the agricultural suitability of the Mining Lease Application (MLA) areas to the east of ML 1405.

Three agricultural suitability classes (Classes 3, 4 and 5) are located within the planned Project disturbance areas. Class 3 agricultural suitability is defined by Cunningham *et al*. (undated in Riddler, 1996) as:

> *Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture. The overall production level is moderate because of edaphic or environmental constraints. Erosion hazard, soil structural breakdown and other factors including climate may limit the capacity for cultivation, and soil conservation or drainage works may be required*.

Class 4 agricultural suitability is defined (Cunningham *et al*., undated) as:

> *Land suitable for grazing but not for cultivation. Agriculture is based on native pastures or improved pastures established using minimum tillage techniques. Production may be seasonally high but the overall level is low as a result of a major environmental constraints*.

Class 5 agricultural suitability is defined (Cunningham *et al*., undated) as:

> *Land unsuitable for agriculture or at best suited only to light grazing. Agricultural production is very low to zero as a result of severe constraints, including economic factors, which preclude land improvement.*

Regional agricultural suitability mapping (DPI, pers. comm., 30 January 2009) was used to determine the agricultural suitability of the CVO Dewatering Facility site. Agriculture suitability Classes 3 and 4 were identified at the CVO Dewatering Facility site.

***Rural Land Capability***

A rural land capability assessment of the Cadia Valley area was conducted by Resource Strategies (2000a) in accordance with the standard NSW eight class system (Emery, 1985). This system is based on assessment of biophysical characteristics categorising land in terms of general limitations such as erosion hazard, climate, and slope. Regional land capability mapping (DECC, 2009a) was used to augment existing mapping and to determine the land capability of the MLA areas.

Five rural land capability classes are located within the planned Project disturbance areas (including the MLA areas) (Classes III, IV, V, VI and VII). Class III Capability is defined (Cunningham *et al*., undated) as:

> *Land capable of being regularly cultivated with structural soil conservation works such as diversion banks, graded banks and waterways, together with soil conservation practices such as strip cropping, conservation tillage and adequate crop rotations.*

Class III land occurs in the tailings storage facilities expansion areas, the Cadia East subsidence zone and the zone of influence. Limiting factors for Class III land include erosion hazard and climate (Cunningham *et al*., undated).

Class IV Capability is defined (Cunningham *et al*., undated) as:

> *Land not capable of being regularly cultivated but suitable for grazing with occasional cultivation with soil conservation practices such as pasture improvement, stock control, application of fertiliser and minimal cultivation for the establishment or re-establishment of permanent pasture*.

Class IV land occurs in the tailings storage facilities expansion areas, the Cadia East subsidence zone, and the zone of influence. Limiting factors for Class IV land include slope, soil type, soil depth, rockiness and erodibility (Cunningham *et al*., undated).

Class V Capability is defined (Cunningham *et al*., undated) as:

> *Land not capable of being regularly cultivated but suitable for grazing with occasional cultivation with structural soil conservation works such as absorption banks, diversion banks and contour ripping, together with the practices as in Class IV*.

Lands classed as Class V can be found in the tailings storage facilities expansion areas, the Cadia East subsidence zone, and the zone of influence. Erosion hazard and landscape complexity are the main limitations of this capability class (Cunningham *et al*., undated).

Class VI Capability is defined (Cunningham *et al*., undated) as:

> *Land not capable of being cultivated but suitable for grazing with soil conservation practices including limitation of stock, broadcasting of seed and fertiliser, prevention of fire and destruction of vermin. This class may require some structural works.*

Class VI land is characterised by steeper grazing lands which occur generally in the steeper parts of the Project area. Limitations include rockiness, shallow depth of soil, erosion hazard and high degree of slope. Class VI land is present in the tailings storage facilities expansion areas, the Cadia East subsidence zone and the zone of influence.

Class VII Capability is defined (Cunningham *et al*., undated) as:

> *Other lands best protected by green timber.*

Class VII land is characterised by steep slopes with moderate to high erosion hazard. Lands classed as Capability Class VII are present within the Cadia East subsidence zone, and the zone of influence.

Regional land capability mapping (DECC, 2009a) was used to determine the land capability of the CVO Dewatering Facility site. Class II land was identified at the CVO Dewatering Facility site.

Class II Capability is defined (Cunningham *et al*., undated) as:

> *Land capable of being regularly cultivated with soil conservation practices such as strip cropping, conservation tillage and adequate crop rotations.*

***Geology***

The Project area is located within the eastern Lachlan Fold Belt of NSW. The Lachlan Fold Belt is divided into northerly trending metamorphic, volcanic and sedimentary belts intruded by numerous igneous rocks such as porphyries and granitoids (CHPL, 2000b). The rocks of the Belt are primarily of Ordovician (500 to 430 million years ago), Silurian (430 to 400 million years ago), and Devonian (400 to 350 million years ago) age.

The intrusive belts of the Lachlan Fold Belt are relatively undeformed and despite their Ordovician age, are only metamorphosed to lower greenschist facies (CHPL, 2000b). Mostly north-south trending fault systems bound the belts and separate them from adjacent Ordovician and Siluro-Devonian volcanics, sediments and granitoids.

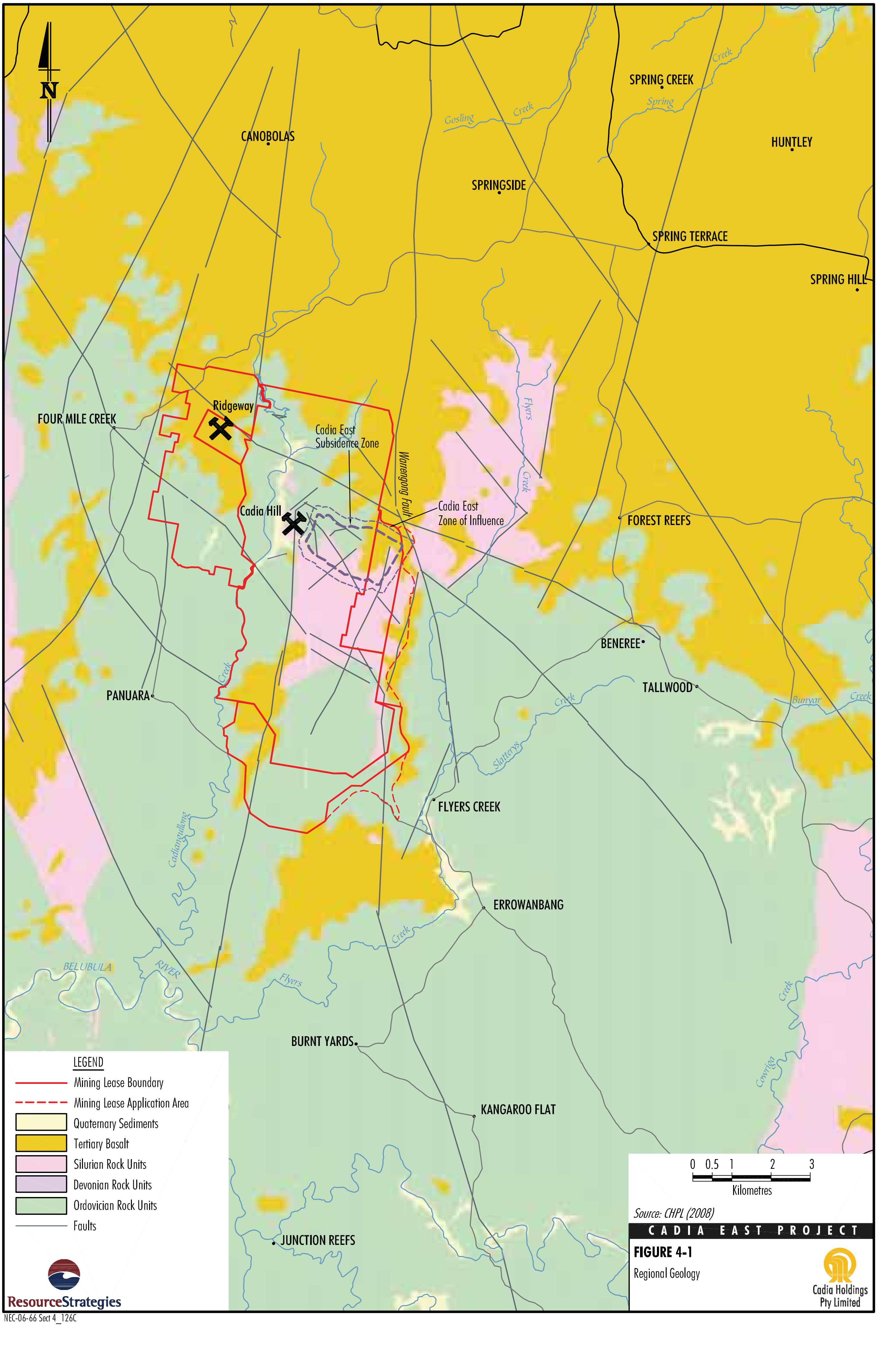
The Cadia Valley area contains westerly dipping, low-angle, reverse faults formed as a result of compressional techonism following the Silurian period (CHPL, 2000b).

The Cadia East orebody is one of a series of porphyry-related gold-copper deposits located within the Cadia Valley. The Cadia Valley deposits occur as part of a Late Ordovician-Early Silurian porphyry alteration-mineralisation system hosted within Ordovician intermediate to basic volcanics, volcaniclastics, comagmatic intrusions and limestones of the Molong Volcanic Belt of the Lachlan Fold Belt (MESH, 2009). Gold-copper mineralisation is spatially and genetically associated with an alkalic intrusive complex of monzonitic composition named the Cadia Intrusive Complex (CIC).

The Cadia Valley is host to three known gold-copper porphyry deposits including Ridgeway, Cadia Hill (including Cadia Quarry), and Cadia East. Two iron-rich skarn deposits named Big Cadia and Little Cadia have also been identified. These occurrences strike along a 6 km long by 2 km wide ‘highly prospective’ mineralised corridor. Emplacement of these mineralised systems is thought to have been facilitated by a structural zone trending north-west to south-east (MESH, 2009).

Key rock units in the Cadia Valley include the Ordovician Forest Reefs Volcanics dominated by volcaniclastic rocks (volcanic ash beds and agglomerates) of andesitic composition with lesser lavas, sub-volcanic intrusions and limestones (MESH, 2009). The Forest Reefs Volcanics conformably overlie older Ordovician turbidite sediments of the Weemalla Formation (siltstones, mudstone and minor volcaniclastics). Rocks of the Forest Reefs Volcanics and Weemalla Formation are intruded by monzonite to quartz-monzonite phases of the CIC. Porter *et al*. (2005) report that the intrusive complex is represented as a stock at Cadia Hill and Cadia Extended, a narrow restricted pipe at Ridgeway and as a series of dykes at Cadia East (MESH, 2009). In the Cadia Valley area, the post mineralisation cover includes Silurian sediments (subdivided into the Ashburnia Group and the overlying Waugoola Group) and Tertiary aged (up to 65 million years ago) basalt of the Mount Canobolas Volcanic complex.

Figure 4-1 shows the simplified regional geology (i.e. Ordovician, Silurian and Tertiary rock units) between the Belubula River and the southern outskirts of Orange. Figure 4-2 and Figure 4-3, respectively, provide a more detailed plan and cross-section of the local geology in the Cadia Valley.




NEC-06-66 Sect 4_126C


LEGEND

| | |
|---|---|
| | Tertiary Basalt |
| Waugoola Group | Massive to thick bedded quartz sandstone |
| | Interbedded siltstone and sandstone |
| | Massive to laminated silstone and coarse-grained micaceous arkose |
| | Polmict siltstone-matrix conglomerate |
| | Cadia Intrusive Complex |
| | Dacite Dykes |
| Forest Reefs Volcanics | Volcaniclastic rocks, lava and rare limestone |
| | Magnetic skarn |
| | Weemalla Formation: Siltstone and turbidites |
| | Faults |
| | Cadia Hill Open Pit |

0 500 1000
Metres

*Source: After Washburn (2008)*

CADIA EAST PROJECT

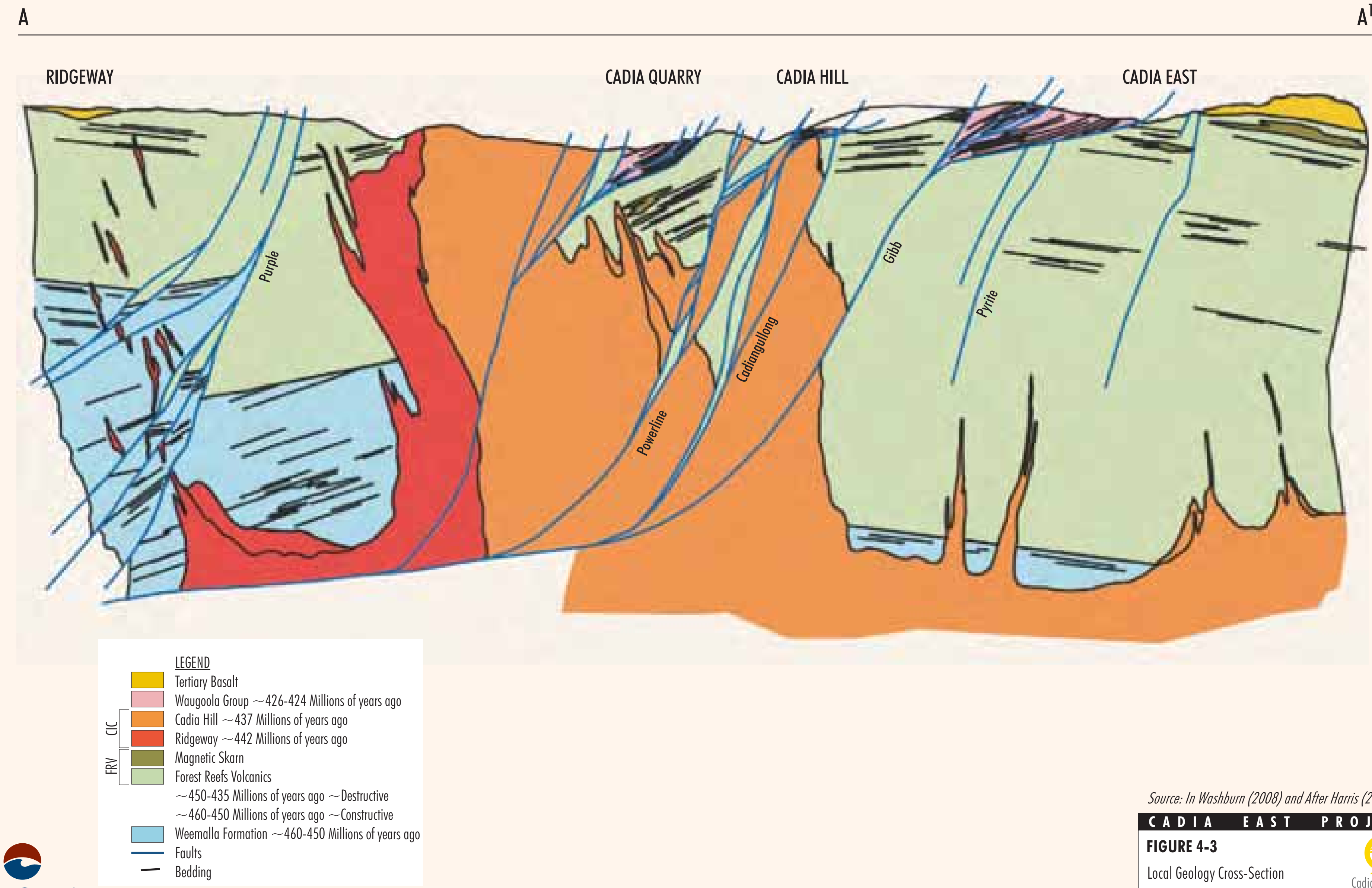
**FIGURE 4-2**

Local Geology

Cadia Holdings Pty Limited

ResourceStrategies

NEC-06-66 Sect4_010B




*Source: In Washburn (2008) and After Harris (2007)*

CADIA EAST PROJECT

**FIGURE 4-3**

Local Geology Cross-Section

Cadia Holdings Pty Limited

ResourceStrategies

The dominant regional structural features are a series of north trending reverse faults and related splays. Washburn (2008) subdivides faults in the Cadia District into three major sets based on orientation as follows:

- north striking, west dipping reverse faults and associated folds and fault splays;
- north-east striking, north-west dipping faults and associated folds that are locally developed at the district scale; and
- west-northwest striking, steeply north dipping oblique-reverse faults.

Washburn (2008) examined the major faults in the Cadia Hill open pit/Cadia East area and made the following observations:

- The Cadiangullong Fault is a 1 to 10 m wide zone of black cataclasite gouge and intensely fractured wall rocks.
- The Foys Fault is a 20 m wide zone of intensely fractured siltstone.
- The Gibb Fault is a 0.5 to 2 m wide zone of milled rock-matrix breccia and clay gouge.
- Copper Gully Fault is planar and narrow and has a reddish clay gouge.

The Warrengong fault is a north-south trending, near vertical structure located approximately 1 km to the east of the Cadia East deposit (Figure 4-1). It is considered to be an extensive regional structure.

***Climate***

Regional meteorological data are available from the Bureau of Meteorology (BoM) weather stations at Orange Agricultural Institute (BoM Station No. 063254), Orange Airport Comparison (BoM Station No. 063231) and the discontinued Blayney Post Office (BoM Station No. 063010). The details of each station are provided in Table 4-1.

Meteorological conditions are currently monitored at the Cadia Valley Operations at on-site meteorological stations within ML 1405 (Southern Lease Boundary [SLB] Station) and ML 1449 (Ridgeway Station). There are also 11 pluviometers (rain gauges) in the vicinity of the Cadia Valley Operations. The locations of these monitoring sites are shown on Figure 4-4.

A summary of the meteorological data collected from the Ridgeway and SLB Stations and BoM weather stations is provided in Table 4-2 and is discussed in the following sections.

*Temperature*

Table 4-2 indicates that regional temperatures are warmest from November to March and coolest from May to August. Average daily maximum temperatures peak in January (26.4 degrees Celsius [°C], 25.9°C, 26.2°C, 28.6°C and 27.7°C for Orange Agricultural Institute, Orange Airport Comparison, Blayney Post Office, SLB Station and Ridgeway Station, respectively), while average daily minimum temperatures are lowest in July (1.4°C, 0.6°C, -1.1°C, 3.6°C and 3.3°C for Orange Agricultural Institute, Orange Airport Comparison, Blayney Post Office, SLB Station and Ridgeway Station, respectively).

**Table 4-1**
**Bureau of Meteorology Station Locations and Recording Period**

| Station Name | Station Number | Period of Record | Location | Approximate Elevation (m AHD) | Approximate Distance and Direction from the Cadia Valley Operations |
|---|---|---|---|---|---|
| Orange Agricultural Institute | 063254 | 1966 to 2009 | 149°05'58"E 33°19'16"S | 922 | 14 km north-east |
| Orange Airport Comparison | 063231 | 1968 to 2009 | 149°07'22"E 33°22'53"S | 948 | 12 km east-northeast |
| Blayney Post Office | 063010 | 1885 to 1992 | 149°16'36"E 33°32'06"S | 863 | 25 km east |

Source: BoM (2009a, 2009b, 2009c).

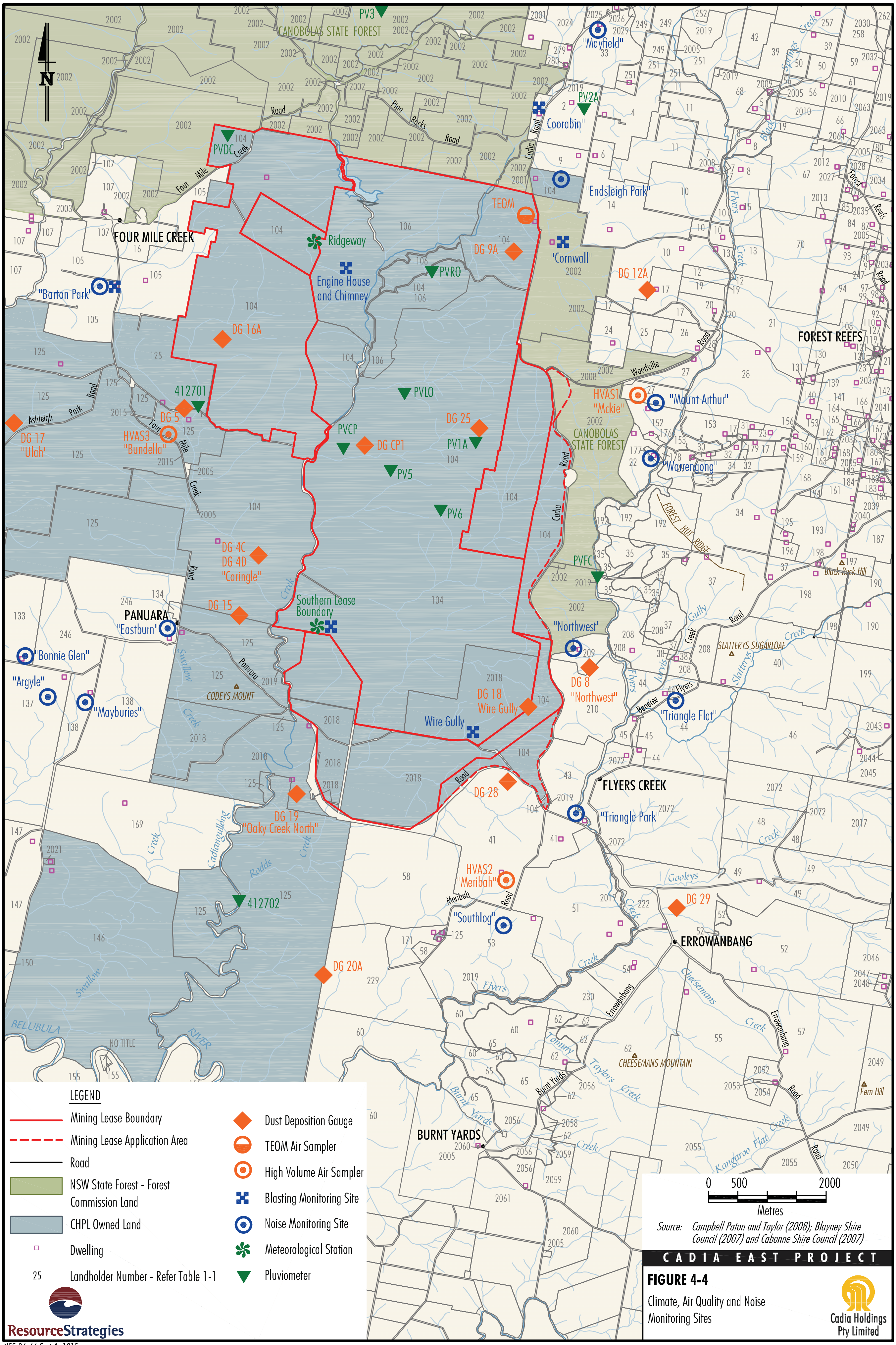



FIGURE 4-4

Climate, Air Quality and Noise Monitoring Sites

NEC-06-66 Sect 4_101F

**Table 4-2**
**Historical Meteorological Data Summary**

| Month | Average Relative Humidity (%) | | | | | Average Air Temperature (°C) | | | | | | | | | | Average Rainfall (mm) | | | | | Mean Monthly Pan Evaporation (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Orange Agricultural Institute[1] | Orange Airport Comparison[2] | | SLB[3] | | Orange Agricultural Institute[1] | | Orange Airport Comparison[2] | | Blayney Post Office[4] | | SLB[5] | | Ridgeway[5] | | Orange Agricultural Institute[6] | Orange Airport Comparison[2] | Blayney Post Office[7] | SLB[5] | Ridgeway[5] | Orange Agricultural Institute[1] |
| | 9 am | 9 am | 3 pm | 9 am | 3 pm | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | | | | | | |
| January | 67 | 67 | 45 | 46 | 32 | 26.4 | 13.2 | 25.9 | 12.1 | 26.2 | 10.6 | 28.6 | 16.6 | 27.7 | 15.1 | 89.3 | 87.6 | 70.8 | 41.3 | 57.1 | 220.1 |
| February | 71 | 73 | 49 | 55 | 41 | 25.8 | 13.1 | 25.2 | 12.2 | 25.4 | 10.8 | 27.4 | 16.1 | 25.9 | 15.1 | 75.3 | 81.8 | 55.6 | 71.4 | 83.3 | 175.2 |
| March | 69 | 73 | 51 | 57 | 44 | 22.8 | 10.6 | 22.4 | 9.6 | 23.4 | 8.1 | 24.5 | 14.0 | 22.8 | 12.8 | 56.9 | 50.4 | 52.7 | 43.0 | 38.4 | 155.0 |
| April | 70 | 74 | 55 | 59 | 45 | 18.5 | 7.2 | 18.3 | 6.1 | 19.2 | 4.0 | 20.5 | 10.8 | 18.6 | 10.1 | 52.0 | 52.9 | 49.7 | 25.7 | 24.6 | 96.0 |
| May | 79 | 83 | 64 | 73 | 56 | 14.2 | 4.7 | 13.9 | 3.6 | 14.3 | 1.1 | 15.3 | 7.3 | 13.9 | 6.6 | 69.6 | 63.7 | 56.1 | 25.8 | 27.0 | 62.0 |
| June | 83 | 88 | 70 | 79 | 65 | 10.5 | 2.5 | 10.4 | 1.5 | 11.5 | -0.5 | 12.1 | 4.7 | 10.2 | 4.7 | 70.3 | 66.4 | 71.8 | 62.8 | 66.5 | 42.0 |
| July | 82 | 86 | 70 | 79 | 65 | 9.3 | 1.4 | 9.3 | 0.6 | 10.3 | -1.1 | 10.9 | 3.6 | 9.2 | 3.3 | 90.5 | 87.4 | 73.5 | 45.2 | 49.8 | 46.5 |
| August | 75 | 80 | 65 | 72 | 58 | 10.9 | 2.1 | 10.7 | 1.4 | 11.2 | 0.3 | 12.5 | 4.2 | 11.0 | 3.9 | 98.3 | 91.7 | 76.7 | 64.8 | 68.2 | 65.1 |
| September | 70 | 74 | 61 | 63 | 52 | 14.0 | 4.1 | 13.6 | 3.2 | 14.6 | 1.6 | 16.3 | 6.5 | 14.9 | 6.3 | 79.3 | 78.1 | 63.9 | 42.6 | 60.8 | 93.0 |
| October | 66 | 68 | 56 | 55 | 45 | 17.6 | 6.6 | 17.2 | 5.7 | 18.1 | 4.6 | 19.5 | 9.0 | 18.4 | 8.5 | 85.9 | 77.7 | 71.5 | 43.5 | 56.9 | 136.4 |
| November | 68 | 70 | 54 | 52 | 42 | 20.9 | 9.0 | 20.3 | 7.8 | 20.7 | 5.6 | 23.7 | 13.0 | 22.6 | 11.5 | 77.9 | 74.7 | 59.8 | 68.6 | 79.1 | 162.0 |
| December | 64 | 65 | 46 | 46 | 35 | 24.4 | 11.3 | 23.9 | 10.0 | 24.4 | 8.2 | 26.0 | 15.0 | 25.3 | 13.3 | 77.4 | 72.5 | 63.7 | 59.0 | 47.8 | 217.0 |
| **Annual Average** | **72** | **75** | **57** | **61** | **48** | **17.9** | **7.1** | **17.6** | **6.2** | **18.3** | **4.4** | **19.8** | **10.1** | **18.4** | **9.3** | - | - | - | **-** | **-** | **-** |
| **Average Annual Total** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | **922.7** | **884.5** | **766.0** | **593.6** | **659.3** | **1,461.0** |

1 For the period January 1976 to January 2009.
2 For the period January 1968 to January 2009.
3 For the period January 2000 to November 2008.
4 For the period 1965 to 1975.
5 For the period December 1999 to November 2008.
6 For the period January 1966 to January 2009.
7 For the period 1885 to 1992.

*Relative Humidity*

Relative humidity records at all sites indicate a seasonal variance with higher humidity in winter and lower humidity in summer. Average monthly morning (9.00 am) relative humidity records for the Orange Agricultural Institute and Orange Airport Comparison were lowest in December (64% and 65%, respectively) and highest in June (83% and 88%, respectively). The average monthly morning (9.00 am) relative humidity at the SLB Station were lowest in December (46%) and January (46%), and highest in June (46%) and July (46%). Average monthly afternoon (3.00 pm) relative humidity records ranged from 45% to 70% at the Orange Airport Comparison to 32% to 65% at the SLB Station.

*Wind Speed and Direction*

Representative windroses for the Project were generated using data from the on-site meteorological stations (Appendix E). Annual and seasonal windroses for the Ridgeway Station are illustrated on Figure 4-5.

The windroses indicate that at the Ridgeway Station, over the period July 2007 to June 2008, the most common winds are from the south-west and north-east. The area did not commonly experience low wind speeds with calm periods (i.e. winds less than or equal to 0.5 metres per second [m/s]) measured only 3.2% of the time.

At the SLB Station, the prevailing winds were generally from the north-eastern quadrant and from the west-southwest to the north-northwest. For the July 2007 to June 2008 period, this site recorded approximately 3.0% of calm periods (i.e. winds less than or equal to 0.5 m/s) (Appendix E).

Annual average wind speeds for the SLB and Ridgeway Stations were 3.7 m/s and 3.5 m/s respectively for the July 2007 to June 2008 monitoring period (CHPL, 2008a).

*Rainfall*

The mean annual rainfall recorded at the Orange Agricultural Institute, Orange Airport Comparison, Blayney Post Office, SLB and Ridgeway Stations is provided in Table 4-2.

The months with the highest and lowest monthly average rainfalls at the SLB and Ridgeway Stations are February (71.4 mm and 83.3 mm) and April (25.7 mm and 24.6 mm), respectively.

The on-site meteorological stations (i.e. SLB and Ridgeway Stations) typically record lower monthly rainfall averages than the regional locations, however the period of records for SLB and Ridgeway Stations have coincided with a period where drought has been a feature of the climate (Appendix F).

*Evaporation*

Total mean annual evaporation based on Orange Agricultural Institute records was 1,461.0 mm per year. January (220.1 mm) had the highest monthly rates of evaporation while June (42.0 mm) had the lowest monthly rates. Table 4-2 demonstrates that while average monthly rainfall was not particularly seasonal, evaporation was markedly different between summer and winter.

***Bushfire Regime***

The bushfire season experienced in the Cadia Valley area and Central West Region is generally from mid-November to mid-March (CHPL, 2000b). Depending on factors such as weather, fuel loads (build up of leaf litter and broken branches) and drought indices, this season can be extended from early September to late April.

There are moderate fuel loads associated with the open forest and woodland areas within the Cadia East subsidence zone and the tailings storage facilities expansion areas.

CHPL-owned land extends over three NSW Rural Fire Brigades brigade jurisdictions (i.e. Burnt Yards/Cadia, Panuara/Four Mile Creek and Springside Brigades) which form part of the Canobolas Zone. CHPL operates the Cadia Valley Operations Emergency Response Team which provides emergency assistance to the NSW Rural Fire Brigade when required.

CHPL has a BMP in place which was prepared in consultation with relevant local bushfire brigades and addresses all CHPL-owned land (CHPL, 2008f). The BMP includes details of training and emergency response procedures, a fuel management plan and an annual hazard reduction programme. The annual hazard reduction programme is prepared in consultation with the Canobolas Zone Bushfire Management Committee.


*Source: Holmes Air Sciences (2008)*

CADIA EAST PROJECT

**FIGURE 4-5**

Ridgeway Station Windroses - July 2007 to June 2008

Cadia Holdings Pty Limited

ResourceStrategies

NEC-06-66 Sect 4_103C

***Geochemistry***

A geochemistry assessment for the Project has been undertaken by MESH (2009) and is presented in Appendix J. The geochemistry assessment included testing of samples of rock within the Cadia East subsidence zone, zone of influence and mine waste rock. A summary of the findings of the assessment is provided below.

*Waste Rock – Cadia Hill and Ridgeway*

Waste rock characterisation at Cadia Hill began in the early to mid 1990s as part of the Cadia Hill EIS (Newcrest, 1995). Static and kinetic testing was conducted on 58 Cadia Hill waste rock samples (selected to be generally representative of the range of lithology and mineralisation conditions at Cadia Hill) which indicated that 78% of the waste rock would be NAF, 14% would be indeterminate and 8% would be PAF (Appendix J).

A geochemical assessment of Ridgeway waste rock was conducted by Environmental Geochemistry International (EGi) (2000) as part of the Ridgeway EIS (CHPL, 2000b). Waste rock characterisation testwork consisted of static testing on 111 samples representative of Ridgeway waste rock (EGi, 2000). The study concluded that nearly all Ridgeway waste rock would be classified as NAF and had a very low risk for ARD (EGi, 2000). EGi (2000) also suggested that PAF zones could potentially form in the underground workings due to higher sulphur contents near the orebody, however available ANC would ensure a long lag period such that acid generation would be unlikely.

Waste rock characterisation studies conducted for Ridgeway Deeps (Perry, 2005) included static testing on 23 samples of the major rock types in the deposit. Overall, the results indicated that four of the 18 Weemalla Formation sediments and one of three intrusive samples were PAF (Perry, 2005).

A description of the existing Cadia Valley Operations waste rock management strategy is provided in Section 2.1.5.

*Waste Rock – Cadia East*

The acid formation and metal leaching potential of Cadia East waste rock is expected to be different to Cadia Hill and Ridgeway as it is a relatively high sulphide mineralisation deposit (compared with the Cadia Hill and Ridgeway). Geochemical testing of the Cadia East deposit Silurian and underlying Ordovician host rock units indicate a distinct difference in the geochemistry of these units (Appendix J).

Samples of Silurian waste rock from within the planned subsidence zone were found to have low total sulphur values (0.01 to 1.11%) and variable ANC (approximately 1 equivalent kilogram of sulphuric acid per tonne [kg $H_2SO_4$/t equiv] to >800 kg $H_2SO_4$/t equiv) (Appendix J). ANC values were strongly related to specific units, with siltstone and limestone units having greater ANC values than the sandstone and sediment units (Appendix J). Based on the testwork, it is expected that the Silurian cover would be predominantly NAF, with only a minor potential for localised acid formation associated with a low load of acidity and negligible metals (Appendix J).

The tested Ordovician host rock units showed greater variability in their geochemical characteristics (Appendix J). Total sulphur values ranged from 0.03 to 5.69% in the subsidence zone and the mine development waste rock ranged from 0.05 to 5.97% (Appendix J). The ANC distribution for waste rock was marginally higher than the subsidence zone with overall ranges from 10 to 288 kg $H_2SO_4$/t equiv and <1 to 259 kg $H_2SO_4$/t equiv, respectively (Appendix J). Based on the testwork results, up to 40% of the mine rock likely to be excavated from the underground workings is predicted to be PAF (Appendix J).

A general correlation with alteration was observed in the Ordovician units suggesting that the sodic, phyllic (pyrite shell) and potassic zones are predominantly PAF, and the propylitically altered zones may be predominantly NAF with some PAF (Appendix J). No clear delineation based on lithology or alteration of PAF and NAF areas within the Ordivician units could be defined (Appendix J).

*Tailings – Cadia Hill and Ridgeway*

Geochemical testwork was conducted on five Cadia Hill tailings samples collected from pilot plant testwork during the preparation of the Cadia Hill EIS. The testwork indicated that four tailings samples classified as NAF and one tailings sample (pyrite ore tailings) classified as indeterminate (Appendix J).

EGi (2000) conducted geochemical testwork on three Ridgeway tailings samples collected from pilot tests and one Ridgeway-Cadia Hill blended tailings sample. Nearly all of the Ridgeway tailings were classified as NAF and had a very low risk for ARD (EGi, 2000).

A description of the existing Cadia Valley Operations tailings management is provided in Section 2.1.7.

*Tailings – Cadia East*

Cadia East tailings are expected to be low in sulphur (<0.1 to 0.36% sulphur) and have associated ANC values ranging from 12 to 96 kg $H_2SO_4$/t equiv. Geochemical characterisation testwork indicates that tailings from the processing of ore from the Cadia East deposit are likely to be NAF and similar to the tailings produced from the processing of Cadia Hill and Ridgeway ore (i.e. most of the sulphides contained in the ore report to the mineral concentrate rather than the tailings) (Appendix J).

The Project would result in the production of approximately 450 Mt of additional tailings (dry weight) at a rate of up to approximately 27 Mtpa. Tailings would be deposited in the NTSF and STSF (Section 2.8 and Figures 2-4a to 2-4d).

### 4.1.2 Potential Impacts

The Project has the potential to alter:

- landuse;
- landforms and topography;
- soil quality and erosion potential;
- soil properties due to contamination; and
- the level of bushfire hazard.

The Project may also result in potential impacts related to the geochemistry of mine waste rock and the Cadia East subsidence zone.

These potential impacts are described in the following sub-sections. Measures to mitigate and manage potential impacts are provided in Section 4.1.3.

***Landuse***

The proposed underground mining method, progressive rehabilitation strategies (Section 5) and construction of the Project infrastructure adjacent to existing disturbance areas should limit the area of land disturbed at any one time during both construction and operation.

Potential impacts would be primarily restricted to the loss of existing landuses associated with the development/modification of the:

- Cadia East subsidence zone and zone of influence;
- Cadia East underground mine surface infrastructure;
- upgraded ore processing facilities;
- NTSF;
- STSF;
- re-aligned Cadia Hill access road;
- augmented water management/supply system (including raising of Rodds Creek Water Holding Dam);
- concentrate and return water pipelines; and
- CVO Dewatering Facility.

***Landforms and Topography***

The main modifications to the existing topography that would result from the Project would comprise:

- Cadia East subsidence zone and zone of influence;
- increasing the heights of the NTSF and STSF;
- increasing the height of the Rodds Creek Water Holding Dam; and
- other minor landform alterations associated with construction/re-alignment of roads, water management and erosion and sediment control features.

The panel caving mining method would result in the gradual fracturing and subsidence of rock overlying the underground workings. At the end of the Project life, the surface subsidence zone would be approximately 255 ha and resemble a dish-shaped depression surrounded by steep slopes on the margin (CHPL, 2008c) (Section 2.5.2). The subsidence zone is expected to extend into areas of state forest within ML 1472 and the MLA area, and sections of Copper Gully are expected to subside. The ultimate extent of the Cadia East subsidence zone is shown on Figure 2-4d. A discussion of hydrogeology and hydrology in relation to the subsidence zone is contained in Sections 4.2 and 4.3. In addition, the subsidence zone would require the re-alignment of Cadia Road as discussed in Section 2.12.3.

The expansion of the NTSF and STSF would change existing topography through the construction of an embankment to a maximum height of approximately 92 m and 70 m above the invert of Rodds Creek, respectively. Similarly, the expansion of the existing embankments of the STSF and NTSF would further inundate upstream sections of the Rodds Creek catchment.

*Soils and Erosion Potential*

Potential impacts of the Project on soils relate primarily to:

- loss of soil resources within the Cadia East subsidence zone;
- alteration of soil structure beneath infrastructure items, hardstand areas and roads;
- soil contamination as a result of spillage of fuels, oils, process reagents and other chemicals;
- increased erosion and sediment movement during construction of mine infrastructure; and
- alteration of physical and chemical soil properties (e.g. structure, fertility, microbial activity) during stripping and stockpiling operations.

***Land Contamination***

The potential land contamination risks have been identified as leaks or spills associated with operator error and/or poor maintenance, spills associated with the transport of hazardous materials, contamination associated with operator error or failure of the waste rock classification system resulting in the use of PAF waste rock as construction material at the Project, and leakages from the new concentrate pipeline.

Leak detection and automatic shutdown systems would be used to minimise the loss of concentrate. However, prior to the pipeline shutting down, some leakage of concentrate slurry could result in localised contamination of the land surrounding the pipeline. Any lost concentrate material or contaminated soil would be cleaned-up quickly for reprocessing (concentrate) or disposal within the South Waste Rock Dump (contaminated soil).

The PHA (Appendix M) included consideration of the potential impacts associated with leaks/spills (on-site and from the concentrate pipeline) causing land contamination.

***Bushfire Hazard***

Fires moving on or off the Project area would present potential impacts to surrounding properties and to Cadia Valley Operations personnel and equipment. The degree of potential impact would vary with climatic conditions (e.g. temperature and wind) and the quantity of available fuel. The PHA (Appendix M) included consideration of the potential impacts associated with bushfire.

***Geochemistry***

Potential impacts in relation to geochemistry would be manifested as potential groundwater/surface water impacts and are addressed in Sections 4.2.2 and 4.3.2. Rehabilitation impacts are addressed in Section 5 and Appendix P.

### 4.1.3 Mitigation Measures and Management

***Landuse***

Land ownership within the Cadia Valley and surrounds is shown on Figure 1-4. CHPL-owned lands not specifically required by CHPL’s existing and proposed mining operations would continue to be managed as rural enterprises during the life of the Project.

Land management activities would be undertaken in accordance with the LMP (CHPL, 2009a) and the FMP (CHPL, 2007b) currently implemented at the Cadia Valley Operations.

Rehabilitation activities would be undertaken in consultation with relevant statutory authorities and the currently approved Mine Closure Plan (CHPL, 2008g) (Section 5).

***Landforms and Topography***

Project infrastructure and landforms have been designed and located to integrate with existing topography and drainage features, as evidenced by:

- accommodation of tailings in the NTSF and STSF (rather than constructing a new facility);
- accommodation of waste rock from the Cadia East underground mine in the South Waste Rock Dump;
- location of Cadia East ore handling and storage infrastructure and the new processing plant adjacent the existing Cadia Valley Operations ore processing facilities;
- use of an underground incline conveyor (rather than production shafts/headframes); and
- maximum use of existing Cadia Valley Operations infrastructure, services and amenities where possible.

Progressive rehabilitation would be undertaken where possible to further integrate constructed landforms with the surrounding landscape. Rehabilitation and landscape management strategies proposed for the Project are detailed in Section 5 and Appendix P.

***Soils***

*Erosion Control*

Erosion control strategies to be implemented for the construction and operational phases of the Project would be as per the existing IESCP (CHPL, 2007a).

The primary objectives of the IESCP are that:

- soil erosion and sediment generation from areas disturbed by mining and construction activities be controlled; and
- water quality (particularly in terms of total suspended solids content) in local watercourses be maintained to permitted standards.

The IESCP would be revised to include the Project disturbance areas. Specific mitigation measures to control soil erosion and sediment migration would include:

- review and approval of construction environmental management plans prepared by the contractors responsible for carrying out construction activities;
- minimising disturbance during all phases of the Project and restricting access to undisturbed areas;
- sequencing construction activities such that sediment control works are completed early in the construction phase;
- diversion of clean water around disturbance areas;
- rehabilitation/revegetation of mine infrastructure areas at the earliest possible stage;
- 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
- construction of collection drains, diversion drains and culverts to control surface runoff from access roads.

Additional erosion control measures for surface exploration activities would include:

- use of existing access tracks where practicable;
- minimising vegetation clearance as far as practicable;
- minimising soil disturbance;
- stripping and stockpiling topsoil;
- revegetating disturbed areas as soon as practicable following completion of drilling activities (i.e. after confirmation that no additional use of the drill site [i.e. re-drilling] would be required); and
- installation of temporary erosion and sediment controls (e.g. silt fences and sediment control structures) prior to disturbance, in accordance with the relevant standards and guidelines (e.g. *Managing Urban Stormwater* [Landcom, 2004]).

Earth bunds would be constructed to redirect clean surface water around drill pads and sumps. The bunds would also assist with minimising the potential for sediments, hydrocarbons and other chemicals to migrate to downstream watercourses.

Erosion and sediment control structures would be left in place until the potential for erosion and sedimentation is minimal. These controls would be regularly inspected and maintained.

*Soil Management*

A number of soil resource management strategies are currently implemented at the Cadia Valley Operations, including:

- formulation of stripping guidelines including nomination of appropriate depths, scheduling and locating areas to be stripped;
- progressive stripping of disturbance areas to optimise topsoil recovery;
- storage of topsoil in a manner which maintains the long-term viability of the resource;
- selective stockpiling of soil according to soil type (i.e. great soil group, topsoil or subsoil); and
- segregation of recovered soil based on seed content (i.e. native pasture area, native woodland area, improved pasture area).

Topsoil stockpiles are managed to maximise long-term viability through implementation of the following practices:

- Stockpiles are located outside of Project disturbance areas.
- Stockpiles are formed with a 'rough' surface to reduce erosion hazard, increase drainage and promote revegetation.
- Stockpiles are fertilised and seeded to maintain soil organic matter levels, soil structure and microbial activity.

These management measures would continue to be implemented for the Project.

Average stripping depths at the Cadia Valley Operations have ranged from 200 mm to 400 mm depending on the soil type and nature of infrastructure proposed on the area being stripped. Preliminary material balance calculations based on these Cadia Valley Operations stripping depths indicate an approximate topsoil volume of 5.9 $Mm^3$ (including existing soil stockpiles) would be available for rehabilitation of the Cadia Valley Operations disturbance areas (Appendix P). The preliminary material balance in Appendix P demonstrates there is sufficient soil available to meet the rehabilitation concepts described in Section 5 and Appendix P.

Stripping of soils from the cleared agricultural lands within the subsidence zone would be undertaken if the soils from these areas are suitable, and they are required for rehabilitation of the South Waste Rock Dump or other Project landforms.

Quantification of soil resources, stripping and re-application schedules and stockpiling inventories, would be included as part of the MOP.

***Land Contamination – Concentrate Pipeline***

Measures that would be used to minimise potential environmental impacts during the operation of the new concentrate pipeline would include:

- automatic cut-off valves for containment of potential leaks;
- encasing the pipeline in steel structures (with the capacity to contain leakage if the pipeline was to fracture before automatic cut-off valves were activated) at larger creek crossings (e.g. Cowriga Creek);
- pipeline would be thick-walled and buried with sacrificial anodes (for corrosion protection);
- leak detection mechanisms including automatic shutdown capability;
- regular pipeline inspections;
- pipeline operating procedures; and
- pipeline signage.

In the event of pipeline failure and leakage of concentrate slurry, the spill would be controlled, contained and cleaned-up in accordance with existing Cadia Valley Operations spill response procedures.

***Land Contamination – Other***

A number of hazard treatment and control measures are described in the following existing Cadia Valley Operations management documents and systems:

- Major Hazard Management Plan;
- Contractor Management Plan;
- IESCP;
- BMP;
- Chemalert (a system that contains details of chemicals stored on-site);
- Emergency Management Plan; and
- Farm Safety Management Plan and Farm Safety Manual.

These documents would be reviewed and revised as necessary to incorporate the Project.

The mitigation measures presented below to prevent or reduce the potential for contamination of land from spills/leaks of hazardous materials are drawn from the recommendations of the PHA. The measures include:

- Maintenance of mobile and fixed plant and equipment in accordance with the manufacturer's recommended maintenance schedule.
- Operator and driver training and (where appropriate) licensing for their job descriptions.
- Construction of all civil engineering structures in accordance with applicable codes, guidelines and Australian Standards.

- All contractors employed by CHPL would be required to operate in accordance with the relevant Australian Standards, NSW Legislation and CHPL's Contractor Management Plan.
- Storage and usage procedures for potentially hazardous materials (i.e. fuels and lubricants) would be developed in accordance with Australian Standards and relevant legislation.

***Bushfire Hazard***

The existing BMP would be revised as necessary to include the Project. The new revision would be prepared in consultation with relevant local bushfire brigades. The BMP includes details of training and emergency response procedures, a fuel management plan and an annual hazard reduction programme. The annual hazard reduction programme is prepared in consultation with the Canobolas Zone Bushfire Management Committee.

***Meteorological Monitoring***

The two on-site meteorological stations (SLB and Ridgeway Stations) would continue to be used to record temperature, relative humidity, solar radiation, barometric pressure, rainfall, evaporation, wind direction and wind speed in the vicinity of the Cadia Valley Operations.

The existing network of pluviometers would continue to be used to measure rainfall in the Swallow, Diggers and Cadiangullong Creek catchments, however pluviometers PV1A and PVLO (Figure 4-4) would be relocated outside of the Cadia East subsidence zone. Three additional pluviometers would be established in the Flyers Creek catchment to improve rainfall data capture.

***Geochemistry***

*Waste Rock*

PAF waste rock generated by the Project would be selectively handled and placed on the South Waste Rock Dump consistent with the current methodology employed for the existing mining operations (Section 2.1.5).

Relatively small volumes of waste rock material (e.g. approximately 11.4 Mt during the mine life) would be generated by the Project. The maximum quantity of waste rock to be mined in any one year of the Cadia East underground mine would be approximately 1 Mt (Table 2-5).

*Tailings*

Tailings generated at the Project would continue to be disposed of in the NTSF and STSF. A description of the proposed tailings management is provided in Section 2.8.

*Subsidence Zone and Zone of Influence*

The predicted changes to surface water and groundwater resources in the vicinity of the Cadia East subsidence zone and zone of influence are discussed in Sections 4.2 and 4.3.

## 4.2 GROUNDWATER

A Groundwater Assessment for the Project was conducted by AGE (2009) and was peer reviewed by Dr Noel Merrick, an internationally recognized hydrogeological expert. The Groundwater Assessment report is presented in Appendix G. A description of the hydrogeology of the Cadia Valley and surrounds is provided in Section 4.2.1. Section 4.2.2 describes the potential impacts of the Project on groundwater resources, while Section 4.2.3 outlines proposed measures to mitigate, manage and monitor the predicted effects.

The assessment was conducted in parallel and was integrated with the Project Surface Water Assessment conducted by Gilbert & Associates Pty Ltd (2009) (Appendix F).

### 4.2.1 Existing Environment

***Review of Existing Groundwater Monitoring and Hydrogeological Information***

A comprehensive review of existing geological and hydrogeological information, as well as relevant monitoring data and mapping, was undertaken by AGE as part of the Groundwater Assessment (Appendix G). The review included evaluation of the following:

- data collected from the existing Cadia Valley Operations groundwater monitoring network;
- information on local water bores and groundwater usage in the vicinity of the Cadia Valley Operations held by DWE;
- publicly available regional geological data;
- detailed local geological data held by the Newcrest South East Australia Exploration Group; and
- geographic information including aerial photography, satellite imagery, digital elevation models, geophysical, cadastral and hydrological data sets.

The review identified that CHPL holds a substantial amount of information on the groundwater levels and quality within the Cadia Valley, as well as the wider region. A sub-set of the available data was used in the Groundwater Assessment. It included the results of groundwater level monitoring in 46 bores and groundwater quality monitoring in 40 of these bores, with data collected from as early as 1994. Figure 4-6 shows the relevant monitoring bores within and surrounding the Cadia Valley. Historical groundwater contours for 1997 (pre-mining), 1999 (Cadia Hill only) and 2006 (Cadia Hill and Ridgeway) are presented in Figure 4-7. As illustrated on Figure 4-7, the piezometric surface on a regional scale has been relatively stable over time, with the exception of the steep zone of depressurisation that has developed locally around the Cadia Hill open pit and Ridgeway underground mine.

AGE's review of groundwater monitoring data identified that the coverage of monitoring bores was very good in the majority of the Cadia Valley, and that additional bores should be installed to the east of the Cadia East deposit towards Cadia Road and Flyers Creek. The review also identified that more information on groundwater users in the region should be compiled as part of the Groundwater Assessment for the Project.

In addition to the review of monitoring and geological data, AGE reviewed the substantial amount of hydrogeological and groundwater impact assessment work previously undertaken at the Cadia Valley Operations. This work includes the following:

- Chestnut and Corkery (1976) *Bathurst-Orange Growth Centre, Summary Report on Geological Factors Influencing Regional Planning*. Report prepared for Department of Mineral Resources.
- Coffey & Partners Pty Ltd (1981) *Cadia Project Orange, NSW, Mine Slope Stability and Groundwater Studies*. Volume 1.
- Woodward-Clyde (1995) *Water Quality and Water Management*. Appendix I, Cadia Gold Mine Environmental Impact Statement.
- Kalf & Associates (1995) *Review of Hydrological Studies by Woodward-Clyde*. Report prepared for the Cadia Hill Gold Mine Commission of Inquiry, 1995.
- Kalf & Associates (2000) *Ridgeway Project Groundwater Management*. Appendix B, Ridgeway Project Environmental Impact Statement.
- Kalf & Associates (2004) *Ridgeway Deeps Groundwater Model, Simulation Update and Hydraulic Impact of Mining to -500 m RL*.
- Aquaterra (2005) *Preliminary Assessment of Groundwater Inflows to the Cadia East Pit*.
- Washburn (2008) *Architecture of the Silurian Sedimentary Cover Sequence in the Cadia Porphyry Au-Cu District, NSW, Australia: Implications for Post-Mineral Deformation*, MSc Thesis, University of British Columbia (Vancouver).
- MESH (2009) *Cadia East Project Geochemical Characterisation of Mine Rock and Tailings*.
- GHD (2008) *Review of Surface Water and Groundwater Data*. 2007/2008 AEMR.

The previous hydrogeological investigations and impact assessment studies focused on the Cadia Hill and Ridgeway deposits (i.e. studies for the Cadia Hill and Ridgeway EISs). Both of these deposits are primarily situated within Ordovician rock units, with the Ridgeway deposit being overlain by 30 to 50 m of Tertiary basalt which 'caps' Ridgeway Hill and is found extensively to the north and north-east of the Cadia Valley. A detailed knowledge of the hydrogeological characteristics of these Ordovician and Tertiary basalt rock units has been generated through the pre-mining groundwater impact assessment studies (including pumping tests and groundwater modelling) and through operational experience at Cadia Hill and Ridgeway.

The Cadia East deposit is also hosted in Ordovician rock units and is partially overlain by a Tertiary basalt cap. However the deposit differs from Cadia Hill and Ridgway in that it is also overlain in parts by 100 to 300 m of Silurian sediments. The Cadia East mineralisation is discussed further in Section 2.2. AGE's review identified that with the exception of the Aquaterra (2005) study, there was relatively little information on the hydrogeological characteristics of the Silurian sediments. In order to gather more information about the Silurian sediments, a hydrogeological investigation programme was designed and conducted under AGE's supervision. In addition, the investigation resulted in the installation of eight bores to the east of the Cadia East deposit (Figure 4-6), at least five of which would be used as long-term monitoring bores.

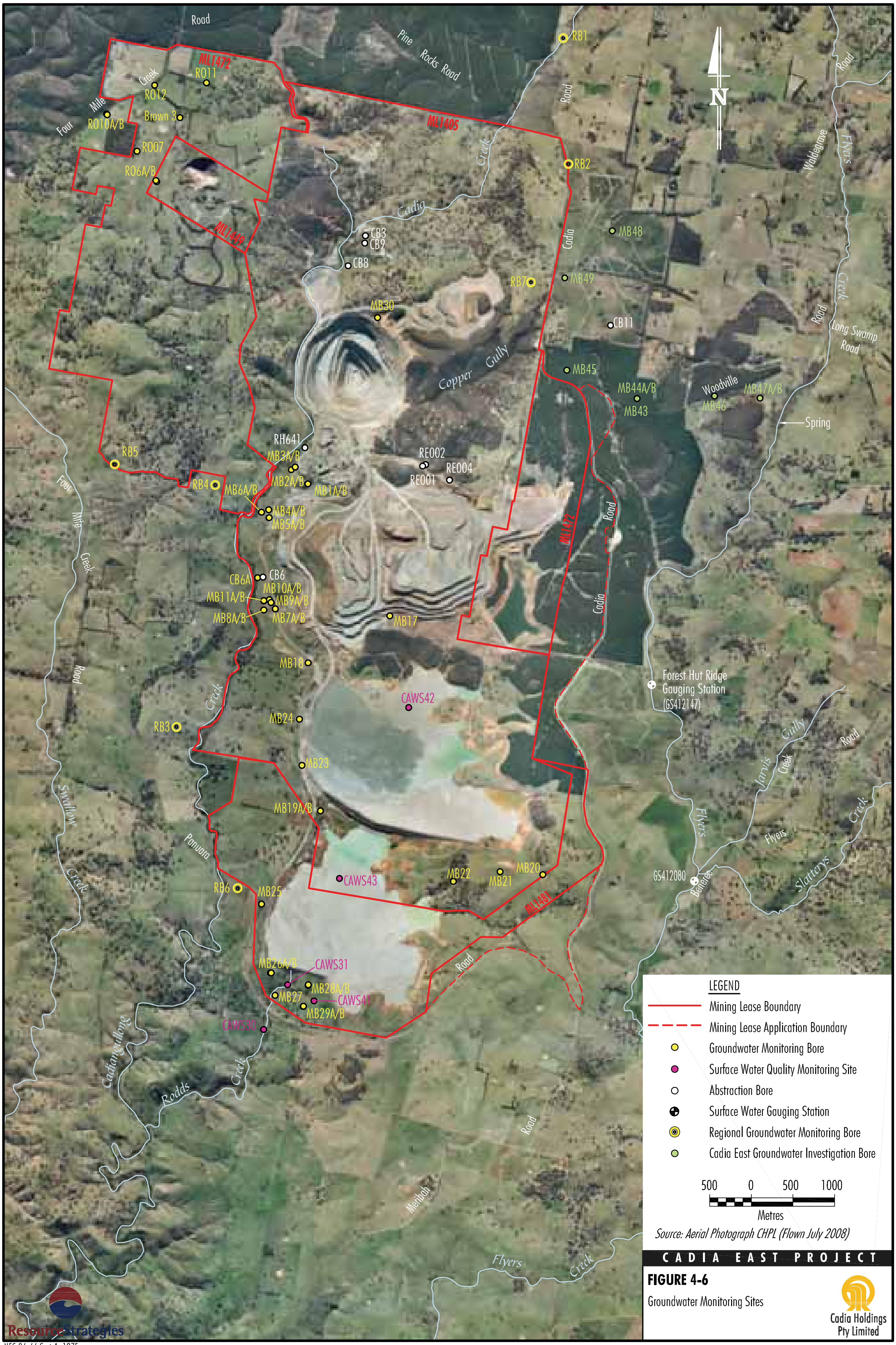
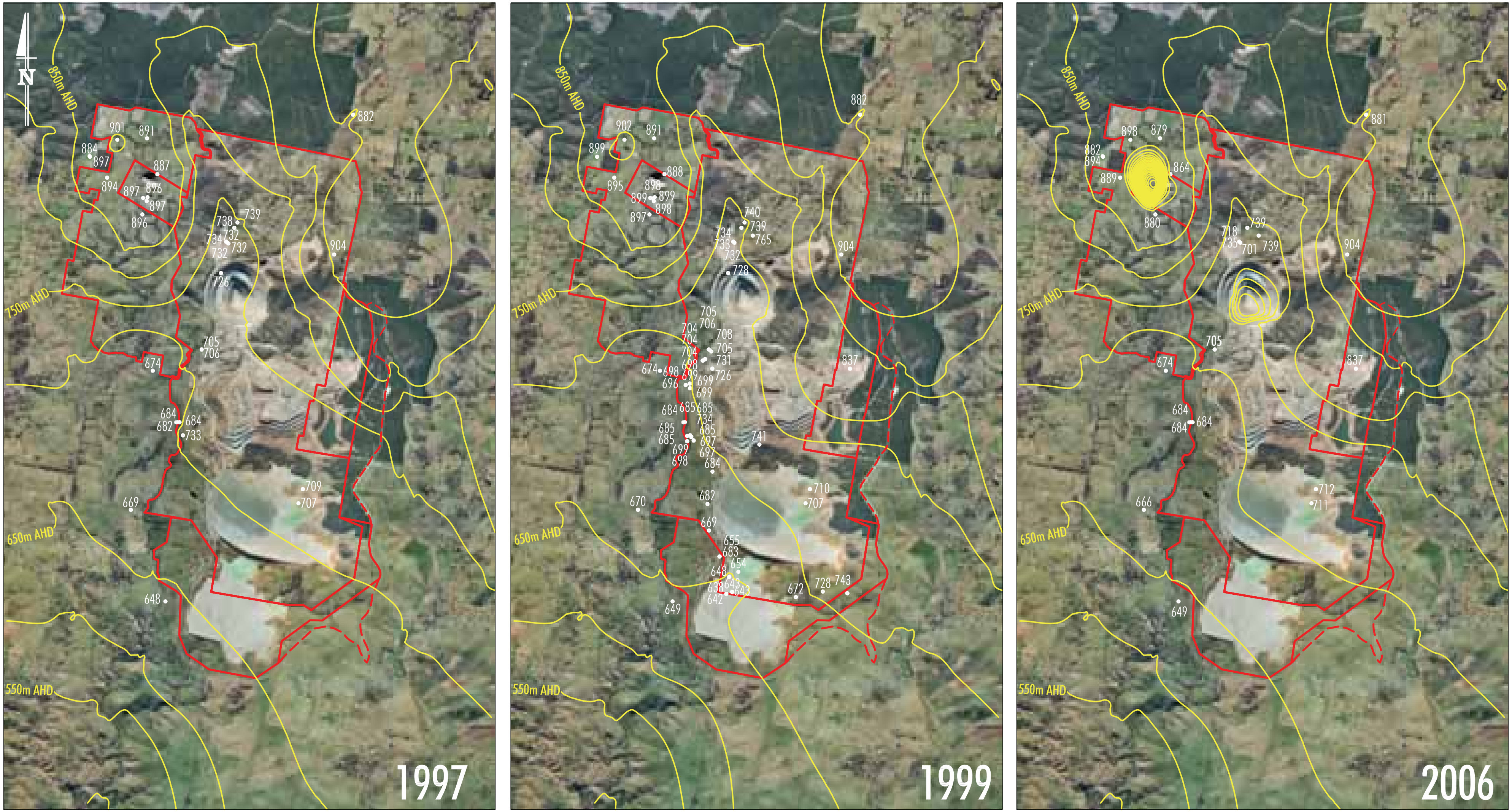



**FIGURE 4-6**

Groundwater Monitoring Sites




LEGEND

Mining Lease Boundary

Mining Lease Application Boundary

685 Measured Groundwater Level (m AHD)

Interpolated Groundwater Level (m AHD)

0 1 2 3 4 5

Kilometres

*Source: Aerial Photograph CHPL (Flown July 2008)*

CADIA EAST PROJECT

**FIGURE 4-7**

Historical Groundwater Levels

Cadia Holdings Pty Limited

ResourceStrategies

NEC-06-66 Sect 4_105C

***Cadia East Hydrogeological Investigation***

The field investigation component of the Groundwater Assessment was conducted in 2007 and 2008. The investigation included the following activities:

- installation of eight groundwater investigation/monitoring bores to depths of between approximately 47 and 182 m to augment the existing groundwater monitoring network and provide additional hydrogeological data;
- installation of a temporary pumping bore and commencement of a short-term pumping test to assess the hydraulic properties of aquifers, and their interaction with overlying strata;
- sampling and water quality analysis of monitoring bores to characterise aquifer water quality; and
- monitoring of groundwater levels to determine the existing hydrogeological regime (groundwater elevations, hydraulic gradients and direction of groundwater flow).

Figure 4-6 shows the location of the eight Cadia East groundwater investigation bores (MB44A/B, MB45, MB46, MB47A/B, MB48 and MB49) and the pumping test bore (MB43) in the area between Cadia Road and Flyers Creek. Figure 4-8 is a conceptual geological cross-section from the Cadia Hill open pit to the east of Flyers Creek showing the location of bores MB45, MB44A/B, MB46 and MB47A/B.

A description of the investigation programme, pumping test results, and the water sampling results is provided in Appendix G. AGE (2009) used the results of the investigation programme plus the existing information to develop a hydrogeological model of the Project area, and to develop and calibrate a numerical groundwater model that could simulate the potential impacts of the Project on the local and regional groundwater resources.

***Description of the Existing Hydrogeology***

AGE (2009) describes the groundwater resources in the Cadia Valley and surrounds based on the available hydrogeological and geological data (Appendix G). A summary is provided below.

Prior to the discovery of the Cadia Hill deposit in 1992, groundwater investigations of the area included studies by Chestnut and Corkery (1976) and Coffey & Partners Pty Ltd (1981). These studies were primarily focused on the occurrence of sub-surface waters in the Orange-Bathurst area, the hydrogeology of the Cadia Hill area and the hydrogeology of the Forest Reefs Gold Prospect (located approximately 8 km east-southeast of Cadia East) (CHPL, 2000b).

Detailed groundwater studies commenced in the vicinity of the Cadia Hill deposit in 1993 (Woodward-Clyde, 1995). These investigations included the drilling of a number of exploratory groundwater bores and the collection of a range of hydrogeological data from mineral exploration and resource identification drilling programmes. In 1995 a detailed groundwater resource evaluation was undertaken. The study involved the drilling of a number of test production and groundwater monitoring bores in the Cadia Hill area, groundwater pumping tests and the collection of groundwater samples for chemical analysis. Kalf & Associates (1995) conducted an independent review and evaluation of the findings of these studies.

The 1995 investigation identified a limited number of predominantly low yielding aquifer units within ML 1405. These were associated with underlying Ordovician basement rocks and included localised limestone units, fractured volcaniclastic and sedimentary units, stratigraphic unconformities and fractured intrusive units (Woodward-Clyde, 1995).

The 1995 investigation also identified the groundwater associated with Tertiary basalts to the north and north-east of ML 1405. Also in 1995, an assessment of the hydrogeology of the NTSF area was undertaken. Rock units intersected included volcanics and volcaniclastics and airlift yield data collected indicated that groundwater flow was primarily restricted to fractures and faults.

Since 1998 further detailed hydrogeological investigations have been conducted by Kalf & Associates (2000, 2004) at Ridgeway as well as the Rodds Creek catchment (where the NTSF, STSF and Rodds Creek Water Holding Dam are located). The groundwater drilling investigation results at Ridgeway indicated that some groundwater is contained in the elluvium (i.e. residual soil layer), however groundwater predominantly occurred within lower sections of the Tertiary basalt cap and within the fractured zones of the underlying Ordovician volcaniclastic rocks (CHPL, 2000b).

A summary of the features of the Tertiary basalt, Silurian sedimentary and Ordovician volcanic rock units and their associated aquifers is provided in the sub-sections below.


ResourceStrategies

CADIA EAST PROJECT

**FIGURE 4-8**
Conceptual East West Cross-Section

Cadia Holdings Pty Limited

NEC-06-66 Sect 4_128B.dwg

***Tertiary Basalt***

Tertiary basalt in the Orange region originated from Mount Canobolas and covers an extensive area to the north and north-east of the Cadia Valley Operations (Figure 4-1). The thickness of the basalt varies between a few metres and approximately 150 m (Appendix G). The Tertiary basalt contains what is known as the Orange basalt fractured rock aquifer. The Australian Natural Resources Atlas (2007) data indicates that groundwater within the Orange basalt fractured rock aquifer occurs at a depth of 20 m and is found in old weathered zones between successive flows, jointed areas and/or scoriaceous zones within the flows. The aquifer typically has low to moderate yields due to the fractured nature of the permeability. Discharge from the aquifer occurs through groundwater discharge (baseflow) to creeks and springs, abstraction from bores, and through percolation into underlying fractured rock formations.

AGE's review of the DWE's database of registered bores indicated that approximately 960 bores have been drilled in the Orange basalt fractured rock aquifer since 1952. The dominant groundwater use is stock and domestic, with some irrigation undertaken where bore yields are higher. A total of 7,684 ML of the estimated sustainable yield of 17,000 ML has been allocated by the DWE. The review of the DWE's database also indicated that the median yield is approximately 1.25 L/s, with 96% of bores having yields of less than 10 L/s (Appendix G).

Tertiary basalt is present in the north-eastern portion of the Cadia East subsidence zone (Figure 4-1). It was also intersected during the 2007/2008 hydrogeological investigation in bores MB43, MB44A, MB44B, MB45 and MB49, which are located to the east and north of the deposit (Figure 4-6). The drilling logs for these bores, and the available magnetic geophysical data indicates that there is a basalt filled palaeochannel located primarily along the ridges to the north and east of the Cadia East subsidence zone (Appendix G).

Kalf & Associates (2000) undertook hydraulic testing in the Tertiary basalt aquifer at Ridgeway. The testing indicated a hydraulic conductivity range of $2 \times 10^{-6}$ m/s (0.17 metres per day [m/day]) to $1 \times 10^{-5}$ m/s (0.86 m/day) with an average value of $8 \times 10^{-6}$ m/s (0.69 m/day).

AGE's review of the available water quality data indicate that groundwater from the Tertiary basalt aquifer in the vicinity of the Cadia Valley Operations is of good quality with a low salinity and low concentrations of trace elements. Groundwater from the wider Orange plateau area is known to be used untreated for potable use by some landholders (Appendix G). Table 4-3 summarises the water quality attributes of Tertiary basalt aquifer groundwater samples taken from monitoring bores MB44B and MB49 (Figure 4-6) in October 2007 and January 2008.

***Silurian Sediments***

The Silurian rock units in the Orange region are shallow to deep water low energy sediments deposited in the Cowra Trough in the early Silurian period. The Silurian sediments are subdivided into the Ashburnia Group and the overlying Waugoola Group. Only scattered remnants of a much larger Silurian basin remain in the region (Figure 4-1). Pogson and Watkins (1998) report the combined thickness of the Ashburnia and Waugoola Groups to be up to about 250 m thick to the south-west of Orange.

Exploration drilling of the Cadia East deposit has typically intersected between 100 m and 300 m of Silurian sediments, with an average depth of about 100 m where it occurs (Figure 4-1). The exception is a single exploration drill hole to the north-east (NC599) which intersected about 1,000 m of Silurian sediments overlying Ordovician volcaniclastics. Drill hole NC599 indicated the presence of a substantial Silurian basin north-east of the Cadia East deposit. This basin is interpreted by the Newcrest South East Australia Exploration Group to have formed in a complex graben zone of which the western margin is a fault zone. This fault zone is referred to as the Warrengong Fault, and is located to the east of the proposed Cadia East underground mine (including the subsidence zone). It is considered to be extensive along a north-south axis, although it has not been accurately mapped to date (Appendix G). Figures 4-1 and 4-8 show the inferred location of the Warrengong Fault in plan and cross-section.

**Table 4-3**
**Tertiary Basalt Aquifer Water Quality (Bores MB44B and MB49)**

| Analyte | Unit | MB44B* | MB49* |
|---|---|---|---|
| pH | - | 7.7 | 6.4 |
| Electrical Conductivity (EC) | µS/cm | 310 | 283 |
| Total Dissolved Solids (TDS) | mg/L | 290 | 228 |
| Chloride (Cl) | mg/L | 11 | 5.2 |
| Sulphate ($SO_4$) | mg/L | 23 | 2 |
| Carbonate ($CO_3$) | mg/L | <2 | <1 |
| Bicarbonate ($HCO_3$) | mg/L | 110 | 138 |
| Calcium (Ca) | mg/L | 13 | 22 |
| Magnesium (Mg) | mg/L | 10 | 10 |
| Sodium (Na) | mg/L | 30 | 16 |
| Potassium (K) | mg/L | 4 | 5 |
| Arsenic (As) | mg/L | 0.003 | <0.001 |
| Cadmium (Cd) | mg/L | 0.00012 | <0.0001 |
| Chromium (Cr) | mg/L | 0.007 | <0.001 |
| Copper (Cu) | mg/L | 0.01 | <0.001 |
| Lead (Pb) | mg/L | 0.017 | <0.001 |
| Silver (Ag) | mg/L | <0.001 | <0.001 |
| Zinc (Zn) | mg/L | 0.057 | 0.043 |
| Iron (Fe) | mg/L | 18 | 1.86 |
| Mercury (Hg) | mg/L | <0.0001 | <0.0001 |
| Ammonia Nitrogen ($NH_4$-N) | mg/L | 0.40 | <0.010 |
| Nitrite + Nitrate as N | mg/L | 0.26 | <0.010 |
| Total Kjeldahl Nitrogen as N (TKN) | mg/L | 0.7 | <0.1 |
| Total Phosphorus as P | mg/L | 0.69 | 0.08 |

Source: Appendix G.

* Refer to Figure 4-6 for location of groundwater monitoring sites.

µS/cm = microSiemens per centimetre.

mg/L = milligrams per litre.

The following Silurian rock types have been observed in exploration drill holes at Cadia East:

- upper sandstone, consisting of interbedded siltstone, sandstone and a massive sandstone unit;
- lower siltstone; and
- a basal unit which is a locally variable, relatively thin, boulder conglomerate, calcirudite limestone, or red siltstone.

Aquaterra (2005) drilled four test holes in the area of the previously proposed Cadia East open pit in 2004 targeting the Silurian sediments. Airlift testing data was used to estimate the hydraulic conductivity of the rock mass and indicated a range of $2 \times 10^{-9}$ to $4 \times 10^{-7}$ m/s with a relatively low average of $4 \times 10^{-8}$ m/s (0.0035 m/day).

As part of the hydrogeological investigation undertaken for the Groundwater Assessment (Appendix G), a short-term constant rate pumping test was undertaken in bore MB43. AGE analysed the pumping test data using the Cooper-Jacob method for confined aquifers and calculated that the Silurian sediments had a transmissivity of about 1 square metre per day ($m^2$/day). Assuming an aquifer thickness of 200 m, this is equivalent to a hydraulic conductivity of $5.7 \times 10^{-8}$ m/s (0.005 m/day), which is similar to the Aquaterra (2005) average for the Silurian sediments of 0.0035 m/day.

Slightly higher hydraulic conductivity values were determined by AGE using falling head tests in three of the 2008 monitoring bores constructed in the Silurian sediments (MB46, MB47B, MB48) ranging from 0.07 m/day to 0.18 m/day (Appendix G).

The data suggests that the hydraulic conductivity of the Silurian sediments is typically relatively low, however in areas where fractures are closely spaced hydraulic conductivities can be locally higher (Appendix G).

Recharge to the Silurian sediments is expected to occur via direct rainfall infiltration at the surface and leakage from the overlying Tertiary basalt (Appendix G). The leakage rate from the Tertiary basalt aquifer into the underling Silurian sediments is expected to be controlled by the nature of the contact between the two formations. In the palaeochannel to the north-east of the Cadia East deposit, the base of the channel was observed by AGE to be typically filled with up to about 10 m of clay sediments that would limit the rate of groundwater leakage between the two formations (Appendix G). Outside the palaeochannel area where the Tertiary basalt is deposited directly on the Silurian surface, the hydraulic connection is expected to be more direct (Appendix G).

Groundwater discharge occurs predominantly to creeks incised into the Silurian sediments including Copper Gully, Flyers Creek and Rodds Creek (Appendix G).

Baseflow in Flyers Creek is partially maintained by an area of springs approximately 1,200 m downstream of Long Swamp Road (Figure 4-6). Gilbert & Associates (2009) identified an individual spring in this area with an estimated flow of about 20 L/s in autumn 2007 (Appendix F). Monitoring bores MB47A/MB47B are located approximately 300 m to the north-west of the spring zone and were located to provide data on the Silurian strata which feed the springs (Appendix G).

The available water quality data for the Silurian sedimentary aquifer is shown in Table 4-4. AGE's analysis of the data indicated that the groundwater in the Silurian sediments had a relatively low salinity. However the salinity of the groundwater was found to increase along the flow path from the elevated areas to the north-east of the Cadia East deposit towards the lower lying land in the west near the existing Cadia Hill open pit. Monitoring bore MB48 (974 m AHD) reported an EC of 294 µS/cm increasing to 787 µS/cm in CE60 (856 m AHD) which is located approximately 3.3 km to the south-west. This trend was not observed from the ridgeline to the east of the mine moving towards Flyers Creek in the east, where the water quality remained relatively fresh (Appendix G).

***Ordovician Volcanics***

The Forest Reefs Volcanics are the major Ordovician rock units in the Cadia East area. They are exposed in the central portion of the proposed subsidence zone (Figure 4-1). Kalf & Associates (2000) undertook pumping tests on three bores constructed in the Ordovician volcanics at Ridgeway. Based on the pump tests, the hydraulic conductivity was estimated to be in the range 0.01 m/day to 0.16 m/day using a fully confined analysis method and between 0.02 m/day and 0.3 m/day for a leaky confined analysis. In latter numerical modelling conducted for Ridgeway Deeps, Kalf & Associates (2004) adopted a much lower uniform hydraulic conductivity of 0.001 m/day for the Ordovician aquifer with storativity set at $4 \times 10^{-3}$. On a regional scale the hydraulic conductivity and transmissivity of the Ordovician volcanics is relatively low (Appendix G).

Recharge to the Ordovician aquifer occurs via direct rainfall infiltration at the surface and leakage from overlying Tertiary basalt and Silurian aquifers (Appendix G). Pumping tests undertaken by Kalf & Associates (2000) for Ridgeway showed leakage between the Tertiary basalt and the underlying Ordovician aquifer. AGE suggests that groundwater discharge from the Ordovician volcanics occurs predominantly via baseflow into local creeks (i.e. Swallow Creek, Cadiangullong Creek and the southern section of Flyers Creek) (Appendix G).

AGE's analysis of the available Ordovician volcanic aquifer monitoring data indicates that salinity varies between 500 mg/L up to a maximum of approximately 9,500 mg/L (Appendix G). Most bores in the Ordovician aquifer report a brackish water quality with an EC ranging from 2,000 to 5,000 µS/cm. In general, the Ordovician groundwater has a higher salt content than the groundwater in the Tertiary basalt and Silurian aquifers and is generally non-potable and only suitable for limited stock watering (Appendix G).

Low yields and variable water quality limit the number of groundwater bores constructed in the Ordovician volcanics (Appendix G).

**Table 4-4**
**Silurian Sedimentary Aquifer Water Quality**

| Analyte | Unit | CE058* | CE060* | MB44A* | MB46* | MB47A* | MB47B* | MB48* | Flyers Creek Spring*[1] |
|---|---|---|---|---|---|---|---|---|---|
| | | 2004 | 2004 | Jan 08 | Nov 07 | Nov 07 | Nov 07 | Oct 07 | May 07 |
| pH | - | 7.87 | 8.1 | 7.15 | 7.87 | 7.15 | 7.81 | 6.72 | 7.6 |
| EC | µS/cm | 762 | 787 | 264 | 280 | 355 | 383 | 294 | 490 |
| TDS | mg/L | 976 | 1050 | 177 | 324 | 332 | 305 | 220 | - |
| Cl | mg/L | 18 | 80 | 7.3 | 13.3 | 2.8 | 3 | 7.8 | 3.3 |
| $SO_4$ | mg/L | 433 | 172 | 5 | 8 | 3 | <20 | 16 | 1.4 |
| Hydroxide Alkalinity | mg/L | - | - | <1 | <1 | <1 | <1 | <1 | - |
| Carbonate Alkalinity | mg/L | - | - | <1 | <1 | <1 | <1 | <1 | <2 |
| Bicarbonate Alkalinity | mg/L | 195 | 137 | 112 | 117 | 215 | 165 | 115 | 250 |
| Total Alkalinity | mg/L | - | - | 112 | 117 | 215 | 165 | 115 | - |
| Ca | mg/L | 118 | 87 | 21 | 20 | 70 | 50 | 9 | 81 |
| Mg | mg/L | 40 | 27 | 10 | 13 | 7 | 6 | 20 | 7.8 |
| Na | mg/L | 65 | 41 | 13 | 15 | 8 | 9 | 13 | 8.2 |
| K | mg/L | 27 | 4 | 3 | 3 | 2 | 3 | 2 | 2.1 |
| As | mg/L | - | - | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | - |
| Cd | mg/L | - | - | <0.0001 | <0.0001 | 0.0003 | <0.0001 | <0.0001 | - |
| Cr | mg/L | - | - | <0.001 | 0.001 | <0.001 | <0.001 | <0.001 | - |
| Cu | mg/L | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.002 |
| Pb | mg/L | - | - | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | - |
| Ag | mg/L | - | - | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | - |
| Zn | mg/L | 0.732 | 0.115 | 0.048 | 0.015 | 0.006 | <0.005 | 0.042 | <0.005 |
| Fe | mg/L | 0.2 | <0.1 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | 0.14 |
| Hg | mg/L | - | - | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | - |
| $NH_4$-N | mg/L | - | - | 0.098 | 0.022 | <0.010 | 0.014 | <0.010 | - |
| Nitrite + Nitrate as N | mg/L | 0.02[2] | 0.22[2] | <0.010 | <0.010 | 0.321 | 0.268 | <0.010 | 0.3[2] |
| TKN | mg/L | - | - | <0.1 | <0.1 | <0.1 | 0.5 | <0.1 | - |
| Total Phosphorus as P | mg/L | - | - | 0.11 | 0.07 | 0.39 | 1.21 | 0.36 | - |

Source: Appendix G.

* Refer to Figure 4-6 for location of groundwater monitoring sites.

1 Provided for comparative purposes.

2 Sample tested for nitrate only.

***Rodds Creek Hydrogeology***

A description of the topography and hydrogeology of the Rodds Creek catchment was provided by Kalf & Associates (2000) as a component of the groundwater assessment for Ridgeway (CHPL, 2000b).

Prior to the construction of the existing STSF, NTSF and Rodds Creek Water Holding Dam the pre-mining topography of the Rodds Creek catchment was generally undulating to the south and hilly to the north. The northern half of the Rodds Creek catchment area is underlain by Silurian age shales, siltstones and mudstones while the southern half is underlain by Ordovician volcanics. Prior to construction of the tailings storage facilities, exposures of the basement rock were evident along the creek bed. Kalf & Associates (2000) described the exposures as showing some evidence of fracturing, but that they were for the most part limited at depth. The basement rocks are overlain in elevated areas by a relatively thin layer of Tertiary basalt. The basement rocks are partly overlain by Quaternary elluvial, colluvial and alluvial soils (Kalf & Associates, 2000).

Groundwater occurs within both the unconsolidated soil and sediment pore spaces and in isolated fractures within the basement Silurian and Ordovician rocks. Localised groundwater seepages were recorded by Kalf & Associates (2000) as occurring as swampy terrain or as ponded surface water. Seepages were known to occur during sustained wet periods at locations where the shallow fractured rock was exposed. These seepages occurred primarily along or near the drainage lines where the topography fell below the surrounding watertable and/or where groundwater flows occurred at the base of the soil profile and above the underlying basement as perched flow (Kalf & Associates, 2000).

Based on observation and drilling data, it is known that the bulk of the underlying basement rock within the Rodds Creek catchment has a low permeability (Appendix G). Kalf & Associates (2000) described this low permeability as contributing to the limited occurrence of surface seepages within the Rodds Creek catchment by restricting vertical percolation into the underlying basement rocks.

In 2008 CHPL commissioned separate studies by GHD and AGE into potential seepage from the STSF, in particular the water quality at surface and groundwater monitoring sites downstream of the embankment. The findings of both studies were reported in the 2007/2008 AEMR.

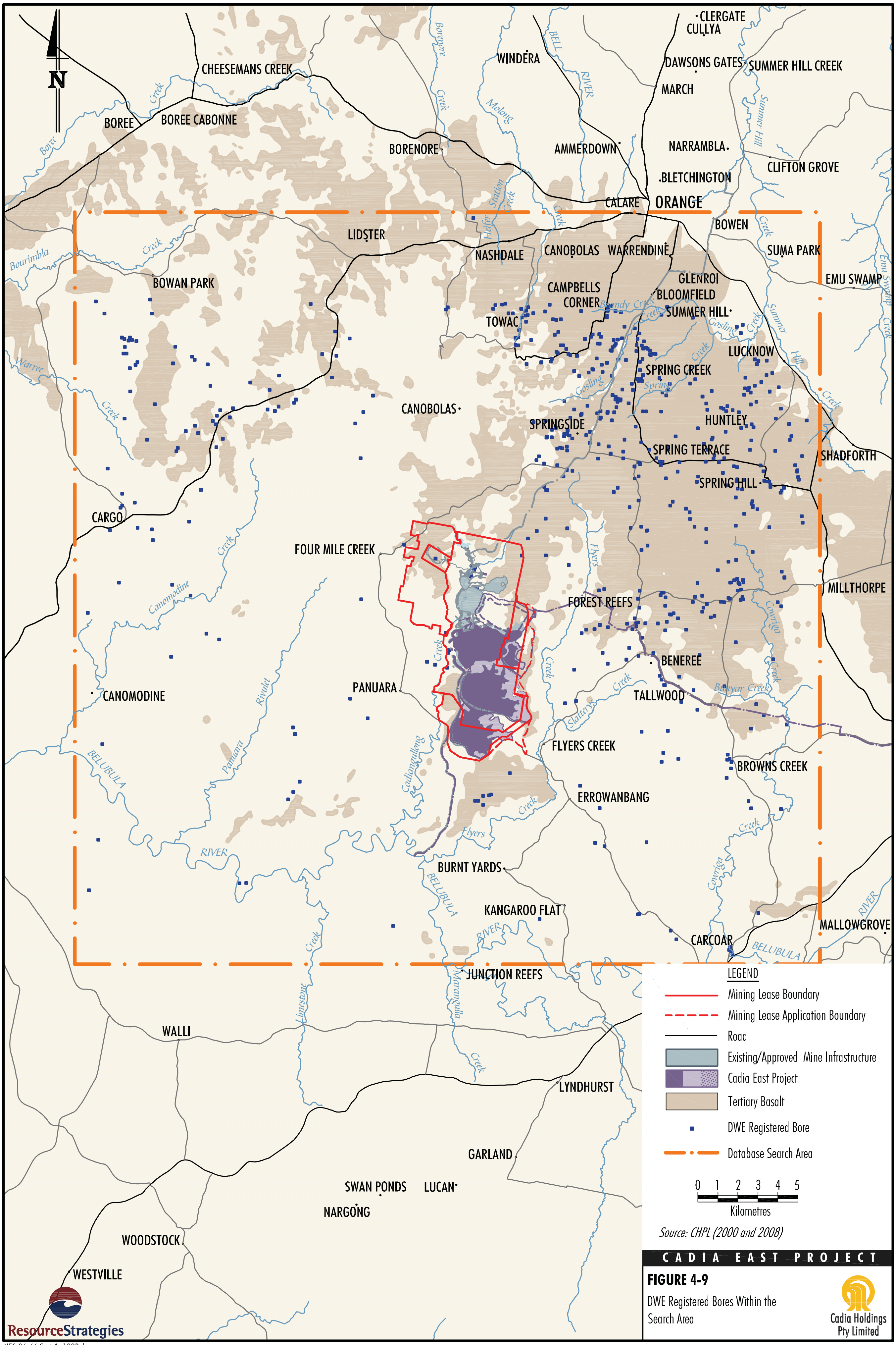
The scope of the 2008 GHD study included comparing the data collected during the reporting year (i.e. 1 July 2007 to 30 June 2008) against historic and baseline data in order to identify significant changes and developing trends. The 2008 AGE review involved an evaluation of water quality data from the STSF seepage collection pond and weir (i.e. CAWS31 and CAWS41), water samples collected from a site within the STSF (CAWS43), and samples from several groundwater monitoring bores downstream of the STSF (i.e. MB26A/B, MB27, MB28A/B, MB29A/B) (Figure 4-6).

GHD observed rising trends in EC, calcium, sodium, sulphate and chloride at the Rodds Creek monitoring site CAWS30, with a recorded EC value of 1,750 µS/cm in December 2007, and recorded values of 96 mg/L for sodium and 174 mg/L for chloride in a sample collected in June 2008. A continuing decreasing trend in pH was also observed, although it remained slightly basic.

GHD noted that the rising trends at CAWS30 appeared to be closely related to the rising trends observed at the STSF seepage collection pond (i.e. CAWS31) (Figure 4-6). AGE found that water quality in the seepage collection pond and weir (i.e. CAWS31 and CAWS41) was likely to be a mixture of water from the STSF and natural groundwater. AGE also noted that although seepage volumes appeared to be low, the monitoring data indicated slowing rising water levels, which could indicate that seepage volumes could increase over time.

***Groundwater Use***

A search of the DWE database of registered bores was used by AGE to locate bores within the vicinity of the Project (Appendix G). The search area covered a 30 km x 30 km area and showed 646 water bores listed in the database, with the majority (i.e. 66%) shallower than 60 m. Approximately one third of the bores identified by AGE were located more than 15 km from Cadia East deposit and over 90% of them were located more than 5 km away. Within a 3 km radius, only CHPL-owned bores were found to occur. Figure 4-9 shows the location of the DWE registered water bores within the AGE search area, as well as the regional occurrence of the Tertiary basalt.




CADIA EAST PROJECT

**FIGURE 4-9**

DWE Registered Bores Within the Search Area

NEC-06-66 Sect 4_129B.dwg

The average depth of bores was found to decrease significantly with distance from the Cadia Valley Operations. This was explained by the presence of deeper bores drilled at the Cadia Valley Operations that increase the average (Appendix G). As the distance from the mine increases so does the number of shallower water bores that "dilutes" the influence of the mine bores. This indicates that the majority of the water bores outside of the mine site are shallower than 60 m and therefore they would be unlikely to intercept deep aquifers (Appendix G).

In order to verify the occurrence of groundwater bores within the vicinity of the Project, a bore census was undertaken in early 2007 and late 2008/early 2009 (Appendix G). Details of 93 bores were collected during the census. Where the owner of the bore was able to be contacted, and gave permission, the water level was measured and the available bore age, construction, yield and water usage information was recorded (Appendix G).

In addition to the bore inspections, a review and inspection of groundwater seepage areas, spring fed dams and springs was conducted in the upper headwaters of Cadia and Flyers Creeks in March and April 2009. The inspections focussed on the area to the north-east of the Project based on the preliminary findings of the groundwater modelling (Appendix G), which indicated that groundwater drawdown could potentially occur in this upper catchment area. Where the owner was able to be contacted and gave permission to access the property, the following parameters were recorded: location, water level, flow measurements (where practicable), water quality and use (Appendix G).

### 4.2.2 Potential Impacts

The panel caving mining method would result in the formation of a zone of broken rock (caving zone) that would gradually extend from the Cadia East underground mine through the overlying host rock and eventually break through to the surface in approximately 2018. The voids created by the mine workings and subsidence zone would significantly increase the permeability of this material. Groundwater stored in and adjacent to the Silurian sediments, Ordovician volcanics and overlying Tertiary basalt within the caving zone would flow downward towards the open mine workings. Waters entering the mine workings would be pumped to the surface for use in the ore processing facilities (Section 2.10.2).

The drawdown of groundwater would initially affect only the material immediately above the orebody (due to the low Ordovician host rock permeability). However, as the upward fracturing continues, and the caving zone extends towards the surface, the drawdown effect would also extend upwards and outwards (i.e. radial groundwater inflow would occur from rocks immediately adjacent to the caving zone). Some inflow into the declines and ventilation shafts would also occur.

Once the caving zone reaches the surface in approximately 2018, mine inflows would also include surface flow from the remaining portion of Copper Gully and rainfall infiltration in the subsidence zone. The percentage of rainfall that infiltrates and passes through the subsidence zone has been modelled by AGE at 40% (Appendix G).

Numerical groundwater modelling was undertaken by AGE in order to predict the magnitude of the drawdown impacts on local and regional aquifers during mining operations (medium-term) and following mine closure (long-term). The impact assessment was made by comparing the results of five steady state models (Appendix G). The five models represented the following key Project development times and hydrogeological changes:

- Model I – groundwater regime prior to development of the Cadia Valley Operations.
- Model II – existing Cadia Valley Operations at their maximum approved extent.
- Model III – existing Cadia Valley Operations and the Project at full development.
- Model IV – recovery following completion of the Project and the existing Cadia Valley Operations (with full/saturated NTSF and STSF).
- Model IVa – recovery following completion of the Project and the existing Cadia Valley Operations (with dry/de-saturated NTSF and STSF).

Steady state modelling provides conservative estimates of potential impacts during operations (i.e. through comparison of Model II and Model III). It is conservative due to the assumption that the stresses on the groundwater regime such as the boundary conditions representing the mine structures are in place ad infinitum. In reality this would not be the case and stresses on the groundwater regime would only be active for the life of the Cadia East underground mine (i.e. 21 years) which would limit the spatial extent to which the impacts would occur in comparison to the model predictions (Appendix G).

Model III is considered by AGE to be additionally conservative as it included simultaneous dewatering of the Cadia East underground mine plus dewatering of the Ridgeway underground mine and the Cadia Hill open pit (Appendix G). Ridgeway is currently scheduled to be completed in 2017 at which point dewatering would cease and groundwater levels in the vicinity of the underground mine would begin to recover. Operations at the Cadia Hill open pit are currently scheduled to cease in 2013, however pit dewatering is expected to continue through the Project life due to potential safety issues associated with a partially filled void in close proximity to the active Cadia East underground mine.

All five models excluded geological structures such as faults. This was due to the variable amount of hydrogeological information on the faults which occur in the modelled area (i.e. relatively good information in the existing orebodies, and poor information in the wider region), plus the extra level of complexity and computing time that would be involved in including geological structures.

The exclusion of faults is considered by AGE to add to the conservatism of the assessment (Appendix G), as it is likely that at least some of these faults would compartmentalise the aquifers. In particular, the generally north south orientation of the Warrengong fault (Figure 4-1 and Figure 4-8) is such that it could represent a significant barrier to groundwater flow towards the mine from the east and north-east. This would reduce the impact of the mine on groundwater levels and stream baseflow in these areas (which is where the majority of groundwater users occur). To test this, a model sensitivity analysis was conducted by AGE which included the Warrengong fault as a flow barrier. The sensitivity analysis showed a significant reduction in the predicted amount of baseflow loss (Appendix G).

***Predicted Changes to Regional Groundwater Levels during Operations***

A plan showing the difference between the modelled groundwater levels for the existing approved Cadia Valley Operations at their full extent (i.e. Model II) and the Project at full development (i.e. Model III) is provided in Figure 4-10. The contours represent the maximum predicted Project-induced changes to groundwater levels during operations. In areas where the groundwater levels are lowered (i.e. drawdown) the contours have positive values, and in areas where groundwater levels rise (i.e. mounding), the contours have negative values.

The predicted Project-induced drawdown effect from the Cadia East subsidence zone heading north-northeast is directly related to the higher hydraulic conductivity in this area, mostly coming from the Tertiary basalt. As indicated on Figure 4-10, the predicted impacts are generally contained within the upper Cadiangullong Creek and Cadia Creek area, and the upper Flyers Creek area above the Forest Hut Ridge gauging station.

Figure 4-10 shows that the groundwater levels below the NTSF and STSF and the Rodds Creek Water Holding Dam would increase due to the raising of the embankment heights. The remainder of the contours on Figure 4-10 show that groundwater levels would decline, and marked declines would occur directly above the Cadia East subsidence zone. The modelling also showed some minor changes in groundwater level at the surface near Ridgeway (Figure 4-10), these were considered by AGE to most likely be due to impacts at depth where both mines are dewatering, propagating up through the model layers (Appendix G). This modelled effect is conservative as Ridgeway is currently scheduled to cease operation in 2017, whereas the model assumes it is still operating at the end of the Project mine life (i.e. 2030) (Appendix G).

***Predicted Changes to Regional Groundwater Levels Following Mine Closure***

After mining and mine dewatering ceases the final void created by the Cadia Hill open pit and void created by the Cadia East underground mine and subsidence zone would begin to fill with water (Appendix G). The voids would receive water from direct rainfall, from any runoff from the above catchment (i.e. the remaining small section of Copper Gully) and through groundwater inflow induced by the hydraulic head gradient towards the voids. Some water would be lost through evaporation from the Cadia Hill open pit waterbody from the outset. Water would also be removed from the Cadia East subsidence zone waterbody once the groundwater level recovers to a point where it is above the broken rock in the subsidence zone (approximately 665 m AHD).

Modelling of the final void water balance was undertaken by Gilbert & Associates (2009) using an analytical approach taking into account the following inputs:

- rainfall runoff from catchments;
- direct rainfall to the void lake;
- evaporation losses; and
- groundwater inflows (sourced from testing the groundwater flow model).

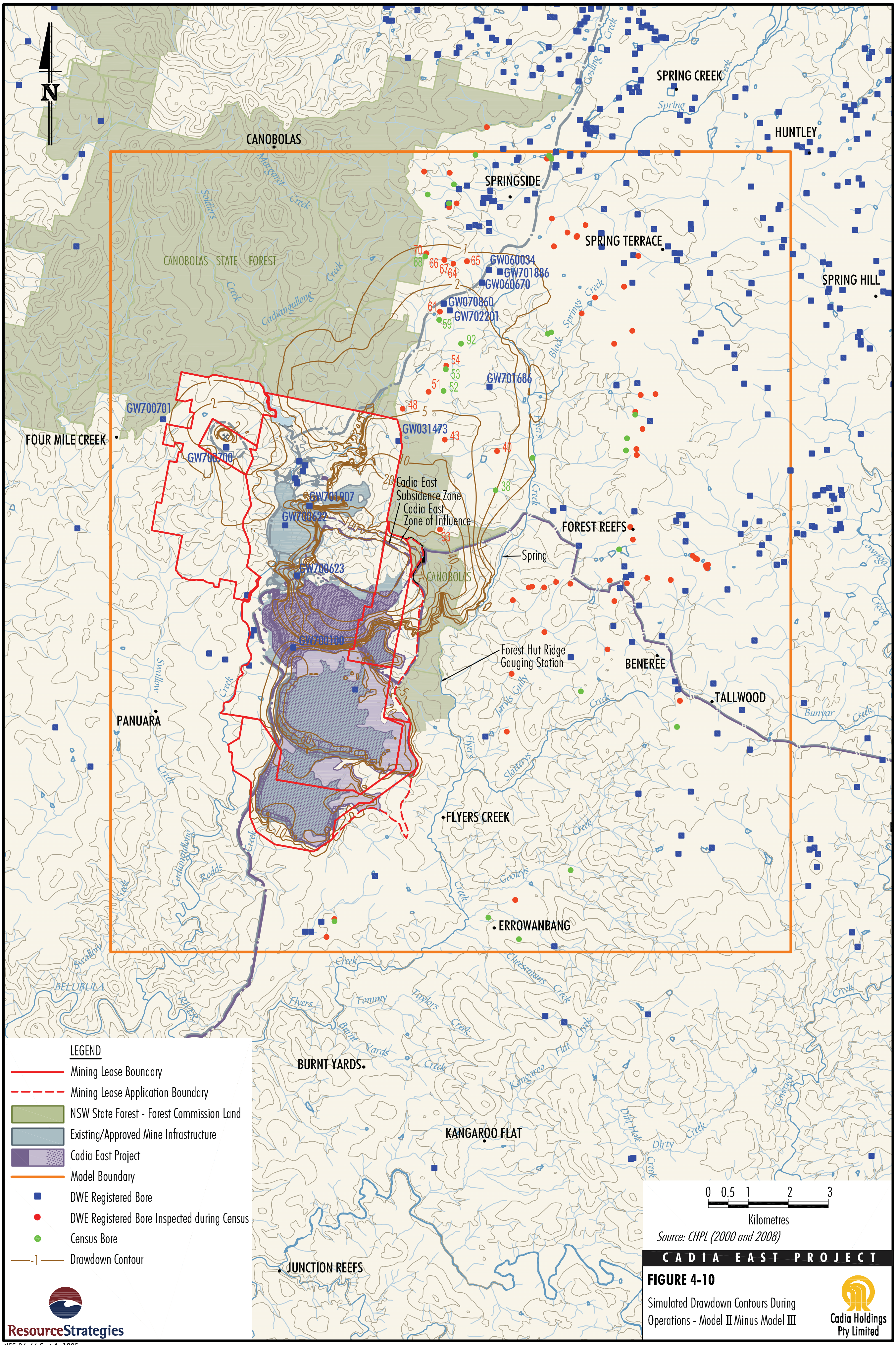



**FIGURE 4-10**

Simulated Drawdown Contours During Operations - Model II Minus Model III

NEC-06-66 Sect 4_130E

Based on these inflow estimates, Gilbert & Associates (2009) estimated that it would take approximately 150 to 160 years for the caving zone to fill with groundwater and a further period of approximately 170 years (i.e. a total of approximately 330 years) for a waterbody to reach equilibrium in the surface subsidence zone (Figure 4-11). The predicted final equilibrium level is approximately 670 m AHD, which is some 45 m below the level of Cadiangullong Creek (Appendix F). Figure 4-12 is a conceptual long section of the Cadia Hill open pit and the Cadia East subsidence zone after the water levels in the final void have reached equilibrium.

A plan showing the difference between the modelled pre-mining groundwater levels (i.e. Model I) and the Project following mine closure and after the tailings have desaturated (i.e. Model IVa) is provided in Figure 4-13.

When the predicted 'full development' and post mining drawdown contours are compared (i.e. Figure 4-10 and Figure 4-13) it is evident that the post–mining recovery is only marginal. This is due to the groundwater level in the final Cadia East subsidence zone not fully recovering to its pre-mining level (i.e. the subsidence zone creates a permanent low point or 'groundwater sink' which continues to cause a drawdown effect).

***Predicted Impacts of Groundwater Users***

Potential impacts of the Project on existing groundwater users were assessed by examining the predicted water levels at the known locations of groundwater bores. Figure 4-10 and Figure 4-13 show the predicted Project-induced drawdown contours and known bores in the vicinity of the Project during operations and post-mining, respectively. As described in Section 4.2.1, bores were identified by AGE through searches of the DWE database and a bore census (Appendix G).

Table 4-5 presents the simulated drawdown for each of the identified bores with greater than 1 m predicted drawdown. Bores in which the numerical model predicted drawdown to be less than 1 m were considered by AGE to not be significantly affected, as the recorded natural variation in regional monitoring bores (i.e. RB1, RB2, RB3, RB4, RB6 and RB7) is between 2 and 5 m, and most bores are constructed to allow for seasonal fluctuations in excess of 1 m (Appendix G).

Based on the conservative modelling, 23 privately owned bores could experience drawdown of more than 1 m (Appendix G). The largest predicted drawdown is 44.24 m, however it is important to note this bore was installed recently (i.e. July 2008) and is not currently in use, although the owner has indicated that he intends to use it in the future for stock watering. The majority of the remaining bores are predicted to experience a drawdown of 1 to 3 m.

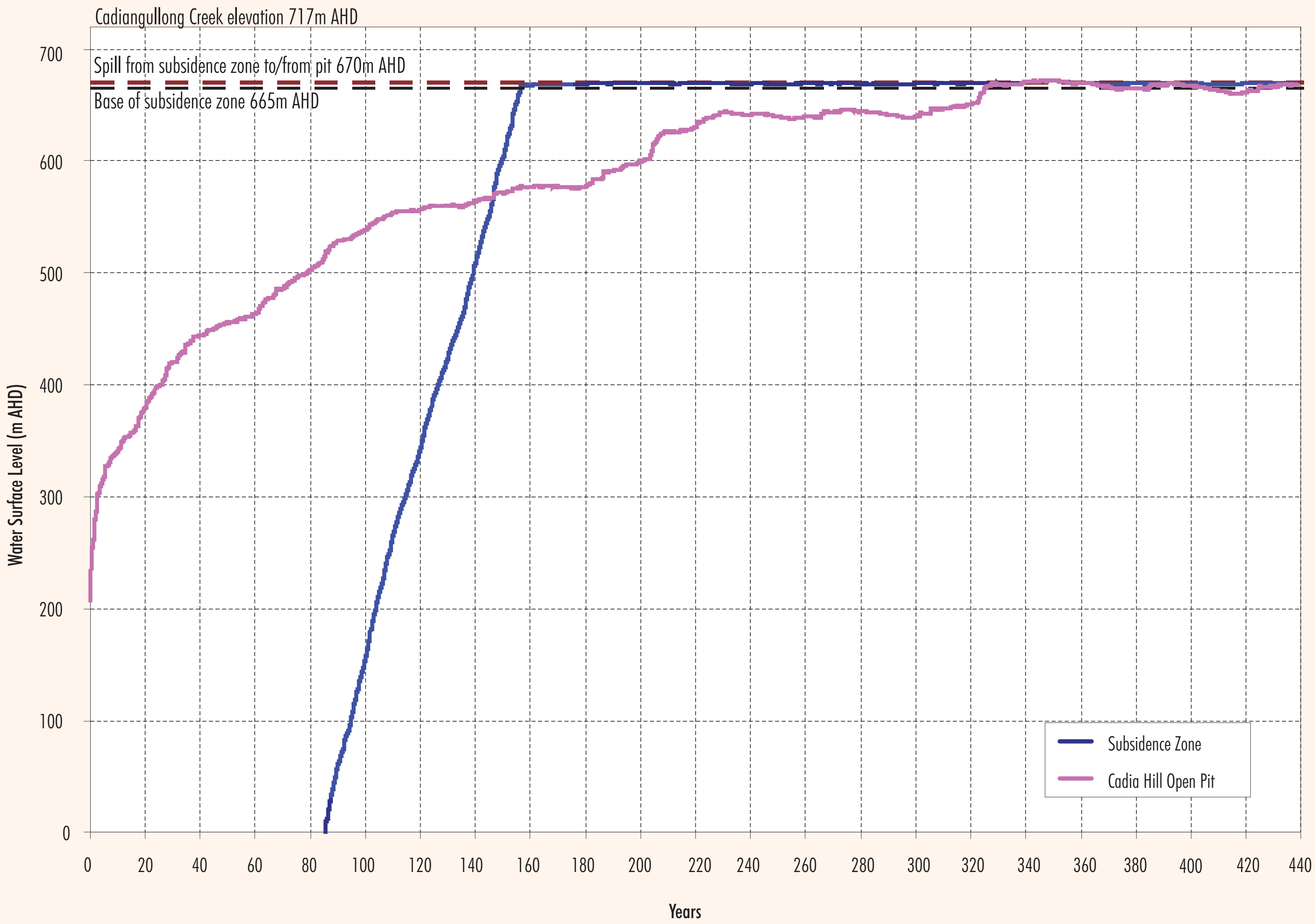
***Potential Impacts on Seepage Areas and Springs***

Seepage areas, spring fed dams and springs were identified in the upper headwaters of the Cadia and Flyers Creeks, in the area where groundwater levels may be drawn down by 1 to 5 m.

Springs are described by AGE (2009) as flows of groundwater that emerge at the land surface. There are a broad range of different types of springs that occur, however to date there is no consistent system for classification of springs (Springer and Stevens, 2009). Based on the understanding of the groundwater regime developed it is considered the following key types of springs are present (Appendix G):

- *Perched Springs* occur where infiltrating rainfall recharge encounters a low permeability unit that restricts downward flow, and results in the water moving laterally, and discharging at the land surface where the low permeability unit outcrops. These types of springs are perched above and not connected to the deeper regional aquifer.
- *Regional Springs* are areas where the topography of the land surface is lower than the level of water pressure in an underlying aquifer, resulting in groundwater being forced to the surface.

Water quality testing undertaken at the spring zones indicates the EC of the spring zones inspected ranged between 32 µS/cm and 227 µS/cm, with and average of 72 µS/cm (Appendix G). In contrast, water samples collected from bores in the Tertiary basalt, typically report an EC ranging between 100 µS/cm and 300 µS/cm and suggest the springs may be largely perched, or have a relatively short flow path in the aquifer. AGE (2009) states that the fresh nature of the spring zone water may also indicate a mixture of fresh runoff and groundwater and that the springs are not fully dependent on groundwater discharges to maintain water levels.




ResourceStrategies

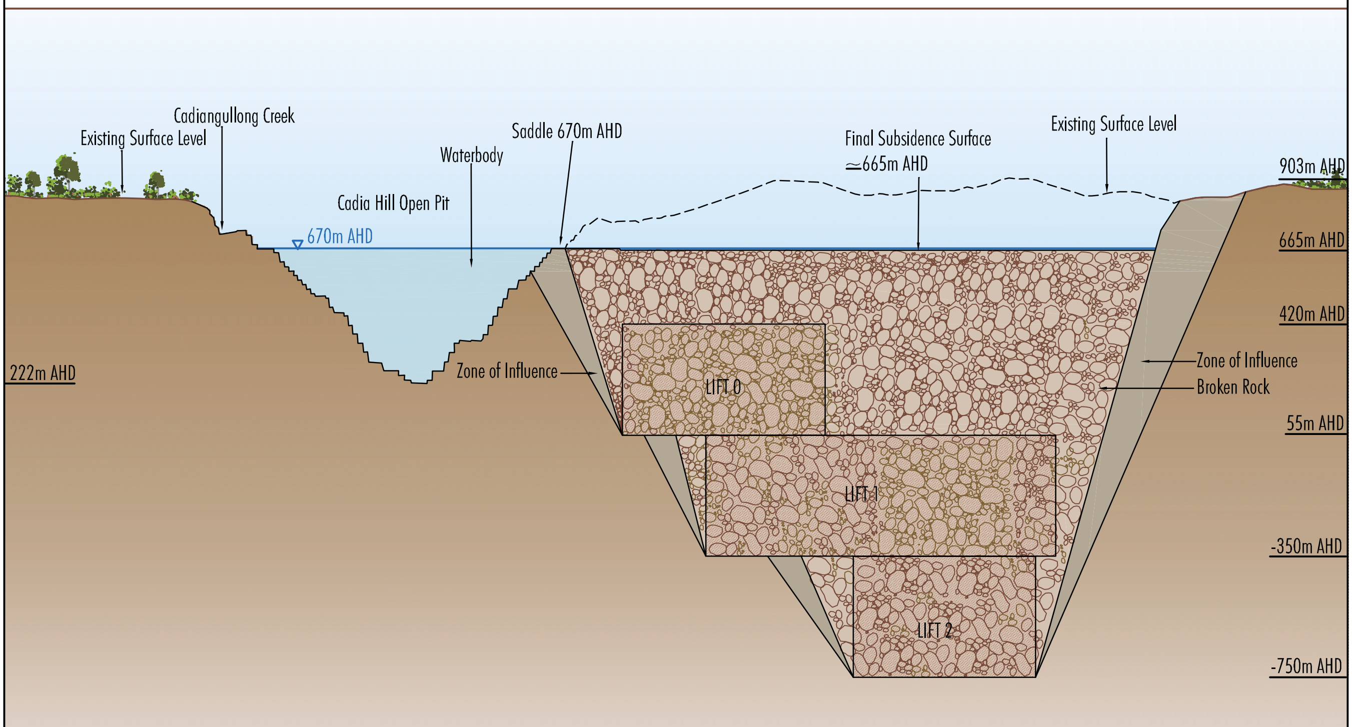
CADIA EAST PROJECT

**FIGURE 4-11**

Simulated Final Void Filling Behavior

Cadia Holdings Pty Limited

NEC-06-66 BSGW_022E


Source: CHPL (2008)

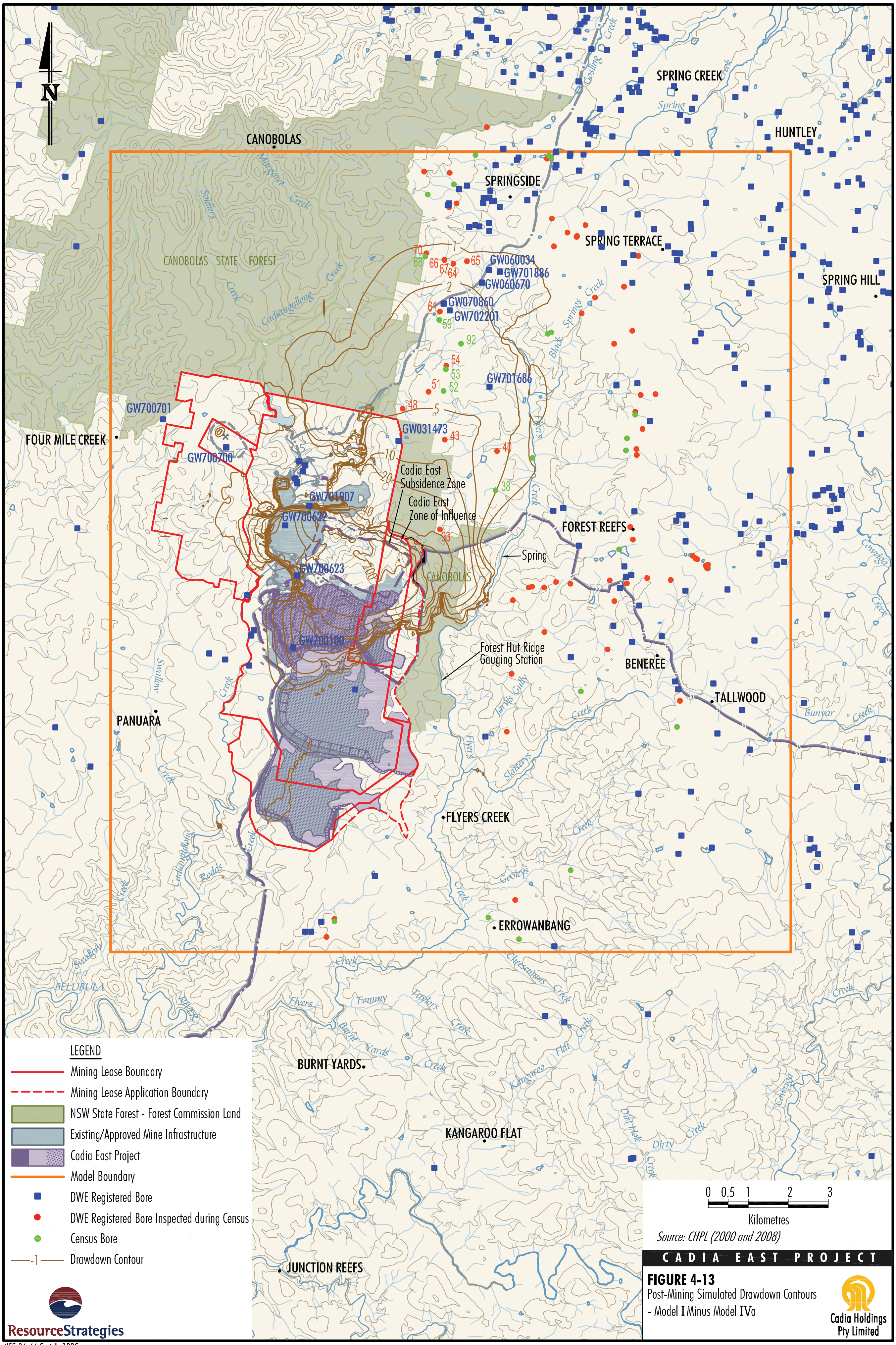
CADIA EAST PROJECT

**FIGURE 4-12**
Conceptual Long Section of the Cadia Hill Open Pit and the Cadia East Subsidence Zone

Cadia Holdings Pty Limited

ResourceStrategies

NEC-06-66 Sect 4_131C




CADIA EAST PROJECT

**FIGURE 4-13**
Post-Mining Simulated Drawdown Contours - Model I Minus Model IVa

NEC-06-66 Sect 4_133C

**Table 4-5**
**Simulated Drawdown on Privately Owned Groundwater Bores**

| Property Number[1] | Bore Number | Approximate Distance from Cadia East (km) | Simulated Drawdown (m) | |
|---|---|---|---|---|
| | | | During Cadia East Mining Operations | Post Mine Closure |
| 24 | 93 | 1.0 | 44.24 | 43.59 |
| 14 | 43 | 3.7 | 6.68 | 6.53 |
| 9 | 51 | 4.6 | 4.53 | 4.40 |
| 6 | 52 | 4.7 | 4.41 | 4.28 |
| 4 | 53 | 5.3 | 3.86 | 3.72 |
| 4 | 54 | 5.3 | 3.86 | 3.72 |
| 11 | GW701686 | 5.2 | 3.55 | 3.44 |
| 251 | 92 | 6.0 | 3.38 | 3.26 |
| 33 | 59 | 6.3 | 2.89 | 2.77 |
| 10 | 40 | 4.4 | 2.93 | 2.85 |
| 33 | GW702201 | 6.4 | 2.89 | 2.77 |
| 33 | 61 | 6.5 | 2.71 | 2.60 |
| 33 | GW070860 | 6.6 | 2.71 | 2.60 |
| 17 | 38 | 3.8 | 2.09 | 2.03 |
| 2071 | GW060670 | 7.4 | 1.95 | 1.87 |
| 2067 | 64 | 7.8 | 1.66 | 1.58 |
| 2069 | GW060034 | 7.7 | 1.56 | 1.49 |
| 2070 | GW701886 | 7.8 | 1.47 | 1.40 |
| 2066 | 66 | 7.8 | 1.41 | 1.34 |
| 2066 | 67 | 7.8 | 1.41 | 1.34 |
| 2065 | 68 | 7.8 | 1.42 | 1.33 |
| 2065 | 70 | 7.9 | 1.42 | 1.33 |
| 2068 | 65 | 8.0 | 1.22 | 1.16 |

Source: Appendix G.
[1] Refer to Table 1-1.

Perched springs would not be impacted by the Project because the perched aquifers are not connected with the regional aquifer, which would be subjected to drawdown by the Project (Appendix G). Springs identified that have no visual outflow and are characterised by damp or wet zones are potentially perched springs with small catchment areas, which would not be impacted by the Project (Appendix G).

Any springs connected to the regional aquifer that are located within the zone of drawdown predicted by the modelling are also considered by AGE (2009) to be highly unlikely to be impacted, due to the conservative assumptions adopted in the numerical modelling. The groundwater modelling assumed a continuous aquifer system, and did not include any faults and fracture zones that have the effect of compartmentalising the aquifer system (and reducing the zone of drawdown created by Cadia East).

The springs identified are also located at a significant distance from Cadia East between 4 to 8 km. Compartmentalisation of the aquifer in this 4 to 8 km buffer zone would likely limit the zone of influence reaching or impacting the springs (Appendix G).

***Predicted Impacts on Local Streams***

The Project Groundwater Assessment included predicted impacts on groundwater discharge (baseflow) in Flyers Creek, and Cadiangullong Creek and its tributaries (i.e. Cadia Creek, Copper Gully and Rodds Creek). These creeks are located on either side of the proposed Cadia East underground mine. The section of Swallow Creek within the modelled area (i.e. to the west of Cadiangullong Creek) was also included in the assessment, although the effects on baseflow in this creek are associated with the existing approved Ridgeway underground mine rather than the proposed Project (Appendix G).

Flyers Creek was divided into two main sections for the assessment of potential baseflow impacts (Appendix G). The first was the section within the model upstream of the Forest Hut Ridge gauging station. The second was the section from the gauging station to the boundary of the model (Figure 4-6). As described in Section 4.2.1, a spring is located approximately 1,200 m downstream of Long Swamp Road (Figure 4-6). Gilbert & Associates (2009) identified that this spring maintains the majority of flow in Flyers Creek, and that there were only small variable increases in flow observed downstream of this point (Appendix F). Potential impacts at this spring were assessed by AGE as a subset of the Flyers Creek upstream baseflow contribution (Appendix G).

Cadiangullong Creek was assessed at the southern boundary of the modelled area. However it was also divided into sections based on its main tributaries. The Cadia Creek tributary section was upstream from its confluence with Cadiangullong Creek (approximately 800 m south of Cadiangullong Dam). The Copper Gully section was upstream of the eastern edge of the Cadia Hill open pit. The Rodds Creek tributary section was upstream from its confluence with Cadiangullong Creek (i.e. approximately 3 km south of the STSF embankment). Potential baseflow impacts on the section of Rodds Creek upstream of the STSF were also assessed (Appendix G).

AGE noted that the modelled baseflow in the Cadia Creek and upper Cadiangullong Creek area is considered likely to be an overestimation of both the existing baseflow contribution, and the predicted baseflow losses (Appendix G). This is because the model was unable to replicate fully the relatively steep topography and tight groundwater contours (particularly in the area between the dam and the eastern Cadia Valley Operations mining lease boundary) and therefore the model compensates by discharging along these steeper sections of the creek (Appendix G).

Table 4-6 presents net groundwater discharge (baseflow) to local streams for each of the five models.

The modelling results show a maximum predicted reduction in baseflow from the Flyers Creek upstream section during operations (i.e. Model II minus Model III) of 0.49 ML/day. Following closure of the mine and once the tailings storage facilities have dried out (i.e. Model II minus Model IVa), the loss of baseflow in this section is only marginally less (i.e. 0.48 ML/day).

There is no predicted baseflow loss during operations for the Flyers Creek downstream section.

The modelled reduction in flow at the Flyers Creek spring zone is 0.26 ML/day. during operations and 0.25 ML/day post-mining.

**Table 4-6**
**Simulated Groundwater Discharge (Baseflow) to Local Streams**

| Stream | **Model I** (ML/day) | **Model II** (ML/day) | **Model III** (ML/day) | **Model IV** (ML/day) | **Model IVa** (ML/day) |
|---|---|---|---|---|---|
| Flyers Creek upstream | 2.39 | 2.38 | 1.89 | 1.89 | 1.9 |
| - Flyers Creek (spring only) | 1.69 | 1.68 | 1.42 | 1.42 | 1.43 |
| Flyers Creek downstream | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Cadiangullong Creek (total) | 6.59 | 5.89 | 4.69 | 4.9 | 4.76 |
| - Cadia Creek | 2.52 | 2.49 | 1.42 | 1.45 | 1.46 |
| - Copper Gully | 0.16 | 0 | 0 | 0 | 0 |
| - Rodds Creek upstream of STSF | 0.51 | 0 | 0 | 0 | 0 |
| - Rodds Creek downstream of STSF | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 |
| - Cadiangullong Creek (remainder) | 3.40 | 3.38 | 3.24 | 3.42 | 3.28 |
| Swallow Creek | 1.09 | 0.76 | 0.76 | 1.11 | 1.07 |

Source: Appendix G.

The modelling results for Cadiangullong Creek (total) at the southern edge of the modelled area show a maximum predicted reduction in baseflow during operations (i.e. Model II minus Model III) of 1.20 ML/day. Following closure of the mine and once the tailings storage facilities have dried out (i.e. Model II minus Model IVa) the loss of baseline flow is slightly less (i.e. 1.13 ML/day).

The modelling of the Cadiangullong Creek tributaries show that baseflow in Cadia Creek would be reduced during operations (i.e. by 1.07 ML/day) and that this effect would only be marginally less following mine closure (i.e. 1.03 ML/day). This effect is primarily due to the creek being located relatively close to the Cadia East subsidence zone, and a large proportion of its catchment being within the Tertiary basalt (i.e. north and north-northeast of the mine). However as indicated above, this predicted impact is considered by AGE to be conservative as the modelled baseflow in Cadia Creek is likely to be higher than what actually occurs due to the relatively steep topography of the creek within the Cadia Valley Operations mining leases (Appendix G).

The groundwater modelling results showed that baseflow from Copper Gully is minor (i.e. 0.15 ML/day in Model I), but flow from this Cadiangullong Creek tributary would be permanently lost due to creation of the subsidence zone (Appendix G). Flow in Copper Gully is currently intercepted by the Cadia Hill open pit.

In the section of Rodds Creek upstream of the STSF, modelling results show a reduction in baseflow contribution of 0.51 ML/day. However, this baseflow reduction would not become apparent due to the presence of the STSF, NTSF and Rodds Creek Water Holding Dam upstream of the STSF.

In the section of Rodds Creek downstream of the STSF, modelling results show a minor increase in baseflow contribution of 0.01 ML/day during operations.

The modelled baseflow reduction for Swallow Creek in the Groundwater Assessment (Appendix G) confirmed the overall findings of the previous studies by Kalf & Associates (2000, 2004) by predicting the existing approved Ridgeway underground mine will result in a reduction in baseflow during operations, but will recover to approximately pre-mining conditions post-closure. The Cadia East underground mine is not expected to materially increase the drawdown effect on Swallow Creek due to the distance between the two; the isolating effect of the intervening Cadia Hill open pit; and the low permeability of the Ordovician volcanic host rocks (Appendix G).

***Groundwater Quality***

*During Mining Operations*

Groundwater within the area of influence would flow towards the mine workings and caving area/subsidence zone during mining. As a result, the potential for water quality impacts on surrounding surface water and groundwater due to the Cadia East underground mine is considered by AGE to be minimal (Appendix G). Water entering the caving zone would be a mixture of direct rainfall and groundwater drained from the surrounding Tertiary basalt, Silurian and Ordovician rock units.

Rainfall infiltration and groundwater from the Tertiary basalt and Silurian sedimentary aquifers entering the caving zone is expected to be relatively fresh (Appendix G). The available monitoring data for the Ordovician aquifers indicate water quality is typically brackish (i.e. EC ranging between 2,000 μS/cm and 5,000 μS/cm). These waters would mix within the caving zone and report to the underground workings. This mixed groundwater would however, interact with the rock within the caving zone, that would be fractured and therefore increasing the surface area and exposure to fresh rock.

The Project Geochemical Assessment undertaken by MESH (2009) indicated that a relatively large proportion of the Ordovician volcanic rock may be PAF (Appendix J), and could therefore produce ARD when exposed to oxidising conditions in the subsidence zone or the exposed walls of the underground mine workings. This acidic drainage would mix with the rainfall infiltration and groundwater from the Tertiary basalt and Silurian sedimentary aquifers.

Groundwater entering the mine workings would also be expected to collect some suspended matter, fuel, drilling fluids and explosives residue. This water would be directed to a sump and pumping station located at the base of the mine workings where it would be pumped to the surface for treatment if necessary, and then used in the ore processing facilities (Section 2.10.2).

*Post Mine Closure*

Once mining operations cease, inflows into the underground workings would no longer be pumped out and the voids (i.e. remaining tunnels and spaces between the broken rock in the caving zone) would begin to fill with groundwater. During this re-saturation phase no water would escape into the surrounding rock as the local hydraulic gradient would be directed to the caving zone and subsidence void (Appendix G).

AGE (2009) predicts that a moderately saline gradient would develop within the broken rock of the caving zone as incident rainfall enters the top of the caving zone creating a fresh water lens lying on top of more brackish groundwater which would flow in from the adjoining Ordovician and Silurian aquifers. Higher salinity water is expected to eventually stabilise at a deeper level within the caving/subsidence zone (Appendix G).

As the water level rises it would reach the top of the caving zone and emerge into the subsidence void approximately 150 to 160 years after mine closure (Gilbert & Associates, 2009). As the void would remain a sink for groundwater flow, salts would slowly concentrate in the open void over time due to the effect of evaporation from the surface of the waterbody. Potential ARD generated from the oxidation of PAF Ordovician volcanic material within and forming the walls of the subsidence zone would reduce the pH and increase dissolved metal concentrations in the water. However, hydraulic gradients would draw local groundwater into the subsidence void, and therefore prevent the mobilisation of the water out into surrounding aquifers (Appendix G).

***Tailings Storage Facilities – Geochemistry and Seepage and Particle Movement***

The Geochemistry Assessment by MESH (Appendix J) included characterisation of pilot tailings representative of that expected to be produced from the processing of Cadia East ore. The characterisation included an evaluation of the acid forming potential and assessment of trace element concentrations and element solubility and leaching. The Cadia East tailings were consistently classified as NAF and are expected to be very similar to that currently produced at the Cadia Valley Operations (Appendix J).

The 15 samples of tailings that were tested by MESH were all found to be low in sulphur (ranging from <0.1 to 0.36% total sulphur), with ANC values ranging from 12 to 96 kg $H_2SO_4$/t equiv. Overall, the results of the Cadia East tailings were similar in nature to those reported for the Cadia Hill and Ridgeway deposits. The reported sulphur content for the Ridgeway tailings was 0.03 to 0.07% total sulphur with moderate ANC values ranging from 38 to 58 kg $H_2SO_4$/t equiv (EGi, 2000). The Cadia Hill tailings were reported to range from 0.01 to 0.32% total sulphur with ANC values from 4 to 30 kg $H_2SO_4$/t equiv (EGi, 2000; Newcrest, 1995).

On this basis, the tailings produced from Cadia East might be expected to have similar sulphur values to Cadia Hill and ANC values more commensurate with that expected from tailings produced from Ridgeway (Appendix J).

As described in Section 2.8.2, the NTSF and STSF would be raised using upstream construction methods up to final heights of 779 m AHD and 702 m AHD respectively. In order to assess the potential impacts of these expansions on seepage migration from the expanded STSF and NTSF, detailed groundwater modelling was undertaken by AGE as part of the Groundwater Assessment (Appendix G). An overview of the modelling and key findings is provided below.

Tailings storage seepage is defined as the fluid that moves beyond the embankment of the tailings storage facilities. Seepage can either appear at the surface downstream of a tailings storage facility or remain beneath the ground. AGE used the MODPATH modelling programme in conjunction with Cadia East groundwater model to simulate seepage flow paths (based on the modelled movement of particles that were placed at intervals around the extent of both the NTSF and STSF). The simulation was conducted for the ‘maximum operations’ scenario (i.e. Model III) and the post-mining scenario after the tailings had de-saturated (i.e. Model IVa).

In summary, the work done by AGE, and documented in Appendix G, indicates that any seepage from the tailings storage facilities is generally not significant. During mining operations, the predicted seepage away from the tailings storage facilities would be very limited (i.e. less than 500 m) except in the direction of the subsidence void and underground workings. This is indicative of the steeper hydraulic gradient that would exist towards the subsidence void due to dewatering activities.

Post mine closure, AGE predicts that there would still be potential for groundwater movement towards the subsidence void, albeit at a reduced rate (Appendix G). This is indicative of the gentler hydraulic gradient that would exist towards the subsidence void due to ceasing of dewatering activities and the de-saturated tailings storage facilities.

### 4.2.3 Mitigation Measures, Management and Monitoring

***Management of Potential Impacts on Groundwater Users***

The modelled drawdown effects on local groundwater aquifers are considered by AGE to be conservative (Appendix G). They are also predicted to develop relatively slowly due to the generally low permeability of the host rock units (Section 4.2.1). During the mine life CHPL would use the results of the groundwater monitoring programme, and additional geological and hydrogeological information to refine the groundwater model and model predictions. This process would be used to evaluate predicted verses actual impacts (in particular, to verify/confirm that the homogenous geology assumption applied in the groundwater model produced a conservative impact assessment [Section 4.2.2]) and could involve additional steady state and/or transient modelling.

In order to prevent Project-induced impacts on the water supply availability of non-CHPL owned bores, CHPL has committed to develop and implement a Groundwater Management Plan for the area potentially affected by the long-term drawdown from the Project (i.e. Figure 4-13). The Plan would include:

- a compilation of the available construction and use information on each existing bore and spring in the potentially affected area;
- details of an inspection of each bore and spring by a suitably qualified hydrogeologist (where permission from the owner was granted);
- details of the groundwater monitoring programme (location, parameters, frequency and reporting) to be used by CHPL to monitor and detect impacts on local aquifers; and
- details of monitoring triggers and corresponding measures to mitigate Project-induced impacts on water supply availability. The mitigation measures could include, but are not necessarily limited to lowering of pumps, deepening of bores, or provision of new bores/alternative water supplies.

***Management of Potential Impacts on Local Streams***

Measures that would be used to minimise the potential impacts on local streams are described in Section 4.3.3.

***Tailings Seepage Mitigation and Management***

The proposed seepage control methods for the expanded STSF and NTSF are described in Section 2.8.5 and Appendix O are summarised below:

- Pre-stripping of soils beneath the expanded embankment footprint.
- Construction of a moisture-conditioned and compacted low permeability clay core embankment and foundation cut-off key beneath the embankment.
- Placement of reworked *in-situ* clay blanketing in selected areas of the storage floor where, and if required.
- Inclusion of a compacted clay facing layer on the upper, southern portion of the South Waste Rock Dump. This layer would be keyed into the natural hill slope and the low permeability zones of the NTSF embankment to minimise the potential for seepage escaping through the waste rock dump (Section 2.8.3).

These control methods are designed to provide a physical control to minimise seepage from the tailings storage facilities. The properties of the tailings and foundation materials are also expected to provide further control.

The mechanisms by which this may occur are:

- consolidation of tailings materials to reduce permeability; and
- adsorption of tailings chemicals onto clay colloids within subsoils beneath the storage.

The proposed rehabilitation and water monitoring strategies for the tailings storage facilities (described in Section 5 and Appendix P) have been designed to facilitate long-term restoration of mine landforms, including the management of any seepage issues.

***Groundwater Monitoring***

The existing Cadia Valley Operations groundwater monitoring programme includes quarterly monitoring of groundwater levels and quality (Section 2.1.12). Five of the new monitoring bores constructed for the Cadia East hydrogeological investigation in 2008 (Section 4.2.1) have been added to the programme and would be used for long-term monitoring of water levels to the east and north-east of the mine during the life of the Project.

Within six months of Project approval, CHPL would install of a further nine groundwater monitoring bores. Three of these bores would be located to the east of the expanded NTSF near Cadia Road (Figure 4-14). These three bores would be used to monitor potential seepage from the relatively low (i.e. 15 m maximum height) trailing embankment which runs along the boundary of the MLA.

The remaining six new bores would be constructed up to 8 km to the east and north-east of the Cadia East deposit within the area where groundwater drawdown is predicted to exceed 1 m (Figure 4-14) and where the 23 potentially impacted non CHPL-owned bores are located. These new bores would be used in conjunction with the three existing regional monitoring bores in this area (i.e. RB1, RB2 and RB7) and five of the Cadia East hydrogeological investigation bores (i.e. MB44A, MB44B, MB45, MB48, MB49) to detect any drawdown in local aquifers. The location of the new bores has been designed by AGE to combine with the existing bores to provide lines of bores at increasing distances from the mine in a north-northeast, north-east, and easterly direction (Figure 4-14). The final location of these bores would be subject to DWE approval, landholder agreement and confirmation of suitable drilling conditions.

Estimates of groundwater inflow rates into the current Cadia East exploration declines and underground workings are able to be calculated by subtracting the quantity of water pumped into the workings from the quantity extracted from the workings. The quantity of raw water entering and water leaving the underground workings during the Project life would continue to be measured on a daily basis.

Monitoring of the spring zones identified to the north-east of the Project area would also be undertaken. An initial investigation of the spring zone hydrology would be undertaken to identify the most appropriate springs for long-term monitoring. The investigation would include construction of shallow bores, at key springs to determine if the spring is perched, or linked to the regional aquifer and allow measurement of groundwater pressures. The findings of the investigation would be used to determine an appropriate subset of springs that would be most appropriate for monitoring. The investigation would be described and the outcomes incorporated in the Groundwater Management Plan.

## 4.3 SURFACE WATER

A Surface Water Assessment for the Project was conducted by Gilbert & Associates (2009) and is presented in Appendix F. A description of the surface water resources is provided in Section 4.3.1. Section 4.3.2 describes the potential impacts of the Project on surface water resources, while Section 4.3.3 outlines the proposed management practices, monitoring programme and contingency measures.

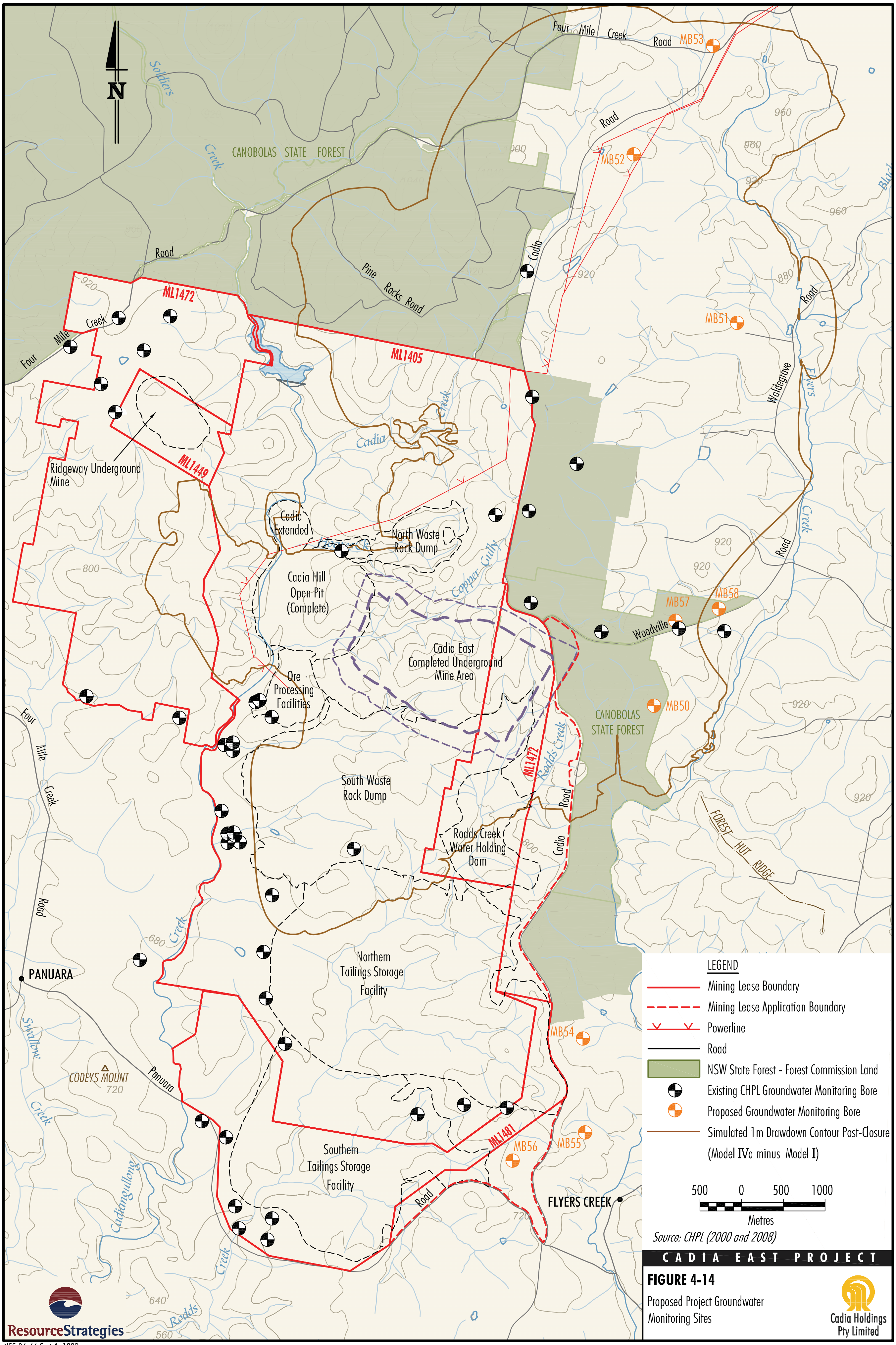
### 4.3.1 Existing Environment

***Regional Hydrology***

The Project is situated within the Cadiangullong Creek catchment. Cadiangullong Creek flows southward through the Cadia Valley to the Belubula River which is a major tributary of the Lachlan River (Figure 4-15). At its confluence with the Lachlan River the Belubula drains a total catchment area of approximately 2,570 $km^2$ and has an estimated mean annual flow of 97,400 ML (Appendix F). The Lachlan is a major inland river system in the NSW section of the Murray-Darling Basin.

The Belubula is a ‘regulated’ river, that is a river proclaimed under the *Water Act, 1912* as having its flow controlled by a major government owned dam, which is in this case Carcoar Dam. Flow is managed by the DWE to meet the needs of licensed downstream water users, whilst ensuring environmental flows are maintained. Carcoar Dam has a catchment of approximately 230 $km^2$ (Appendix F). It is situated on the upper reaches of the Belubula River near the township of Carcoar, approximately 25 km south-east of the Cadia Valley Operations (Figure 4-15). CHPL extracts water from the Belubula River downstream of Carcoar Dam via a dedicated pumping station and pipeline (Section 2.1.10).

The Lachlan River is regulated by several dams, the major one being Wyangala Dam which is situated approximately 65 km to the south (Figure 4-15). The mean annual flow of the Lachlan River at Wyangala is estimated to be approximately 750,000 ML/annum (CHPL, 2000b).

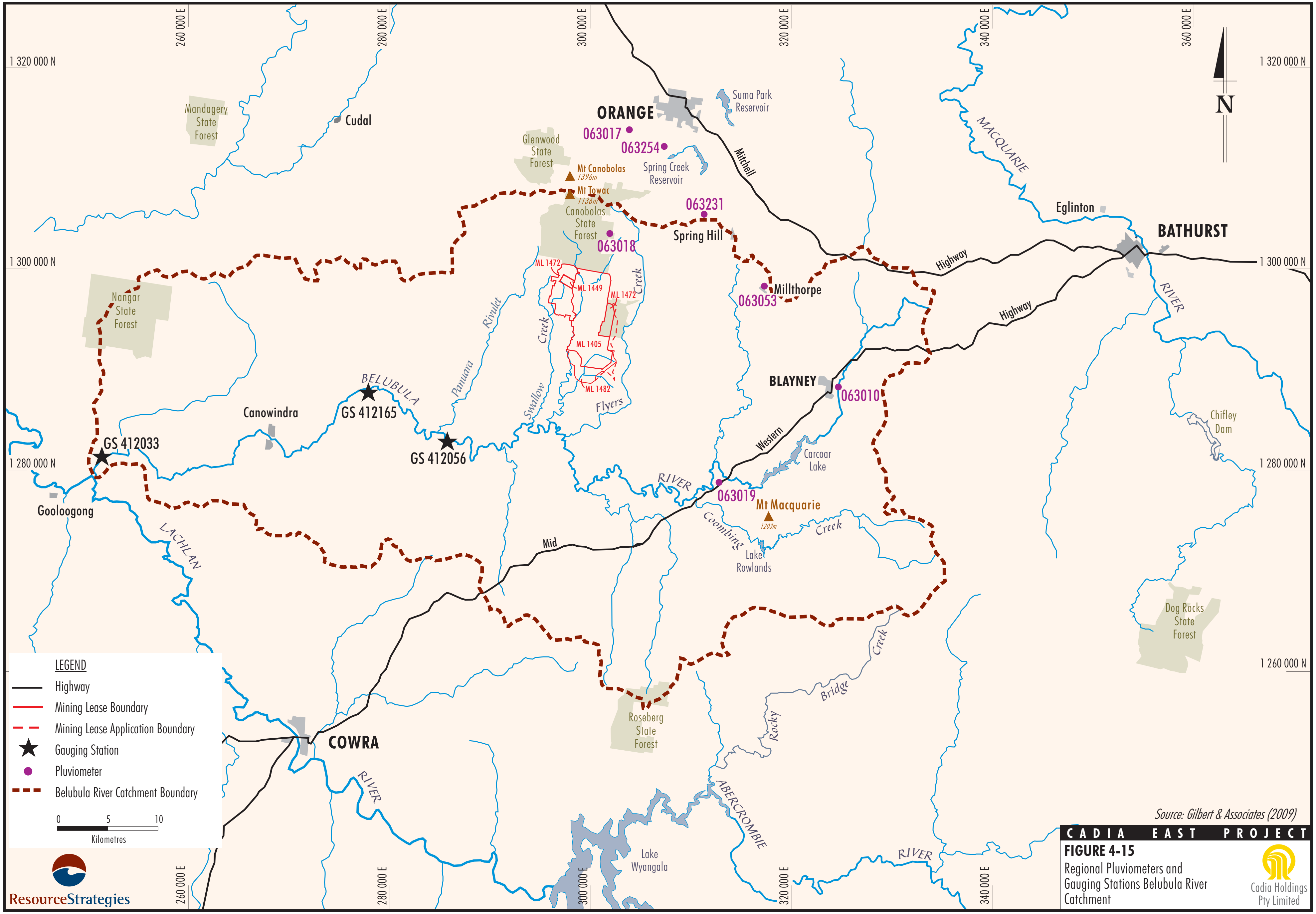



CADIA EAST PROJECT

**FIGURE 4-14**

Proposed Project Groundwater Monitoring Sites

NEC-06-66 Sect 4_132D




NEC-06-66 Sect 4_012D

***Local Hydrology***

The Cadia East deposit is overlain by the Copper Gully catchment, which was a minor tributary of Cadiangullong Creek prior to the development of the Cadia Hill open pit. Other tributaries of Cadiangullong Creek affected by the existing Cadia Valley Operations and the proposed Project are Cadia Creek and Rodds Creek. These tributaries are shown on Figure 4-16. Swallow Creek and Flyers Creek run generally in a north to south direction towards the Belubula River and are located to the west and east of Cadiangullong Creek respectively (Figure 4-16).

A network of calibrated baseflow weirs, gauging stations and pluviometers is used by CHPL to monitor surface water flows and rainfall in the vicinity of the Cadia Valley Operations (Figure 4-16 and Figure 4-4). Flow data obtained from the monitoring programme was used by Gilbert & Associates (2009) to prepare hydrographs (graphs of creek flow rates over time) and, in combination with the results of a detailed hydrogeological (i.e. groundwater) study (Appendix G) assess the surface hydrology of the creeks. The hydrographs were also used to calibrate hydrological models of the creeks potentially affected by the Project (Appendix F).

Gilbert & Associates (2009) used local and regional rainfall and evaporation records with available stream flow records to calibrate the hydrological models (Appendix F). In the period since the installation of the monitoring network, rainfall has been highly variable thus enabling calibration of hydrological models across a wide range of flow conditions (i.e. from dry to extremely wet). The model calibration was peer reviewed by Dr Walter Boughton, an internationally recognised hydrological expert.

Water quality monitoring of creeks in the Cadia Valley area has been conducted by CHPL since 1994. Currently, routine water quality and flow monitoring is conducted by CHPL at locations on Cadiangullong Creek and its tributaries, Flyers Creek and its tributaries, Swallow Creek and Diggers Creek.

Water quality parameters measured include total suspended solids (TSS), TDS, pH, alkalinity, EC, bicarbonate, total alkalinity, nitrate, sulphate, chloride, metals (including arsenic, cadmium, calcium, copper, iron, magnesium, manganese, potassium, sodium, zinc, chromium and mercury), total nitrogen and total phosphorus.

The following is an overview of the hydrological features, flow characteristics and water quality of streams in the vicinity of the Project.

***Cadiangullong Creek***

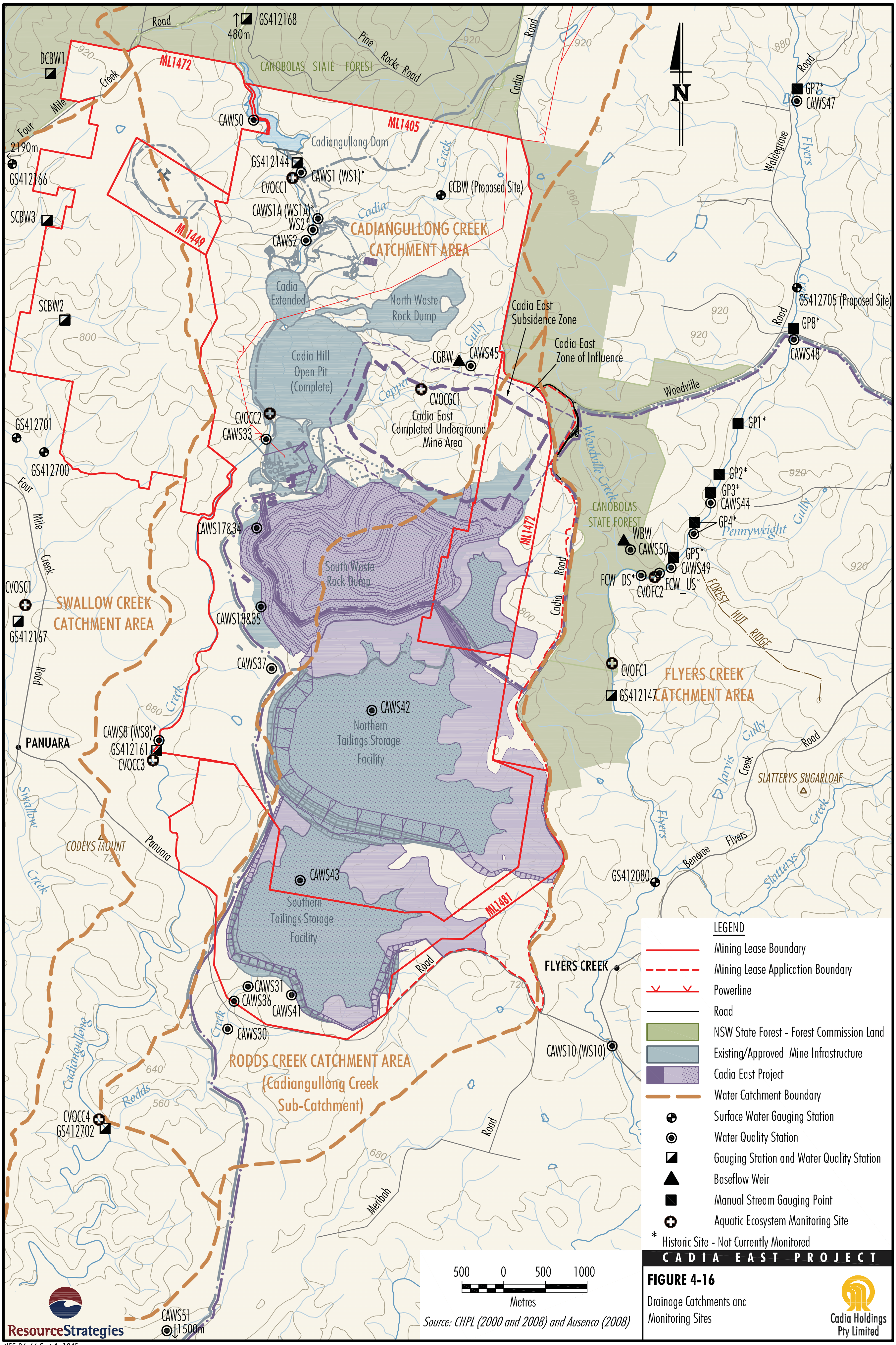
Cadiangullong Creek rises on the southern flanks of Mount Towac (1,136 m AHD) which, together with Mount Canobolas (1,396 m AHD), form the main topographic features to the north of the Cadia Valley (Figure 4-15). It flows in a southerly direction to the Belubula River approximately 12 km to the south of the Project, at which point it has a catchment area of 115 $km^2$.

As described in Section 2.1.10, Cadiangullong Dam has capacity to store some 4,200 ML of water and was constructed as a water supply for Cadia Hill in 1997/1998. Approximately 1.5 km downstream of Cadiangullong Dam the creek has been diverted around the western edge of the Cadia Hill open pit for a distance of approximately 2 km.

The majority of catchment upstream of Cadiangullong Dam consists of Monterey Pine (*Pinus radiata*) plantation (Canobolas State Forest), with approximately 10% native forest. The remainder is scattered eucalypt forest and smaller parcels of cleared rural/pastoral land. Downstream of the Cadiangullong Dam the catchment is generally cleared rural/pastoral land.

Cadiangullong Creek has been historically disturbed by mining and wide scale agricultural activity. Open pit and underground mining was conducted in and around the historical Iron Duke (Big Cadia) mine in the early 1900s, from 1918 to 1929, and from 1941 to 1943. More recently, open pit and underground mining has occurred as part of the Cadia Valley Operations, which commenced in 1998.

There is currently only one non-CHPL owned property with frontage onto Cadiangullong Creek downstream of the Cadia Valley Operations (i.e. Property 169 owned by RL & SL Chamberlain - Figure 1-4). The predominant landuse on this property is rural/pastoral grazing. Water to support these activities is obtained under riparian rights whereby the landholder is entitled to access water without a licence for stock and domestic purposes under section 52 of the *Water Management Act, 2000*. The total maximum stock and domestic water requirements for non-CHPL owned properties on Cadiangullong Creek has been estimated by Gilbert & Sutherland (1997) to be less than 0.05 ML/day (Appendix F).




NEC-06-66 Sect 4_104F

An analysis by Gilbert & Associates (2009) of the available pre-mining flow records from two gauging stations (GS412144 and former gauging station GS412145) that were located upstream of and near the downstream limits of the Cadia Hill open pit respectively, indicated that the percentage of time Cadiangullong Creek (downstream of the Cadiangullong Dam) would have ceased flowing is likely to have been between 15 and 25% of days on average.

Stream flows in Cadiangullong Creek are currently measured at Forestry gauging station (GS412168) (upstream of Cadiangullong Dam) and at the Oaky Creek gauging station (GS412702), which is located downstream of the Rodds Creek confluence (Figure 4-16). Figure 4-17 presents stream flow records (hydrographs) of the surface water flowing into Cadiangullong Dam (i.e. GS412168). Two hydrographs are provided, one illustrating all stream flows and corresponding rainfall records, and the second illustrating flows lower than 50 ML/day.

The flow behaviour in Cadiangullong Creek within and below the Cadia Valley Operations mining leases is influenced by the presence of the Cadiangullong Dam. Releases from the dam are made in accordance with the operating protocols established under the Cadia Hill Development Consent (DA 44/95). The protocol includes the following release requirements:

- For periods when inflows into Cadiangullong Dam fall below 0.4 ML/day (as measured at the Forestry gauging station) water is released from the dam to maintain a flow of 0.4 ML/day at the Oaky Creek gauging station.
- For periods when inflows into Cadiangullong Dam are between 0.4 ML/day and 3.4 ML/day, water is released from the dam to maintain a flow at the Oaky Creek gauging station equivalent to the inflows into the dam.
- For periods when inflows into Cadiangullong Dam are greater than 3.4 ML/day, water is released from the dam to maintain a flow of 3.4 ML/day at the Oaky Creek gauging station.
- Medium flows (of the order of 12 to 15 ML/day) are released up to four times per year, each for a duration of 1 to 3 days, with timing and frequency of such flows determined by hydrographs of typical medium flows.

Experience with this protocol has shown that it is frequently necessary for CHPL to over release to compensate for flow loss between Cadiangullong Dam and the Oaky Creek gauging station, particularly during dry summer months.

It is also known from CHPL's gauging records collected prior to commencement of Cadia Hill open pit mining that Cadiangullong Creek had been subject to similar flow losses in the mining lease area prior to its development (Appendix F). Compliance with the Cadia Hill Development Consent (DA 44/95) release protocols has therefore resulted in more persistent low flows downstream of Cadiangullong Dam than would have been the case prior to mining (Appendix F).

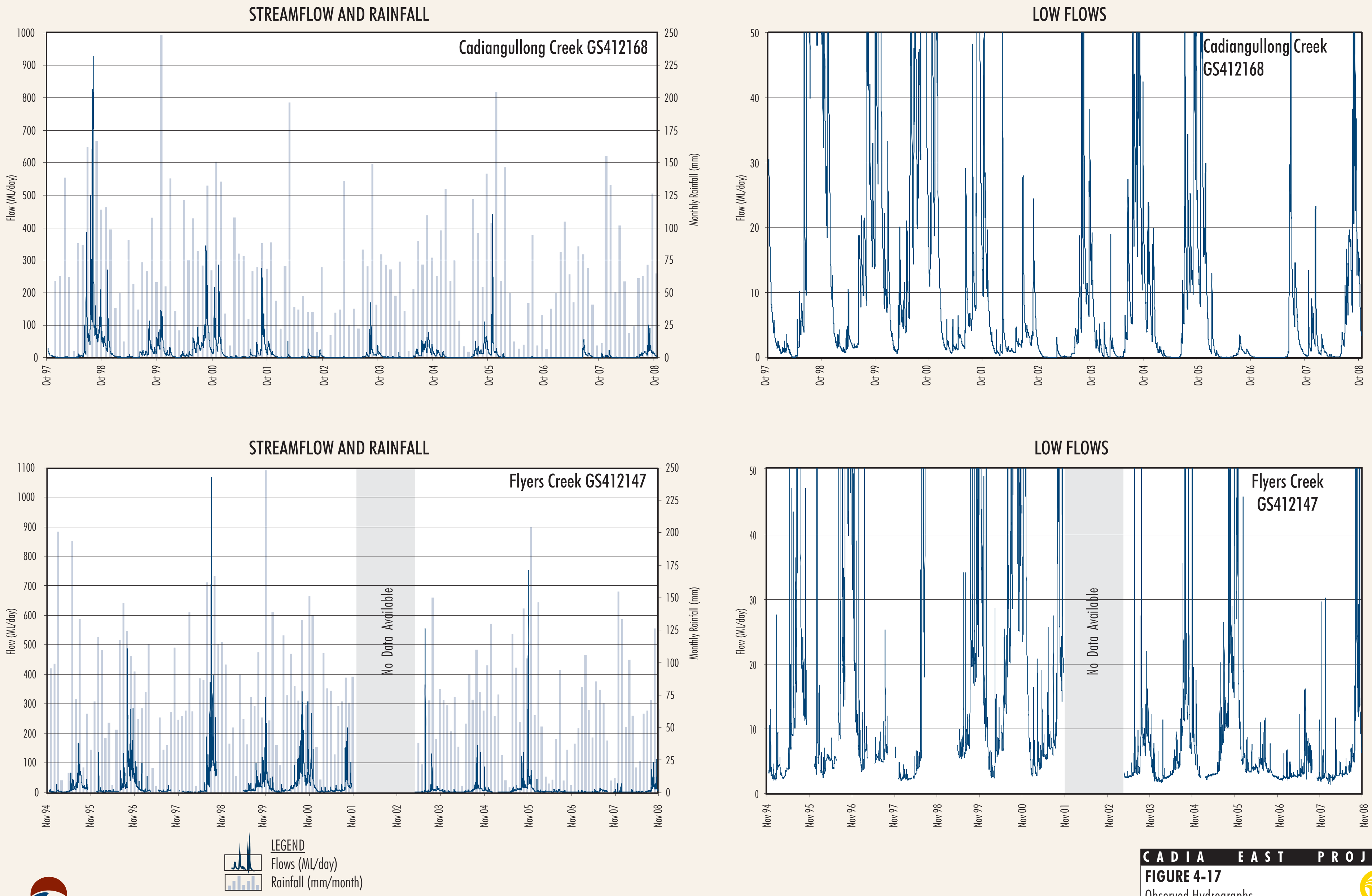
Water quality is currently monitored on Cadiangullong Creek at CAWS0, CAWS33, GS412168, GS412144, GS412161 and GS412702 with previous monitoring conducted at CAWS1, WS2, CAWS1A, CAWS2 and CAWS8 (Figure 4-16). Water quality monitoring results from these sites were compared by Gilbert & Associates (2009) (Appendix F) with the Australian and New Zealand Environment and Conservation Council (ANZECC) guideline (ANZECC, 2000) default triggers. The ANZECC guideline covers a range of different environmental values (or beneficial uses) that can be ascribed to a water resource. The relevant values for the Project are 'protection of aquatic ecosystems' and 'stock watering' (Appendix F).

The ANZECC guideline defines aquatic ecosystem triggers as concentrations of indicators which "…if exceeded, would indicate a potential environmental problem, and so 'trigger' a management response." The ANZECC guidelines recognise three levels of ecosystem condition:

- high conservation/ecological value ecosystems;
- slightly to moderately disturbed ecosystems, and
- highly disturbed ecosystems.

Default triggers for aquatic ecosystem toxicants are provided in the ANZECC guideline for different species protection levels corresponding to concentrations where 99%, 95% 90% and 80% of species would be expected to be unaffected. The 99% species protection level is applicable to high value ecosystems, whilst the 95% and 90% species protection levels are applicable to slightly/moderately modified ecosystems and the 80% protection level is applicable to highly disturbed ecosystems (Appendix F).

Stock watering triggers contained in the ANZECC guideline provide indicator concentrations below which there should be no harmful effects on livestock.




Resource Strategies

*Source: Gilbert and Associates (2009)*

CADIA EAST PROJECT

**FIGURE 4-17**

Observed Hydrographs
Cadiangullong and Flyers Creeks

Cadia Holdings Pty Limited

NEC-06-66 Sect 4_ 013C

The creeks in the vicinity of the Project (including Cadiangullong Creek) have been historically disturbed by mining and/or agricultural activities and are therefore considered by Gilbert & Associates (2009) to be slightly to moderately or highly disturbed ecosystems. However, in accordance with the ANZECC guideline, comparisons of water quality results in the local creeks were made with the 99%, 95% 90% and 80% default trigger values for aquatic ecosystems (Appendix F). A summary of the water quality discussion for Cadiangullong Creek is provided below, with further details contained in Appendix F.

The pH of the monitoring sites on Cadiangullong Creek was found to be generally neutral to slightly alkaline (i.e. mean values ranging from 6.8 to 8.0). The EC at the monitoring sites was low to moderate (i.e. mean values range from 95 to 725 µS/cm). Total nitrogen and total phosphorus were found to exceed the ANZECC guidelines for the protection of aquatic ecosystems at almost all monitoring sites on Cadiangullong Creek (Appendix F). Metal concentrations were found to be generally low relative to the ANZECC guideline default trigger values for aquatic ecosystems, however copper concentrations were found to exceed the ANZECC 80% species protection level at the majority of the monitoring sites downstream of the old Iron Duke workings (i.e. CAWS2 and south). Iron was also found to exceed the ANZECC 80% guideline at the upstream site (GS412168). Zinc exceeded the ANZECC 90% guideline at the majority of monitoring sites while arsenic, cadmium and chromium exceeded the ANZECC 99% guideline at CAWS33 and GS412702. The median values of analytes in Cadiangullong Creek did not exceed the ANZECC guideline trigger levels for stock watering (Appendix F).

Three tributaries of Cadiangullong Creek are of relevance to the Project: Cadia Creek, Copper Gully and Rodds Creek. A description of the characteristics of these tributaries is provided below.

***Cadia Creek***

Cadia Creek is a small eastern tributary of Cadiangullong Creek situated approximately 2 km to the north of the predicted Cadia East subsidence zone (Figure 4-16). Its confluence with Cadiangullong Creek is located approximately 800 m downstream of Cadiangullong Dam. Cadia Creek has a catchment area of approximately 11.6 km$^2$, is approximately 8 km in length and drains the north-eastern portion of ML 1405, a section of the Canobolas State Forest, and agricultural land to the north-east.

The creek is deeply incised over much of its length (Newcrest, 1995). It is near perennial however flows are generally much lower than Cadiangullong Creek because of its smaller catchment area (Newcrest, 1995).

A small overtopping weir was constructed on Cadia Creek in 1998 as part of the development of the Cadia Hill water supply. Water is piped under gravity from the weir to Cadiangullong Dam during periods of high flows.

Gilbert & Associates (2009) note that while flow in Cadia Creek is not gauged, it is expected that on a per hectare basis it would be similar to flows recorded at nearby gauging stations and in particular to flow in Cadiangullong Creek upstream of the Cadiangullong Dam (GS412168) and Swallow Creek at the downstream gauging station (GS4120167). Using the monitored flow data from these two stations Gilbert & Associates (2009) estimate that the mean annual flow of Cadia Creek at its confluence with Cadiangullong Creek would be in the range of 1,400 to 1,800 ML/annum or 3.8 to 4.9 ML/day. Based on the available data from the same two gauged stations it is estimated that baseflow would contribute between 40% and 50% of the total flow, which would equate to an average baseflow of between 1.5 and 2.5 ML/day (Appendix F).

***Copper Gully***

Copper Gully is a former tributary of Cadiangullong Creek that has been truncated by the Cadia Hill open pit. The remainder of Copper Gully drains a catchment of approximately 2.6 km$^2$ to a retention storage above the pit (Appendix F). Part of this catchment is partly located within the predicted Cadia East subsidence zone (Figure 4-16). It is typically comprised of steep and heavily timbered dry sclerophyll forest, but it also contains remnant areas of old historical Little Cadia mine workings left from former copper and gold mining, including some small scale drainage diversions and a partially intact headwater dam (Section 4.9.1).

A baseflow gauging station (CGBW) (Figure 4-16) was installed on Copper Gully in January 2007. Gilbert & Associates (2009) assessment of the data collected since its establishment indicates Copper Gully is ephemeral with a low proportion of baseflow. Since monitoring began, Copper Gully has flowed following, and for a relatively short time after, significant rainfall events (Appendix F).

Water quality in Copper Gully is monitored at CAWS45 (Figure 4-16). The mean pH of the available data is 5.3, which is more acidic than the other surface water monitoring sites in the Cadia Valley and surrounds (Appendix F). Median nitrogen, phosphorus and metal concentrations in Copper Gully at CAWS45 were compared by Gilbert & Associates (2009) to ANZECC guideline triggers for aquatic ecosystems and stock watering. The results showed that median total phosphorus concentrations were higher than the ANZECC guideline default trigger value of 20 µg/L for aquatic ecosystems. Several metal concentrations were found to be elevated (i.e. Cd, Cu, Total Fe and Zn) against the aquatic ecosystem guideline triggers, with the median copper concentration being particularly high.

With the exception of copper, median values of analytes in Copper Gully at CAWS45 did not exceed the ANZECC guideline trigger levels for stock watering protection (Appendix F).

***Rodds Creek***

Rodds Creek is also an eastern tributary of Cadiangullong Creek (Figure 4-16). The upper and mid catchment of the Creek has been heavily modified by the existing Cadia Valley Operations (in particular by the construction of the South Waste Rock Dump, Rodds Creek Water Holding Dam, NTSF and STSF). The remaining 5 $km^2$ catchment below the STSF is predominantly cleared grazing land with scattered tree cover.

Water quality in Rodds Creek is monitored at CAWS30 (Figure 4-16), which is located approximately 350 m downstream of the STSF embankment and has been monitored since 2002. Surface water quality is also monitored upstream of southern boundary of ML 1481 in a seepage collection pond and a weir (i.e. CAWS31 and CAWS41 respectively), which are located between Panuara Road and the toe of the STSF embankment (Figure 4-16). These sites, plus several groundwater bores, are used by CHPL to monitor potential seepage downstream of the STSF. A discussion of the most recent STSF seepage evaluations by AGE and GHD in 2008 is provided in Section 4.2.1 and Appendix G.

Gilbert & Associates (2009) analysis of the available data for CAWS30 indicated that the pH is slightly alkaline (i.e. mean value of 8.1), and the EC is moderate (mean 1,331 µS/cm).

Median nitrogen, phosphorus and metal concentrations in Rodds Creek at CAWS30 were compared by Gilbert & Associates (2009) to ANZECC guideline triggers for aquatic ecosystems and stock watering (Appendix F). The results showed that the median total nitrogen concentration was high and exceeded the guideline default trigger value for aquatic ecosystems. The median concentrations of metals were found to be at or below the 95% aquatic ecosystem trigger values, with the exception of copper and zinc (which were only below the 80% trigger value).

Median values of analytes in Rodds Creek at CAWS30 did not exceed the ANZECC guideline trigger levels for stock watering (Appendix F).

***Flyers Creek***

Flyers Creek is located to the east of the Cadia Valley (Figure 4-16). Its headwaters rise in the elevated plateau to the north-east of the Cadia Valley Operations. It flows southwards towards the Belubula River, at which point it has a catchment area of approximately 168 $km^2$ (Appendix F).

Landuse in the Flyers Creek catchment is predominantly sheep and cattle grazing which is undertaken on closely settled properties (Appendix F). Flow in Flyers Creek is used by graziers who have property access to the creek (Figure 1-4). The pattern of land subdivision along Flyers Creek has specific provision for access to the creek via “give and take”. The phrase “give and take” refers to the situation where the boundary between two properties with a common frontage to Flyers Creek is alternately offset to one side of the creek and then to the other (typically at 100 m intervals), to provide equivalent access to the Creek for stock watering to both properties (Appendix F).

An estimate of the total maximum riparian demand of all landholders with access to Flyers Creek was made by Gilbert and Sutherland in 1997. The average stock carrying capacity of all properties along Flyers Creek was found to be approximately 10 dry sheep equivalents (DSE) per hectare which equates to approximately 100 L per hectare per day. Based on the area of all properties which have direct access to Flyers Creek, this equates to a total riparian water demand for Flyers Creek of 0.85 ML/day at its confluence with the Belubula River. The estimated riparian demand for all the properties upstream of the Forest Hut Ridge gauging station (GS412147 - Figure 4-16) is 0.36 ML/day, with the remaining riparian demand of 0.49 ML/day being attributed to downstream properties (Appendix F).

As part of the Project Surface Water Assessment, Gilbert & Associates (2009) reviewed the current DPI sheep and cattle watering guidelines and DSE calculation guidelines. This review confirmed that the stocking rates and associated water demand estimates used from the Gilbert and Sutherland 1997 survey were consistent with contemporary DPI guidelines (Appendix F).

Currently on Flyers Creek, there are four licences issued by the DWE that enable the holder to extract water under the *Water Act, 1912*. The largest licensed entitlement is held by CHPL and has a total extractable water allocation of 4,200 ML per year (Section 2.1.10). This limit applies to all water taken from the watercourses specified in the licence including Flyers Creek, Cadiangullong Creek and Rodds Creek. CHPL commenced water extraction from the Flyers Creek weir (Figure 4-16) in mid-2007. In the period from July 2008 to December 2008 approximately 730 ML was extracted from Flyers Creek for use at the Cadia Valley Operations. Conditions of the licence require that natural flows of up to 3.5 ML/day, measured at the Flyers Creek weir, be allowed to pass uninterrupted downstream, and that water extraction be limited to medium to high flows.

The remaining three entitlements are for small volumes of water (i.e. less than 22 ML/year) and are licensed to be used for stock and domestic watering, minor irrigation and industrial use (Appendix F).

Streamflow in Flyers Creek is measured at a CHPL gauging station located at Forest Hut Ridge (GS 412147) (Figure 4-16), and at a DWE gauging station located at Beneree (GS 412080), which is located further downstream. Figure 4-17 presents rainfall records and corresponding hydrographs of the surface water flows at the Forest Hut Ridge gauging station (GS 412147). The recorded streamflow data show strong low flow persistence with no instances of flow having been recorded below 1.6 ML/day.

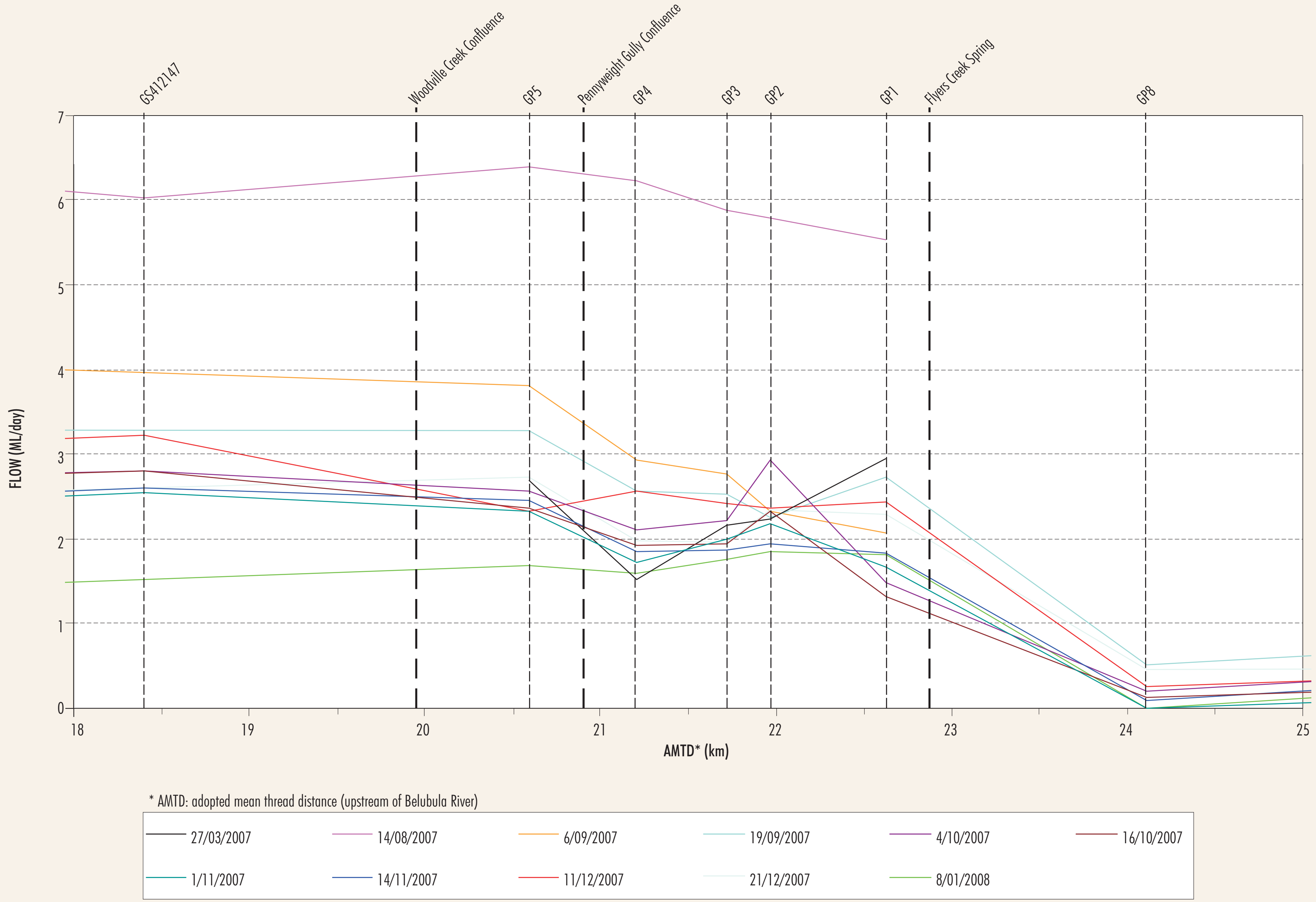
The upper reaches of Flyers Creek drain a Tertiary basalt plateau (Section 4.2.1). The geology in the middle and lower parts of the catchment comprises Silurian and Ordovician age sediments and volcaniclastic rocks respectively (Appendix G). Groundwater inflows from the Tertiary basalt to Flyers Creek occur as small intermittent seeps in lower areas of the basalt plateau and where the creek crosses the contact between the Tertiary age basalt and the underlying Silurian sediments (Appendix F).

In autumn 2007 Gilbert & Associates inspected Flyers Creek and conducted dry weather streamflow measurements (gaugings) to investigate flow variation along the creek. Further stream gauging was conducted in winter 2007, spring 2007 and summer 2007/2008. Gauge point (GP) locations are shown on Figure 4-16. The gauging results are presented in Figure 4-18. The 2007 inspection identified an area of springs approximately 1.2 km downstream of Long Swamp Road where Silurian limestone outcrops. An individual spring in this area was estimated by Gilbert & Associates (2009) to have a flow of approximately 20 L/s. The gauging results indicate that the springs downstream of Long Swamp Road maintained a significant proportion of flow downstream during dry weather with relatively small increases in flow being observed in the reaches downstream of the springs (Appendix F).

Surface water samples have been taken at numerous sites along Flyers Creek, with the majority of sampling sites clustered upstream of the confluence with Woodville Creek (Figure 4-16). The pH of the monitoring sites on Flyers Creek was found to be generally near neutral to slightly alkaline (i.e. mean values ranging from 6.6 to 8.1). EC at the monitoring sites was low to moderate (i.e. mean values range from 58 to 1046 μS/cm) (Appendix F).

Median nitrogen, phosphorus and metal concentrations in Flyers Creek were compared by Gilbert & Associates (2009) to ANZECC guideline triggers for aquatic ecosystems and stock watering (Appendix F). Median total nitrogen concentrations exceed the ANZECC guideline trigger value for aquatic ecosystems of 250 μg/L in the reaches of Flyers Creek upstream of the Forest Hut Ridge gauging station. Median total phosphorus concentrations equalled or exceeded the ANZECC guideline trigger of 20 μg/L for aquatic ecosystems at all locations (Appendix F).

The median copper concentrations equalled or exceed the 90% species protection trigger value at upstream locations (i.e. CAWS47 and CAWS48), while downstream median concentrations reduced to levels consistent with the 99% trigger value (Appendix F). Median zinc concentrations exceeded the 80% species protection trigger value in the upstream reaches of the creek (i.e. CAWS47 and CAWS48 ) and 90% species protection trigger values in the downstream reaches (with the exception of the Panuara Road crossing site [CAWS10] which was below the 99% trigger level).




Source: Gilbert and Associates (2009)

CADIA EAST PROJECT

**FIGURE 4-18**

Flyers Creek Gauged Flows

Cadia Holdings Pty Limited

ResourceStrategies

NEC-06-66 Sect 4_014B

Arsenic and cadmium concentrations exceeded the 99% species protection trigger value at CAWS47, CAWS44 and GS412702 and chromium exceeded the 99% trigger value at CAWS47. Iron concentrations exceeded the 80% species protection trigger value at CAWS48. Median values of analytes in Flyers Creek did not exceed the ANZECC guideline trigger levels for stock watering (Appendix F).

***Woodville Creek***

Woodville Creek is a small tributary on the western side of Flyers Creek east of the proposed Cadia East subsidence zone and on the margin of the predicted zone of influence (Figure 4-16). Its catchment is small (2.1 $km^2$), generally steep throughout its length, with an incised channel and little or no floodplain in its reaches. The majority of the catchment area consists of Monterey Pine (*Pinus radiata*) plantation (Canobolas State Forest), with smaller areas of native remnant woodland and cleared grazing land in the lower riparian reaches.

Recorded streamflow data from a baseflow monitoring weir on Woodville Creek show that it is an ephemeral stream with negligible baseflow. The recorded flows have generally been limited to short periods during and after significant rainfall events (Appendix F).

Surface water samples were collected by CHPL at the Woodville Creek baseflow monitoring weir (WBW) from mid/late 2007 to late 2008 (Appendix F). Lack of flows during this period has limited water quality monitoring to three samples, therefore median water quality values were not calculated by Gilbert & Associates (2009) for Woodville Creek. Results from the three water quality samples suggest that water quality is similar to that observed at upstream sampling locations on Flyers Creek (Appendix F).

### 4.3.2 Potential Impacts

This sub-section describes the potential impacts that the Project may have on surface water resources. Measures that would be used by CHPL to manage these impacts are described in Section 4.3.3. In summary the potential impacts include:

- reduction of surface water quality due to runoff, seepage, the release of process water from construction or operational areas, or salinity;
- reduced flows in local streams draining the Project area due to extraction for the Project water supply and loss of groundwater contribution through the formation of a permanent subsidence zone; and
- changes in flows in the Belubula River due to extraction for the Project water supply and loss of baseflow in local creeks (tributaries of the Belubula River).

***Potential Impacts on Surface Water Quality During Construction and Operations***

Surface water runoff from disturbed areas could potentially contain sediments, dissolved solids, oil, grease, process reagents, metals, salts and by-products (e.g. tailings). The potential surface water quality impacts of the Project that relate to these contaminants are summarised in Table 4-7.

The Project water management system would be integrated with the existing Cadia Valley Operations water management system. The objectives of the Project water management system are to control erosion and sedimentation, and to manage water quality in local watercourses (Appendix F and Section 2.11). Water management strategies have been developed based on those used at the existing Cadia Valley Operations. The management strategies involve the principles described below.

*Minimising Disturbance Areas*

Land disturbance caused by mining would be minimised. The site would be partitioned into undisturbed runoff areas, development/construction runoff areas, and operational runoff areas to minimise the generation of waters requiring on-site containment.

**Table 4-7**
**Potential Surface Water Quality Impacts**

| Development/Construction[1] and Operational Areas[2] | Potential Impact Scenario | Type of Potential Contamination |
|---|---|---|
| Ore processing facilities | Drainage of sediment laden runoff to downstream surface waters during construction of new/upgraded processing areas/hardstands. Spillage to downstream surface waters during operation. | Sediments, process reagents, fuel, oil, lubricants and process by-products. |
| New water supply pipeline from the Belubula River | Drainage of sediment laden runoff to downstream surface waters during construction of the new pipeline. | Sediments. |
| New water pipeline from Cadiangullong Dam to the Rodds Creek Water Holding Dam | Drainage of sediment laden runoff to downstream surface waters during construction of the pipeline. | Sediments. |
| South Waste Rock Dump | Drainage of sediment laden runoff to downstream surface waters. Uncontrolled drainage from the waste rock dump to downstream surface waters. | Sediments and potential soluble metals. |
| Raised NTSF and STSF embankments | Drainage of sediment laden runoff to downstream surface waters during construction. Spillage during extreme rainfall events and/or seepage to downstream surface waters. Uncontrolled runoff from the embankments. Surface expression seepage from the STSF. Overtopping and spillage of stored water. | Sediments, dissolved solids, process reagents and potential soluble metals. |
| Infrastructure (roads, hardstands and soil stockpiles) | Drainage of sediment laden runoff to downstream surface waters during construction. Spillage to downstream surface waters during operation. | Fuel, oil, hydraulic fluid, sediments and process reagents. |
| Subsidence zone | Development of a saline, potentially acidic waterbody in the long-term (150 to 160 years following mine closure). Potential for saline waters from the subsidence zone to discharge to downstream surface waters. | Salinity, potential acidity and soluble metals. |
| New concentrate and return water pipelines to Blayney | Drainage of sediment laden runoff to downstream surface waters during construction of the pipelines. Spillage to downstream surface waters during operation. | Sediments, concentrate. |
| New CVO Dewatering Facility at Blayney | Drainage of sediment laden runoff to downstream surface waters during construction of plant area/hardstand. Spillage to downstream surface waters during operation. | Sediments, concentrate, fuel, oil, lubricants. |

1 Areas significantly disturbed by Project-related development or construction activities.

2 Areas containing fuels, lubricants, process reagents, mine waste, concentrate or process by-products (e.g. tailings).

*Containment and Recycling*

Runoff from development/construction areas and operational areas would be intercepted and channelled to containment storages across the site. Secure storages would be provided for the containment of spills and runoff from within these areas. Accumulation of waters stored in these storages would be managed by priority re-use in the ore processing facilities. A summary of the capacity and function of the containment storages is provided in Table 4-8.

Following stabilisation of the outer batters of the above containment storages and structures, it is anticipated that any runoff from the batters would be of comparable quality to runoff from surrounding undisturbed areas.

Control methods that would be used to manage seepage at the tailings storage facilities are described in Section 2.8.5. Any limited seepage that is expressed as surface runoff would be intercepted by the seepage collection pond downstream of the STSF.

The existing South Waste Rock Dump leachate dams provide erosion, sedimentation and leachate control for the existing operations. These dams were designed in consultation with the relevant authorities. The existing Water Management Plan would be revised to include the details of the existing leachate dams and confirm that these dams are adequate to meet their design requirements.

*Erosion and Sediment Control*

Erosion and sediment control measures would be designed in accordance with the above water management principles and would be described in a revision of the IESCP (Section 2.11.1).

**Table 4-8**
**Summary of Containment Water Storages**

| Component | Function | Capacity |
|---|---|---|
| Rodds Creek Water Holding Dam | Storage of water extracted from the Belubula River, water transferred from Cadiangullong Dam, treated effluent from Orange and Blayney, upslope runoff and excess water in the site water management system (including excess water from tailings storage facilities).<br>Water pumped to the process water pond. | Runoff from the contributing catchment resulting from a 1 in 100 year ARI rainfall event lasting 72 hours. |
| STSF and NTSF | Storage of tailings, rainfall and upslope runoff.<br>Decanted water pumped to the process water pond or the Rodds Creek Water Holding Dam. | Runoff from the contributing catchment resulting from a 1 in 100 year ARI rainfall event lasting 72 hours. |
| STSF runoff/seepage collection dam | Storage of rainfall and upslope runoff/seepage from the STSF.<br>Water pumped to the STSF. | Runoff from the contributing catchment resulting from a 1 in 100 year ARI rainfall event lasting 72 hours. |
| Ore processing facilities site runoff pond | Ore processing facilities runoff storage and emergency containment of process water or reagent spills.<br>Water pumped to the process water pond. | Runoff from the contributing catchment resulting from a 1 in 100 year ARI rainfall event lasting 48 hours. |
| Sediment control structures | Storage of runoff from Development/ Construction Areas.<br>Water pumped or delivered to the process water pond. | Runoff from the contributing catchment resulting from a 1 in 20 year 1 hour storm. |
| Process water and tailings reticulation containment system | Containment of spills from reticulation system.<br>Spills pumped back into the reticulation system. | Volume from 10% of the maximum pumping capacity for a 4 hour period plus volume stored in upslope portions of pipe. |

Source: Appendix F.

***Potential Impacts on Surface Water Quality Post-Closure***

*Revegetation of Disturbed Areas*

Disturbance areas would be rehabilitated progressively as they become available during the mine life, with any residual areas to be completed once operations cease (e.g. revegetation of the surface of the tailings storage facilities). Temporary sediment retention storages, silt fences and vegetation buffers would be used as interim erosion and sediment control measures where necessary during the rehabilitation process. It is anticipated that once rehabilitated areas become established, surface runoff would be of comparable quality to undisturbed areas.

The existing sediment ponds and leachate collection ponds downstream of the South Waste Rock Dump and the STSF would be retained until the final surface of these landforms is successfully revegetated and/or stable, and the runoff quality is acceptable.

Section 5 and Appendix P provide further detail on the approach to rehabilitation and landscape management for the Project.

*Final Void*

As described in Section 4.2.2 and Appendix G, after mining ceases the remaining tunnels and spaces between the broken rock in the Cadia East caving zone would begin to fill. A moderate salinity gradient is expected to develop within the broken rock of the caving zone as incident rainfall enters the top of the caving zone creating a fresh water lens lying on top of more brackish groundwater which would flow in from the adjoining Ordovician and Silurian aquifers. Higher salinity water is expected to eventually stabilise at a deeper level within the caving/subsidence zone (Appendix G). The water is predicted to reach the top of the caving zone and emerge into the Cadia East subsidence void after approximately 150 to 160 years. After a further 170 years (i.e. approximately 330 years in total) the waterbody is predicted to have joined with the Cadia Hill open pit waterbody and reached an equilibrium level at approximately 670 m AHD (Figures 4-11 and 4-12). AGE (2009) predicts that no water would escape into the surrounding rock post-closure because the subsidence zone/open pit void would remain a sink for groundwater flow.

A similar, albeit smaller, subsidence zone waterbody is predicted to occur at Ridgeway once mining ceases. Due to it being a groundwater sink, and because of evaporation, the salinity of the Ridgeway subsidence zone waterbody is predicted to increase over time (i.e. salinity in the order of 2,300 mg/L after 250 years, and approximately 5,000 mg/L after 350 years) (CHPL, 2000b).

The salinity of the Cadia East/Cadia Hill final waterbody would also be expected to slowly increase over time after it reaches its equilibrium level in approximately 330 years. The increasing salinity would be primarily due to the effect of evaporation from the surface of the waterbody, although some dissolution of salts and precipitates on the cave rock would be expected to occur as the caving zone fills.

Acidic drainage generated from the oxidation of PAF Ordovician volcanic material within the Cadia East caving zone is likely to reduce the pH and increase dissolved metal concentrations in the water. However, hydraulic gradients would continue to draw local groundwater into the subsidence void, and therefore prevent the mobilisation of the water out into surrounding aquifers (AGE, 2009).

***Water Supply System and Site Water Balance***

The upgrade and augmentation of the existing water supply system would be required to meet the increased demands for the Project (anticipated to be approximately 55.8 ML/day). This is approximately a 5.9 ML/day increase from existing operational water demand (i.e. an increase of approximately 12%). Allowing for return water from the tailings storage facilities and other storages on-site, residual make-up requirements would be approximately 31.4 ML/day (i.e. water required from other sources) (Appendix F).

The increased demand for water for the Project would be met by the expansion and augmentation of existing infrastructure to allow more efficient harvesting of surface water. The proposed changes are described in Section 2.10.2 and are summarised below:

1. Installation of a transfer pipeline between Cadiangullong Dam and Rodds Creek Water Holding Dam to transfer water from Cadiangullong Dam to Rodds Creek Water Holding Dam at a maximum rate of 20 ML/day. Transfer would occur until the volume in Cadiangullong Dam drops to 10% capacity, at which point transfers would cease until the volume equals or exceeds 10%.

During these periods where the level of Cadiangullong Dam is at or below 10% CHPL would continue to release water from Cadiangullong Dam in accordance with the existing environmental release protocol described in Section 4.3.2.

These releases would continue up to the point when the storage level falls below the lowest release point on the multi-level off-take in the dam (set at 764.9 m AHD). This protocol is targeted at maintaining a storage "reserve" within the dam for environmental releases for downstream users on Cadiangullong Creek.

2. Enlarging the capacity of the Rodds Creek Water Holding Dam from 3,700 ML to approximately 14,500 ML by raising the embankment and spillway crest level by 15 m to achieve a final spillway level of 780 m AHD. The Rodds Creek Water Holding Dam would be used to store water from the following sources:
   - water transferred from Cadiangullong Dam;
   - treated effluent pumped from the Orange Sewage Treatment Plant and Blayney Sewage Treatment Plant;
   - licensed water extraction from the Belubula River and Flyers Creek Weir;
   - rainfall runoff from the dam catchment (<5 km$^2$); and
   - excess water in the site water management system, including but not limited to excess water in the tailings storage facilities, water from on-site sediment dams and water from underground dewatering activities.
3. Increasing the extraction capacity of the Belubula River pumping system from 20 ML/day to a maximum of 30 ML/day. CHPL would upgrade the existing pipe and pumping infrastructure to improve harvesting of unregulated flows under CHPL's HSE licence.

A water balance model was developed and used by Gilbert & Associates (2009) to assess the performance of the Project water supply scheme for a wide range of climatic conditions over the Project life (Appendix F). The model was integrated with modelling of the Belubula River using the Integrated Quantity-Quality Model (IQQM), which is used by the DWE to assess water resources in the Belubula and determine future allocation announcements.

The model included up to 1 ML/day of groundwater that would be dewatered from the Cadia East underground workings[1], plus an additional 1 ML/day of groundwater abstracted from the on-site groundwater borefield. As described in Section 2.10.2, CHPL is proposing to use water abstracted from this borefield for process water make-up on an ongoing basis (i.e. not just under exceptional circumstances). CHPL would also use the water pumped from the Cadia East underground mine for Project water supply.

Rainfall data used in the simulations comprised a greater than 1,000 year stochastic data set (Appendix F). Stochastic data was generated from a 'seed' of regional rainfall data from rainfall stations with long periods of record, including data from Canobolas State Forest, Orange and Blayney, which provided 118 years of record applicable to the Cadia Valley Operations and the Belubula River valley. The stochastic data was used in the model to generate 1,000 possible mine-life 'sequences' which were used to simulate the performance of the water management system over a wide range of climatic possibilities (Appendix F). The model simulation was run commencing with the mine as at 31 December 2008 and running until the end of 2030 (22 years).

The three climatic sequences modelled by Gilbert & Associates (2009) are listed below:

1. *Dry Rainfall Sequence* – 10$^{th}$ percentile dry 22 year rainfall sequence (corresponding to a low rainfall sequence, or one that is exceeded in 90% of 22 year periods).
2. *Median Rainfall Sequence* – Median 22 year rainfall sequence (corresponding to a median rainfall sequence, or one that is exceeded in 50% of 22 year periods).
3. *Wet Rainfall Sequence* - 10$^{th}$ percentile wet 22 year rainfall sequence (corresponding to a high rainfall sequence, or one that is exceeded in 10% of 22 year periods).

[1] It is noted that this is less than the underground inflows predicted by AGE (2009) (Appendix G). However, given the conservatism in AGE's groundwater model, 1 ML/day was used in the water balance modelling conducted by Gilbert & Associates (2009) to ensure that water supply reliability is not contingent on AGE's groundwater inflow predictions.

The water balance modelling conducted by Gilbert & Associates (2009) demonstrated a water supply reliability of 97.2% (i.e. on average, the full water demand of the Project would be able to be met on 97.2% of days simulated). In addition, the water management system performed within its design requirements over all conditions represented in the greater than 1,000 year rainfall set data (Appendix F).

The Project Surface Water Assessment also indicated that, averaged over all climatic sequences modelled, the percentage of time that the Cadiangullong Dam would be effectively empty (i.e. when the storage level falls below the lowest release point on the multi-level off-take in the dam) would increase from 2.8% of the time to 9.4% of the time (Appendix F).

***Potential Impacts on Local Creeks***

The Groundwater Assessment (Appendix G) included predicted impacts on groundwater discharge (baseflow) in Flyers Creek, and Cadiangullong Creek and its tributaries (i.e. Cadia Creek, Copper Gully and Rodds Creek). The predicted baseflow volumes in the local creeks under each of the five groundwater model scenarios are provided in Table 4-6.

The assessment of these predicted groundwater drawdown effects on surface water flows in Flyers Creek and Cadiangullong Creek and its tributaries is provided in Appendix F, and is summarised below.

*Flyers Creek*

The groundwater modelling results show a maximum predicted reduction in baseflow from Flyers Creek upstream of the Forest Hut Ridge gauging station during operations (i.e. groundwater Model II minus Model III) of 0.49 ML/day. Following closure of the mine and once the tailings storage facilities have dried out (i.e. groundwater Model II minus Model IVa), the loss of baseline flow in this section is predicted to only be marginally less (i.e. 0.48 ML/day). The modelling showed no additional baseflow loss during operations or post–mining in the section of Flyers Creek downstream of the Forest Hut Ridge gauging station (Appendix G).

A hydrological model of Flyers Creek was developed and calibrated by Gilbert & Associates (2009) using observed rainfall, evaporation and streamflow data (Appendix F).

The calibrated model was used to generate simulated streamflow (i.e. flow duration curves) at the Forest Hut Ridge gauging station (Figure 4-16) for the following scenarios:

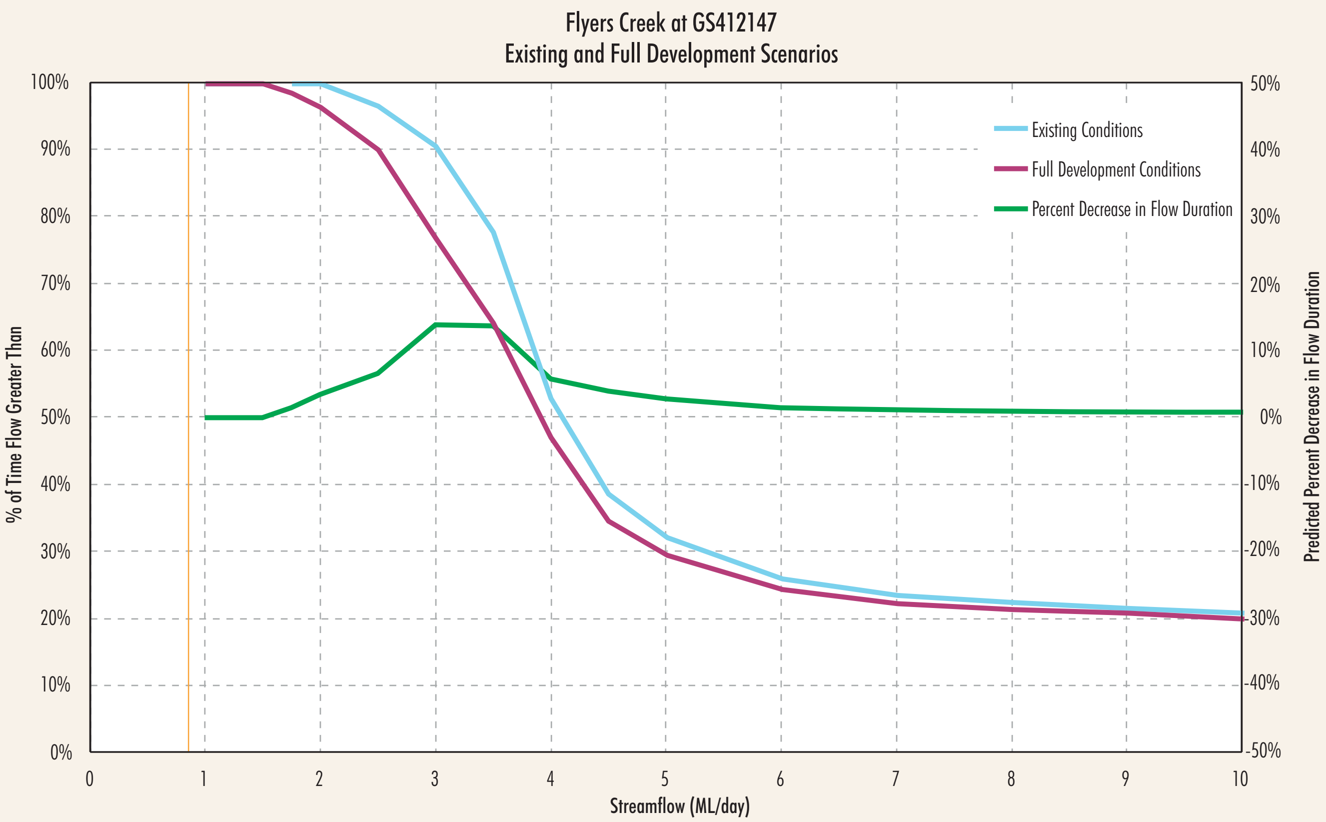
- no development of the Project but with continued operation of the Cadia Valley Operations, including licensed extraction of water from the weir on Flyers Creek;
- full development of the Project (with predicted baseflow loss of 0.49 ML/day) plus full development of the Cadia Valley Operations, including licensed extraction by CHPL from the weir on Flyers Creek; and
- post Project closure (with predicted baseflow loss of 0.48 ML/day) with no extraction by CHPL from the weir on Flyers Creek.

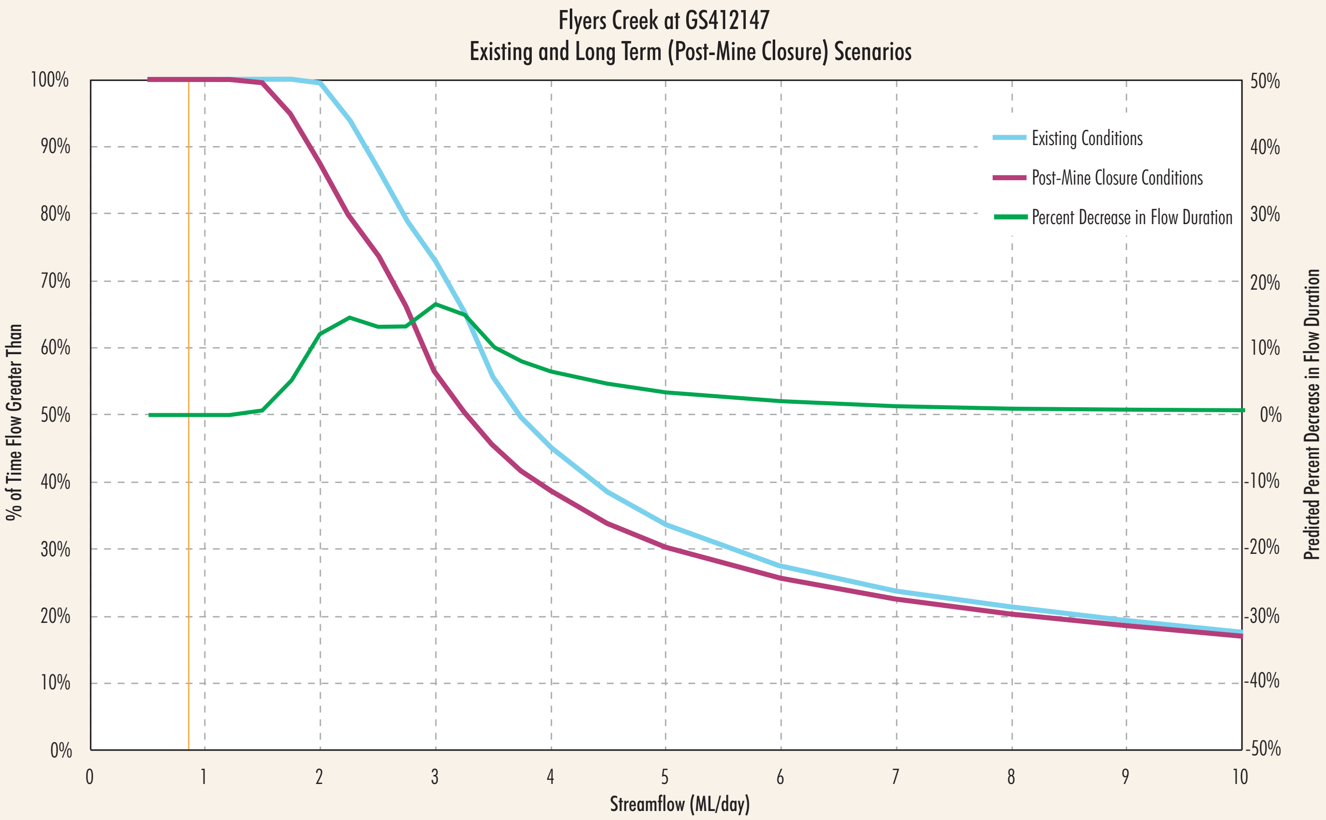
Flow duration curves show the relationship between streamflow in ML/day and the percentage of time that these flows are exceeded on average. A percentage change curve is also presented on each flow duration curve. This curve shows the predicted percentage change (i.e. increase or decrease) in the percentage of time that different daily flows are exceeded as a result of the Project under full development and post-mining conditions.

Flow duration curves are generated from long periods of flow record and consequently represent the average condition.

Figure 4-19 presents the full development and post-closure flow duration curves, showing the predicted changes to flows in Flyers Creek. The figure illustrates that the Project at full development would potentially increase the proportion of time low flows occur in Flyers Creek, principally in the range of 2 to 4.5 ML/day (Figure 4-19). The maximum effect is predicted to occur to flows of approximately 3 ML/day with an increase in the percentage of time that flow is less than 3 ML/day of approximately 14% (Appendix F).

The Surface Water Assessment includes consideration of the effect of the predicted flow changes on the movement of water, flow depths and flow channel width in Flyers Creek under low flow conditions. To illustrate these changes, Appendix F contains a series of photographs of the existing creek under low flow conditions.




*Source: Gilbert and Associates (2009)*

ResourceStrategies

CADIA EAST PROJECT

**FIGURE 4-19**

Flyers Creek Flow Duration Curves

Cadia Holdings Pty Limited

NEC-06-66 Sect 4_ 015D

For each photograph Gilbert & Associates (2009) has provided a corresponding description of how the creek would be expected to change at that point if the predicted baseflow losses were to eventuate (Appendix F). The predicted changes are generally restricted to small decreases in stream width and stream depth (e.g. 1 to 2 centimetres [cm] shallower).

The potential impacts of the Project on stock and domestic water supply reliability for Flyers Creek landholders during operations are assessed in Appendix F. The estimated riparian demand for all of the properties on the sections of Flyers Creek above and below the Forest Hut Ridge gauging station is 0.36 ML/day and 0.49 ML/day respectively, which equates to a total of 0.85 ML/day for the whole creek (Section 4.3.1 and Appendix F). When the maximum predicted loss (0.49 ML/day) is subtracted from the minimum recorded flow at the Forest Hut Ridge gauging station (1.6 ML/day) it leaves 1.11 ML/day, which is greater than the estimated 0.49 ML/day required for riparian users downstream of the Forest Hut Ridge gauging station, plus the 0.06 ML/day of existing private licence entitlements (Appendix F).

The modelled post Project closure scenario removed the extraction of water by CHPL from the weir on Flyers Creek (as this is only required when the mine is operating), but kept the simulated long-term reduction in groundwater baseflow to the creek (i.e. 0.48 ML/day). The results indicated that the long-term effect of the Project on low to medium flows would be similar to the full development scenario (i.e. an increase in the percentage of time that flow is less than 3 ML/day of approximately 17%) (Figure 4-19).

*Cadiangullong Creek*

The groundwater modelling by AGE (2009) predicted a maximum reduction in Cadiangullong Creek baseflow of 1.2 ML/day (Appendix G) at full Project development. Of this total, up to approximately 1.07 ML/day would be from baseflow reductions in the Cadia Creek tributary. This is due to Cadia Creek being located relatively close to the Cadia East subsidence zone, and a large proportion of its catchment being located within the Tertiary basalt to the north and north-northeast of the mine (Section 4.2.2).

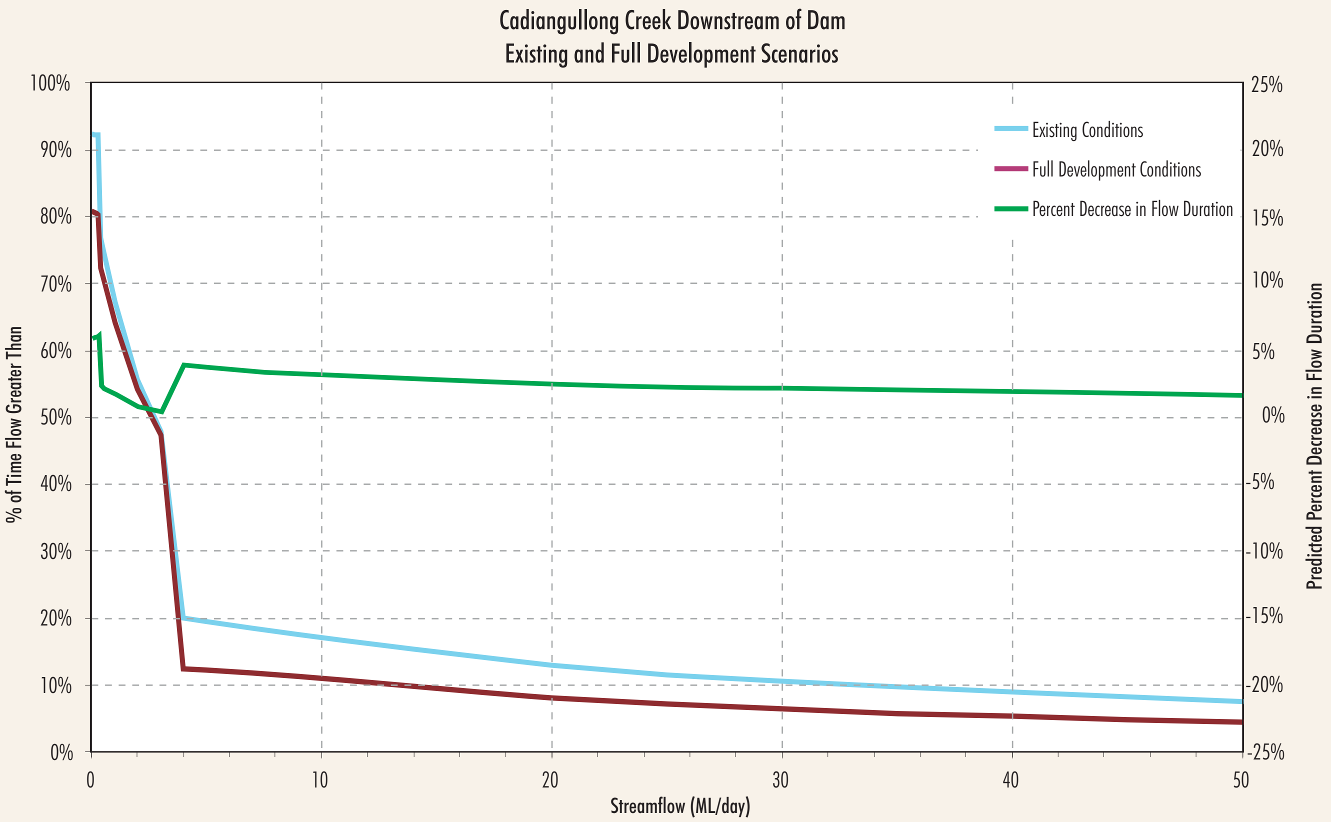
Following closure of the Project, AGE (2009) predicted that the reduction of baseline flow at the southern edge of the modelled area would be slightly less than during operations (i.e. 1.13 ML/day), with the predicted loss from Cadia Creek also less, albeit only marginally (i.e. 1.03 ML/day) (Appendix G).

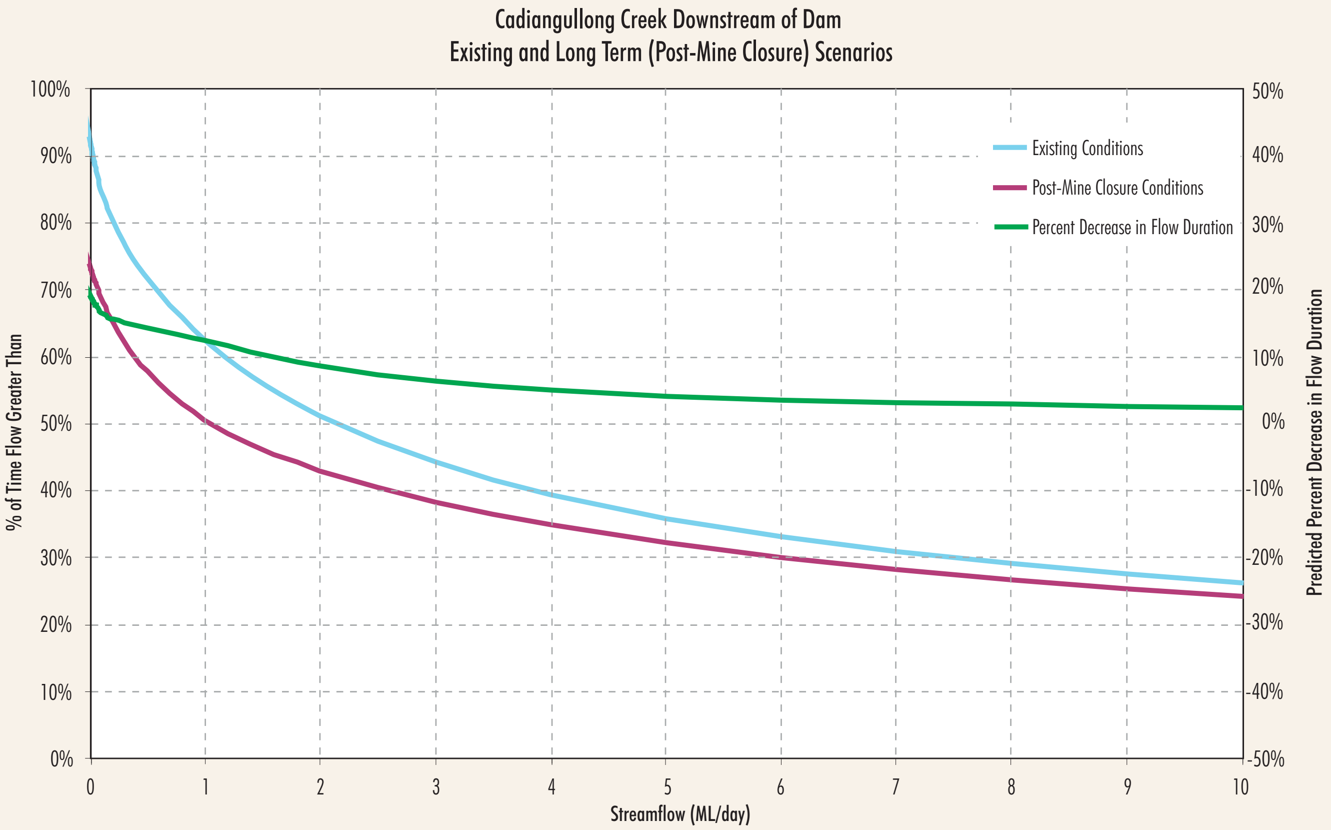
Gilbert & Associates (2009) used hydrological modelling to assess the effect of the Project on flows in Cadiangullong Creek upstream of GS412702 (i.e. the Oaky Creek gauging station). The model was used to generate flow duration curves (Figure 4-20) for the following scenarios:

- no development of the Project but with continued operation of the Cadia Valley Operations, including licensed extraction of water from the Cadiangullong Dam;
- full development of the Project (with predicted baseflow loss of 1.07 ML/day from Cadia Creek) plus full development of the Cadia Valley Operations, including the additional effects of the pipeline from Cadiangullong Dam to the Rodds Creek Water Holding Dam; and
- post Project closure with no extraction by CHPL from Cadiangullong Dam.

Figure 4-20 illustrates that the modelled effect of the Project at full development would be minimal in the 2 to 3.4 ML/day flow range. At higher flows there would be a more notable reduction in flow frequency (i.e. by approximately 7.8% at 3.4 ML/day). This percentage reduction would gradually decrease at higher flows (i.e. 3% predicted reduction at flow rates of 50 ML/day) (Appendix F). At the very low flow rates (i.e. less than 2 ML/day) Gilbert & Associates (2009) predicts a drop in the frequency that these flows would occur of up to approximately 12% (Appendix F). The percentage of time that Cadiangullong Creek (downstream of Cadiangullong Dam) would cease flowing is predicted to increase from approximately 8% of days to 19% of days. However, as described in Section 4.3.1, Cadiangullong Creek prior to mining was perennial and the percentage of time it ceased flowing downstream of Cadiangullong Dam is likely to have been between 15 and 25% of days on average (Appendix F).

Following closure of the Project, flows in Cadiangullong Creek would be affected by the presence of Cadiangullong Dam and how it is operated by the future owner. Under the scenario that Cadiangullong Dam is managed passively after mine closure (i.e. no releases other than it spilling when it is full), Gilbert & Associates (2009) estimated that the maximum effect would occur to zero flows with an approximate 19% increase in the frequency of zero flow days (Appendix F). This is similar to the expected frequency of zero flow days that would have prevailed prior to mining (Gilbert & Associates, 2009).




*Source: Gilbert and Associates (2009)*

CADIA EAST PROJECT

**FIGURE 4-20**

Cadiangullong Creek Flow Duration Curves

Cadia Holdings Pty Limited

ResourceStrategies

NEC-06-66 Sect 4_016C

A second scenario was also simulated by Gilbert & Associates (2009) assuming that flows were released from the dam to maintain minimum flows downstream. The results of that simulation show that it would be possible to create perennial flow conditions below Cadiangullong Dam (Appendix F).

*Belubula River*

The predicted impacts on flows at CHPL's Belubula River pumping station during full Project development have been assessed by comparing flow duration curves developed from the modelled streamflow in the Belubula River just downstream of the pumping station (Figure 4-21). Gilbert & Associates (2009) also assessed the potential impacts of the Project post-closure on the Belubula River (Appendix F) by considering the long-term effects of the predicted loss of baseflow from Flyers Creek and Cadiangullong Creek. A summary of the findings is provided below.

The overall effect of the Project on flows in the Belubula River at CHPL's Belubula River pumping station was assessed by Gilbert & Associates (2009) by comparing modelled flows in the river for the following scenarios:

- no development of the Project but with continued operation of the Cadia Valley Operations, including extraction of water from the Belubula River at the currently approved rate of 20 ML/day and from Flyers Creek weir (under the existing licence conditions [Section 4.3.1]); and
- the additional effects of extraction by CHPL from the Belubula River (at an increased rate of 30 ML/day) and from Flyers Creek weir for Project water supply (under the existing licence conditions [Section 4.3.1]), and the maximum simulated Project-related reduction in groundwater inflows to Flyers Creek at full development (i.e. 0.49 ML/day).

The changes to the flow regime of the Belubula River at CHPL's Belubula River pumping station during full Project development were assessed using the Project water balance model which includes the Belubula River IQQM to simulate flows in response to rainfall, releases from Carcoar Dam and licensed extractions by CHPL (Appendix F).

Figure 4-21 illustrates that the greatest potential impact of the Project on flows at CHPL's Belubula River pumping station during full Project development would peak in the 10 to 20 ML/day flow range (Figure 4-21).

The maximum effect was predicted for flows of approximately 10 to 25 ML/day, with an increase in the percentage of time flow is less than these flows of approximately 3.2%. For flows less than 10 ML/day, the flow reduction diminishes and small flow reductions (less than 1%) are predicted for flows greater than approximately 30 ML/day (Figure 4-21).

Following Project closure, CHPL would no longer abstract water directly from the Belubula River (i.e. from CHPL's Belubula River pumping station) or from its tributaries (i.e. Cadiangullong and Flyers). However, baseflow losses from Cadiangullong Creek (i.e. 1.13 ML/day) and Flyers Creek (i.e. 0.48 ML/day) are predicted to continue to occur due to the formation of a groundwater sink near the Cadia East subsidence zone (Section 4.2.2). The combined effect of these predicted losses (i.e. 1.61 ML/day or 588 ML/annum) represents approximately 0.6% of the mean annual flow in the Belubula River at its confluence with Cadiangullong Creek (Appendix F).

### 4.3.3 Mitigation Measures, Management and Monitoring

***Construction Surface Water Management Measures***

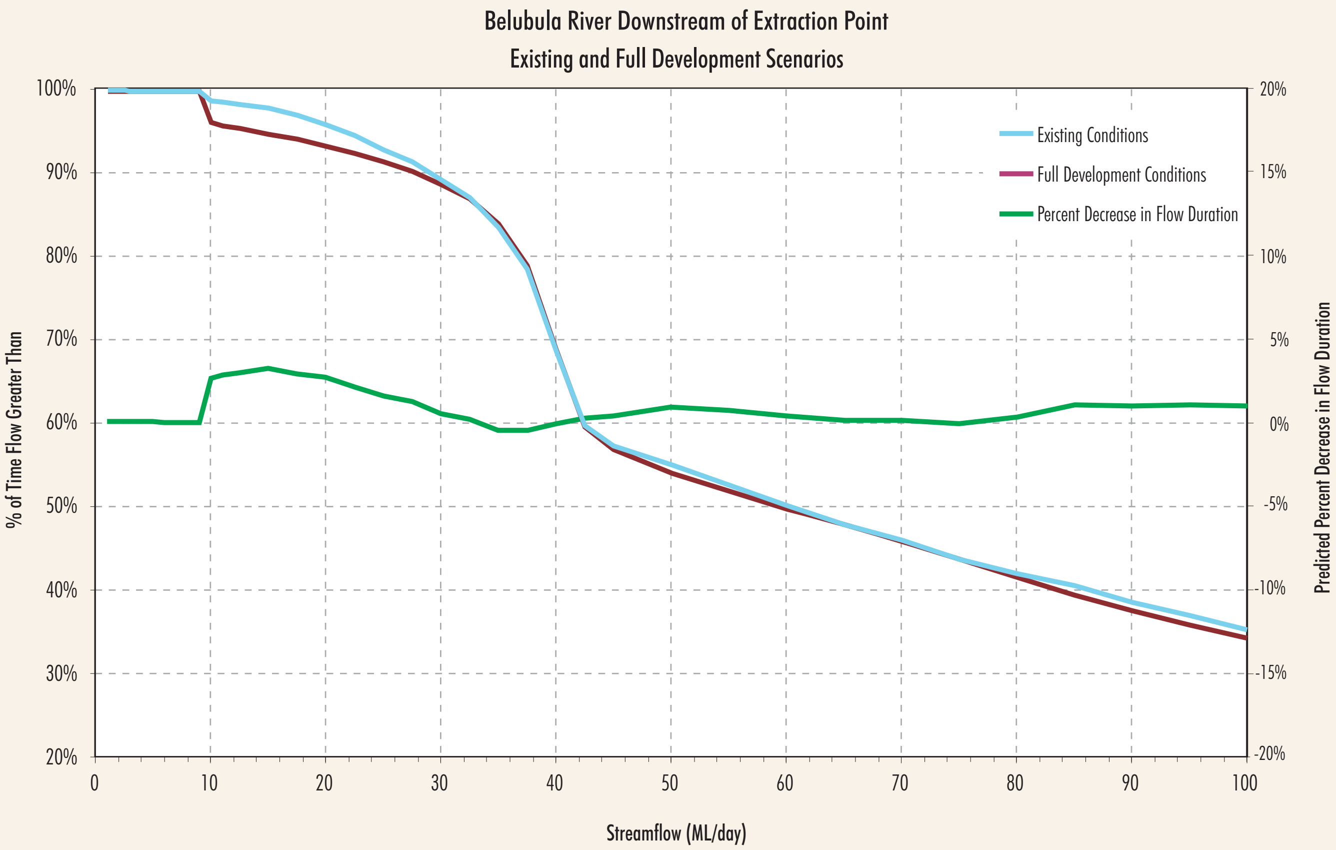
Temporary erosion and sediment controls would be installed prior to the commencement of construction activities. Erosion and sediment control measures would be designed in accordance with relevant water management principles and guidelines.

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;




*Source: Gilbert and Associates (2009)*

C A D I A   E A S T   P R O J E C T

**FIGURE 4-21**

Belubula River Flow Duration Curves

Cadia Holdings Pty Limited

ResourceStrategies

NEC-06-66 Sect 4_ 017C

- 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.

*Site Water Balance*

The Project 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.

***Operational Surface Water Management Measures***

*Ore Processing Facilities and Ore Stockpile Areas*

Runoff from the ore processing facilities area drains to the site runoff pond which is dewatered by pumping to the upslope process water pond. If necessary, the existing site runoff pond would be enlarged to provide containment of all catchment runoff from the 1 in 100 year ARI, 48 hour rainfall event above its normal operating capacity. The site runoff pond would also be augmented if required to provide capacity for containment of 120% of the volume of the largest vessel containing potentially hazardous substances.

*Tailings Storage Facilities*

The NTSF and STSF would be operated to maintain small decant pools in order to maximise water recovery, reduce evaporation loss and optimise drying of the tailings beaches. The return water system would continue to pump water (including stormwater) collected in the decant pools of the NTSF and STSF via the central pumping station to the process water pond for re-use or to the Rodds Creek Water Holding Dam for storage.

Seepage would report to the seepage collection system below the STSF. A float controlled electric pump would be used to return collected seepage water to the STSF. The seepage collection system would remain during the life of the Project.

*CVO Dewatering Facility*

The CVO Dewatering Facility would be constructed approximately 1.7 km east of the Blayney township. Runoff from the CVO Dewatering Facility would be directed to a runoff collection pond sized to provide containment of catchment runoff from a 1 in 100 year ARI, 48 hour rainfall event above its normal operating capacity. The runoff collection pond would be dewatered by pumped transfer to the process water pond via the return water pipeline. Final design of the CVO Dewatering Facility would include determination of 100 year ARI flood levels for the area and, if necessary, detailing of flood protection works.

***Mitigation and Compensation Measures***

CHPL would implement measures to manage potential Project-induced impacts on the availability of stock and domestic water supply to riparian users on Cadiangullong Creek and Flyers Creek. Measures to mitigate the potential impacts of the predicted baseflow loss from the Belubula River would also be implemented.

*Cadiangullong Creek*

CHPL would maintain low to medium-sized flows in Cadiangullong Creek by releasing water from Cadiangullong Dam in accordance with the existing flow protocol described in Section 4.3.1. During the mine life, the protocol would mitigate the impact of the predicted loss of baseflow on the downstream riparian users on Cadiangullong Creek (while the Cadiangullong Dam has sufficient water in it to allow releases to occur). Following mine closure it is envisaged that a new flow release protocol would be developed to accommodate the future use of Cadiangullong Dam and the requirements of the downstream water users.

Large flow events in Cadiangullong Creek would continue to pass over the Cadiangullong Dam spillway (i.e. once the dam is filled to capacity), and would not be significantly impacted by the Project because CHPL is not proposing to increase the size of the dam or the amount of the licensed ‘cap’ of 4,200 ML/annum (Appendix F).

As described in Appendix F and Section 4.3.2, a storage reserve level of approximately 10% of the volume of Cadiangullong Dam would be used during the life of the Project. This would allow CHPL to continue to provide low flow releases (i.e. 0.4 to 3.4 ML/day) up to the point where the level in the dam falls below the lowest release point on the multi-level off-take in the dam.

Once this level is reached, CHPL would not actively pump and release the remaining water from the dam, however it would leave the lowest release valve open to enable flows that do occur to pass downstream (once the water level reaches the valve).

The Project surface water modelling conducted by Gilbert & Associates (2009) indicates that the use of the new pipeline to the Rodds Creek Water Holding Dam, together with the predicted baseflow losses, would increase the percentage of time that the Cadiangullong Creek would cease flowing, and the proportion of time the dam would be effectively emptied (i.e. from 2.8% of the time to 9.4% of the time) (Section 4.3.2). The overall effect of this would be that the creek would more closely resemble the pre-mining low flow conditions (i.e. prior to mining flows ceased from time to time during very dry periods and droughts) (Appendix F). The current flow protocol sustains low flows for considerably longer through dam releases, even when there is no inflow to Cadiangullong Dam.

Notwithstanding the above, a small potential impact on the non-CHPL owned property downstream of the Cadiangullong Dam (i.e. Property 169 - Figure 1-4) is predicted to occur when the water level falls below the lowest release point on the multi-level off-take in the dam (i.e. under very dry to drought conditions) (Appendix F). Once this point is reached, water in Cadiangullong Dam would continue to be lost through evaporation up to the point where it dries out completely. This in itself would not necessarily constitute an impact on the downstream user, as the creek would have been dry under pre-mining similar circumstances anyway. However, the small potential impact on Property 169 could occur once rainfall in the Cadiangullong Creek catchment recommences (i.e. the drought breaks) because it would take a period of time to fill the dam back up to the level of the lowest release point on the multi-level off-take in Cadiangullong Dam (when the flow protocol releases can recommence) (Appendix F).

The scale of the potential impact on Property 169 would depend on where the rain falls in the Cadiangullong Creek catchment, and on how long it takes to fill the dam up to the point where releases can recommence (Appendix F). Gilbert & Associates (2009) concluded that if rain falls throughout the catchment then it is likely that Cadiangullong Creek would begin to flow both upstream and downstream of Cadiangullong Dam, in which case the impact on Property 169 is likely to be negligible or zero. This would be because the property owner would have access to the flows that occur in the lower part of the creek (Appendix F).

If rain only falls in the upper catchment above the dam the period of impact would be proportional to the number of days taken to fill the dam back up to the release point. The stock watering demand for the non-CHPL owned property downstream of the dam has been estimated to be less than 0.05 ML/day (Section 4.3.1 and Appendix F).

In order to minimise the potential impact of this effect on the non-CHPL owned Property 169, CHPL would provide alternative stock water (or otherwise agreed alternative measures) to this property during the periods when the water level in Cadiangullong Dam has fallen below the lowest release point on the multi-level off-take and inflows to the dam are occurring (i.e. the dam is re-filling but it has not yet reached a point where flow releases can re-commence). CHPL would review and revise the existing contingency plan required under Condition 43 of the Cadia Hill Development Consent (DA 44/95) to incorporate the details of the alternative stock watering measures for Property 169.

CHPL would also establish a notification process for the owner of Property 169, DWE and DoP, whereby it would advise these parties when the level in Cadiangullong Dam falls below 20% capacity. From this point CHPL would provide weekly updates of the water level in the dam and the inflow amounts until such time as the capacity exceeds 20% (or otherwise agreed). This would provide advance notice of Cadiangullong Dam potentially falling below 10% capacity, and CHPL potentially being no longer able to continue flow releases (if the dam level continues to fall to below the lowest release point).

*Flyers Creek*

The Surface Water Assessment concluded that the Project is not predicted to have a material impact on Flyers Creek to the extent that flows would fall below the total maximum riparian demand of the landholders with access to the creek (Appendix F). As described in Section 4.3.1 and Appendix F, the estimated riparian demand for all of the properties on the sections of Flyers Creek above and below the Forest Hut Ridge gauging station is 0.36 ML/day and 0.49 ML/day respectively. This equates to a total of 0.85 ML/day for the whole creek.

The minimum recorded flow at the Forest Hut Ridge gauging station is 1.6 ML/day and the predicted reduction in groundwater discharge at this point is up to 0.49 ML/day. This estimate of baseflow loss is considered by AGE (2009) to be conservative (i.e. the actual loss of baseflow during operations and post-closure could be significantly less).

Notwithstanding, when this predicted loss is subtracted from the minimum recorded flow it leaves 1.11 ML/day, which is greater than the estimated 0.49 ML/day required for riparian users downstream of the Forest Hut Ridge gauging station (Appendix F).

As a contingency for the unlikely event that the loss of baseflow from Flyers Creek is greater than predicted by AGE (2009) and significant and adverse impacts on riparian users do occur, CHPL would review and revise the Contingency Water Supply Plan required under Condition 43 of the Cadia Hill Development Consent (DA 44/95). As required by the existing condition, CHPL would liaise with all landowners who have direct water dependency on Flyers Creek downstream of Long Swamp Road and formulate a contingency plan to be implemented in the event that a disruption of supply occurs. The Contingency Water Supply Plan would include details of how and under what circumstances CHPL would provide alternative water supply or other agreed measures.

The current Flyers Creek landcare group undertakes restoration projects through the enhancement of riparian vegetation and progressive removal of Willows and replanting with local species. CHPL would increase its support of the Flyers Creek landcare group and/or assist with the establishment and support a new independent non-profit environmental organization with the objective of protecting and improving the sustainability of the Flyers Creek catchment area. The organization would seek to collaborate with the DPI, LCMA, and other relevant agencies to develop and implement a long-term catchment management plan and drive ongoing water management and agricultural management projects with the involvement of local Flyers Creek landholders.

*Belubula River*

The total loss water to the Belubula River catchment is predicted to be up to 588 ML/annum (Appendix F). This loss is a result of the predicted reduction of groundwater discharge (baseflow) into Flyers and Cadiangullong Creeks. In order to mitigate the impact of this loss on water users in the Belubula River catchment, CHPL would retire active licences issued under the *Water Act, 1912* equivalent to the volume of the loss. The licences would be retired at a time agreed with the DWE and DoP, in consideration of the timing and magnitude of the actual loss of water from the Belubula River (e.g. licences would be retained until the predicted impacts begin to be realised).

***Surface Water Monitoring***

The existing Cadia Valley Operations surface water quality programme involves sampling of sites in Swallow Creek, Diggers Creek, Cadiangullong Creek, Cadia Creek, Copper Gully, Rodds Creek and Flyers Creek on a quarterly or monthly basis. Water quality samples are analysed for standard cations and anions, TSS, TDS, pH, alkalinity, EC, copper, iron, manganese, zinc, total nitrogen and total phosphorus. Arsenic, cadmium, lead, chromium and mercury are tested on an annual basis. Total coliforms and *Escherichia coli* are also sampled at 34 potable water sources (POT001 to POT034) and the site runoff pond (SROP).

Flows in Swallow Creek, Diggers Creek, Cadiangullong Creek, Rodds Creek, Flyers Creek and the Belubula River are monitored using a combination of baseflow monitoring devices (calibrated weirs) and gauging stations (Figure 4-16). The flow monitoring programme was developed to assess the effects of the Cadia Valley Operations on local creeks. This programme would continue to be used during the Project life.

In addition to the existing sites, CHPL would install an additional gauging station on Flyers Creek upstream of Long Swamp Road at GS412705. A baseflow weir would also be installed on Cadia Creek at CCBW. Both of these sites are shown on Figure 4-16. These sites would be used with the existing monitoring network to gauge the effects of reduced groundwater discharge (baseflow) on Flyers Creek and Cadia Creek.

CHPL would monitor the manual gauging points on Flyers Creek (i.e. GP1, GP2, GP4, GP5, GP7 and GP8) to measure any potential changes to flow depths and flow channel width in the creek under low flow conditions.

CHPL would install additional pluviometers in the Flyers Creek catchment located near existing manual rain gauges with at least five years of rainfall data to increase spatial rainfall data capture in this catchment upstream of the Forest Hut Ridge gauging station (Appendix F).

Erosion and sediment control structures at the Cadia Valley Operations are inspected on a regular basis and following rainfall events greater than 10 mm in a 24 hour period in order to assess the structural integrity and effectiveness of control structures. In accordance with the EPL No. 5590, water quality of stormwater control structures is sampled for a number of parameters during discharge events to Cadiangullong Creek and Rodds Creek. These inspections are an integral component of the IESCP.

The regular inspection and monitoring programme for erosion and sediment control structures would be expanded to include any new sediment dams required for the Project. The IESCP would be revised and updated in consultation with key government agencies prior to the commencement of construction activities and would be updated as new work areas are developed and/or as new work phases commence.

***Climate Change and its Implications for Surface Water Management***

The Project Surface Water Assessment included consideration of climate change predictions on water management during the mine life (Appendix F).

The CSIRO has recently published an assessment of future climate change effects on Australia (CSIRO, 2007). The assessment used predictions of future climate from various models to formulate probability distributions for a range of climatic variables including temperature, rainfall potential evaporation, snow cover and drought. The predictions were made relative to 1990 conditions for 2030, 2050, 2070 and 2100. Predictions for 2030 were relatively insensitive to future emission scenarios because they largely reflect greenhouse gases that have already been emitted, however longer-term predictions become increasingly sensitive to future emission scenarios (Appendix F).

Future rainfall and potential evapotranspiration predictions were considered by Gilbert & Associates (2009) in the Project Surface Water Assessment. A summary of the findings is provided below, with more detail contained in Appendix F.

Predictions of future precipitation in south-eastern Australia are generally for overall decreased rainfall, but with increases in rainfall per day and for the number of dry days (defined as days with less than 1 mm of rainfall) (Appendix F). The predictions also suggest that there would be reduced rainfall in the non-summer periods with a slight increase in summer. This is considered to reflect a lessening of the current temperate rainfall patterns toward a more sub-tropical regime (Appendix F).

Predictions of future potential evapotranspiration are more closely aligned to predicted changes in temperature (Appendix F). In the NSW Central Tablelands, the median of the model predictions are for a slight increase by 2030 (2 to 4%) increasing to between 4 and 8% by 2050 and 2070 (Appendix F). The increases are expected to be greater in autumn and winter and lesser in spring and summer.

CSIRO has also undertaken a study of the effects of climate change predictions on water availability in the Lachlan Catchment (CSIRO, 2008). The study was based on assessing the implications of the following four scenarios on water supply availability in 2030 compared to 1990:

- Scenario A uses historical climate (1895 to 2006) and current development and has been used as a comparison to other scenarios.
- Scenario B uses recent climate (1997 to 2006) and current development.
- Scenario C uses future climate (2030) and current development.
- Scenario D uses future climate (2030) and future development.

While the average rainfall and runoff were found to be 8% and 24% lower respectively over the period 1997 to 2006 than over the full historical period, this was found not to be a statistically significant difference and Scenarios C and D were compared to averages over the full historical period (i.e. Scenario A).

The results of the CSIRO rainfall runoff modelling in the north-eastern part of the Lachlan Catchment (which includes the Cadia Valley), indicated a 10% decrease in runoff at 2030 under Scenario C and about 10.5% reduction under Scenario D conditions. Average total flows in local creeks including Cadiangullong Creek and Flyers Creek would be expected to reduce by these amounts in total (Appendix F). The Project Surface Water Assessment did not identify any additional information on changes to specific components of flow such as high flows, low flows or baseflow contributions.

The CSIRO river system modelling suggested that there would be a 7% increase in extractions using HSE licences in the Belubula River by 2030 due to increasing demand and a reduction in extractions under GSE licences (Appendix F). It was also predicted that there would be a 10% reduction in end of system flows in the Belubula River.

The implications of these climate change predictions for water management at the Cadia Valley Operations during the 21 year Project life are that the average reliability of the water supply components which rely on rainfall and runoff process would be expected to reduce slightly (Appendix F). Similarly, access to water in the Belubula River via releases is predicted to reduce.

Gilbert & Associates (2009) also predicts that access to water from off-allocation flows in the Belubula River may also reduce, although this is less certain because there are currently no specific predictions about the effects of climate change on the frequency and intensity of larger rainfall events.

As described in Section 4.3.2, the water balance modelling predicted an average water supply reliability of 97.2% over the life of the Project.

The management and contingency measures for potential Project-induced impacts on local creeks and riparian users described in the above sub-sections and Appendix F are considered by Gilbert & Associates (2009) to be sufficiently broad to accommodate the potential climate changes described above.

## 4.4 FLORA

A Flora Assessment has been prepared for the Project by FloraSearch (Dr. Colin Bower) and Resource Strategies (2009) and is presented in Appendix B. The Flora Assessment was prepared in accordance with the *Draft Guidelines for Threatened Species Assessment* (DEC and DPI, 2005).

### 4.4.1 Existing Environment

***Regional Setting***

The Project area is located within the Central Tablelands botanical region and close to the boundary of the Central Western Slopes botanical region (Harden, 1990). The Project area also lies on the boundary between the South Eastern Highlands Bioregion and the NSW South Western Slopes Bioregion as defined in the *Interim Biogeographic Regionalisation of Australia* (IBRA) (Thackway and Cresswell, 1995; Environment Australia, 2000; DEWHA, 2009a).

***Local Setting***

The Cadia Valley has been predominantly cleared for agricultural activities but contains small, mostly modified, fragments of native forest and woodland vegetation communities. Remnant vegetation typically exists as scattered individual trees, isolated clumps in grazing paddocks and as riparian vegetation along some sections of the local watercourses. The more substantial remnants of native vegetation generally persist on sites unsuitable for agriculture. Lands surrounding the mining leases are predominantly used for agriculture, together with State Forest plantations of Monterey Pine (*Pinus radiata*).

Native riparian vegetation in the Cadia Valley has also been subject to high levels of past disturbance, mainly from clearing and grazing.

River Sheoak Forest (*Casuarina cunninghamiana*) occurs as riparian vegetation along the Belubula River, Cadiangullong Creek, Swallow Creek, Flyers Creek and Rodds Creek, while, Ribbon Gum/ Blackwood Forest (*E. viminalis/Acacia melanoxylon*) occurs as riparian vegetation in the deep narrow valleys associated with Copper Gully and Rodds Creek. In some riparian areas, introduced Willows (*Salix* spp.) dominate the riparian vegetation, particularly in the upper reaches of Flyers Creek.

***Flora Surveys***

Numerous flora studies have been undertaken in the Project area and surrounds. Many of these studies were associated with environmental assessments for various stages of Cadia Hill and Ridgeway developments. A review of relevant flora studies in the area was undertaken as part of the flora assessment (Appendix B) and included (but was not limited to) the following (in order of relevance):

- FloraSearch (2005) *Cadia East Study Area Flora Assessment*. This report is provided as Attachment BA in Appendix B.
- FloraSearch (2008) *Flora Survey of the Cadia to Blayney Slurry Pipeline Route and the Blayney Dewatering Plant Site*. This report is provided as Attachment BB in Appendix B.
- Resource Strategies (2002a) *Ridgeway Gold Mine Remnant Woodland Enhancement Programme Wire Gully Baseline Monitoring Survey*.
- Resource Strategies (2002b) *Southern Remnant Flora and Fauna Survey*.
- Resource Strategies (2002c) *Cadia Extended Modification Flora and Fauna Assessment*.
- Bower and Resource Strategies (2000) *Ridgeway Project Flora Survey and Assessment Report.*
- Bower (1999) *Flora Survey - Flyers Creek and Belubula River and Rodds Creek Study Sites*.
- Bower *et al.* (1998) *Flora Survey of the Ridgeway Trial Development Application Area and Surrounds.*
- Bower and Medd (1995) *Flora Report for Newcrest Mining on the Cadia Project.*

Flora surveys covering the Project subsidence zone and zone of influence are largely those represented by the studies by FloraSearch (Appendix B) and Bower and Medd (1995). Flora surveys of the proposed tailings storage facilities expansion areas are largely represented by the studies by Orchid Research in Resource Strategies (2002a, 2002b), though these areas have been surveyed as part of a larger survey conducted by Bower and Resource Strategies (2000).

Flora surveys were conducted along the route of the proposed concentrate pipeline in August 2007 and March 2008 (Appendix B).

Targeted searches for threatened flora species were conducted, as part of the above studies. The above studies are discussed further in Appendix B and below where relevant.

***Vegetation in the Project Area***

The following vegetation communities occur within the Project area (Figure 4-22):

- 1a - White Box Woodland (*Eucalyptus albens*) - occurs within the subsidence zone and zone of influence, within a limited area on a north facing slope east of Copper Gully.
- 2a - Long-leaved Box/Blakely's Red Gum/ Yellow Box Tall Woodland (*E. goniocalyx/ E. blakelyi/ E. melliodora*) - predominantly occurs within the subsidence zone and zone of influence with a smaller patch to the east of the NTSF. This community is generally found on deeper more fertile soils on less rugged terrain than Vegetation Communities 3a and 3b.
- 2b - Apple Box/Blakely's Red Gum/Yellow Box Tall Woodland (*E. bridgesiana/E. blakelyi/ E melliodora*) - occurs within the STSF expansion area, immediately to the south of the existing NTSF and to the east of the existing mining leases south of Woodville Road.
- 3a - Red Stringybark/Long-leaved Box Open Forest (*E. macrorhyncha/E. goniocalyx*) - occurs within the subsidence zone and zone of influence. It is found on steep, shaded, usually south facing, slopes on shallow stony soils.
- 3b - Red Box/Red Stringybark Open Forest (*E. polyanthemos/E. macrohyncha*) - occurs within the subsidence zone and zone of influence as well as between the South Waste Rock Dump and the NTSF (in an area referred to as Southern Remnant). Two smaller patches of Vegetation Community 3b occur to the east of the NTSF.
- 4a - Ribbon Gum/Blackwood Forest (*E. viminalis/Acacia melanoxylon*) - occurs within the zone of influence as a thin strip, in relatively deep alluvial soils along Copper Gully and colluvial soils on the lower hillslopes adjacent to the creek, and along a gully to the east of the subsidence zone which would be traversed by the proposed Cadia Road re-alignment.

The largest area of native vegetation within the Project area occurs adjacent and to the east of the existing Cadia Hill open pit. It is dominated by Red Stringybark/Long-leaved Box Open Forest (Vegetation Community 3a) and Red Box/Red Stringybark Open Forest (Vegetation Community 3b). Overall, this area of vegetation is considered to be regionally significant for its flora diversity and condition. The other communities show signs of considerable disturbance and reduced conservation condition.

Scattered trees in cleared agricultural land surround the remnant vegetation community patches as a result of historic clearing for grazing purposes (Figure 4-22). Scattered trees are remnants or regrowth components of the former vegetation communities, most likely at varying quantities of the above vegetation communities. The understorey of the cleared areas is dominated by introduced flora species (Appendix B).

The new concentrate and return water pipelines would be located within the road corridors between the Cadia Valley Operations and Blayney, adjacent to the existing concentrate and return water pipelines. The natural plant communities that formerly occurred along the route have been removed by past road works. Most remaining areas, where the soil does not appear to have been recently disturbed, are extensively invaded by introduced flora species. The CVO Dewatering Facility is located in cleared agricultural land with improved pasture (Appendix B).

The Canobolas State Forest occurs directly to the north and east of the Project area, and consists of plantations of introduced Monterey Pine (*Pinus radiata*). The pine plantations typically have very low native flora species diversity (Appendix B).

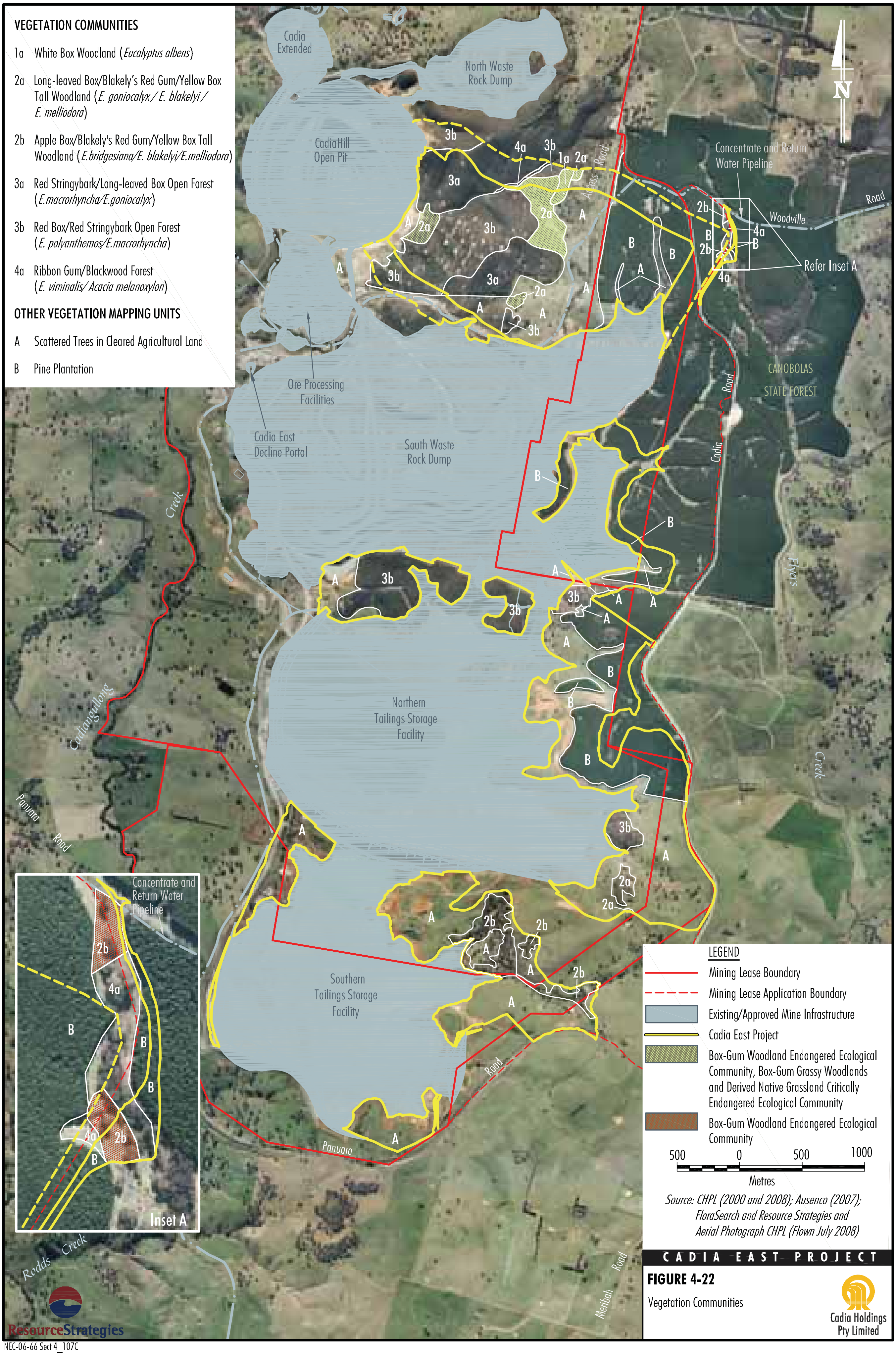



FIGURE 4-22
Vegetation Communities

***Flora Species Composition***

Appendix B provides a complete list of flora species that have been identified in surveys of land owned by CHPL from 1995 to 2008 (after Bower and Medd, 1995; Bower *et al.,* 1998; Bower and Resource Strategies, 2000; Resource Strategies, 2002a; Resource Strategies, 2002b; Resource Strategies, 2002c; FloraSearch, 2005, 2008).

During the 2005 flora survey by FloraSearch, a total of 234 vascular plant species were identified, of which 160 (68.4%) were native and 74 (31.6%) introduced (Appendix B). A similar number was recorded by Bower and Medd in 1995 (166 native species) (Appendix B).

During the Southern Remnant flora survey by Orchid Research (Resource Strategies, 2002b), a total of 33 vascular plant species were recorded in Vegetation Community 3b. Of these, 29 (88%) were native and 4 (12%) introduced. During the Wire Gully flora survey by Orchid Research (Resource Strategies, 2002a), a total of 34 vascular plant species were identified in Vegetation Community 2b, of which only 11 (32 %) are native compared to 23 (68 %) introduced (Appendix B).

***Introduced Flora Species and Noxious Weeds***

A total of 171 introduced flora species have been recorded during past surveys in the Project area and surrounds, including noxious weeds listed for Upper Macquarie County Council (which includes the Blayney Local Government Area) and/or CSC[2] (Bower and Medd, 1995; Bower *et al.,* 1998; Bower and Resource Strategies, 2000; Resource Strategies, 2002a, 2002b; FloraSearch, 2005, 2008). Noxious weeds previously recorded include Blackberry, Hemlock, Sweet Briar, St Johns Wort, Bathurst Burr, Sifton Bush, African Lovegrass, Creeping Oxalis, Scotch Thistle, Stemless Thistle, Star Thistle, Crack Willow, Basket Willow and Tree-of-heaven. CHPL manage environmental weeds and noxious weeds in accordance with the LMP (CHPL, 2009a).

***Threatened Flora Species***

A literature and database review was conducted in addition to targeted surveys to identify threatened flora species which could potentially occur within the Project area.

No threatened flora species have been recorded within the Project area.

Three threatened flora species have been recorded near the Project area, namely Silver-Leaf Candlebark (*Eucalyptus canobolensis*), New England Bush-pea (*Pultenaea campbellii*) and Narrow-leaved Black Peppermint (*Eucalyptus nicholii*). These species are discussed below.

*Silver-leafed Candlebark*

The Silver-leafed Candlebark is listed as 'Vulnerable' under both the TSC Act and the EPBC Act. The Silver-leafed Candlebark is a short Eucalypt tree that grows to 10 m in height (DECC, 2009b). The Silver-leaf Candlebark is largely restricted to the Mount Canobolas State Recreation Area near Orange, where it mainly occurs between 1,100 and 1,300 m AHD (DECC, 2009b). In 1998, six specimens of Silver-leafed Candlebark were recorded on the basalt soils of the higher parts of Ridgeway Hill at altitudes above 900 m AHD (Bower *et al*., 1998; Bower and Resource Strategies, 2000 in CHPL, 2000b). The occurrences comprise only scattered remnant trees in cleared farmland beside the Four Mile Creek Road.

Although potential habitat for Silver-leafed Candlebark occurs within the Project area, it is considered that if this species were present within the Project area it would have been recorded during the various targeted surveys as it is a perennial tree (Appendix B).

*New England Bush-pea*

The New England Bush-pea is listed under the EPBC Act as 'Vulnerable'. Until 1999, the New England Bush-pea was listed as 'Vulnerable' under the TSC Act, but was delisted following the discovery of numerous large populations in NSW conservation reserves (NSW Scientific Committee, 1999). In 1998 and 2000, a *Pultenaea* specimen was collected north of the Project area (Bower *et al.,* 1998; Bower and Resource Strategies, 2000 in CHPL, 2000b). The specimen was classified as *Pultenaea* sp. F which is included in the Commonwealth listing of New England Bush-pea. New England Bush-pea is unlikely to occur in the Project area as it has not been recorded during various targeted surveys conducted under conditions suitable to detect the species (Appendix B).

2 The northern portion of the Project area is situated within the Cabonne Shire LGA and the southern portion is situated in the Blayney Shire LGA as shown on Figure 1-1.

*Narrow-leaved Black Peppermint*

A planting of the Narrow-leaved Black Peppermint was recorded during the survey for the proposed concentrate pipeline (Appendix B). These trees had been planted for amenity purposes in parkland adjacent to the proposed concentrate pipeline route, near Blayney. The Narrow-leaved Black Peppermint is listed as 'Vulnerable' under the TSC Act and is a medium size Eucalypt tree 15 to 20 m in height. The species is naturally confined to the New England Tablelands of NSW (DECC, 2009b).

***Threatened Ecological Communities***

Areas of Box-Gum Woodland in the Project area meet the criteria of two threatened ecological communities, namely the (Figure 4-22):

- Box-Gum Woodland EEC under the TSC Act; and
- Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC under the EPBC Act.

Both of these threatened ecological communities are composed of various proportions of White Box (*Eucalyptus albens*), Yellow Box (*E. melliodora*) and Blakely's Red Gum (*E. blakelyi*). In the Project area, these threatened ecological communities are represented by the following three vegetation communities:

- 1a - White Box Woodland;
- 2a - Long-leaved Box/Blakely's Red Gum/Yellow Box Tall Woodland; and
- 2b - Apple Box/Blakely's Red Gum/Yellow Box Tall Woodland.

Not all occurrences of these vegetation communities are representative of the threatened Box-Gum Woodland EEC and/or CEEC. Remnants of these threatened ecological communities generally occur as scattered paddock trees or small patches in a predominantly cleared agricultural landscape. It is recognised that such remnants have usually lost most of their original component plant and animal species due to clearing, grazing, weed invasion and ploughing for pasture improvement or cropping.

Different approaches to the conservation of Box-Gum Woodlands have been adopted by the State and Commonwealth Governments. The NSW approach under the TSC Act is to regard all Box-Gum Woodland remnants, even highly disturbed ones that would respond to 'assisted natural regeneration' 'under appropriate management' (NSW National Parks and Wildlife Service [NPWS], 2002a), as belonging to the listed Box-Gum Woodland EEC. On the other hand, the Commonwealth Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC definition under the EPBC Act includes only high quality Box-Gum Woodland remnants that have groundcovers rich in native perennial herbaceous species (Threatened Species Scientific Committee, 2006a, 2006b). In summary, the Commonwealth listing seeks only to protect the higher quality, more pristine natural remnants.

***Critical Habitat***

No critical flora habitat occurs within the vicinity of the Project area as designated by the Register of Critical Habitat held by the Commonwealth Minister for the Environment, Heritage and the Arts (DEWHA, 2009b), Register of Critical Habitat held by the Director-General of the DECC (DECC, 2009c), the Register of Critical Habitat held by the Director-General of the DPI-Fisheries (DPI-Fisheries, 2009), the Cabonne LEP or the Blayney LEP. Therefore, the Project would not affect any critical flora habitat (Appendix B).

***Threatened Flora Populations***

No threatened flora populations listed under the TSC Act are relevant to the Project (Appendix B).

***Existing Management Measures***

CHPL currently implements the following environmental management plans relevant to the management of flora, and potential impacts on flora, at the Cadia Valley Operations and surrounds:

- FFMP (CHPL, 2009b);
- Site Management Plan (CHPL, 2009c);
- LMP (CHPL, 2009a);
- BMP (CHPL, 2008f);
- DMP (CHPL, 2009d); and
- FMP (CHPL, 2007b).

### 4.4.2 Potential Impacts

The following sub-sections evaluate the potential impacts of the Project on flora species, populations and ecological communities, and their habitats in accordance with the *Draft Guidelines for Threatened Species Assessment* (DEC and DPI, 2005). This evaluation includes identification of the magnitude, extent and significance of the potential impacts. Proposed measures to avoid, mitigate and offset potential impacts on flora are provided in Section 4.4.3.

***Vegetation Removal and Modification***

Vegetation disturbance associated with the Project would result in a decrease in the diversity of flora in the local area. Approximately 238 ha of native vegetation communities would be disturbed for the Project, which includes (Figure 4-22):

- approximately 85 ha of native vegetation which would be cleared through the expansion of the tailings storage facilities;
- approximately 115 ha of native vegetation which is located within the Cadia East subsidence area and would be lost as the rock and soil beneath it subsides;
- approximately 38 ha which is located within the surrounding Cadia East zone of influence which may be subject to surface cracking but the ground itself is not expected to subside; and
- less than 1 ha of native vegetation which would be cleared for the Cadia Road re-alignment.

Vegetation communities that would be cleared or modified for the Project include (Figure 4-22):

- approximately 3 ha of White Box Woodland, within the Cadia East subsidence zone and zone of influence;
- approximately 24 ha of Long-leaved Box/Blakely's Red Gum/Yellow Box Tall Woodland, predominantly within the Cadia East subsidence zone and zone of influence with a smaller patch to the east of the NTSF;
- approximately 23 ha of Apple Box/Blakely's Red Gum/Yellow Box Tall Woodland, predominantly within the area for the proposed increase to the STSF with two small patches within the Cadia East zone of influence and Cadia Road re-alignment;
- approximately 60 ha of Red Stringybark/ Long-leaved Box Open Forest, within the Cadia East subsidence zone and zone of influence;
- approximately 126 ha of Red Box/Red Stringybark Open Forest, within the subsidence zone and zone of influence, between the South Waste Rock Dump and the NTSF, and two smaller patches to the east of the NTSF; and
- approximately 2 ha of Ribbon Gum/Blackwood Forest, within the Cadia East subsidence zone and zone of influence and within the Cadia Road re-alignment.

Approximately 360 ha of scattered trees in cleared agricultural land would be cleared or modified for the Project, which includes approximately 266 ha which would be cleared through the expansion of the tailings storage facilities, approximately 73 ha which is located within the Cadia East subsidence zone and approximately 21.5 ha which is located within the surrounding zone of influence (Figure 4-22).

A total of 184 ha of pine plantation would be disturbed for the Project, which includes 107 ha which would be cleared through the expansion of the tailings storage facilities and the Rodds Creek Water Holding Dam, approximately 42 ha which is located within the Cadia East subsidence zone, approximately 34.5 ha which is located within the surrounding zone of influence and approximately 1 ha which would be cleared for the Cadia Road re-alignment (Figure 4-22).

The concentrate pipeline route from the Cadia Valley to the CVO Dewatering Facility would be designed to avoid native vegetation where practicable. The CVO Dewatering Facility site is located in approximately 2.6 ha of cleared agricultural land.

***Alteration to the Natural Flow Regimes of Rivers and Streams and their Floodplains and Wetlands***

The *Alteration to the Natural Flow Regimes of Rivers and Streams and their Floodplains and Wetlands* is a Key Threatening Process listed under the TSC Act (NSW Scientific Committee, 2002a). Degradation of native riparian vegetation along NSW watercourses is also a relevant Key Threatening Process under the FM Act. These Key Threatening Processes are discussed below in relation to flora impacts from the Project. The potential impacts from the Project on surface water and groundwater are provided in Sections 4.2 and 4.3 and Appendices F and G.

*Copper Gully*

Copper Gully is an ephemeral creek that is located in the Project area within the Cadia East subsidence zone and zone of influence (Figure 4-16). Currently the creek terminates at a dam on the edge of the existing Cadia Hill open pit. Vegetation Community 4a is the main riparian vegetation type along Copper Gully (1 ha) which would be impacted as part of the Project as it occurs within the Cadia East zone of influence (Figure 4-22).

*Rodds Creek*

The Rodds Creek Water Holding Dam would be raised and expanded as part of the Project. The existing dam is surrounded by pine plantation which would be partially removed as part of the expansion. No native vegetation would be disturbed as a result of the expansion of the Rodds Creek Water Holding Dam (Figure 4-22).

*Cadiangullong Creek*

Cadiangullong Creek was an ephemeral creek prior to the commencement of the Cadia Valley Operations and the construction of the Cadiangullong Dam. The low to medium water flows within the creek are now controlled through riparian flow releases from Cadiangullong Dam (Section 4.3.1).

The natural vegetation along Cadiangullong Creek is predominantly River Sheoak Forest (*Casuarina cunninghamiana*). River Sheoaks commonly grow along relatively permanent freshwater streams (Botanic Gardens Trust, 2009), but also grow along ephemeral creek systems (Appendix B).

As described in Section 4.3.2, the Surface Water Assessment by Gilbert & Associates (2009) (Appendix F) predicted that the Project would increase the proportion of time that no flow would occur in Cadiangullong Creek downstream of Cadiangullong Dam.

It is likely that the predicted increase in the proportion of time that no flow would occur in Cadiangullong Creek downstream of Cadiangullong Dam would more closely replicate what would have occurred prior to Cadiangullong Dam being constructed (Appendix F). The increase in the proportion of time that no flow would occur is not likely to impact the riparian vegetation along Cadiangullong Creek given River Sheoak Forest naturally occurs along creek systems under similar drought, no flow conditions.

The Cadiangullong Creek was an ephemeral creek prior to the construction of the Cadiangullong Dam, albeit one that had been significantly impacted by historic mining (Herr *et al*., 2004).

*Flyers Creek*

Flyers Creek is located to the east of the Project area and joins to the Belubula River to the south (Figure 4-15). As described in Section 4.3.1, low flows in the creek south of Long Swamp Road are sustained by groundwater discharge (baseflow). The dominant native vegetation along Flyers Creek is Willow (*Salix* spp.) in the northern reaches and River Sheoak and occasional *Eucalyptus* spp. in the southern reaches (Appendix B).

As described in Section 4.2.2, the Groundwater Assessment conducted for the Project by AGE (2009) (Appendix G) found that the Project would reduce the groundwater discharge to Flyers Creek by up to 0.49 ML/day. The Surface Water Assessment by Gilbert & Associates (2009) (Appendix F) concluded that the reduction in surface water flow would generally be expressed within Flyers Creek as small decreases in stream width and stream depth depending on the width of the stream (e.g. 1 to 2 cm shallower). Therefore an effect on the riparian vegetation along Flyers Creek is not likely as a result of the predicted reduction in groundwater discharge.

*Belubula River*

The proposed continued extraction of water from the Belubula River in accordance with existing annual extraction limits (Section 2.10.2) is not expected to impact riparian flora associated with the Belubula River because the DWE's existing end of system flow target would be maintained (Appendix F).

***Groundwater Dependent Vegetation***

The groundwater modelling conducted by AGE (2009) for the Project predicted that groundwater levels in the vicinity of the subsidence zone would be drawn down during operations and post-closure. The predicted area of groundwater drawdown is considered by AGE (2009) to be conservative and primarily extends to the north-east and east of the subsidence zone up to a distance of approximately 8 km. The Orange basalt fractured rock aquifer is the main groundwater aquifer located in this area. The regional water level in this aquifer is reported by the Australian Natural Resources Atlas (2007) as being 20 m from the surface (Appendix G).

Using the results of the Groundwater Assessment, the potential impacts on groundwater dependant vegetation have been evaluated in the Flora Assessment (Appendix B), including consideration of the NSW State Groundwater Dependent Ecosystems Policy (DLWC, 2002). The land within the predicted area of groundwater drawdown to the immediate east and north-east near Cadia Road consists of Monterey Pine (*Pinus radiata*). Further from the subsidence zone it is predominantly scattered trees in cleared agricultural land. The vegetation within the predicted area of groundwater drawdown is not likely to use the regional aquifer due to its reported depth of 20 m.

AGE (2009) identified several seepage areas and springs in the agricultural land in the upper headwaters of Cadia and Flyers Creeks to the north and the north-northeast of the subsidence zone. These springs are likely to be either perched or regional springs (AGE, 2009). It is possible that native tree species which occur in the vicinity of some of these localised seepages or springs (e.g. Yellow Box [*E. melliodora*]) may use groundwater. However, AGE (2009) has assessed the potential impacts on these features and has concluded that significant impacts are unlikely to occur (Section 4.2.2 and Appendix G). As a result, no potential adverse impacts on this vegetation are expected to occur as a result of the Project.

***Introduced Flora***

Native vegetation disturbance can act as a catalyst for weed incursion and, if management initiatives are not implemented, proliferation of weeds can occur. The Project is not considered likely to significantly increase the potential for weed incursion, given the weed control measures outlined in the various Cadia Valley Operations management plans (Section 4.4.1), which would continue to be implemented (Appendix B).

***Introduced Fauna***

*Competition and grazing by the feral European Rabbit* is a Key Threatening Process listed under the TSC Act (NSW Scientific Committee, 2002b). The European Rabbit and other introduced animals can result in erosion problems as well as reduce recruitment and survival of native plants (Appendix A). However, given the pest control measures currently implemented at the Cadia Valley Operations (Section 4.5.1), the Project is unlikely to significantly increase the potential impacts of introduced animal on flora (Appendix B).

***Vegetation and Dust***

Studies have shown that excessive dust generation can impact on the health and viability of surrounding vegetation. Dust can affect vegetation by inhibiting physiological processes such as photosynthesis, respiration and transpiration, and allow penetration of phytotoxic gaseous pollutants (Eller, 1977; Farmer, 1993; Grantz *et al.,* 2003).

The potential for dust emissions associated with the Project would originate predominantly from the haulage of materials within the mining leases and wind blown emissions (particularly from the South Waste Rock Dump and tailings storage facilities). However appropriate dust control measures are in place (Section 4.4.3).

***Bushfire Risk***

High intensity fire can adversely impact flora. The risk of fire would be reduced through the management measures described in Section 4.1.3. It is considered unlikely that the Project would result in a significant change in the frequency of fires (Appendix B).

***Threatened Flora Species***

The potential impacts from the Project on threatened flora species was assessed in Appendix B based on the *Draft Guidelines for Threatened Species Assessment* (DEC and DPI, 2005).

In summary, the Project is unlikely to affect any threatened flora species under the TSC Act or EPBC Act (Appendix B). The three threatened flora species which have been recorded in close proximity to the Project area, namely the Silver-Leaf Candlebark, New England Bush-pea and Narrow-leaved Black Peppermint are also unlikely to be impacted. Although potential habitat for the Silver-Leaf Candlebark and New England Bush-pea occurs within the study site, it is considered that if these species were present within the Project area they would have been recorded during the various surveys (Appendix B). The planting of Narrow-leaved Black Peppermint in Blayney would be avoided by the Project.

***Box-Gum Woodland under the NSW TSC Act and Commonwealth EPBC Act***

As described in Section 4.4.1, the Box-Gum Woodland which occurs in the Project area meets the criteria for the Box-Gum Woodland EEC and Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC.

The potential impacts from the Project on threatened ecological communities was assessed in Appendix B based on the *Draft Guidelines for Threatened Species Assessment* (DEC and DPI, 2005), with consideration of the *EPBC Act Policy Statement 3.5* for the Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC (DEH, 2006a) and *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance* (DEH, 2006b).

No relevant impacts are considered to be unknown or unpredictable. Approximately 23.5 ha of the Box-Gum Woodland EEC (of which 23 ha meets the criteria for the Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC) would be lost or modified for the Project, which includes (Figure 4-22):

- approximately 18.2 ha, represented by Vegetation Community 1a and 2a, which would be irreversibly lost within the subsidence zone as the rock and soil beneath it subsides and the final void waterbody forms;
- approximately 4.8 ha, represented by Vegetation Community 1a, 2a and 2b, which may be modified within the surrounding zone of influence which may be modified by surface cracking but the ground itself is not expected to subside; and
- less than 0.5 ha, represented by Vegetation Community 2b, which would be cleared for the Cadia Road re-alignment.

The threatened Box-Gum Woodland within the Project area represents a subset of the full diversity of the former core areas of the community in the region. The areas of the threatened Box-Gum Woodland within the Project area have been semi-cleared to varying degrees to facilitate grazing. Vegetation Community 1a has been heavily thinned so that only scattered trees and clumps of trees remain. Some areas of Vegetation Community 2a are more intact with generally continuous tree canopies, albeit of predominantly regrowth woodland following clearing together with relatively few old trees (Appendix B).

Other areas of threatened Box-Gum Woodland occur in the Cadia Valley. In the order of 310 ha (in addition to the area proposed to be disturbed) of Box-Gum Woodland on CHPL-owned land meets the criteria for the Box-Gum Woodland EEC, of which approximately 240 ha meets the criteria for the Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC (Appendix B). Further, the proposed offset area on Black Rock Range, 11 km to the west, contains approximately 210 ha of Box-Gum Woodland EEC and approximately 154 ha of the Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC (Appendix B).

It is considered unlikely that the Project would have a significant impact on the Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC given the measures to avoid, mitigate and offset potential impacts Section 4.4.3.

### 4.4.3 Mitigation Measures and Management

The potential impacts of the Cadia Valley Operations on flora are currently managed via implementation of existing management measures outlined in Section 4.4.1.

The following measures would be implemented to avoid, mitigate and offset potential impacts of the Project on flora, and their habitats:

- rehabilitation and revegetation of Project disturbance areas;
- management of flora in the surrounding Cadia Valley;
- Vegetation Clearance Protocol;
- Threatened Species Management Protocol (TSMP);
- fire management;
- dust controls and monitoring;
- weed management;
- animal pest management and monitoring; and
- offset measures.

These measures are discussed below.

***Rehabilitation and Revegetation of Project Disturbance Areas***

The Project disturbance areas (e.g. tailings storage facilities expansion areas and infrastructure) would be rehabilitated and revegetated.

As discussed in Section 4.3.2, a final void waterbody would eventually form within the subsidence zone and therefore revegetation would not be possible in the subsidence zone. However, prior to the waterbody being formed, some vegetation growth on the walls of the subsidence zone may occur, but this is expected to be restricted by the steepness of the slopes and their relative instability and growth may be limited in some areas by geochemistry of the rock exposed in the subsidence zone (e.g. Ordovician volcanics).

As the subsidence zone fills with water it would inundate any vegetation which had established in the 150 to 160 years since the subsidence zone formed.

The revegetation programme for the other mine landforms and disturbance areas associated with the Cadia Valley Operations would provide for a combination of woodland and grassland habitats as well as facilitating landscape connectivity through its concurrent contribution to the local and regional habitat corridor network (refer to *Management of Flora in the Surrounding Cadia Valley* section below). The Cadia Valley Operations rehabilitation and woodland enhancement conceptual arrangement is shown on Figure 4-23. The revegetation of woodland areas would include the planting of species characteristic of the Box-Gum Woodland EEC and Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC (e.g. White Box, Yellow Box and Blakely's Red Gum overstorey as well as appropriate understorey). Rehabilitation and revegetation of Project disturbance areas is further discussed in Section 5 and Appendix P.

***Flora Management***

CHPL has developed and implemented the FFMP (CHPL, 2009b) for the Cadia Valley Operations. The FFMP provides measures to minimise impacts on flora and fauna and their habitats (including species listed as threatened under the EPBC Act and the TSC Act). Measures include the Vegetation Clearance Protocol and TSMP, both of which are discussed further below.

CHPL would review and revise the FFMP (CHPL, 2009b) to incorporate new areas and features associated with the Project.

***Management of Flora in the Surrounding Cadia Valley***

CHPL has developed and implemented the LMP (CHPL, 2009a) for the Cadia Valley Operations which applies to the mining areas and neighbouring CHPL-owned land.

In relation to flora, an objective of the LMP (CHPL, 2009a) is to manage existing pastures and remnant vegetation to minimise degradation as well as sustain and enhance the agricultural value of the lands. The LMP (CHPL, 2009a) currently includes the following measures which are illustrated by number on Figure 4-23:

- *Rehabilitation of Project disturbance areas* (1) – with a combination of woodland and native grassland. Measures include native seed collection by local companies (e.g. trees, shrubs, groundcovers and grasses) and propagation by local nurseries for use in the rehabilitation programme.
- *Riparian Restoration* (2, 3 and 4) – a programme removing introduced Willows and planting appropriate native species along reaches of Cadiangullong Creek, Swallow Creek and Rodds Creek to improve the riparian vegetation.
- *Remnant Woodland Protection and Management* (5) – the management of an existing Box-Gum Woodland Habitat Enhancement Area (Figure 4-23) in relation to the South Waste Rock Dump approval and existing Ridgeway Development Consent (DA 134-04-00) Condition 3.4.1(d).
- *Weed Management Measures* (6) – including control of environmental and noxious weeds. In addition to the measures outlined in the LMP, CHPL is also investigating integrated weed management trials.
- *Soil Management* (7) – including erosion control measures.

CHPL has undertaken the following in addition to formal requirements:

- *CHPL Farm Tree Initiative* (8) – Annually CHPL provides free endemic native trees and shrubs to local landholders (CHPL, 2009a).

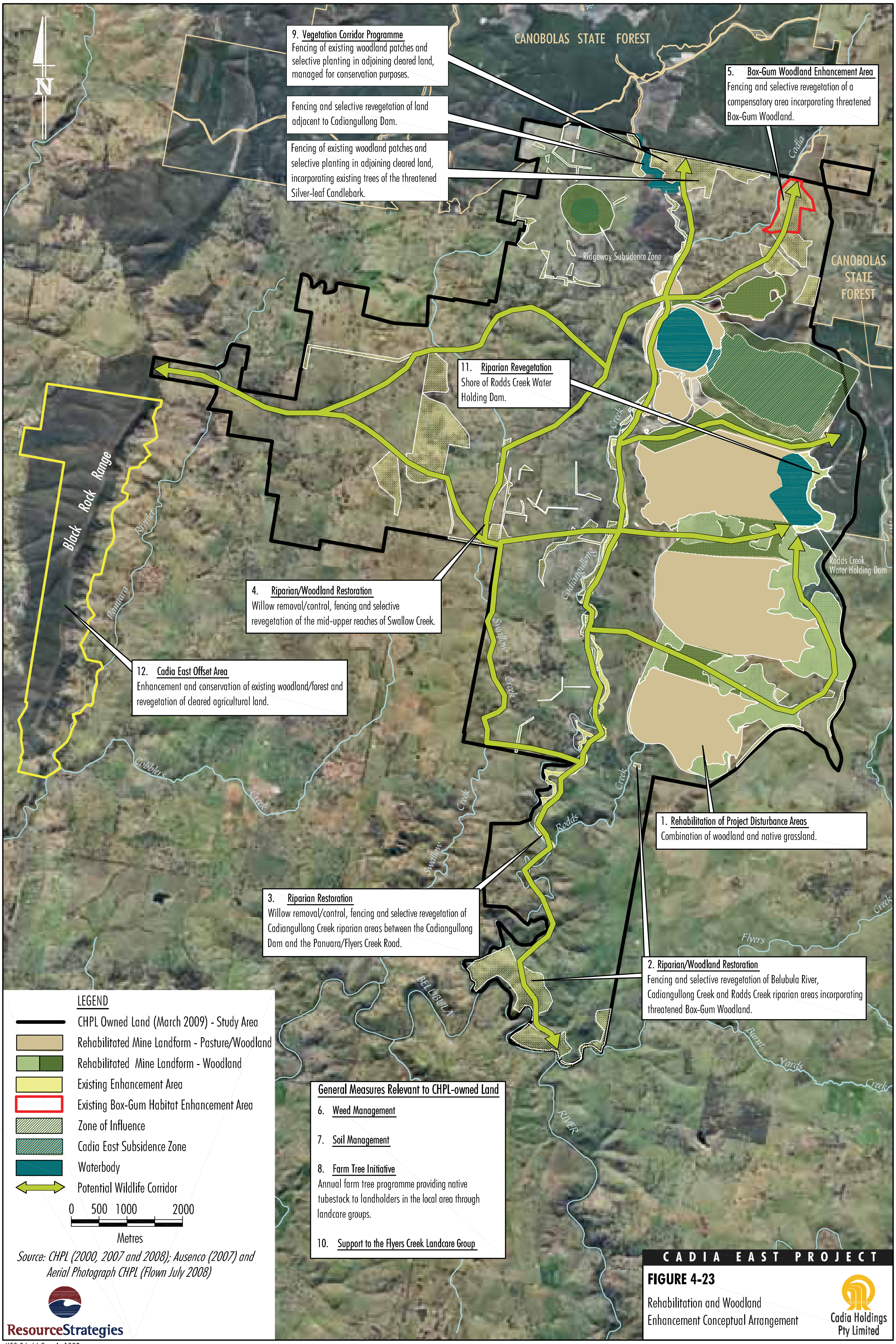



FIGURE 4-23
Rehabilitation and Woodland Enhancement Conceptual Arrangement

NEC-06-66 Sect 4_108D

- A *Vegetation Corridor Programme* (9) – The aim of the Programme is to establish vegetation corridors on land owned by CHPL. Figure 4-23 shows the areas which have been fenced, and subject to selected planting of tubestock and seeding, as well as weed management.
- *CHPL is an active member of the Flyers Creek Landcare Group* (10) – provides support for restoration activities in relation to Flyers Creek.

The LMP (CHPL, 2009a) would be reviewed and revised by a suitably qualified person(s) to include the following measures as part of the Project:

- revegetation to the east of the Rodds Creek Water Holding Dam (11), which would increase flora habitats; and
- integration of the Vegetation Corridor Programme introduced above into the revised LMP.

The general flora and fauna attributes of the Vegetation Corridor Programme would be that it would:

- link significant areas of remnant vegetation, including the proposed offset area at Black Rock Range (12);
- enhance habitat for native flora and fauna, including threatened species and ecological communities (i.e. Box-Gum Woodland);
- facilitate the movement of genetic material between flora and fauna populations;
- increase the sustainability and biodiversity of CHPL-owned farms and environs; and
- sustain and enhance the agricultural value of the lands.

***Vegetation Clearance Protocol***

A Vegetation Clearance Protocol has been developed to minimise the impact of vegetation clearance on flora and fauna and is provided in the FFMP (CHPL, 2009b). Vegetation immediately adjoining any proposed clearance areas is delineated and clearly marked to avoid accidental damage during vegetation clearance activities or construction works.

Native seed collection would be undertaken within the Cadia East subsidence zone to augment existing seed collection. In addition, habitat resources, such as hollows, within the Cadia East subsidence zone would be opportunistically salvaged for placement within rehabilitation areas or other fauna habitat enhancement areas, where practicable.

***Threatened Species Management Protocol***

A TSMP has been developed and implemented to facilitate the identification and management of threatened flora and fauna species and is provided in the FFMP (CHPL, 2009b). The key components of the TSMP are observations/surveys for threatened species (prior to disturbance and throughout operations), completion of a Threatened Species Assessment and Management Strategy, regulatory reviews and monitoring.

***Fire Management***

As discussed in Section 4.1.3, the BMP would be implemented to facilitate management of bushfires in the Cadia Valley and surrounds. Details are provided in the BMP (CHPL, 2008f), which would be updated for the Project.

***Dust Controls and Monitoring***

Dust controls would be employed, including watering of potential dust generating surfaces, to minimise dust emissions from the Project and associated potential impacts on surrounding vegetation. Details are provided in the DMP (CHPL, 2009d), which would be updated for the Project.

***Weed Management and Monitoring***

The LMP (CHPL, 2009a) provides measures to control weeds. The weed control measures include mapping the location of priority weed species, direct removal (e.g. Willow removal along Cadiangullong Creek) and chemical application. These measures would be continued for the Project.

***Animal Pest Management and Monitoring***

The FFMP (CHPL, 2009b) describes measures to control rabbits and other animal pests. The pest control measures include removing available feed, locating and removing warrens and baiting. These measures would be continued for the Project.

***Offset Measures***

The EARs for Project (Attachment 1) state that the EA must include a description of the measures that would be implemented to offset the impacts of the Project. The offset measures are proposed in consideration of the *DECC Principles for the Use of Biodiversity Offsets in NSW* (DECC, 2009d) and the *Draft Policy Statement: Use of Environmental Offsets under the EPBC Act* (DEWR, 2007).

An integrated approach to offsetting flora and fauna impacts is proposed. Measures to offset the flora and fauna impacts of the Project include:

- rehabilitation of post-mining landforms (described above and in Section 5);
- provision of a Squirrel Glider monitoring programme (described in Section 4.5.3); and
- enhancement and conservation of vegetation and habitat within an offset area[3], as described below.

The flora and fauna assessments for the Project (Appendix A and B) state that it is likely that the proposed offset measures would constitute a suitable offset against residual flora and fauna impacts associated with the Project, given the anticipated improvement in the flora and fauna habitat value of the land within the offset area in the medium to long-term.

*Offset Area*

CHPL has entered into an agreement to acquire a large area of remnant bushland and adjoining agricultural land at Black Rock Range, for the Project offset area (Figures 4-23 and 4-24). The offset area is suitably located as it is within the vicinity of the Project, being situated approximately 11 km to the west, and within the same bioregion. The offset area is located on freehold land currently zoned as Zone 1(a) under the Cabonne LEP. The land is currently largely unprotected and is grazed by sheep and cattle.

While approximately 238 ha of native vegetation communities would be cleared for the Project (Figure 4-22), it is proposed that significant areas of existing native vegetation communities would be enhanced (some 653 ha) and significant areas of cleared agricultural land would be revegetated (some 173 ha) in the offset area (Figure 4-24; Table 4-9).

**Table 4-9**
**Cadia East Offset Quantification**

| Area | Description | Approximate Size (ha) |
|---|---|---|
| Disturbance Area | Remnant vegetation communities/habitat which would be cleared, lost or modified as a result of the Project. | 238* |
| Enhancement Area | Remnant vegetation communities/habitat which would be enhanced through natural regeneration and management for conservation. | 653# |
| Revegetation Area | Re-establishment of woodland in cleared agricultural land by revegetation. | 173# |
| | **Total Area Conserved (ha)** | **826#** |

* Approximate areas are based on vegetation mapping shown on Figure 4-22.

\# Approximate areas are based on vegetation mapping shown on Figure 4-24.

Black Rock Range also offsets for the 365 ha of scattered trees in cleared agricultural land which would be removed by the Project.

*Flora and Fauna Values within the Offset Area*

The offset area and surrounds was surveyed by FloraSearch (2006) (flora), Western Research Institute (2006) (general vertebrate fauna) and Greg Richards and Associates (2006) (bat fauna). A description of the flora and fauna values of the offset area is provided below.

3 The offset area also includes an offset for the disturbance associated with the South Waste Rock Dump modification in accordance with current Cadia Hill Development Consent (DA 44/95) Condition 32A and Ridgeway Development Consent (DA 134-04-00) Condition 3.4.1(e).

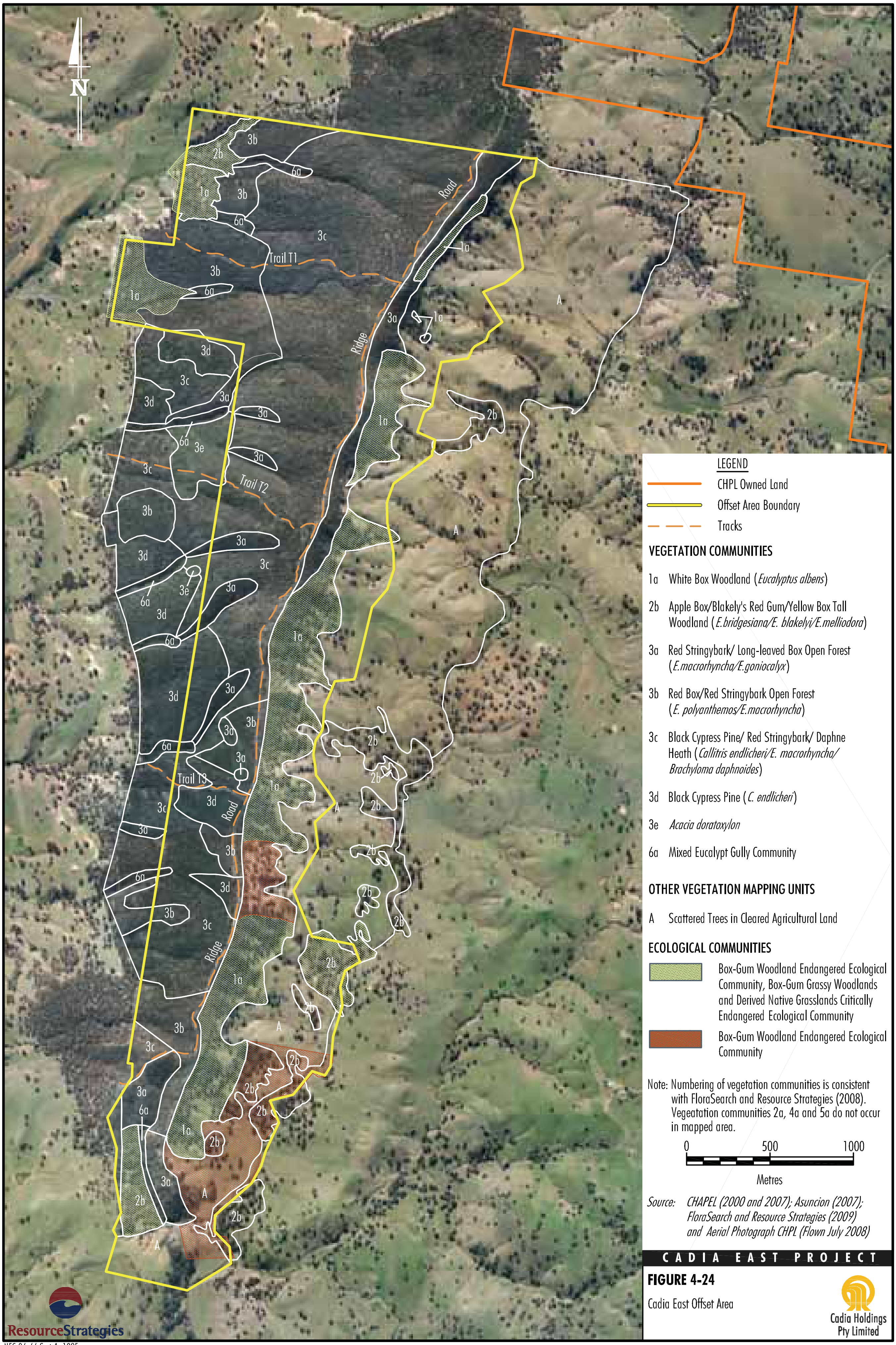



**FIGURE 4-24**

Cadia East Offset Area

NEC-06-66 Sect 4_109E

The enhancement and conservation measures proposed as part of the offset would help maintain (and very likely improve) the flora biodiversity values of a substantial area of vegetation outside of the Project area. The following existing native vegetation communities occur within the offset area[4] (Figure 4-24):

- 1a - White Box Woodland (*Eucalyptus albens*);
- 2b - Apple Box/Blakely's Red Gum/Yellow Box Tall Woodland (*E. bridgesiana/E. blakelyi/ E. melliodora*);
- 3a - Red Stringybark/Long-leaved Box Open Forest (*E. macrorhyncha/E. goniocalyx*);
- 3b - Red Box/Red Stringybark Open Forest (*E. polyanthemos/E. macrorhyncha*);
- 3c - Black Cypress Pine/ Red Stringybark/Daphne Heath (*Callitris endlicheri/E. macrorhyncha /Brachyloma daphnoides*);
- 3d - Black Cypress Pine (*C. endlicheri*);
- 3e - *Acacia doratoxylon;* and
- 6a - Mixed Eucalypt Gully Community.

Similar vegetation communities occur in the Project area and within the offset area, particularly Vegetation Communities 1a, 3a and 3b. The differences in flora species between the offset area and Project area are outlined in Appendix B and include absence of *E. dives* in the offset area and more *E. blakelyi* associated with *E. melliodora* within the offset area. The differences are not considered to undermine the suitability of the offset area.

A higher diversity of fauna habitat niches are available within the offset area, including dry western gullies, wetter western gullies (with ephemeral streams and rock pools), Box-Gum Woodland, Sandstone cliff formation, regrowth heathy woodland, old growth woodland, cleared agricultural land, riparian habitat along the Panuara Rivulet, and rocky outcrops (Appendix A).

The offset area is one continuous area of vegetation. It is located within a highly fragmented landscape with the valley floors and mid-slopes having been cleared (wholly or partially) for agricultural purposes.

It forms part of an important localised discontinuous bushland complex (Barton Nature Reserve, Black Mountain, Mount Canobolas, Grahams Mountain, Lees Mountain, Columbine Mountain and the Black Rock Range) with inter-connection provided by smaller remnant woodland areas, semi and uncleared Box Woodlands on valley floors and mid-slopes, with either native or improved pasture understoreys, as well as important creek and early order drainage lines acting as important integrative wildlife corridors (Appendix A).

The vegetation and habitat within the offset area ranges from good to highly degraded condition. Grazing by sheep and cattle is considered to be the greatest existing threat to the vegetation and to a lesser extent weeds, animal pests and fire management (FloraSearch, 2006; Western Research Institute, 2006; Greg Richards and Associates, 2006).

In addition to addressing residual flora and fauna impacts associated with the Project, the offset area has been specifically targeted to offset the Project impacts on matters protected by the EPBC Act, by enhancing substantial areas of existing Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC and foraging habitat for threatened woodland birds (i.e. Superb Parrot and Swift Parrot), and the re-establishment of a further 173 ha of vegetation/habitat.

The Box-Gum Woodland within the offset area is largely represented by Vegetation Communities 1a and 2b (Figure 4-22). Approximately 210 ha of the Box-Gum Woodland which occurs in the offset area meets the criteria of the Box-Gum Woodland EEC listed under the TSC Act (after NPWS, 2002a, 2002b; NSW Scientific Committee, 2002c; DECC, 2009b), and approximately 154 ha meets the criteria of the Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC under the EPBC Act (after Threatened Species Scientific Committee, 2006a, 2006b; DEH, 2006a) (Figure 4-24). There is an opportunity to enhance the condition of the remaining 56 ha of Box-Gum Woodland EEC so it meets the criteria for the Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC. The Box-Gum Woodland within the offset area is considered to be equal or better quality and is more typical of core areas of the community than the Box-Gum Woodland which would be lost as a result of the Project (FloraSearch, 2006).

[4] Note that the numbering of vegetation communities is in accordance with Appendix B.

The following threatened fauna were recorded within the offset area or adjoining habitat: Rosenberg's Goanna, Superb Parrot, Barking Owl, Brown Treecreeper (eastern subspecies), Speckled Warbler, Diamond Firetail, Eastern Bentwing-bat, and Yellow-bellied Sheathtail-bat (Western Research Institute, 2006; Greg Richards and Associates, 2006). The offset area also provides potential habitat for other threatened fauna species recorded at Cadia East (e.g. Swift Parrot and Squirrel Glider).

As previously stated, approximately 173 ha of cleared agricultural land also occurs within the offset areas. The proposal to revegetate these cleared areas with woodland vegetation provides the opportunity to increase the existing area of the remnant vegetation.

Overall, the surveys indicated that the habitat within the offset area is considered of equal or higher conservation value when compared to the habitat which would be cleared for the Project.

*Security of the Offset Area*

The conservation of the offset areas would be secured through rezoning relevant tenure to reflect conservation purposes (i.e. *Zone E2 Environmental Conservation* under the *Standard Instrument [Local Environmental Plans] Order 200*6). The zoning and re-conditioning would be undertaken in consultation with the DoP and CSC. The security of the offset would be established within 12 months of Project Approval or a time period to the satisfaction of the Director-General of the DoP. The offset area would be managed for conservation purposes in perpetuity.

*Management of the Offset Area*

A management plan would be prepared by a suitably qualified person(s) to facilitate the revegetation and regeneration of native vegetation and habitats and provide a framework for continued management and monitoring. The management plan would be prepared within 12 months of Project Approval or a time period to the satisfaction of the Director-General of the DoP.

The plan would describe measures including, but not necessarily limited to:

- provision of appropriate fencing to exclude grazing from the remainder of the Ulah Property (the background landowner of Black Rock Range) thereby assisting natural regeneration;
- native revegetation plantings using a local seed source;
- removal of unnecessary existing fences to facilitate fauna movement;
- soil erosion management;
- weed and pest management;
- fire management measures to include irregular mosaic burnings;
- signage of the offset area;
- restriction of vehicular and people access; and
- monitoring, auditing and reporting the performance of the offset.

The management plan would also provide details of the expected costs associated with the measures described in the plan.

*Performance of the Offset Area*

The offset management plan would contain a monitoring programme developed by a suitably qualified person(s) to assess the performance of the management measures in enhancing habitats for flora and fauna.

The monitoring would provide information on the landscape resilience, landscape function, habitat quality and diversity and species diversity within the offset area. Baseline monitoring would be conducted within two years of Project Approval, and be used to assess change over time.

The monitoring programme would provide for monitoring of revegetation areas (e.g. using Landscape Function Analysis/Ecosystem Function Analysis [or equivalent], photo points) and the monitoring of existing woodland/ forest areas (e.g. using permanent quadrats and photo points).

Terrestrial fauna surveys would also be conducted every five years to monitor the use of the offset areas by vertebrate fauna.

The offset area would be independently audited at intervals agreed with relevant authorities. The audits would be conducted by a suitably qualified person(s) to confirm:

- compliance with the management plan;
- assess the performance of the offset area;
- review the adequacy of the management measures and monitoring programme; and
- recommend actions or measures to improve the performance of the offset, management plan, or monitoring programme.

***Measures Applicable to the Box-Gum Woodland under the EPBC Act***

In consideration of the *EPBC Act Policy Statement 3.5* for the Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC (DEH, 2006a), the following measures would be implemented to avoid, mitigate and offset potential impacts of the Project on Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC:

- rehabilitation and revegetation of Project disturbance areas;
- management of flora in the surrounding Cadia Valley; and
- enhancement and conservation of the Box-Gum Woodland and habitat within an offset area.

The DoP would be responsible for endorsing and approving each of the above measures. These measures are described below in relation to the Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC.

*Rehabilitation and Revegetation of Project Disturbance Areas*

The revegetation of woodland areas would include the planting of species characteristic of the Box-Gum Woodland EEC and Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC (e.g. White Box, Yellow Box and Blakely's Red Gum overstorey as well as appropriate understorey). Rehabilitation and revegetation of Project disturbance areas is further described in Section 5 and Appendix P.

*Management of Flora in the Surrounding Cadia Valley*

Approximately 240 ha of Box-Gum Woodland on CHPL-owned land meets the criteria for the Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC (Appendix B). The management of the Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC would be facilitated by the proposed revised LMP.

*Offset Area*

The offset area would secure the long-term viability of a substantial area of the Box-Gum Woodland outside of the Project area, (approximately 154 ha of existing Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC).

There is an opportunity to enhance the condition of the 56 ha of Box-Gum Woodland EEC so it may also meet the criteria for the Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC.

Management measures would aim to control weed species, expand and connect existing patches of Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC by selective planting within cleared agricultural land, manage fire, and remove grazing.

It is considered that there is minimum risk to the success of enhancing the existing Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC, when compared to the relatively higher risk of success in revegetation of cleared areas. Based on CHPL's experience gained through revegetation initiatives on CHPL-owned land in the Cadia Valley, the risks involved in revegetation predominantly relate to tubestock and seeding failure due to drought conditions.

## 4.5 FAUNA

A Fauna Assessment was prepared for the Project by Western Research Institute (Assoc. Prof. David Goldney) and Resource Strategies (2009) and is presented in Appendix A. The Fauna Assessment was prepared in accordance with the *Draft Guidelines for Threatened Species Assessment* (DEC and DPI, 2005).

### 4.5.1 Existing Environment

***Regional Setting***

As discussed in Section 4.4.1, the Project area is located at the interface between the NSW South Western Slopes and the South Eastern Highlands IBRA bioregions. It is also located within the Bassian Zoogeographic Region (Spencer, 1896; Schodde, 1994) which is a coarse but more useful predictor of faunal assemblages in some cases then the IBRA bioregion boundaries.

***Fauna Surveys***

A significant number of vertebrate fauna surveys and studies have been conducted which are applicable to the Project area and surrounds, including:

- Cenwest Environmental Services (2005) *Cadia East Study Area Terrestrial Vertebrate Fauna Assessment*. This report is provided in Attachment AA of Appendix A.

- Western Research Institute (2007) *Cadia East Project Terrestrial Vertebrate Fauna Surveys (Excluding Bats)*. This report is provided in Attachment AB of Appendix A.
- Greg Richards and Associates (2005) *Cadia East Study Area Bat Fauna Assessment.* This report is provided in Attachment AC of Appendix A.
- Greg Richards and Associates (2007) *A Survey of Bat Fauna at a Proposed Tailings Dam, Cadia East, NSW.*
- Resource Strategies (2002a) *Cadia Extended Modification Flora and Fauna Assessment*.
- Resource Strategies (2002b) *Southern Remnant Flora and Fauna Survey*.
- Resource Strategies (2002c) *Ridgeway Gold Mine Remnant Woodland Enhancement Programme Wire Gully Baseline Monitoring Survey*.
- James Warren and Associates (2000a) *Ridgeway Project Fauna Survey - Ridgeway Project*.
- James Warren and Associates (2000b) *Swallow and Diggers Creeks Amphibian Survey – Ridgeway Project*.
- Greg Richards and Associates (2000) *An Assessment of the Bat Fauna In Infrastructure Zones at the Ridgeway Mining Cadia East Project, Central New South Wales*.
- Charles Sturt University and Resource Strategies (1998) *A Vertebrate Survey of the Ridgeway Trial Development Application Area and Surrounds*.
- Fisher and Goldney (1995) *Fauna Survey – Cadia Hill*.

Of these studies listed above, Assoc. Prof. David Goldney was involved in the following:

- Cenwest Environmental Services (2005);
- Western Research Institute (2007);
- Charles Sturt University and Resource Strategies (1998); and
- Fisher and Goldney (1995).

Targeted searches for threatened fauna species were conducted, as part of a number of the above studies.

Local creeks in the Cadia Valley have been surveyed for aquatic macroinvertebrates and fish since 1994. Gibbs (1995), Gibbs (1997) and Ecowise (2008) have conducted aquatic macroinvertebrate sampling on Cadiangullong Creek, and fish have been recorded on Cadiangullong Creek by Bauer (1994, 1995), Charles Sturt University and Resource Strategies (1998) and Ecowise (2008). Aquatic macroinvertebrate sampling has been conducted on Rodds Creek by Gibbs (1995) and Gibbs (1997) and at Copper Gully by Gibbs (1995) and Ecowise (2008).

Flyers Creek has been subject to fish surveys (Bauer, 1994, 1995; Ecowise, 2008), aquatic macroinvertebrate sampling (Ecowise, 2008) and platypus surveys (Education and Environment Services, 2000). Platypus surveys were also conducted in the Belubula River (Education and Environment Services, 2000).

A study was also undertaken by Herr *et al.* (2004) in regard to the efficiency of the environmental flows in Cadiangullong Creek below Cadiangullong Dam in maintaining instream ecological health.

The above studies are discussed further in Appendix A and below where relevant.

***Fauna Habitat within the Project Disturbance Area***

The following broad fauna habitat types were identified within the Project area and surrounds (Appendix A):

- *Cleared Agricultural Land with or without Scattered Paddock Trees* - This habitat type dominates the Cadia Valley area and the Project area and comprises predominately cleared agricultural pasture (native and introduced) with remnant native Eucalypt trees occurring in clumps or as isolated paddock trees and stags. Mature trees and stags provide roosting/nesting resources and foraging habitat.
- *Open Woodland* - Open woodland is found in discrete patches throughout the Cadia Valley and the Project area. Regrowth patches are usually dominated by trees estimated to be around 30-50 years of age, but which have not yet entered their hollow forming phase. Understorey layers have been either cleared or been impacted by sheep and cattle grazing.

- *Open Forest* - Open forest within the Project area tends to be dominated by regrowth trees with a majority of trees are estimated to be 30 to 50 years of age. The density of the understorey and midstorey varies throughout this habitat type.
- *Aquatic Habitat* - Aquatic habitats that occur within the Project area and wider surrounds includes:
  - Farm dams - in cleared or semi cleared areas with and without a complement of freshwater plants such as reeds and rushes. These have moderate habitat, staging and refugia values.
  - Rodds Creek Water Holding Dam - currently a staging ground for many waterbirds. However the habitat offered by the Rodds Creek Water Holding Dam is moderate to low, due to lack of edge and shallow water emergent vegetation habitat.
  - Tailings storage facilities - are part of the existing mine infrastructure. The presence of free surface water associated with water edges merging with woodland or forest communities and occasional first order drainage lines, offers limited habitat for a range of vertebrate species.
  - Copper Gully - occurs within the Cadia East subsidence zone and zone of influence. Its flow to Cadiangullong Creek has been truncated by the existing Cadia Hill open pit. Copper Gully contains an ephemeral creek and is often little more than a series of disconnected ponds that gradually dry up. Copper Gully is very modified, deeply incised and degraded. The creek provides moderate habitats with limited value in being able to meet the habitat needs of most species.
  - Cadiangullong Creek - occurs to the immediate west of the existing Cadia Hill open pit. It was an ephemeral creek prior to the Cadia Valley Operations and the construction of the Cadiangullong Dam, albeit one that had been significantly impacted by historic mining (Herr *et al.*, 2004). The surface water flows within the creek are now controlled through riparian flow releases from Cadiangullong Dam.
  - Belubula River - occurs 5 km from the southern lease boundary of the Cadia Valley Operations. The river is a tributary of the Lachlan River which it joins approximately 50 km south-southwest of the Project area (Figure 4-15).
  - Flyers Creek - occurs to the east of the Project area and is a perennial creek. The native riparian vegetation along Flyers Creek is high degraded with introduced Willows the most prominent riparian vegetation.
- *Monterey Pine Plantation* - Areas managed for forestry are characterised by stands of pine of different age classes with little or no undergrowth. The dense cover offered by these trees provides some habitat for species such as kangaroos, wallabies, foxes and rabbits. Some native species may breed within pine plantations but generally the native species diversity is low. Pine plantations rate as very poor quality habitat for native vertebrate fauna.

In addition to the above, the proposed CVO Dewatering Facility site and pipelines are located in cleared agricultural land with little to no extant native vegetation present. This is considered to be very impoverished habitat for native vertebrate species (Appendix A).

***Native Terrestrial Fauna Species Composition***

As discussed above, a significant number of vertebrate fauna surveys have been conducted which are applicable to the Project area and surrounds. A total of 205 native terrestrial fauna species have been recorded in the Project area and surrounds, including 13 amphibians, 31 reptiles, 131 native birds and 30 native mammals. A comprehensive list of fauna species recorded within the Cadia Valley by previous studies is provided in Appendix A.

***Introduced Terrestrial Fauna Species***

A total of 14 introduced terrestrial fauna species have been previously recorded in the Project area and/or surrounds, including six birds and eight mammals. Further detail is provided in Appendix A.

***Aquatic Vertebrate Fauna***

In addition, fish surveys in Copper Gully, Rodds Creek, Cadiangullong Creek, Belubula River and Flyers Creek have recorded five fish species, namely:

- Mountain Galaxias (*Galaxias olidus*) in Cadiangullong Creek (Bauer, 1994, 1995; Ecowise, 2008) and Flyers Creek (Bauer, 1994, 1995; Ecowise, 2008);

- Rainbow Trout (*Oncorhynchus mykiss*) in Cadiangullong Creek (Bauer, 1994, 1995) and Flyers Creek (Bauer, 1994, 1995; Education and Environment Services, 2000);
- Brown Trout (*Salmo trutta*) in Cadiangullong Creek (Charles Sturt University and Resource Strategies, 1998);
- Redfin Perch (*Perca fluviatilis*) in Cadiangullong Creek (Ecowise, 2007 in Ecowise 2008); and
- Carp (*Cyprinus carpio*) in Belubula River and Flyers Creek (Education and Environment Services, 2000).

The Rainbow Trout, Redfin Perch, Brown Trout and Carp are introduced fish species and the Mountain Galaxias is a common native fish.

***Critical Habitat***

No critical fauna habitat occurs within the vicinity of the Project area as designated by the:

- Register of Critical Habitat held by the Commonwealth Minister of the Environment, Heritage and the Arts (DEWHA, 2009b);
- Register of Critical Habitat held by the Director-General of the DECC (DECC, 2009c);
- Register of Critical Habitat held by the Director-General of the DPI-Fisheries (DPI-Fisheries, 2009); or
- identified within the Cabonne LEP or the Blayney LEP.

Therefore, the Project would not affect any critical habitat.

***Threatened Fauna Species***

A literature and database review was conducted in addition to targeted surveys to identify threatened fauna species which could potentially occur within the Project area (Appendix A).

Table 4-10 provides a list of threatened fauna species with records within or near the Project area and therefore may be affected by the Project (Appendix A).

No threatened fauna under the FM Act have been recorded in Project area or surrounding creeks.

**Table 4-10**
**Threatened Fauna Species with the Potential to be Affected by the Project**

| Scientific Name | Common Name | Conservation Status | |
|---|---|---|---|
| | | TSC Act[1] | EPBC Act[2] |
| ***Birds*** | | | |
| *Polytelis swainsonii*[3] | Superb Parrot | V | V |
| *Lathamus discolor*[3] | Swift Parrot | E | E |
| *Neophema pulchella*[3] | Turquoise Parrot | V | - |
| *Climacteris picumnus victoriae*[3] | Brown Treecreeper (eastern subspecies) | V | - |
| *Pyrrholaemus sagittatus*[3] | Speckled Warbler | V | - |
| *Anthochaera phrygia*[3,4] | Regent Honeyeater | E | E |
| *Stagonopleura guttata*[3] | Diamond Firetail | V | - |
| ***Mammals*** | | | |
| *Petaurus norfolcensis*[3, 5] | Squirrel Glider | V | - |
| *Saccolaimus flaviventris*[3, 5] | Yellow-bellied Sheathtail-bat | V | - |
| *Miniopterus schreibersii oceanensis*[3, 5] | Eastern Bentwing-bat | V | - |

Source: Appendix A.

1 Threatened Species status under the TSC Act.

2 Threatened Species status under the EPBC Act.

V = Vulnerable.

E = Endangered.

3 Located within the Project area.

4 Listed as *Anthochaera phrygia* under the EPBC Act and *Xanthmyza phrygia* under the TSC Act.

5 Likely to be a viable population within the Project area.

Of the threatened species listed in Table 4-10, only the Squirrel Glider, Yellow-bellied Sheathtail-bat and the Eastern Bentwing-bat are considered likely to have viable populations within the Project area. All of the species listed in Table 4-10 are discussed below and in detail in Appendix A. The effect of the Project on these species is described in Section 4.5.2.

*Superb Parrot*

The Superb Parrot has been recorded in CHPL-owned land in 2000, 2002, 2006 and 2007 (Resource Strategies, 2000b; Resource Strategies, 2002c; Appendix A). All records have been located near the southern end of the Project area (Figure 4-25). It is unlikely that a viable population of the species lives and breeds within the Project area, rather individuals or small groups may use the Project area as part of their feeding range.

*Swift Parrot*

A single Swift Parrot was recorded flying between trees within the south of the Project area in November 2006 (Appendix A). It is very unlikely that a viable population of the Swift Parrot exists within the Project area given the Project area is located within the over-wintering range of the Swift Parrot albeit likely to be a very minor component of the species habitat.

*Turquoise Parrot*

The Turquoise Parrot has been recorded on one occasion on CHPL-owned land (Figure 4-25) (Resource Strategies, 2000b). It is very unlikely that a viable population of the Turquoise Parrot is extant within the Project area, the one existing record being of a nomadic bird.

*Brown Treecreeper (eastern subspecies)*

The Brown Treecreeper (eastern subspecies) has been recorded on two separate occasions, in 2000 and 2004 (Figure 4-25) (Resource Strategies, 2000b; Appendix A). A single Brown Treecreeper (eastern subspecies) was recorded in riparian habitat along Copper Gully in the Project area during spring 2004 (Appendix A). The other record is outside the Project disturbance area to the south. It is unlikely that a viable population of the Brown Treecreeper is extant within the Project area given the already fragmented nature of the habitat in the Project area.

*Speckled Warbler*

In 2006, a single Speckled Warbler bird was recorded in habitat within the disturbance area by Western Research Institute (Appendix A) (Figure 4-25). It is very unlikely that a viable population of the Speckled Warbler is extant within the Project area given the already fragmented nature of the habitat in the Project area.

*Regent Honeyeater*

A single immature Regent Honeyeater was recorded in a patch of remnant vegetation at the Ashleigh Park property, which is located approximately 5 km to the west of the Cadia Hill open pit during an avifauna survey conducted by Debus in December 1999 (Resource Strategies, 2000b). It is possible that the Regent Honeyeater may occasionally use habitat within the Project area, due to the migratory nature of the species, and the availability of habitat within the Project area. The Regent Honeyeater has not been recorded within the Project area.

*Diamond Firetail*

The Diamond Firetail was recorded during the baseline fauna survey conducted for the Ridgeway EIS (James Warren and Associates, 2000a) (Figure 4-25). A single bird was again recorded in 2006 by Western Research Institute (Appendix A) (Figure 4-25). It is unlikely that a viable population of this species is extant within the Project area given the already fragmented nature of the habitat in the Project area.

*Squirrel Glider*

In 2002, the Squirrel Glider was recorded within the Project area by Place Design Group within Red Stringybark open forest habitat (Resource Strategies, 2002b) (Figure 4-25). At that time, two individuals were sighted. In May 2008, Place Design Group re-recorded the Squirrel Glider during vegetation clearance activities associated with the South Waste Rock Dump Modification (Resource Strategies, 2008). The records were from a response to call playback and sighting an individual Squirrel Glider during spotlighting.

It appears likely that a viable population of the Squirrel Glider may be extant within very localised habitat of the Project area, given the identification of the Squirrel Glider within the habitat in separate years (i.e. 2002 and 2008).

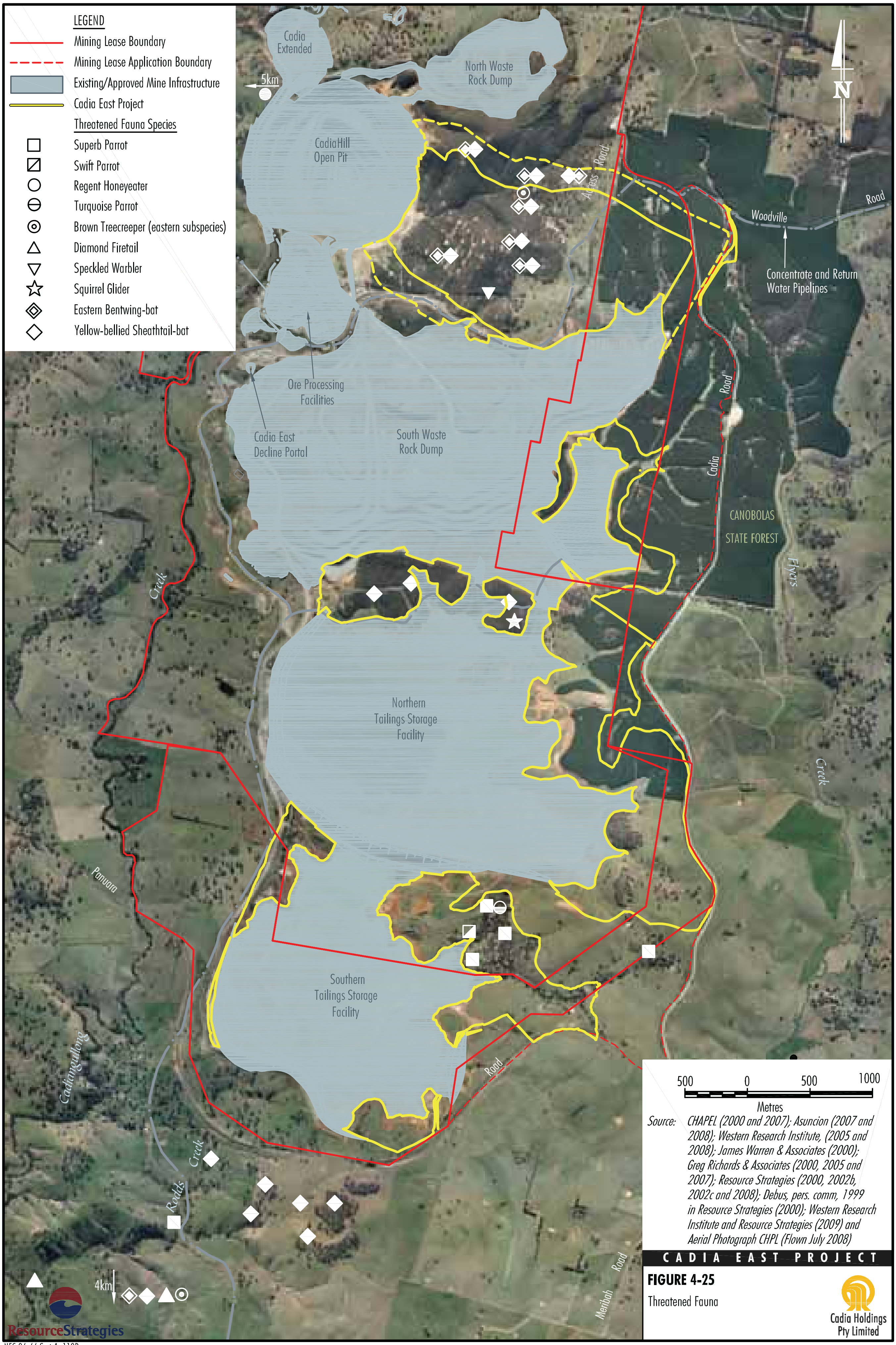



**FIGURE 4-25**

Threatened Fauna

The identification of the Squirrel Glider in the Cadia Valley appears significant as it is more than 50 km from the closest Squirrel Glider record (DECC, 2008b). It is possible that the Squirrel Gliders which were recorded are confined to the habitat remnant within the Project area given the lack of adjacent suitable habitat and the requirement that Squirrel Gliders are typically restricted to treed areas to allow movement by gliding between trees (after Rowston *et al.*, 2002).

*Yellow-bellied Sheathtail-bat*

Echolocation calls of the Yellow-bellied Sheathtail-bat have been widely recorded during the various bat fauna surveys (Figure 4-25) (Appendix A; Resource Strategies, 2002b; Greg Richards and Associates, 2000, 2007). The Yellow-bellied Sheathtail-bat roosts in tree hollows and forages on insects above tree canopies. However, the habitat to be removed is only a small portion of the habitat for this species in the wider area.

*Eastern Bentwing-bat*

The Eastern Bentwing-bat has been previously recorded during the bat fauna survey of the Project area conducted in 2004 (Appendix A) and was previously recorded during the baseline bat fauna survey conducted for the Ridgeway EIS (Greg Richards and Associates, 2000). The Project area provides foraging resources for the Eastern Bentwing-bat. However, the foraging habitat to be removed is only a small portion of the habitat for this species in the wider area.

***Endangered Fauna Populations under the NSW TSC Act and FM Act***

Nineteen fauna populations are listed as endangered under the TSC Act and two fauna populations are listed under the FM Act, however, none are applicable to the Project area.

***Threatened Ecological Communities***

As discussed in Section 4.4.1, two threatened ecological flora communities are present in the Project area, namely Box-Gum Woodland EEC under the TSC Act and Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC under the EPBC Act, both of which provide fauna habitat.

Another threatened ecological community occurs in the surrounds, namely the *Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Lachlan River* (Lachlan River Catchment EEC). This community is listed as endangered under the FM Act.

The Lachlan River Catchment EEC includes all native fish and aquatic invertebrates within all natural rivers, creeks, streams and associated lagoons, billabongs, lakes, wetlands, palaeochannels, flood-runners, floodplains and effluent streams of the Lachlan River (DPI Threatened Species Unit, 2006). The listing includes several waterways (including the Belubula River below Carcoar Dam) that have been listed by the DPI Threatened Species Unit (2006). However, watercourses that occur 500 m above sea level, which are not specified in the DPI's list of included waterways, are excluded from the EEC (DPI Threatened Species Unit, 2006).

The Cadia Valley is drained by Cadiangullong Creek which flows into the Belubula River. The Belubula River is a tributary of the Lachlan River which it joins approximately 50 km south-southwest of the Project area. However the Project area is more than 500 m above sea level and is therefore not included as part of the Lachlan River Catchment EEC.

***Migratory Species under the Commonwealth EPBC Act***

Table 4-11 presents the migratory species listed under the EPBC Act that have been recorded in the Project area and surrounds.

**Table 4-11**
**Migratory Species Recorded in the Project Area and/or Surrounding Region**

| Scientific Name | Common Name[1] |
|---|---|
| *Bubulcus ibis* | Cattle Egret |
| *Ardea alba* | Great Egret |
| *Gallinago hardwickii* | Latham's Snipe |
| *Plegadis falcinellus* | Glossy Ibis |
| *Tringa stagnatilis* | Marsh Sandpiper |
| *Tringa nebularia* | Common Greenshank |
| *Calidris ruficollis* | Red-necked Stint |
| *Calidris acuminata* | Sharp-tailed Sandpiper |
| *Calidris ferruginea* | Curlew Sandpiper |
| *Falco peregrinus* | Peregrine Falcon |
| *Falcunculus frontalus* | Crested Shrike-tit |
| *Hirundapus caudacutus* | White-throated Needletail |
| *Ninox novaeseelandiae* | Southern Boobook |
| *Merops ornatus* | Rainbow Bee-eater |
| *Anthochaera phrygia* | Regent Honeyeater |
| *Rhipidura rufifrons* | Rufous Fantail |
| *Myiagra cyanoleuca* | Satin Flycatcher |
| *Acrocephalus australis* | Australian Reed-warbler |

Source: Appendix A.

[1] Nomenclature in accordance with Clayton *et al.* (2006).

Potential habitat for migratory bird species in the Project area and surrounds is largely represented by artificial habitats, namely Rodds Creek Water Holding Dam, farm dams and Cadiangullong Dam. The tailings storage facilities also provide some limited habitat for migratory bird species.

***Existing Management Measures***

CHPL currently implements the following environmental management plans relevant to the management of fauna, and potential impacts on fauna, at the Cadia Valley Operations and surrounds:

- FFMP (CHPL, 2009b);
- Site Management Plan (CHPL, 2009c);
- LMP (CHPL, 2009a);
- BMP (CHPL, 2008f);
- NMP (CHPL, 2009e);
- Lighting Management Plan (CHPL, 2009f); and
- FMP (CHPL, 2007b).

### 4.5.2 Potential Impacts

The following sub-sections evaluate the potential impacts of the Project on fauna species, populations and ecological communities, and their habitats in accordance with the *Draft Guidelines for Threatened Species Assessment* (DEC and DPI, 2005). This evaluation includes identification of the magnitude, extent and significance of the potential impacts. Proposed measures to avoid, mitigate and offset potential impacts on fauna are provided in Section 4.5.3.

***Habitat Removal and Modification***

The quantities of native vegetation which would be cleared, lost or modified are presented in Section 4.4.2. Major fauna habitat types that would be cleared and modified for the Project include:

- approximately 360 ha of cleared agricultural land with scattered paddock trees;
- approximately 50 ha of open woodland;
- approximately 188 ha of open forest; and
- approximately 184 ha of pine plantation.

Since the original EPBC Act controlled action decision in 2007, CHPL has modified the Project to exclude the originally proposed FSTSF and mine the Cadia East deposit using underground mining methods rather than open pit mining methods. As a result, approximately 61 ha of scattered remnant native woodland vegetation is no longer proposed to be cleared for the Project.

The concentrate and return water pipeline route from the Cadia Valley to the CVO Dewatering Facility would be designed to avoid native vegetation, where practicable. The CVO Dewatering Facility is located in approximately 2.6 ha of cleared agricultural land.

The habitat loss associated with the Project would result in the following Key Threatening Processes under the TSC Act: Removal of Dead Wood and Dead Trees, Bushrock Removal and Loss of Hollow-bearing Trees. An assessment of these Key Threatening Processes is provided in Appendix A.

The wider area surrounding the Cadia Valley Operations contains several islands of remnant vegetation scattered amongst agricultural land. The existing Cadia Valley Operations already presents a barrier to the movement of many types of wildlife (including amphibians, reptiles, low-flying birds and mammals). As the disturbance areas associated with the Project are located adjacent to the existing Cadia Valley Operations, their disturbance is unlikely to result in a substantial additional reduction in habitat connectivity within the surrounding landscape.

***Alteration to the Natural Flow Regimes of Rivers and Streams and their Floodplains and Wetlands and Degradation of Native Riparian Vegetation along NSW Watercourses***

As stated in Section 4.4.2, the *Alteration to the Natural Flow Regimes of Rivers and Streams and their Floodplains and Wetlands* is a Key Threatening Process listed under the TSC Act (NSW Scientific Committee, 2002a) and degradation of native riparian vegetation along NSW watercourses is also a relevant Key Threatening Process under the FM Act. These Key Threatening Processes are discussed below in relation to fauna impacts from the Project. The potential impacts from the Project on groundwater and surface water are provided in Sections 4.2 and 4.3 and Appendices F and G.

*Copper Gully*

Copper Gully contains an ephemeral creek that is located in the Project area (Figure 4-16). The creek now terminates at a dam on the eastern edge of the existing Cadia Hill open pit. The catchment of this creek is now confined to the area upstream of the dam and is located within the Cadia East subsidence zone. A section of native riparian vegetation along Copper Gully would be impacted as a result of the subsidence associated with the Project. The section of riparian habitat that would be lost is relatively small and part of an already modified habitat (i.e. terminates at the small Copper Gully dam). The truncated Copper Gully is very limited in its capacity to provide riparian fauna habitat connectivity (Appendix A).

*Rodds Creek*

The Rodds Creek Water Holding Dam would be raised and expanded as part of the Project. The existing dam is surrounded by pine plantation which would be partially removed as part of the expansion. Fauna habitat which has established on its edge since its construction and subsequent filling would be partially removed as part of the Project.

*Cadiangullong Creek*

Cadiangullong Creek was an ephemeral creek prior to the Cadia Valley Operations and the construction of the Cadiangullong Dam, albeit one that had been significantly impacted by historic mining (Herr *et al*., 2004). The surface water flows within the creek are now controlled through riparian flow releases from Cadiangullong Dam (Section 4.3.1).

As described in Section 4.4.2, the dominant natural vegetation along Cadiangullong Creek is predominantly River Sheoak Forest (*Casuarina cunninghamiana*).

As described in Section 4.3.2, the Surface Water Assessment by Gilbert & Associates (2009) (Appendix F) predicted that the Project would increase the proportion of time that no flow would occur in Cadiangullong Creek downstream of Cadiangullong Dam.

The Cadiangullong Creek has been demonstrated to be extremely resilient and its macroinvertebrate diversity of a high order in spite of the significant and adverse impacts of historic mining (Herr *et* al., 2004). It is likely that the predicted reduction in riparian flow releases as a result of the Project would extend the periods of no flows below the Cadiangullong Dam.

The effect on both macroinvertebrate and vertebrate fauna is likely to be similar to other natural ephemeral creek drying and wetting cycles. The evidence from previous studies on the Cadiangullong Creek is that fauna is well adapted to drying and wetting cycles (Herr *et al*., 2004).

*Flyers Creek*

Flyers Creek is a perennial creek which flows to the east of the Project area and joins the Belubula River to the south (Figure 4-15). As described in Section 4.3.1, low flows in the creek are sustained by groundwater discharge (baseflow).

As described in Section 4.2.2, the Groundwater Assessment conducted for the Project by AGE (2009) (Appendix G) found that the Project would reduce the groundwater discharge to Flyers Creek by up to 0.49 ML/day. However, the Surface Water Assessment by Gilbert & Associates (2009) (Appendix F) concluded that the reduction in surface water flow would generally be expressed within Flyers Creek as small decreases in stream width and stream depth depending on the width of the stream (e.g. 1 to 2 cm shallower), and therefore an effect on the riparian vegetation along Flyers Creek is not likely as a result of the reduction in groundwater discharge.

Further, the reduction in creek flows is unlikely to significantly change the in-stream aquatic fauna habitat characteristics since Gilbert & Associates (2009) predicts that the creek would still continue to flow at rates that would maintain the pool riffle system. It follows that there is unlikely to be a significant impact on instream invertebrate and vertebrate species diversity. This prediction is supported by the macroinvertebrate studies carried out by Charles Sturt University in the Cadiangullong Creek (Herr *et al*., 2004).

*Belubula River*

Continued extraction of water from the Belubula River in accordance with existing annual extraction amounts (Section 2.10.2) is unlikely to impact fauna associated with the Belubula River.

***Introduced Fauna***

The European Rabbit, European Red Fox and Feral Cat are introduced animal species which have been recorded during surveys undertaken in the Cadia Valley area. Each of these species has a corresponding Key Threatening Process listed under the TSC Act (NSW Scientific Committee, 2000b, 2002b, 2004), namely:

- Competition and grazing by the feral European Rabbit;
- Predation by the European Red Fox; and
- Predation by the Feral Cat.

Activities associated with the Project may provide increased refuge and scavenging resources (e.g. discarded food scraps) for these introduced species, unless appropriately managed.

Appropriate management of potential refuge and scavenging resources (e.g. discarded food scraps) for these species associated with the Project would likely ensure that introduced species would not increase, and likely decrease in response to targeted control measures.

***Introduced Flora***

As described in Section 4.4.2, disturbance can act as a catalyst for weed incursion and, if management measures are not in place, proliferation of weeds can occur. This may potentially impact on fauna by modifying their habitat without weed management measures.

***Fauna and Noise***

A number of recent literature reviews have been conducted on the effects of noise on wildlife (Radle, 2007; Kaseloo, 2005; Institute for Environmental Monitoring and Research, 2001). Noise can potentially adversely impact certain fauna species, although studies on the effect of noise on wildlife have shown very variable responses to potential impacts. Many studies have shown that fauna are well adapted to human activities and noise, while other studies have shown that noise can cause masking of vocalisation, physiological stress and changes in movement and patterns of behaviour (Radle, 2007; Kaseloo, 2005; Institute for Environmental Monitoring and Research, 2001). It is considered that the impact of noise generated by the Project on vertebrate fauna adjacent to the Project area is likely to be minimal, particularly given the lack of nearby sizable native vegetation remnants.

***Fauna and the Subsidence Zone***

As described in Section 4.3.2,it is predicted that a waterbody would eventually form in the subsidence zone and reach an equilibrium level of approximately 670 m AHD (Figure 4-12). Due to the chemical composition of the rock in the subsidence zone, the waterbody is predicted to become saline, of poor water quality, and unsuitable for fauna (aquatic, edge and as a temporary staging-feeding area).

The impact of the subsidence zone on fauna would be reduced by the following:

- a bund and stock fence would be constructed around the void to restrict entry by medium to large fauna;
- the waterbody is likely to be unattractive to vertebrate fauna given the likely high saline conditions that are expected to develop over time; and
- more suitable waterbodies occur in the Cadia Valley, including the Rodds Creek Water Holding Dam and Cadiangullong Dam.

Further to the above, habitat enhancement of the shores of Rodds Creek Water Holding Dam and Cadiangullong Dam is proposed as part of the Project.

The management of the subsidence zone post-closure is further described in Section 5 and Appendix P.

***Fauna and the Tailings Storage Facilities***

Tailings storage facilities are part of the existing mine infrastructure at the Cadia Valley Operations. The presence of free surface water in the tailings storage facilities offers habitat for a range of vertebrate species. Under the current operating conditions the impacts on fauna are minimal.

The Project would result in an increase in the surface area and height of the tailings storage facilities, however it is not predicted to result in a significant change in the water quality due to the tailings having similar geochemical characteristics (Section 4.2.2), therefore the risk to fauna is not likely to change.

***Fauna and Artificial Lighting***

Artificial lighting for the Project has the potential to affect the behavioural patterns of some fauna species. For example, some bird and bat species are attracted to insects that swarm around artificial lights leading them to become vulnerable to predation by larger predators (e.g. owls). Based on experience with the existing Cadia Valley Operations, this is likely to be a minor issue, if at all.

***Vehicular Traffic Movements***

Vehicular traffic movements associated with the Project have the potential to increase the mortality of some fauna species. It is considered unlikely that the additional vehicular traffic movements required for the Project would significantly impact fauna given the location of the proposed traffic movements and the measures to avoid and mitigate potential impacts described in Section 4.10.3.

***Bushfire Risk***

*Ecological Consequences of High Frequency Fire* is listed as a Key Threatening Process under the TSC Act (NSW Scientific Committee, 2000c). The risk of fire would be similar to the existing situation without the Project through the management measures described in Section 4.1.3.

***Threatened Fauna Species***

The potential impacts from the Project on threatened fauna species was assessed in Appendix A in consideration of the *Draft Guidelines for Threatened Species Assessment* (DEC and DPI, 2005) and *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance* (DEH, 2006b) (where appropriate).

Disturbance associated with the proposed Project would result in the removal of fauna habitats and the displacement and/or loss of native vertebrate individuals. However, the Project is unlikely to lead to the extinction of any threatened fauna species or ecological community or place any at risk of extinction.

The identification of the Squirrel Glider at the Cadia Valley appears significant as it is more than 50 km from the closest Squirrel Glider record (DECC, 2008b) and it is possible that the Squirrel Gliders which were recorded are confined to the habitat remnant within the Project area given the lack of adjacent suitable habitat.

Furthermore Squirrel Gliders are typically restricted to treed areas to allow movement by gliding between trees (after Rowston *et al.*, 2002). The removal of the Squirrel Glider's habitat is very likely to result in the displacement of the local population of Squirrel Gliders, and ultimately very likely lead to the loss of the population. Offset measures are described in Section 4.5.3.

***Threatened Box-Gum Woodland***

As discussed in Section 4.4.1, two threatened ecological communities are present in the Project area, both of which provide fauna habitat. These are the Box-Gum Woodland EEC and Box-Gum Grassy Woodland and Derived Native Grassland CEEC. These communities are recognised habitat for threatened species including the Superb Parrot, Regent Honeyeater (DEH, 2006a), Swift Parrot (Swift Parrot Recovery Team, 2001) and Turquoise Parrot (NPWS, 2000). Potential impacts on the threatened ecological communities are described in Section 4.4.2.

***Migratory Species under the Commonwealth EPBC Act***

The Project is not likely to have a significant impact on migratory species, as it is unlikely to:

- substantially modify, destroy or isolate an area of important habitat of any of the potential migratory species;
- result in invasive species that are harmful to the potential migratory species becoming established in an area of important habitat of the migratory species; or
- seriously disrupt the lifecycle of an ecologically significant proportion of the population of the potential migratory species.

### 4.5.3 Mitigation Measures and Management

The potential impacts of the Cadia Valley Operations on fauna are currently managed via implementation of existing management measures outlined in Section 4.5.1.

The following measures would be implemented to avoid, mitigate and offset potential impacts of the Project on fauna, and their habitats:

- habitat rehabilitation;
- management of fauna habitats in the surrounding Cadia Valley;

- Vegetation Clearance Protocol;
- TSMP;
- animal pest management and monitoring;
- aquatic ecosystem monitoring;
- fire management;
- measures to reduce artificial lighting impacts;
- noise controls and monitoring;
- traffic controls;
- other fauna protection and management initiatives; and
- offset measures.

These measures are discussed below.

***Habitat Rehabilitation***

As described in Section 4.4.3, the revegetation programme for the Cadia Valley Operations would provide for a combination of woodland and native grassland habitats as well as facilitating landscape connectivity through its concurrent contribution to the local and regional habitat corridor network. Revegetation of woodland areas would include the planting of species characteristic of the Box-Gum Woodland EEC and Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC (e.g. White Box, Yellow Box and Blakely's Red Gum overstorey as well as appropriate understorey), thereby proving habitat for fauna in the medium to long-term. Rehabilitation of Project disturbance areas is further discussed in Section 5 and Appendix P.

***Fauna Management***

As discussed in Section 4.4.3, CHPL has developed and implemented the FFMP (CHPL, 2009b) for the Cadia Valley Operations. It documents how CHPL manages the Cadia Valley Operations to minimise impacts on flora and fauna resources (including species listed as threatened under the EPBC Act and the TSC Act). The FFMP would be updated to include the Project.

***Management of Fauna Habitats in the Surrounding Cadia Valley***

As discussed in Section 4.4.3, CHPL has developed and implemented the LMP (CHPL, 2009a) for the Cadia Valley Operations which applies to the mining areas and neighbouring CHPL-owned land. The LMP would be updated for the Project.

The key measures which would be provided in the revised LMP in relation to the management of fauna habitats in the surrounding Cadia Valley are illustrated on Figure 4-23 and include (references to Figure 4-23 are in parentheses below):

- rehabilitation of Project disturbance areas (1);
- riparian habitat restoration (2, 3 and 4);
- remnant woodland protection and management (5);
- weed management measures (6);
- soil management (7);
- CHPL farm tree initiative (8);
- vegetation corridor programme (9);
- support to the Flyers Creek Landcare Group (10); and
- revegetation on the eastern edge and shoreline of the Rodds Creek Water Holding Dam (11) to optimise water and shore bird use for staging and breeding.

The proposed offset area (12) at Black Rock Range is further described below.

These measures are described in Section 4.4.3.

***Vegetation Clearance Protocol***

A Vegetation Clearance Protocol has been developed to minimise the impact of vegetation clearance on flora and fauna. Procedures have been put in place for the identifying of areas requiring clearing; conducting pre-clearance surveys where necessary; and developing specific fauna management strategies associated with vegetation clearing, including minimising and/or eliminating harm to fauna species and where practicable relocating species within CHPL-owned lands.

The removal of native vegetation is undertaken, where practicable, in consideration of seasonal factors to minimise disturbance to potential breeding and hibernation activities. Where practicable, habitat features (e.g. large hollows and some suitable logs) may be salvaged during vegetation clearance activities and either stockpiled for future use or relocated to areas undergoing rehabilitation or where habitat enhancement is required.

***Threatened Species Management Protocol***

As described in Section 4.4.3, a TSMP has been developed and implemented to facilitate the identification and management of threatened flora and fauna species and is provided in the FFMP (CHPL, 2009b). The key components of the TSMP are observations/surveys for threatened species (prior to disturbance and throughout operations), completion of a Threatened Species Assessment and Management Strategy, regulatory reviews and monitoring.

***Animal Pest Management and Monitoring***

The FFMP (CHPL, 2009b) and LMP (CHPL, 2009a) provide measures to control rabbits and other animal pests. The pest control measures include removing available feed, locating and removing warrens (e.g. by mechanical excavation) and baiting. These measures would be continued for the Project.

***Aquatic Ecosystem Monitoring***

An aquatic ecosystem monitoring programme has been developed and implemented at the Cadia Valley Operations as described in the FFMP (CHPL, 2009b) and detailed in the AEMRs. The monitoring programme involves the assessment of the health of macroinvertebrates and fish populations, and aquatic habitat condition of steams within and surrounding the Cadia Valley Operations. Eight sites are currently monitored biannually (Spring and Autumn) and include four sites on Cadiangullong Creek, two sites on Flyers Creek, one site on Swallow Creek and one site on Copper Gully (Figure 4-16), enabling comparison of aquatic ecosystem health in the different catchments. This monitoring programme would be continued for the Project.

Prior to the Cadia East subsidence propagating to the surface, aquatic ecosystem monitoring site CVOCG1 on Copper Gully would be relocated to a new location upstream of the predicted zone of influence, subject to a suitable site being available.

***Fire Management***

The potential for a change in the frequency of fires due to the Project would be reduced through the implementation of the BMP (CHPL, 2008f), which would be updated for the Project.

***Measures to Reduce Artificial Lighting Impacts***

Lighting strategies/control measures to minimise potential artificial lighting impacts would include the use of unidirectional lighting fixtures. Details are provided in the Lighting Management Plan (CHPL, 2009f), which would be updated for the Project.

***Noise Controls and Monitoring***

A range of noise control measures are implemented at the Cadia Valley Operations to minimise noise emissions. Examples include the restriction of truck movements, adjustment of reversing alarms, scheduling the use of noisy equipment and keeping equipment well maintained. These measures would also be applicable to the Project. Details are provided in the NMP (CHPL, 2009e), which would be updated for the Project.

***Traffic Controls***

Speed limits have been imposed on vehicles using roads and tracks within the mining leases to reduce the potential of fauna mortality via vehicular strike. Signposting has also been installed to remind personnel of the danger of vehicles to wildlife. These measures would be continued for the Project.

***Other Fauna Protection and Management Initiatives***

Other fauna protection and management initiatives have been implemented at the Cadia Valley Operations. These measures include:

- the maintenance of a clean, rubbish-free area; and
- preparation of procedures which detail how to care for animals found at risk of harm or injured in the mining area at Cadia Valley Operations. These procedures should include information such as how to contact the NSW Wildlife Information and Rescue Service (WIRES) and/or the DECC, if necessary.

***Offset Measures***

As described in Section 4.4.3, the EARs for the Project state that the EA must include a description of the measures that would be implemented to offset the impacts of the Project.

The offset area is described in Section 4.4.3. The enhancement and conservation measures proposed as part of the offset would help maintain (and very likely improve) the fauna biodiversity values of a substantial area of fauna habitat outside of the Project area. The key benefits of the offset area in relation to fauna include:

- a higher diversity of fauna habitat niches are available within the offset area, including dry western gullies, wetter western gullies (with ephemeral streams and rock pools), Box-Gum Woodland, Sandstone cliff formation, regrowth tree heath, old growth woodland, cleared agricultural land, riparian habitat along the Panuara Rivulet, and rocky outcrops;
- the offset area is one continuous area of vegetation. It forms part of an important localised discontinuous bushland complex (Barton Nature Reserve, Black Mountain, Mount Canobolas, Grahams Mountain, Lees Mountain, Columbine Mountain and the Black Rock Range);
- the offset area has been specifically targeted to offset the Project impacts on matters protected by the EPBC Act, by enhancing substantial areas of existing Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC and foraging habitat for threatened woodland birds (i.e. Superb Parrot and Swift Parrot), and the re-establishment of a further 173 ha of vegetation/habitat;
- threatened fauna recorded within the offset area or adjoining habitat included the Rosenberg's Goanna, Superb Parrot, Barking Owl, Brown Treecreeper (eastern subspecies), Speckled Warbler, Diamond Firetail, Eastern Bentwing-bat, and Yellow-bellied Sheathtail-bat;
- the offset area also provides potential habitat for other threatened fauna species recorded at Cadia East (e.g. Swift Parrot and Squirrel Glider);
- the fauna survey indicated comparable diversity of amphibians between the Black Rock Range Study Area and the Project area, though a significantly greater diversity of reptiles and birds at Black Rock Range (Western Research Institute, 2006); and
- approximately 173 ha of cleared agricultural land also occurs within the offset areas which would be revegetated with woodland vegetation thereby increasing the existing area of the habitat patches.

Overall, the surveys indicated that the habitat within the offset area is considered of relatively high conservation value when compared to the habitat which would be cleared for the Project.

*Squirrel Glider Monitoring Programme*

The identification of the Squirrel Glider in the Project area is described in Section 4.5.1.

A monitoring programme would be prepared for the Squirrel Glider within six months of Project Approval. The objectives of the monitoring programme would be to:

- confirm the presence of a viable population of the Squirrel Glider within the remnant and determine the approximate numbers of animals in this population and if possible the sex ratio, age structure and breeding success of the population;
- determine the home ranges of selected individuals within the Squirrel Glider population and their use of existing remnant habitats and adjacent habitats;
- quantify the extent of hollows and other critical resources available to this population within the existing remnant and in adjacent areas;
- detail the use of Squirrel Glider nest boxes as a habitat enhancement option within the offset area; and
- develop and implement management measures for the Squirrel Gliders including a translocation programme[5].

The monitoring programme would be regularly reviewed in accordance with these objectives to facilitate appropriate and flexible management of monitoring methods and design. The review would be conducted by CHPL in consultation with the DoP and DECC after the completion of an agreed stage of the monitoring programme, and a report prepared with the findings and implications for the conservation of this population.

5 Translocation is the movement of living organisms from one area with free release in another.

***Measures Applicable to Threatened Fauna Species and Ecological Communities under the Commonwealth EPBC Act***

Measures applicable to the Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC are summarised in Section 4.4.3.

The measures would be implemented to avoid, mitigate and offset the potential impacts of the Project on threatened fauna species listed under the EPBC Act, in particular the Superb Parrot, Swift Parrot and Regent Honeyeater. They include, but are not necessarily limited to:

- use of the Vegetation Clearance Protocol and TSMP;
- control of introduced animal fauna, fire management and weed control;
- rehabilitation of Project disturbance areas with species characteristic of the Box-Gum Woodland EEC and Box-Gum Grassy Woodlands and Derived Native Grasslands CEEC; and
- long-term security and conservation of habitat within the offset area.

## 4.6 AIR QUALITY

A cumulative Air Quality Impact Assessment for the Project has been undertaken by Holmes Air Sciences (2009) and is presented in Appendix E. The assessment follows the procedures outlined by the DECC in its guidance document titled *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005b).

### 4.6.1 Existing Environment

The DMP (CHPL, 2009d) has been implemented at the existing Cadia Valley Operations. The DMP includes air quality monitoring requirements, complaints handling procedures, management measures and stakeholder consultation requirements (CHPL, 2009d).

As a component of the Air Quality Assessment, background air quality data were reviewed, including data from the current dust monitoring network which includes one Tapered Element Oscillating Microbalance (TEOM) analyser, three high volume samplers (HVAS) and 15 dust deposition gauges (Figure 4-4). The following section provides an overview of existing air quality for the relevant parameters and the appropriate air quality criteria.

***Air Quality Criteria***

*Dust Deposition*

The DECC amenity criteria for dust deposition seeks 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 lead to health and amenity impacts. The likely risk of these impacts depends on a range of factors including the size, chemical make-up and concentration of the particulate matter and the general health of the person (NSW Health and NSW Minerals Council, 2006).

Such particles (referred to as Total Suspended Particles [TSP]) are typically less than 50 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 4-12.

**Table 4-12**
**Air Quality Standards/Assessment Criteria for Particulate Matter Concentrations**

| Pollutant | Standard/Goal/Criterion |
|---|---|
| TSP | 90 μg/m$^3$ (annual mean) |
| $PM_{10}$ | 50 μg/m$^3$ (24-hour average – maximum)* |
| | 30 μg/m$^3$ (annual mean) |

* Based on recent approvals granted for mining projects, this goal is taken to be non-cumulative for assessment purposes, provided the mine operates with best-practice dust control measures (Appendix E).

***Dust Deposition***

Since 1994, there have been approximately 40 locations in the Cadia Valley and surrounds where monthly dust deposition has been measured. The dust deposition monitoring network has been consolidated by CHPL over time to reflect changes in monitoring objectives for the Cadia Valley Operations and currently consists of 15 dust deposition gauges (Figure 4-4).

Annual averages from data collected between 1994 and 2008 are presented in Appendix E. The monitoring results presented in Appendix E show that the area generally experiences, on average, dust deposition levels below 4 g/m$^2$/month. For the purposes of the Air Quality Assessment, a value of 2.1 g/m$^2$/month (average at relevant receivers between 1994 and 2008) was taken to be the background dust deposition level that would apply at all sensitive receivers.

***Suspended Particulates***

*$PM_{10}$*

$PM_{10}$ data were obtained from the three HVAS (Figure 4-4) for the period April 2006 to June 2008. The monitors measure 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 Cadia Valley Operations. A 24-hour average $PM_{10}$ concentration measurement is available on every sixth day.

$PM_{10}$ data were also collected from the TEOM analyser (Figure 4-4) for the period between 1 March 2006 and 30 June 2008. $PM_{10}$ concentrations are measured continuously by the TEOM analyser and data are logged every five minutes. The estimated average $PM_{10}$ value over the entire monitoring period was approximately 15.4 μg/m$^3$ (Appendix E).

The monitoring results shows that the 24-hour average $PM_{10}$ concentrations have been above the DECC's assessment criterion of 50 μg/m$^3$ on at least one occasion at each of the sites over the monitoring period. The highest $PM_{10}$ concentration recorded to date was approximately 82 μg/m$^3$, on 27 January 2007 (Appendix E).

In NSW and elsewhere in Australia, it is quite common to measure 24-hour average concentrations above the DECC criterion of 50 μg/m$^3$ on occasions. Events such as bushfires or dust storms are often the cause of elevated $PM_{10}$ concentrations, which can be observed over large geographical areas (Appendix E).

Appendix E summarises the annual average $PM_{10}$ concentrations for the three HVAS and TEOM. In the past three years, the inferred annual average $PM_{10}$ concentrations have been below the DECC's annual average criterion of 30 μg/m$^3$.

For the purposes of the Air Quality Assessment, a value of 20 μg/m$^3$ at the 'Meribah' monitoring site in 2006 (the highest annual average recorded at all of the sites) (Figure 4-4) was conservatively taken to be the annual average $PM_{10}$ background concentration that would apply at all sensitive receivers (Appendix E).

*TSP*

TSP concentrations can be inferred from the $PM_{10}$ monitoring data, by assuming that 40% of the TSP is $PM_{10}$. This relationship was obtained from data collected by co-located TSP and $PM_{10}$ monitoring operated for reasonably long periods of time in the Hunter Valley (NSW Minerals Council, 2000). Based on inferred concentrations, it has been assumed that the annual average TSP background concentration is 50 μg/m$^3$, which is below the DECC assessment criterion of 90 μg/m$^3$ (Appendix E).

### 4.6.2 Potential Impacts

The Air Quality Assessment 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 Cadia Valley Operations. The background levels adopted for this assessment include contribution of dust emissions from the existing Cadia Valley Operations. The Project levels would therefore double-count some of the approved Cadia Hill and Ridgeway emissions (since they are also included in the predicted Project levels), providing for a conservative cumulative assessment.

Emissions associated with operation of the Project would be primarily derived from the haulage of materials within the Project area and wind blown emissions (particularly from waste rock dumps and tailings storage facilities) as well as ore processing, general construction activities and ventilation shaft emissions.

***Modelling Scenarios***

Potential impacts for dust deposition and suspended particulates were modelled for three scenarios (i.e. Year 1, Year 4 and Year 17). A full description of the dispersion model and the emissions inventory (including the locations of dust sources) and modelling outputs is provided in Appendix E.

The provisional Project production schedule is presented in Table 2-5.

*Year 1 (2010)*

Year 1 would be representative of the maximum potential dust and suspended particulate emissions from the Project (Appendix E). Year 1 operations would include the highest mining rate at the Cadia Hill open pit (i.e. the most emission intensive component of the Project), Ridgeway underground mine and Cadia East underground mine and construction activities.

*Year 4 (2013)*

Year 4 would include ore production at the Cadia Hill open pit , Ridgeway underground mine and Cadia East underground mine. As the mining rate at the Cadia Hill open pit reduces significantly during Year 4, the predicted dust emissions also reduce (Appendix E).

*Year 17 (2026)*

Year 17 would include the Cadia East underground mine at full production (i.e. ore production solely from the Cadia East deposit). Progressive mine rehabilitation would reduce the proportion of the waste rock dumps exposed for wind erosion (Appendix E). Predicted emissions from the NTSF and STSF would be more significant as the area exposed to wind erosion increases due to progressive raises.

***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 1, 4 and 17.

Incremental increases in annual average dust deposition (Project only) are not predicted to exceed the applicable 2 g/m$^2$/month DECC amenity criterion at any of the sensitive receivers in the vicinity of the Project during Years 1, 4 and 17 (Appendix E).

Annual average dust deposition due to the Project plus the assumed background (2.1 g/m$^2$/month) was also not predicted to exceed the applicable 4 g/m$^2$/month DECC amenity criterion at any sensitive receiver (Appendix E). Figure 4-26 shows the predicted annual average background dust concentrations resulting from the Project in Year 1.

***Suspended Particulates***

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 4-12). The maximum 24-hour average $PM_{10}$ criteria was assessed for the Project alone, whilst the annual average $PM_{10}$ and TSP assessment criterion/standards relate to the Project emissions in addition to background concentration levels (Appendix E).

On the basis of baseline air quality monitoring data, the background annual average $PM_{10}$ concentration for the Project was conservatively estimated to be 20 $\mu$g/m$^3$ (Section 4.6.1). The inferred annual average TSP background level was estimated to be 50 $\mu$g/m$^3$ (Section 4.6.1).

*Maximum 24-hour average $PM_{10}$*

Maximum 24-hour average $PM_{10}$ concentrations modelled for Years 1, 4 and 17 were not predicted to exceed the DECC assessment criterion (Project only) of 50 $\mu$g/m$^3$ at any sensitive receiver (Appendix E). Figure 4-27 shows the predicted maximum 24-hour average $PM_{10}$ concentrations resulting from the Project in Year 1.

*Annual Average $PM_{10}$*

Predicted annual average $PM_{10}$ (Project plus background) concentrations modelled for Years 1, 4 and 17 were not predicted to be above the 30 $\mu$g/m$^3$ DECC assessment criterion at any sensitive receiver (Appendix E). Figure 4-28 shows the predicted annual average $PM_{10}$ (Project plus background) concentrations resulting from the Project in Year 1.

*Annual Average TSP*

Annual average TSP (Project plus background) concentrations modelled for Years 1, 4 and 17 were not predicted to be above the DECC assessment criterion of 90 $\mu$g/m$^3$ at any sensitive receiver (Appendix E).

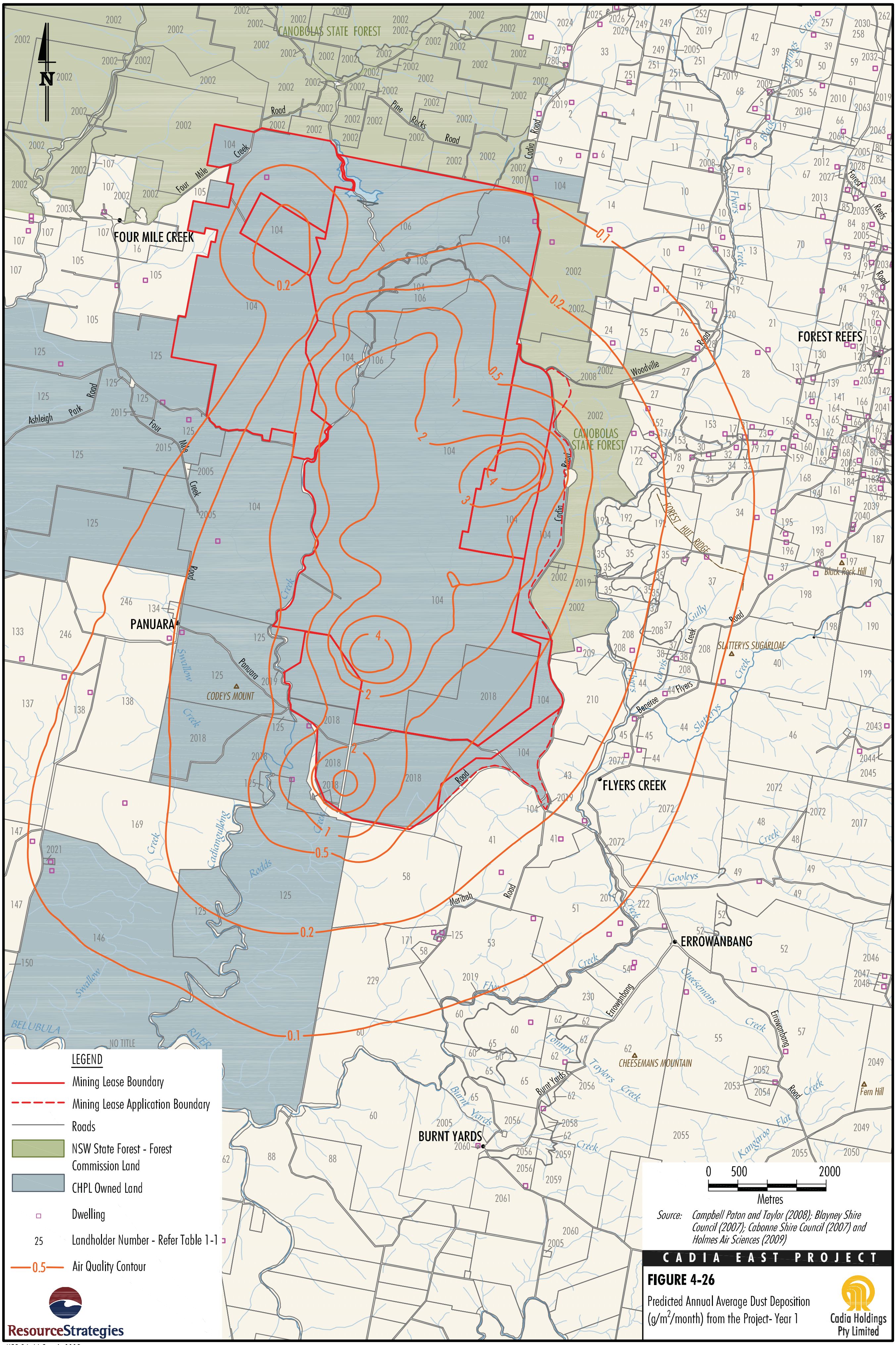



**FIGURE 4-26**

Predicted Annual Average Dust Deposition ($g/m^2$/month) from the Project- Year 1

NEC-06-66 Sect 4_111D

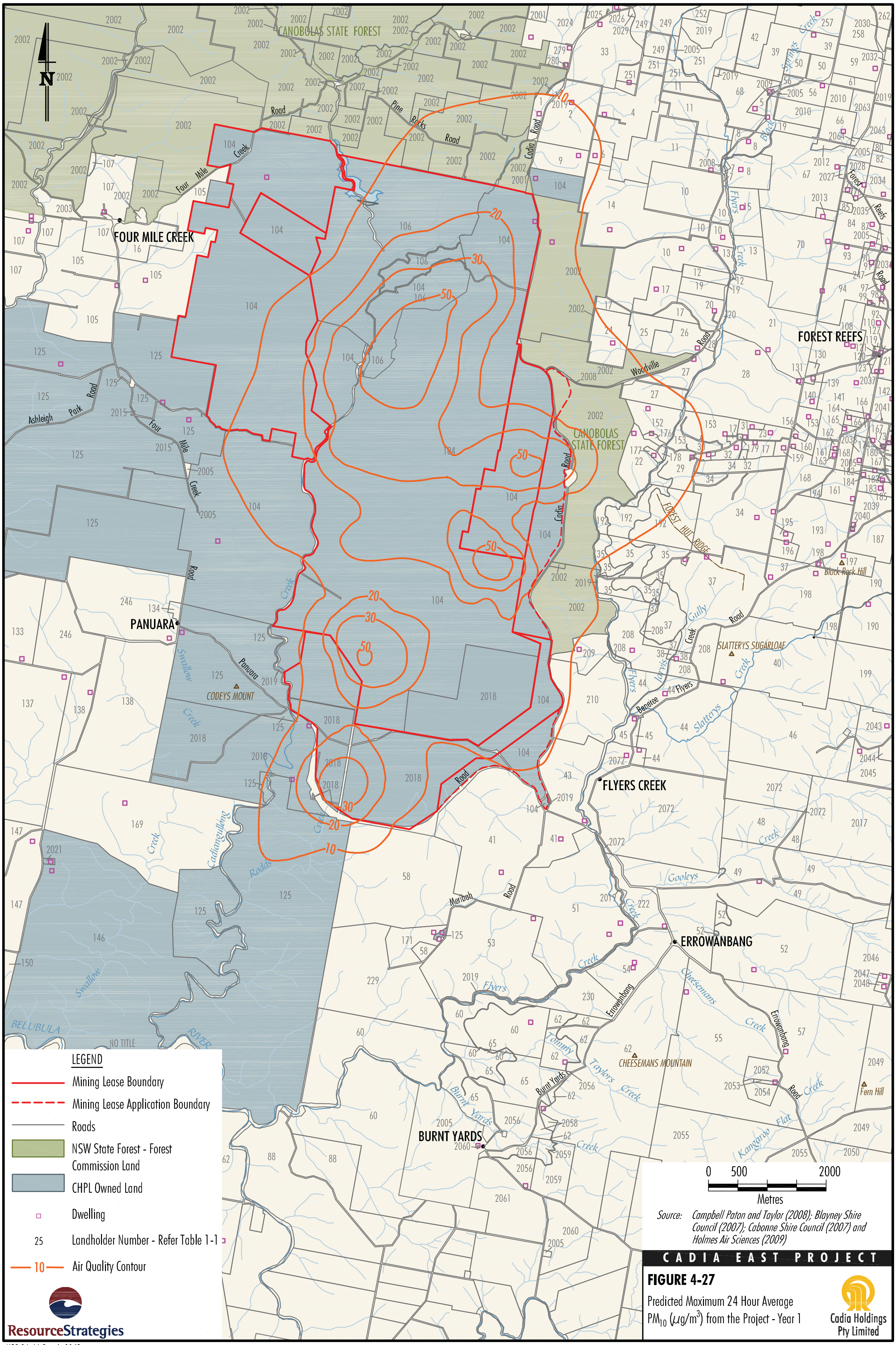



FIGURE 4-27

Predicted Maximum 24 Hour Average $PM_{10}$ ($\mu g/m^3$) from the Project - Year 1

NEC-06-66 Sect 4_114D

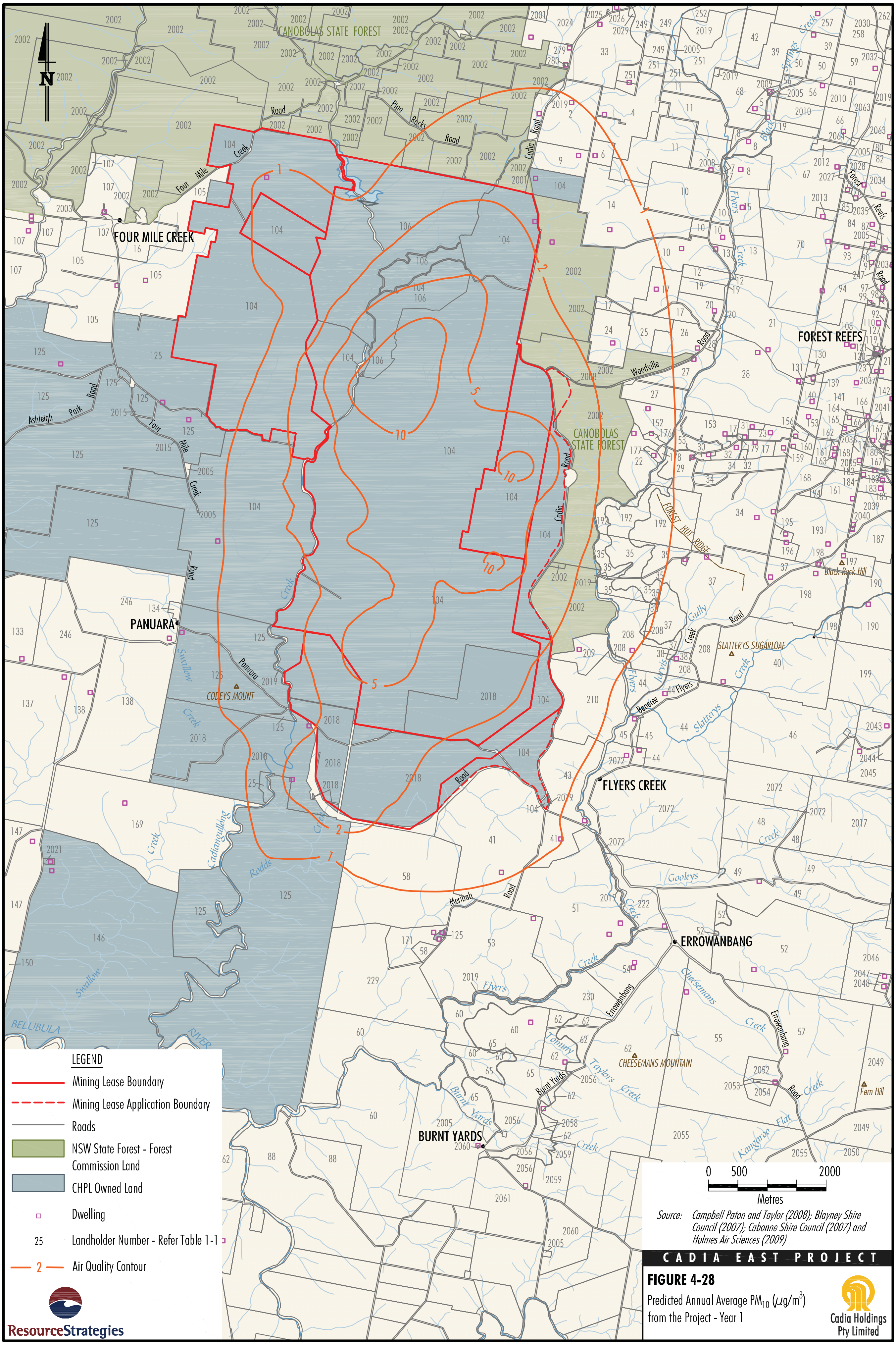



**FIGURE 4-28**

Predicted Annual Average $PM_{10}$ ($\mu g/m^3$) from the Project - Year 1

***CVO Dewatering Facility***

*Construction*

Potential emissions associated with the construction of the CVO Dewatering Facility at Blayney would include dust generated from earth moving equipment and wind erosion from exposed surfaces. As construction activities involving surface disturbance would be limited in duration, a quantitative assessment of air quality impacts was not undertaken for this location (Appendix E). It is considered that the potential dust impacts associated with the construction activities are likely to be minimal with the application of water sprays during earthworks. Mitigation and management measures for air quality during the construction of the CVO Dewatering Facility are described in Section 4.6.3.

*Operations*

During operations, a front-end loader would be used to pick up concentrate from inside the CVO Dewatering Facility enclosure and deposit it in shipping containers outside of the enclosure on the hardstand. It is not anticipated that there would be any adverse dust impacts due to the high moisture content of the material being handled, enclosure of the facility and use of (enclosed) shipping containers for product transport (Appendix E).

***Greenhouse Gas Emissions***

*Background*

A greenhouse gas assessment is required by the Project EARs and has been undertaken by Holmes Air Sciences (Appendix E).

The Greenhouse Gas Protocol (GHG Protocol) contains methodologies for assessing and calculating greenhouse gas emissions (World Business Council for Sustainable Development [WBCSD] and World Resources Institute, 2004). The GHG Protocol defines three "Scopes" of emissions (Scope 1, Scope 2, and Scope 3) for greenhouse gas accounting and reporting purposes (WBCSD and World Resources Institute, 2004). Scopes 1 and 2 have been defined to ensure that two or more entities will not account for emissions in the same Scope.

<u>Scope 1: Direct Greenhouse Gas Emissions</u>

Direct greenhouse gas emissions are defined as those emissions that occur from sources that are owned or controlled by the entity (WBCSD and World Resources Institute, 2004). Direct greenhouse gas emissions are those emissions that are principally the result of the types of activities listed below:

- Generation of electricity, heat, or steam. These emissions result from combustion of fuels in stationary sources (e.g. boilers, furnaces, turbines).
- Physical or chemical processing. Most of these emissions result from manufacture or processing of chemicals and materials (e.g. the manufacture of cement, aluminium, adipic acid and ammonia, or waste processing).
- Transportation of materials, products, waste, and employees. These emissions result from the combustion of fuels in entity owned/controlled mobile combustion sources, (e.g. trucks, trains, ships, aeroplanes, buses and cars).
- Fugitive emissions. These emissions result from intentional or unintentional releases (e.g. equipment leaks from joints, seals, packing, and gaskets, methane emissions from coal mines and venting, hydrofluorocarbon (HFC) emissions during the use of refrigeration and air conditioning equipment, and methane leakages from gas transport) (WBCSD and World Resources Institute, 2004).

<u>Scope 2: Electricity Indirect Greenhouse Gas Emissions</u>

Scope 2 emissions are a category of indirect emissions that accounts for greenhouse gas emissions from the generation of purchased electricity consumed by the entity.

Purchased electricity is defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity (WBCSD and World Resources Institute, 2004). Scope 2 emissions physically occur at the facility where electricity is generated (WBCSD and World Resources Institute, 2004). Entities report the emissions from the generation of purchased electricity that is consumed in its owned or controlled equipment or operations as Scope 2.

Scope 3: Other Indirect Greenhouse Gas Emissions

Under the GHG Protocol, Scope 3 is an optional reporting category that allows for the treatment of all other indirect emissions.

Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. Some examples of Scope 3 activities provided in the GHG Protocol are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services (WBCSD and World Resources Institute, 2004).

*Greenhouse Gas Assessment*

An assessment of Project greenhouse gas emissions is provided in Appendix E. The outcomes of the assessment are summarised below.

The assessment of the Project greenhouse gas emissions (Scope 1, 2 and 3 ) was conducted using empirical emission factors provided by the *National Greenhouse Accounts Factors* (the NGA factors) (Commonwealth Department of Climate Change [DCC, 2008a]) and included the following Project activities:

- combustion of diesel during mining operations;
- use of explosives;
- vegetation clearance;
- off-site generation of the electricity consumed at the Project;
- combustion of diesel during the transport of mineral concentrate product from the CVO Dewatering Facility to Port Kembla;
- combustion of diesel during the transport of molybdenum from the Project to Sydney;
- combustion of diesel and petrol by employees commuting to and from the Project;
- combustion of diesel by contractors delivering goods to the Project;
- combustion of aviation gas due to Project employees travelling by air for business purposes; and
- landfill disposal of paper/cardboard and co-mingled waste generated by the Project.

The major source of greenhouse gas emissions from the Project would be the indirect use of electricity used in electrically powered mining and ore processing equipment and combustion of diesel used in diesel-powered equipment (Appendix E).

The total direct (i.e. Scope 1) emissions over the life of the Project is estimated to be approximately 0.84 Mt carbon dioxide equivalent ($CO_2$-e), which is an average of approximately 0.04 Mt $CO_2$-e pa over the life of the Project (Appendix E).

The total indirect emissions (i.e. Scope 2 and 3) associated with the on-site use of fuel and electricity over the life of the Project are estimated to be 28.8 Mt $CO_2$-e, which is an average of approximately 1.37 Mt $CO_2$-e pa (Appendix E).

The total average annual emission estimate for the life of Project (i.e. Scopes 1, 2 and 3) would be approximately 1.41 Mt $CO_2$-e pa (Appendix E).

The average annual greenhouse gas emission estimate can be compared with the following 2006 estimates provided by the DCC in the latest *Australian National Greenhouse Gas Inventory* report (DCC, 2008b) (Appendix E):

- estimate of Australia's 2006 net emissions, 576.0 Mt $CO_2$-e; and
- estimate of Australia's 2006 net emissions for the energy sector, which is the major contributor to carbon dioxide emissions, 400.9 Mt $CO_2$-e.

### 4.6.3 Mitigation Measures and Management

***Dust Deposition and Suspended Particulate Emission Management.***

Air quality management measures are currently implemented at the Cadia Valley Operations in accordance with the DMP to minimise the generation of wind blown and mine generated dust. As described in Section 4.6.1, the DMP includes air quality monitoring requirements, complaints handling procedures, management measures and stakeholder consultation requirements. These management measures would continue to be implemented for the Project. The existing air quality monitoring network (Figure 4-4) would continue to be used for the Project.

Management measures for the Project would include, but would not necessarily be limited to:

- watering of unsealed haul roads and disturbed surfaces (including construction areas);
- restricting the size of disturbed areas as much as practicable;
- collection of fine dust from drilling;
- prevention of truck over-loading;
- regular maintenance of all haul roads;
- enclosure of material transfer points;
- fixed water sprays located on top of the coarse ore stockpiles;
- progressive reshaping and revegetation of waste emplacement areas;
- clear marking of all haul roads; and
- fixed speed limits for all roads around the surface facilities.

CHPL would use real-time monitoring of $PM_{10}$ concentrations, via the TEOM, to assist in dust management at the Cadia Valley Operations. An air quality monitoring protocol would be prepared as part of the DMP for the Project and would include management strategies and a complaint response protocol. The air quality monitoring protocol would be included in an update of the DMP.

During construction of the CVO Dewatering Facility, the above management measures would be implemented, where practicable. In addition, dust gauges for use during the construction phase would be installed at potentially sensitive receivers in the vicinity of the facility (Figure 1-3) as part of the DMP.

*Greenhouse Gas Emissions*

Maximising energy efficiency is a key consideration in the development of the mine plan, because energy costs are often one of the highest operating and capital expenses. Hence, significant savings of greenhouse gas emissions (through increased energy efficiency) can be attributed to appropriate mine planning.

CHPL would assess and implement, where practicable, energy and greenhouse gas management initiatives during the various phases of the Project.

Some of the opportunities available to CHPL for improving energy efficiency and reducing greenhouse gas emissions from the Project are:

- regular on-site energy audits to optimise energy efficiency and minimise energy consumption;
- consideration of energy efficiency in plant and equipment selection/purchase (e.g. fuel efficient vehicles and air-conditioning/ refrigeration unit energy ratings);
- avoiding unnecessary use of high energy consuming plant and equipment items;
- minimising operation interruptions (i.e. start-up/shutdown);
- consideration of energy efficient lighting (e.g. automatic luminosity control and avoiding use of non-essential lighting);
- regular maintenance of plant and equipment to minimise fuel consumption and associated emissions;
- installation of solar-powered monitoring equipment and other instrumentation where practicable; and
- the implementation of a vegetation offset (Section 4.4.3).

CHPL has prepared and implemented an Energy Savings Action Plan (ESAP) in accordance with the NSW *Energy Administration Amendment (Water and Energy Savings) Act, 2005* formerly administered by the Department of Energy, Utilities and Sustainability (DEUS) (now DWE). CHPL is also a participant in the Energy Efficiency Opportunities (EEO) programme as required by the Commonwealth *Energy Efficiency Opportunities Act, 2006* administered by the Commonwealth Department of Industry, Tourism and Resources (DITR). Through these programmes CHPL has conducted a comprehensive analysis of energy usage and management strategies at the Cadia Valley Operations, and has identified and implemented cost-effective energy saving opportunities, minimising greenhouse gas emissions.

CHPL would continue to assess the potential for further energy efficiency improvements, report the outcomes of assessments and responses, and review and revise plans in accordance with the relevant legislation.

## 4.7 NOISE

A Noise and Blasting Impact Assessment for the Project has been undertaken by Wilkinson Murray (2009) and is presented in Appendix D. The Noise and Blasting Assessment was prepared in accordance with the *NSW Industrial Noise Policy* (INP) (EPA, 2000), *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* (ANZECC, 1990), *NSW Environmental Criteria for Road Traffic Noise* (ECRTN) (EPA, 1999) and *Draft Construction Noise Guideline* (DECC, 2008c).

The Noise and Blasting Assessment included assessment of:

- potential on-site operational noise impacts from the Cadia Valley Operations (including the Project activities) and the CVO Dewatering Facility;
- potential construction noise impacts from the CVO Dewatering Facility;
- potential blasting impacts from the Cadia Valley Operations (including the Project activities); and
- potential off-site road traffic noise impacts.

The assessed noise levels described in this section are expressed in A-weighted decibels (dBA).

Measured or predicted noise levels are expressed as statistical noise exceedance levels ($L_{AN}$) which are the levels exceeded for a specified percentage (N) of the interval period. For example, $L_{A10}$ is the noise level that is exceeded for 10% of the sampling period and is considered to be the average maximum noise level.

The equivalent continuous noise level ($L_{Aeq}$) refers to the steady sound level, which is equal in energy to the fluctuating level over the interval period.

Table 4-13 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.

Overpressure (or airblast) is reported in linear decibels (dBL) and is the measurable effect of a blast on air pressure, including generated energy that is below the limit of human hearing. Ground vibration is the measurable movement of the ground surface caused by a blast and is measured in millimetres per second (mm/s) as Peak Vector Sum (PVS) vibration velocity.

**Table 4-13**
**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 | Inside subway train. | 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 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. | - |
| 10 | Silent | Threshold of hearing. | - |

After: United States Department of the Interior (1994) and Richard Heggie Associates (1995).

Discernible blast emission effects can be divided into the three categories listed below:

1. Occupants of a building are inconvenienced or disturbed (i.e. temporary amenity effects).
2. Contents of a building are affected.
3. Integrity of a building structure is affected.

An individual's response to blasting vibration and overpressure is highly dependent on previous experience and expectations.

### 4.7.1 Existing Environment

A NMP has been implemented at the existing Cadia Valley Operations. The NMP includes noise monitoring requirements, noise complaints procedures, noise reduction strategies and stakeholder consultation requirements (CHPL, 2009e).

In addition, CHPL has implemented a BVMP (CHPL, 2009g) at the existing Cadia Valley Operations. The BVMP includes blasting monitoring requirements, complaints procedures, management measures and stakeholder consultation requirements (CHPL, 2009g).

***Background Noise Levels – Cadia Valley***

The INP (EPA, 2000) stipulates that:

> *the background noise levels to be measured are those that are present at the time of the noise assessment and without the subject development operating. Hence, for the assessment of modifications to an existing development, the noise from the existing development should be excluded from background noise measurements.*

Baseline noise surveys were conducted for the Cadia Hill EIS in 1994 and 1995 (i.e. prior to the commencement of mining operations) and surveys conducted for the Ridgeway EIS in 1998 (i.e. defining the background noise at sensitive receivers to the west of the Cadia Valley). These results are presented in Tables 4-14 and 4-15.

It is considered that the background noise levels in Table 4-14 and 4-15 are typical of a noise environment in a rural setting, in the absence of major industry (Appendix D).

*Cadia Valley Operations Noise Monitoring*

Regular attended and unattended noise monitoring has been undertaken at the Cadia Valley Operations at up to eight locations. During the past two years, the following noise-related actions have been undertaken at the Cadia Valley Operations:

- the Cadia East exploration decline ventilation raise (VR3) fans were relocated from the surface to underground to minimise noise emissions, following complaints from sensitive receivers to the east of the Cadia Valley Operations; and
- monitoring using BarnOwl™ noise monitors to allow for the directional monitoring of noise so that noise sources can be identified from other (extraneous) noise sources.

Noise compliance results presented in the last two AEMRs indicate that there were no exceedances of the Cadia Valley Operations noise limits recorded during attended noise monitoring (Appendix D).

Ten noise-related complaints were recorded during the reporting periods for the last two AEMRs (i.e. July 2006-June 2007 and July 2007-June 2008). Four of these complaints were related to the Cadia East exploration decline ventilation raise (VR3) fans (Appendix D).

***Background Noise Levels – Blayney***

An ambient noise survey was carried out in March 2008 at the following potentially sensitive receivers (dwellings) in the vicinity of the CVO Dewatering Facility site (Figure 1-3):

- D Palmer;
- MC & PA Ewens;
- H Tetlaw; and
- D Somervaille.

Ambient noise monitoring at residences was conducted by means of unattended noise logging over a period of at least one week in accordance with the INP. Monitoring at the Somervaille receiver was conducted using the BarnOwl™ noise monitoring device which, augmented by periods of attended monitoring, provides for recording of the direction and level of environmental noise.

**Table 4-14**
**Background Noise Levels – Cadia Hill EIS**

| Sensitive Receiver | | Property Name | Summer | | | Winter | | |
|---|---|---|---|---|---|---|---|---|
| Ownership | Property Number | | Daytime (dBA) $L_{A90}$ | Evening (dBA) $L_{A90}$ | Night-time (dBA) $L_{A90}$ | Daytime (dBA) $L_{A90}$ | Evening (dBA) $L_{A90}$ | Night-time (dBA) $L_{A90}$ |
| CHPL | 104 | Tunbridge Wells | 32 | 32 | 30 | 30 | 22 | 21 |
| CHPL | 104 | Caringle | 37 | 37 | 32 | 32 | 29 | 28 |
| Contango Agricultural Company Pty Ltd (CHPL) | 125 | Bundella | 28 | 29 | 23 | - | - | - |
| CHPL and Contango Agricultural Company Pty Ltd (CHPL) | 2018 | Stratton Vale | 31 | 31 | 25 | 30 | 29 | 29 |
| JI McLennan | 209 | Northwest | 28 | 27 | 23 | 26 | 24 | 24 |
| State Forest of NSW – Forests NSW | 2002 | Willunga (Cornwall) | 32 | 32 | 27 | 35 | 34 | 33 |
| RE & J Newton | 19 | Lagoon Farm | 29 | 31 | 29 | - | - | - |

Source: Appendix D.

**Table 4-15**
**Background Noise Levels – Ridgeway EIS**

| Sensitive Receiver | | Property Name | Daytime $L_{A90}$ (dBA) | Evening $L_{A90}$ (dBA) | Night-time $L_{A90}$ (dBA) |
|---|---|---|---|---|---|
| Ownership | Property Number | | | | |
| KA Hughes | 105 | Barton Park | 28 | 26 | 26 |
| KC Williams | 107 | Ashburnia | 30 | 27 | 27 |
| TJ & RM Christopherson[1] | - | Avonlea | 28 | 26 | 26 |
| Contango Agricultural Company Pty Ltd (CHPL) | 125 | Bundarra | 30 | 28 | 27 |

Source: Appendix D.
1 Denotes ownership as per Ridgeway EIS.

The Rating Background Levels (RBLs) adopted for assessment purposes at the CVO Dewatering Facility site are representative of the background noise environment, with RBLs ranging from 30 dBA at night-time to 35 dBA during the day. Table 4-16 summarises the measured RBLs for relevant assessment periods at the four monitoring locations.

**Table 4-16**
**Blayney Noise Environment for Project Assessment Purposes**

| **Sensitive Receiver** (refer to Figure 1-3) | **Rating Background Levels (dBA)** | | |
|---|---|---|---|
| | Day[3] | Evening[4] | Night[5] |
| D Palmer[1] | 35 | 34 | 30 |
| MC & PA Ewens[2] | 34 | 30 | 30 |
| H Tetlaw | 35 | 31 | 30 |
| D Somervaille | 33 | 33 | 30 |

Source: Appendix D.
1 This location is considered representative of Blayney township residences.
2 This location is considered representative of the residences to the east of the proposed CVO Dewatering Facility.
3 7.00 am to 6.00 pm.
4 6.00 pm to 10.00 pm.
5 10.00 pm to 7.00 am.

### 4.7.2 Potential Impacts

***Cadia Valley Operations***

*Noise Criteria*

The INP assessment procedure for industrial noise sources has two components (EPA, 2000):

- controlling potential intrusive noise impacts in the short-term for residences; and
- maintaining noise level amenity for particular landuses, for residences and other landuses.

Noise from the Project would coincide with noise from the continuation of the existing Cadia Valley Operations (i.e. Cadia Hill and Ridgeway), and hence the potential cumulative noise impacts from all these sources has been assessed. Since these continuing operations have existing noise criteria outlined in existing Development Consents (i.e. DA 44/95, DA 134-04-00, DA 257-10-2004) and the Cadia Valley Operations EPL No. 5590, the Project noise criteria were derived from these existing criteria, where applicable (Appendix D).

Noise criteria in the existing Development Consents and EPL has been set based on ambient noise surveys conducted at nearby residential receivers (Section 4.7.1) and noise modelling undertaken during the preparation of the Cadia Hill EIS and the Ridgway EIS and are set in terms of $L_{A10(15minutes)}$. Since the Cadia Hill and Ridgeway Development Consents (DA 44/95 and DA 134-04-00) were granted, the DECC has published the INP. In that document the relevant noise descriptor for assessing intrusive industrial noise impacts is $L_{Aeq(15minutes)}$. In order to use the INP noise descriptor in this assessment (i.e. $L_{Aeq(15minutes)}$), the following relationship between the two descriptors is employed (Appendix D):

$$L_{Aeq(15minutes)} = L_{A10(15minutes)} - 2\ dBA$$

The difference of 2 dBA is based on measured noise levels from other similar mining operations and is considered by Wilkinson Murray to be appropriate in this assessment (Appendix D). The modified Project-specific noise criteria in terms of $L_{Aeq(15minutes)}$ are outlined in Table 4-17 for sensitive receivers previously identified in the Ridgeway EIS.

Criteria for noise sensitive receivers not listed in Table 4-17 have been devised as follows:

- Night-time criterion has been set at $L_{Aeq(15minutes)}$ 35 dBA, consistent with the lowest night-time criterion in Table 4-17[6].
- Daytime and evening criteria have been set at 43 dBA and 38 dBA, respectively, consistent with the criteria in Table 4-17.

6 The lowest INP project specific criterion would also be $L_{Aeq(15minutes)}$ 35 dBA (i.e. the INP default minimum noise background of 30 dBA plus 5 dBA), therefore this level has been adopted as the night-time criterion (Appendix D).

**Table 4-17**
**Project-specific Noise Criteria Derived from the Ridgeway Development Consent**

| Sensitive Receiver | | Property Name | Day Noise Limit $L_{Aeq\ (15minutes)}$ (dBA) | Evening Noise Limit $L_{Aeq\ (15minutes)}$ (dBA) | Night Noise Limit $L_{Aeq\ (1\ minute)}$ (dBA) |
|---|---|---|---|---|---|
| Ownership | Property Number | | | | |
| JC & V Hamilton[1] | 147 | Miawarra | 43 | 38 | 35 |
| JM Cantrill | 37 | Willow Creek | 43 | 38 | 35 |
| State Forests of NSW – Forests NSW | 2002 | Cornwall[2] | 43 | 38 | 36 |
| AR Colman | 44 b | Triangle Flat | 43 | 38 | 36 |
| KA Hughes | 105 a,b | Barton Park | 43 | 38 | 36 |
| LC & LR Baker | 133 | Bonnie Glen | 43 | 38 | 36 |
| GT & JA Christou | 1 | Coorabin | 43 | 38 | 37 |
| MP & LA Ellis | 137 | Argyle | 43 | 38 | 37 |
| RL & SL Chamberlain | 169 | Weemalla | 43 | 38 | 37 |
| CW Knox | 41 a,b | Meribah | 43 | 38 | 38 |
| CJ Healey | 43 | Triangle Park | 43 | 38 | 38 |
| AC & A Bailey | 138 | Mayburies | 43 | 38 | 38 |
| CC Colman | 45 | Mirrabooka | 43 | 38 | 38 |
| CK Channell & KP & DV Donlan | 246 | Eastburn | 43 | 38 | 38 |
| JI McLennan | 209 | Northwest | 43 | 38 | 38 |
| GA Knox | 171 a,b | Southlog | 43 | 38 | 38 |

Source: Appendix D.

1 This modified night-time criterion is 35 dBA rather than 34 dBA as this would be the minimum INP criterion.

2 Dwelling leased by CHPL from Forests NSW, then sub-leased to a third party.

The proposed Project-specific noise criteria for other sensitive receivers (i.e. those not listed in Table 4-17) are detailed in Table 4-18.

**Table 4-18**
**Project Specific Noise Criteria at Other Sensitive Receivers**

| Day Noise Limit $L_{Aeq(15minutes)}$ (dBA) | Evening Noise Limit $L_{Aeq(15minutes)}$ (dBA) | Night Noise Limit $L_{Aeq(15minutes)}$ (dBA) |
|---|---|---|
| 43 | 38 | 35 |

Source: Appendix D.

The applicable Project-specific intrusiveness criterion is the most stringent of the criteria described in Appendix D that need to be satisfied. Amenity and sleep disturbance criteria (Appendix D) are therefore not discussed in this section.

In those cases where the INP Project-specific assessment criteria is exceeded, it does not automatically follow that all people exposed to the noise would find the noise noticeable or unacceptable.

In subjective terms, exceedances of the INP Project-specific assessment criteria can be generally described as follows (Appendix D):

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

For the purposes of assessing potential noise impacts, exceedances can be separated into a noise management zone (i.e. 1 to 5 dBA above the criteria) and a noise affectation zone (i.e. greater than 5 dBA above the criteria).

*Noise Modelling*

An acoustic model was developed that simulates the Project components and noise source information (i.e. sound levels and locations). The sources of noise identified for the Project are outlined in Appendix D. The model also considers meteorological effects, surrounding terrain, distance from source to receiver and noise attenuation.

The INP generally directs the use of a single set of adverse meteorological data to use in the assessment of noise impacts. However, for noise modelling at the Cadia Valley Operations, Wilkinson Murray (2009) has adopted a more rigorous approach where noise levels at residences are calculated under a varied set of existing meteorological conditions, using meteorological data recorded on-site. Measured statistical occurrences of these conditions over a discrete period are then applied to the results, and a $10^{th}$ percentile exceedance level calculated (i.e. the level that is exceeded 10% of the time), which is then compared with relevant criteria. This approach has been accepted by the DECC and DoP for other similar large-scale resource projects (Appendix D).

<u>Noise Emission Scenarios</u>

Three Project scenarios (based on the progressive development of the Project) were assessed. The three Project scenarios assessed were Project Years 1, 4 and 17. Figures 2-4a to 2-4c show the general arrangements of the three Project scenarios. The main components of the Project scenarios that were included in noise modelling are detailed below:

Year 1 (2010)

- Continued mining of Cadia Hill open pit (26.0 Mt) (including stockpiling of some ore), continued placement of waste rock on the South Waste Rock Dump and development of Project infrastructure.
- Final year of mining at Ridgeway underground mine (0.7 Mt ore) and second year of Ridgeway Deeps (4.5 Mt ore) underground mining. Cadia East underground mine has 0.2 Mt of ore produced during this year.
- Processing of Cadia Hill, Ridgeway and Cadia East ore (at 24 Mtpa).
- Construction of Cadia East underground mine infrastructure (conveyors, ventilation shafts).
- Raising of the Rodds Creek Water Holding Dam embankment.
- Upgrade of the existing ore processing facilities.
- Progressive raising of embankments for the NTSF and STSF (in accordance with existing approvals).

Year 4 (2013)

- Final year of mining at Cadia Hill open pit (0.8 Mt ore), with reclamation of an additional 4.4 Mt of stockpiled ore.
- Continued Ridgeway Deeps underground mining (8.0 Mt ore).
- Cadia East underground mine (Lifts 0 and 1) (13.8 Mt ore).
- Processing of Cadia East, Ridgeway Deeps and Cadia Hill ore at 27 Mtpa.
- Progressive raising of embankments for the NTSF and STSF.

Year 17 (2026)

- Cadia East underground mine (Lift 1) (27.0 Mt ore) (full production).
- Processing of Cadia East underground mine ore (at 27.0 Mt).
- Progressive raising of embankments for the NTSF and STSF.

*Predicted Noise Emissions*

Predicted cumulative operational and construction noise levels are generally lower than the Project-specific criteria at each location during daytime, evening and night-time operations for all three Project scenarios. The one exception being JL Gill & CA Jackson (Property 22), where a minor 1 dBA exceedance of night-time Project-specific noise criterion is predicted during Year 1.

The highest predicted noise levels would occur during Year 1 daytime, when the majority of proposed construction works would take place. Noise levels would then fall on average by around 2 dBA in Year 4 and then would reduce by a further 2 to 3 dBA by Year 17. A full list of point-source calculations at sensitive receivers is provided in Appendix D.

Noise contours for the night-time operational scenarios were developed for the three Project years modelled. Contours indicating predicted 30 dBA, 35 dBA and 40 dBA cumulative 10th percentile $L_{Aeq(15minutes)}$ intrusive noise levels for Year 1, Year 4 and Year 17 are shown in Figures 4-29 to 4-31 respectively. The contours present the worst-case season at each residential location.

With regard to noise contours, the calculation involves numerical interpolation of noise level arrays with a graphical accuracy of up to approximately 1 dBA to 2 dBA. This means that in some cases the contour locations presented in Figures 4-29 to 4-31 will differ slightly from the point-source calculations presented in Appendix D.

***CVO Dewatering Facility***

*Construction*

Noise Criteria

The *Draft Construction Noise Guideline* (DECC, 2008c) was used to determine construction noise criteria for the CVO Dewatering Facility (Appendix D). The proposed construction activities would take place within the recommended standard hours (i.e. 7.00 am to 6.00 pm weekdays and 8.00 am to 1.00 pm on Saturdays) and therefore the adopted noise management level is the RBL + 10 dBA. Based on the *Draft Construction Noise Guideline* (DECC, 2008c), and in consideration of the baseline noise monitoring results (Table 4-16), the appropriate construction noise criteria for residential receivers is presented in Table 4-19.

**Table 4-19**
**Recommended Standard Construction Noise Management Levels**

| **Sensitive Receiver** (refer to Figure 1-3) | **Noise Management Level** $L_{Aeq(15minutes)}$ **(dBA)** | **Highly Affected Noise Level** $L_{Aeq(15minutes)}$ **(dBA)** |
|---|---|---|
| D Palmer | 45 | 75 |
| MC & PA Ewens | 44 | |
| H Tetlaw | 45 | |
| D Somervaille | 43 | |
| GP Nixon & Sons Pty Ltd | 44 | |
| ML Gardner | 44 | |
| GJ Keen | 44 | |

Source: Appendix D.

Predicted Noise Emissions

Construction of the CVO Dewatering Facility would be undertaken in several phases (i.e. bulk earthworks, fill and compaction, detailed earthworks and concreting). The fill and compaction phase of construction was considered worst-case in terms of construction noise and was conservatively used as the modelling scenario for the assessment of potential noise impacts on local residences (Appendix D).

Calculated $L_{Aeq(15minutes)}$ noise levels at each residence assessed for the construction scenario are outlined in Table 4-20, and compared with the construction noise management levels (Table 4-19).

Predicted noise from construction activities is below the construction noise management level at sensitive receivers with the exception of MC & PA Ewens, GP Nixon & Sons Pty Ltd and ML Gardner (Appendix D). The predicted level of exceedance at those residences during bulk excavation works is predicted to be 10 dBA, 7 dBA and 5 dBA respectively. Noise levels were predicted by Wilkinson Murray (2009) to be below the 'highly affected noise level' at all sensitive receivers.

*Operations*

Noise Criteria

The INP prescribes detailed calculation routines for establishing Project specific $L_{Aeq(15minutes)}$ intrusive noise criteria and $L_{Aeq\ (period)}$ amenity noise criteria for a development (Appendix D).

The INP-based intrusive and amenity noise assessment criteria at the surrounding sensitive receivers (based on the measured RBLs [Table 4-16]) are presented in Table 4-21. These criteria are nominated for the purposes of assessing potential noise impacts associated with the operation of the CVO Dewatering Facility.

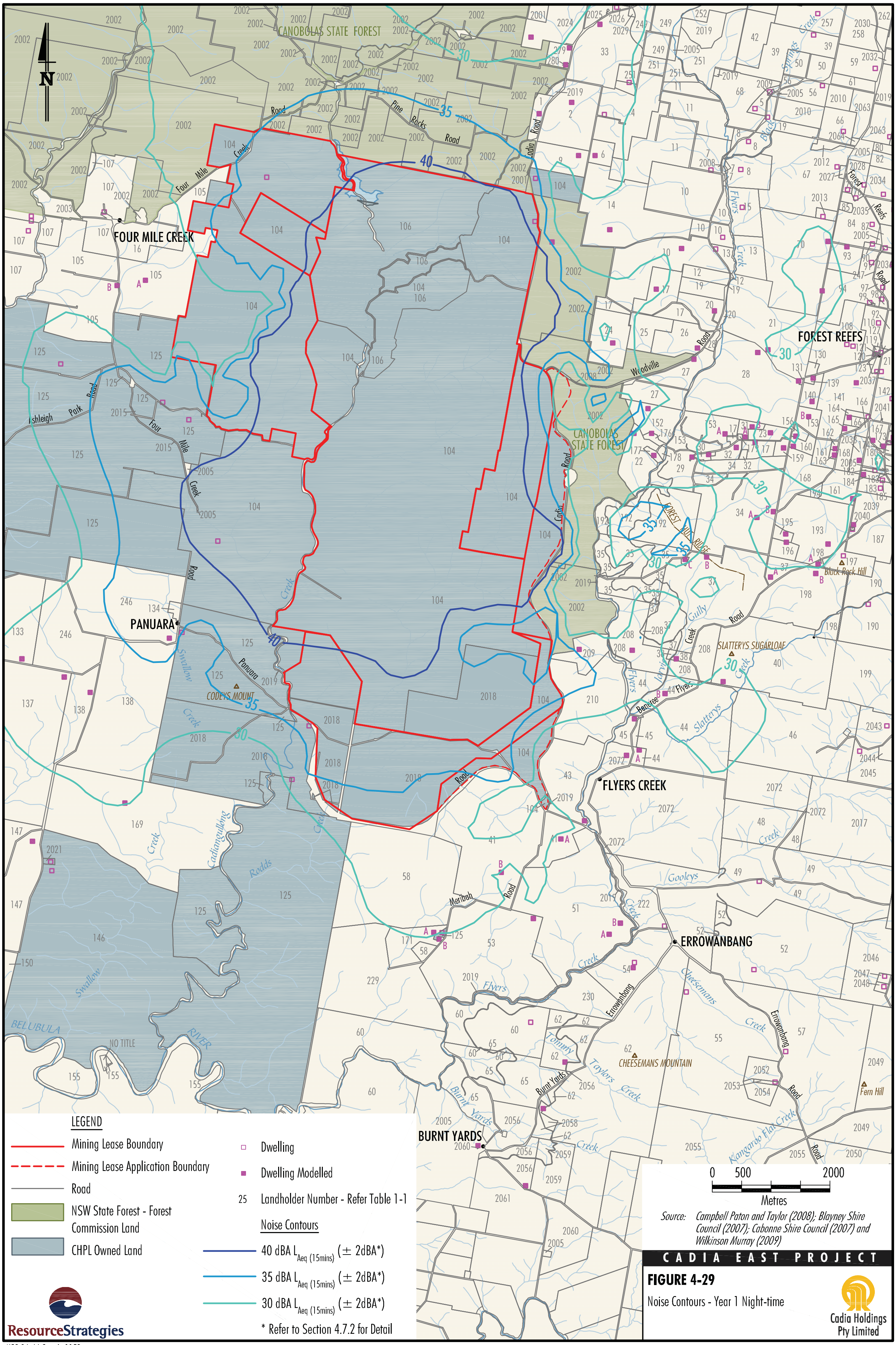



FIGURE 4-29

Noise Contours - Year 1 Night-time

NEC-06-66 Sect 4_115D

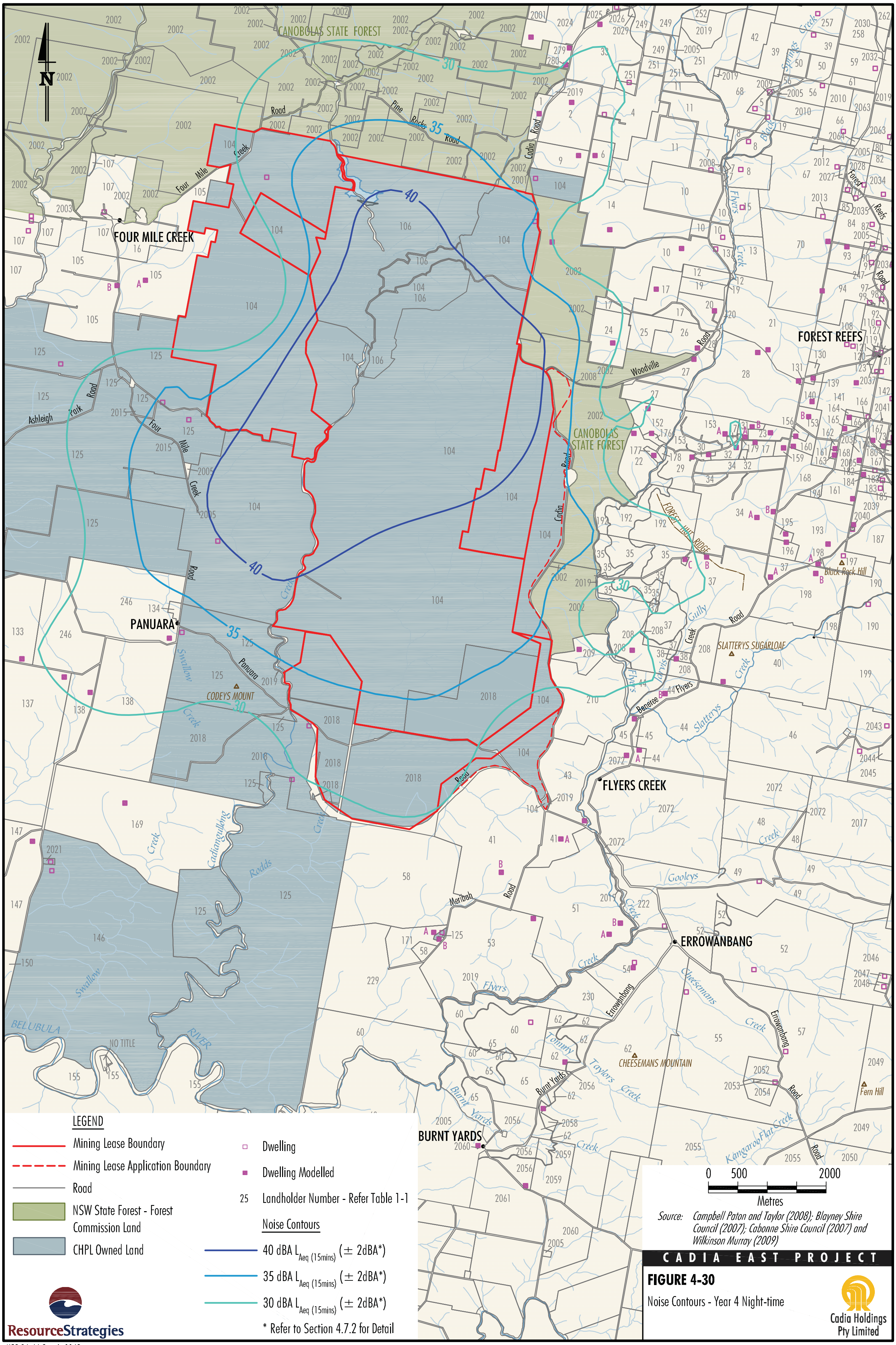
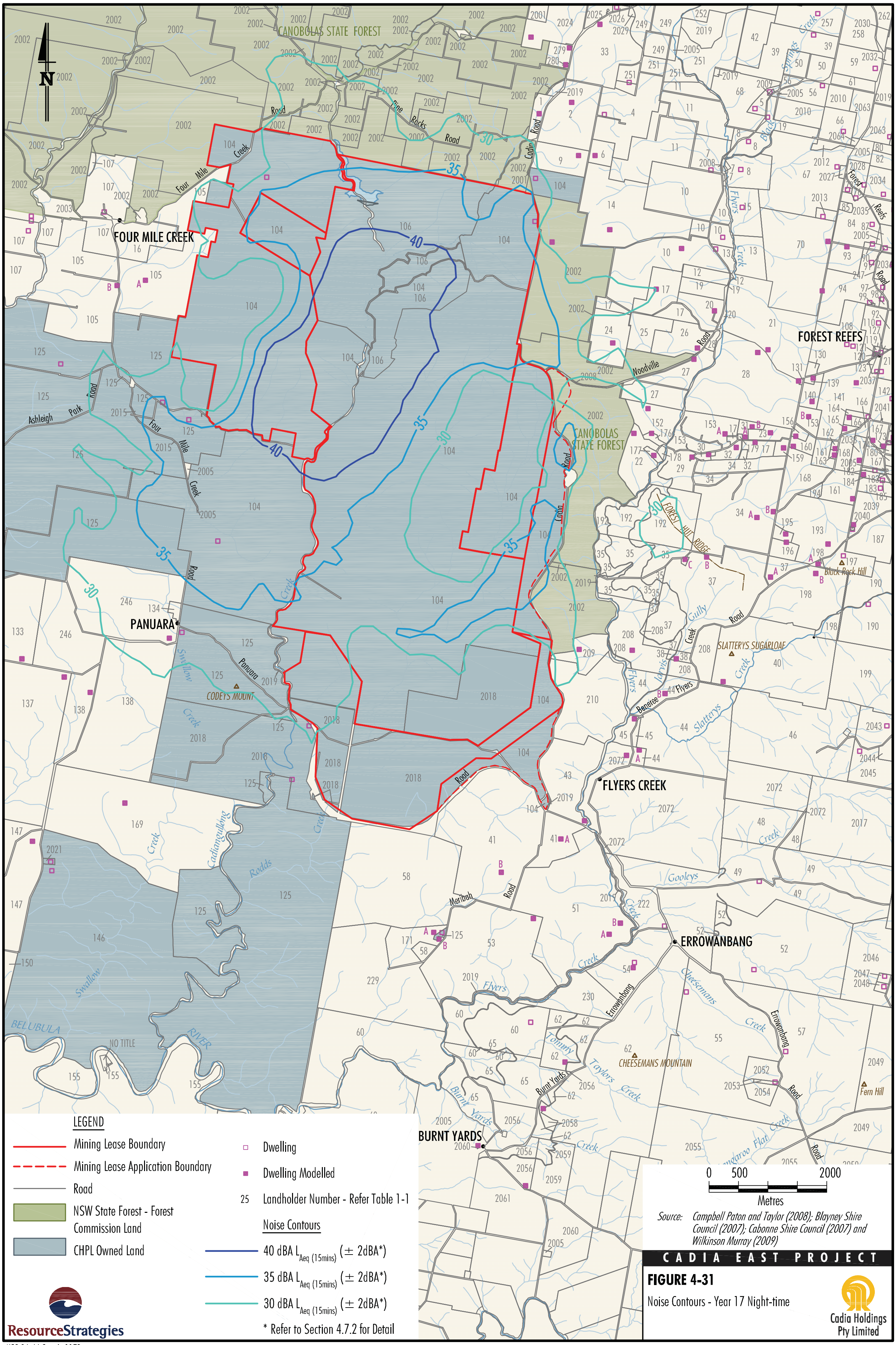



**FIGURE 4-30**

Noise Contours - Year 4 Night-time

NEC-06-66 Sect 4_116D




NEC-06-66 Sect 4_117D

**Table 4-20**
**Predicted Construction Noise Levels**

| **Sensitive Receiver** (refer to Figure 1-3) | **Calculated $L_{Aeq(15minutes)}$ Noise Level (dBA)** | **Noise Management Level $L_{Aeq(15minutes)}$ (dBA)** | **Highly Affected Noise Level $L_{Aeq(15minutes)}$ (dBA)** |
|---|---|---|---|
| D Palmer | 31 | 45 | 75 |
| MC & PA Ewens | **54** | 44 | |
| H Tetlaw | 34 | 45 | |
| D Somervaille | 39 | 43 | |
| GP Nixon & Sons Pty Ltd | **51** | 44 | |
| ML Gardner | **49** | 44 | |
| GJ Keen | 44 | 44 | |

Note: Bold text denotes exceedance of the noise management level.
Source: Appendix D.

**Table 4-21**
**INP Project-specific Noise Assessment Criteria**

| **Sensitive Receiver** (refer to Figure 1-3) | **Project-specific Noise Assessment Criteria** | | | | | |
|---|---|---|---|---|---|---|
| | **Intrusive $L_{Aeq(15minutes)}$ (dBA)** | | | **Recommended Acceptable Amenity $L_{Aeq(period)}$ (dBA)** | | |
| | **Day** | **Evening** | **Night** | **Day** | **Evening** | **Night** |
| D Palmer[1] | 40 | 39 | 35 | 55 | 45 | 40 |
| MC & PA Ewens[2] | 39 | 35 | 35 | 50 | 45 | 40 |
| H Tetlaw | 40 | 36 | 35 | | | |
| D Somervaille | 38 | 38 | 35 | | | |
| GP Nixon & Sons Pty Ltd | 39 | 35 | 35 | | | |
| ML Gardner | 39 | 35 | 35 | | | |
| GJ Keen | 39 | 35 | 35 | | | |

Source: Appendix D.
1 This location is considered representative of Blayney township residences and is considered to be suburban for INP Amenity criteria purposes.
2 This location is considered representative of the residences to the east of the CVO Dewatering Facility.

The recommended acceptable amenity criteria are based on the rural indicative noise amenity area, with the exception of D Palmer, which is based on suburban as this sensitive receiver is in Blayney (Appendix D). The $L_{Aeq(15minutes)}$ intrusive criteria are the controlling noise limits at all noise sensitive receivers.

Predicted Noise Emissions

Predicted noise levels for daytime operations exceed the Project-specific criteria at three sensitive receivers (i.e. MC & PA Ewens, GP Nixon & Sons Pty Ltd and ML Gardner) to the east of the CVO Dewatering Facility site, with the greatest exceedance of 11 dBA predicted to occur at MC & PA Ewens (Appendix D).

Predicted noise levels for evening/night-time operations exceed the criteria at one sensitive receiver (i.e. MC & PA Ewens) to the east of the CVO Dewatering Facility site, with exceedances up to 7 dBA at this receiver (Appendix D).

Based on the predicted cumulative 10$^{th}$ percentile $L_{Aeq(15minutes)}$ intrusive noise levels, Table 4-22 presents a summary of the three sensitive receivers where the Project-specific criteria are anticipated to be exceeded.

**Table 4-22**
**Dwellings within Noise Management or Affectation Zones**

| Noise Management Zone | | Noise Affectation Zone |
|---|---|---|
| 1 dBA to 2 dBA above Project-specific Criteria | 3 dBA to 5 dBA above Project-specific Criteria | >5 dBA above Project-specific Criteria |
| ML Gardner – Day | GP Nixon & Sons Pty Ltd – Day | MC & PA Ewens – Day, Evening, Night |

Source: Appendix D.

***Recommended Procedure for General Terms of Approval***

It is anticipated that following consideration of the EA, the DECC would provide the DoP with recommended General Terms of Approval (GTAs), including operational noise limits. Wilkinson Murray (2009) recommends that GTAs be determined on a landowner by landowner basis according to the following procedure:

- Where the predicted noise level is less than (or equal to) the Project-specific criteria then the Project-specific criteria is the GTA noise limit.
- Where predicted noise level is within the noise management zone then the predicted noise level is applied as the achievable GTA noise limit.
- Where predicted noise level is within the noise affectation zone then the upper limiting level applying to the noise management zone is the GTA noise limit.

***Concentrate and Return Water Pipelines Construction***

New concentrate and return water pipelines would be constructed as part of the Project (Section 2.4.7). It is anticipated that more than 100 m of pipeline would be typically laid per day. Given that individual sensitive receivers would be exposed to construction activities for a relatively short period of time, a qualitative assessment as defined in the *Draft Construction Noise Guideline* (DECC, 2008c) is considered acceptable by Wilkinson Murray to assess potential noise impacts from the pipeline construction (Appendix D).

The equipment that would primarily be involved in construction of the pipeline would be a small excavator and a crane. Where hard rock is encountered it may also be necessary to employ a rock hammer for short periods of time.

Given the short-term exposure of potentially sensitive receivers, it is considered that the potential noise impacts associated with the construction of the concentrate and return water pipeline would be minimal (Appendix D).

***Road Traffic Noise***

The Project has potential to generate additional traffic on public roads as a result of personnel and heavy vehicle movements. The traffic noise assessment has been prepared in accordance with the ECRTN.

*Traffic Noise Criteria*

The local road network that supports existing and proposed traffic is shown on Figure 4-32. Roads identified in the Road Transport Assessment (Appendix I) which would potentially be impacted by Project vehicles are listed in Table 4-23. Table 4-23 also lists the relevant ECRTN road classification.

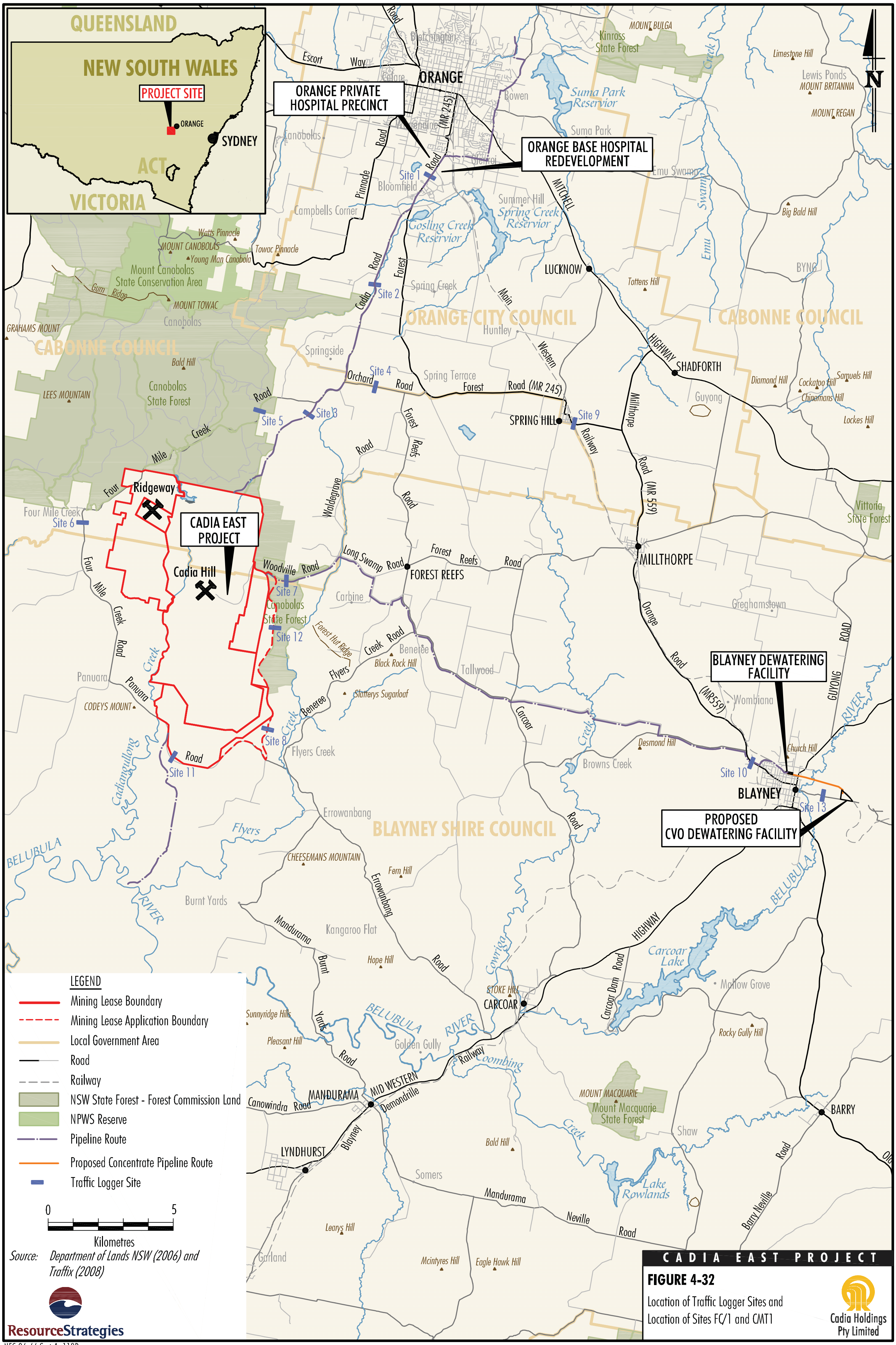
Criteria for assessment of noise from traffic on public roads are set out in the ECRTN. The relevant criteria for roads under assessment in the proposal are set out in Table 4-24.

The ECRTN states that an increase of up to 2 dBA over existing road traffic noise levels is deemed to be acceptable, where the traffic noise goal is already exceeded (Appendix D).

*Assessment Methodology*

Existing and proposed Project traffic volumes used in the road traffic noise assessment by Wilkinson Murray (2009) were sourced from the Road Transport Assessment (Appendix I).

In accordance with the ECRTN, traffic noise impacts for local roads were assessed using the Project peak hour traffic volumes. The Project peak hour would be 6.00 am to 7.00 am (Appendix I). Under the ECRTN, traffic noise in the early morning (i.e. before 7.00 am) is considered under the more stringent night-time criteria (Appendix D). For sub-arterial roads the critical assessment period would be 10.00 pm to 7.00 am in accordance with the ECRTN.




CADIA EAST PROJECT

**FIGURE 4-32**

Location of Traffic Logger Sites and Location of Sites FC/1 and CMT1

Cadia Holdings Pty Limited

NEC-06-66 Sect 4_118D

**Table 4-23**
**Local Roads and ECRTN Classification and Assessment Periods**

| Site | Road | ECRTN | |
|---|---|---|---|
| | | Classification | Assessment Period |
| 1 | Forest Road (MR 245) South of Orange | Sub-arterial | 10.00 pm to 7.00 am |
| 2 | Cadia Road South of Forest Road | Local | 6.00 am to 7.00 am |
| 3 | Cadia Road South of Four Mile Creek Road | Local | 6.00 am to 7.00 am |
| 4 | Orchard Road East of Cadia Road | Local | 6.00 am to 7.00 am |
| 5 | Four Mile Creek Road West of Cadia Road | Local | 6.00 am to 7.00 am |
| 6 | Four Mile Creek Road South of Ridgeway | Local | 6.00 am to 7.00 am |
| 7 | Woodville Road East of Cadia Road | Local | 6.00 am to 7.00 am |
| 8 | Cadia Road North of Panuara Road | Local | 6.00 am to 7.00 am |
| 9 | Forest Road at Spring Hill (MR 245) | Sub-arterial | 10.00 pm to 7.00 am |
| 10 | Orange Road (MR 559) at Railway Overbridge | Sub-arterial | 10.00 pm to 7.00 am |
| 11 | Panuara Road East of Four Mile Creek Road | Local | 6.00 am to 7.00 am |
| 12 | Cadia Road South of Woodville Road | Local | 6.00 am to 7.00 am |

Source: Appendix D.

**Table 4-24**
**Applicable Road Traffic Noise Goals**

| Classification | Policy Application | Descriptor | Traffic Noise Goal (dBA) |
|---|---|---|---|
| Sub-Arterial | Landuse developments with the potential to create additional traffic existing on sub-arterial roads | Daytime[1] $L_{Aeq(15hour)}$ | 60 |
| | | Night-time[2] $L_{Aeq(9hour)}$ | 55 |
| Local | Landuse developments with the potential to create additional traffic existing on local roads | Daytime[1] $L_{Aeq(1hour)}$ | 55 |
| | | Night-time[2] $L_{Aeq(1hour)}$ | 50 |

Source: After Appendix D.
[1] 7.00 am to 10.00 pm.
[2] 10.00 pm to 7.00 am.

The increase in traffic noise levels was calculated using the Calculation of Road Traffic Noise (CoRTN) (United Kingdom Department of Transport, 1988) prediction algorithm. This methodology is recognised by the DECC for use in road traffic noise assessments (Appendix D).

For those sections of road where the predicted increase in traffic noise levels is greater than 2 dBA over existing levels, a detailed noise model was constructed by Wilkinson Murray (2009) taking into account speed, pavement surface and local topography. This allows calculation of the actual noise levels rather than the change in noise levels, and these can be compared with criteria in the ECRTN.

*Predicted Project Traffic Movements*

Anticipated employee and heavy vehicle movements for three scenarios over the life of the Project were assessed in Appendix I and are discussed in Section 4.10. Year 2 of the Project would be the worst-case with regard to potential noise impacts at sensitive receivers (Appendix D). It is also noted that peak employee vehicle movements and peak truck movements drop substantially after Year 2 of the Project, therefore, the peak is temporary relative to the life of the 21 year Project (Appendix I).

Notwithstanding the above, a greater proportion of Project traffic would travel along Cadia Road south of Woodville Road during scenario 3 (Year 17) compared to the other scenarios as the Cadia Hill site access road would be re-aligned to intersect with Cadia Road further to the south during Years 5 and 6. In addition, this section of Cadia Road would also be re-aligned during Years 5 and 6 of the Project further to the east, closer to potentially sensitive receivers. This section of Cadia Road has therefore been assessed during Year 17.

*Impact Assessment*

Using the traffic count data from Appendix I, the increases in traffic noise levels were calculated for all relevant sections of road using the CoRTN prediction algorithms. The predicted increase in road traffic noise due to the Project is shown for each road under assessment in Table 4-25.

The calculated change in road traffic noise levels due to the Project is within ECRTN allowances for the majority of the road network assessed, however an exceedance of the allowed 2 dBA increase is predicted at four roads (i.e. Orchard Road, Forest Road, Woodville Road and Panuara Road) during Year 2 (Appendix D).

The traffic noise levels at Cadia Road, south of Woodville Road, is predicted to increase by greater than 2 dBA during Year 17 (Appendix D).

The offset distances at which ECRTN traffic noise goals would be achieved were calculated for the relevant sections of road under assessment using procedures based on the CoRTN prediction algorithms. Table 4-26 shows the calculated offset distance at which appropriate the noise criteria would be met for Years 2, 4 and 17.

*Discussion of Results*

<u>Year 2</u>

- Exceedances of the allowable 2 dBA increase under the ECRTN are predicted at four roads, namely, Orchard Road, Forest Road, Woodville Road and Panuara Road (Table 4-25).
- The offset distance to meet compliance with the ECRTN traffic noise goals for Orchard Road, Woodville Road and Forest Road would increase from 85 m to 160 m; 50 m to 110 m and 5 m to 25 m, respectively (Table 4-26).
- Panuara Road complies with the ECRTN traffic noise goal at a distance of less than 10 m (Table 4-26), which indicates compliance with these criteria (Appendix D).

<u>Year 4</u>

- No exceedances of the allowable 2 dBA increase under the ECRTN are predicted (Table 4-25).
- For indicative purposes, the offset distances to meet the relevant ECRTN traffic noise goals for Orchard Road, Woodville Road and Forest Road are 110 m, 60 m and 15 m, respectively (Table 4-26).
- Panuara Road complies with the ECRTN traffic noise goal at a distance of less than 10 m (Table 4-26), which indicates compliance with these criteria (Appendix D).

<u>Year 17</u>

- No exceedances of the allowable 2 dBA increase at Orchard, Forest, Woodville and Panuara Roads under the ECRTN are predicted (Table 4-25).
- For indicative purposes, the offset distances to meet the relevant ECRTN traffic noise goals for Orchard Road, Woodville Road and Forest Road are 100 m, 45 m and 10 m, respectively (Table 4-26).
- The re-aligned Cadia Road (south of Woodville Road) is predicted to exceed the allowable 2 dBA increase under the ECRTN. The offset distance to meet the relevant ECTRN traffic noise goal is 250 m (Table 4-26).
- Panuara Road complies with the ECRTN traffic noise goal at a distance of less than 10 m (Table 4-26), which indicates compliance with these criteria (Appendix D).

In summary, whilst Orchard, Forest, Woodville and Panuara Roads exceed the allowable 2 dBA increase during peak traffic movements during Year 2, compliance is achieved from Year 4. The re-aligned Cadia Road would be likely to exceed the allowable 2 dBA increase from Year 7 (i.e. when the re-aligned Cadia Hill access road is commissioned), however the relevant ECRTN noise goal would be achieved at approximately 250 m.

**Table 4-25**
**Predicted Increases in Traffic Noise Levels**

| Site | Road | ECRTN Classification | ECRTN Assessment Period | Existing Traffic (Assessment Period)[1] | | Year 2 Additional Traffic (Assessment Period)[2] | | Increase In Traffic Noise Level (dBA) – Year 2 | Year 4 Additional Traffic (Assessment Period)[2] | | Increase In Traffic Noise Level (dBA) Year 4 | Year 17 Additional Traffic (Assessment Period)[2] | | Increase In Traffic Noise Level (dBA) Year 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | LV | HV | LV | HV | | LV | HV | | LV | HV | |
| 1 | Forest Road (MR 245) South of Orange | Sub-arterial | 10.00 pm - 7.00 am | 224.1 | 16.9 | 82.7 | 10.7 | 2.0 | Compliance demonstrated in Year 2 – not assessed further | | | | | |
| 2 | Cadia Road South of Forest Road | Local | 6.00 am - 7.00 am | 206.9 | 27.1 | 59.3 | 4.0 | 1.0 | | | | | | |
| 3 | Cadia Road South of Four Mile Creek Road | Local | 6.00 am - 7.00 am | 184.1 | 22.3 | 68.4 | 9.9 | 1.5 | | | | | | |
| 4 | Orchard Road East of Cadia Road | Local | 6.00 am - 7.00 am | 5.7 | 7.3 | 8.0 | 5.9 | **2.5** | -0.4 | 1.7 | 0.5 | -3.3 | 1.7 | 0.5 |
| 5 | Four Mile Creek Road West of Cadia Road | Local | 6.00 am - 7.00 am | 8.3 | 0.7 | 1.0 | 0.0 | 0.5 | Compliance demonstrated in Year 2 - not assessed further | | | | | |
| 6 | Four Mile Creek Road South of Ridgeway | Local | 6.00 am - 7.00 am | 4.0 | 0.4 | 1.0 | 0.0 | 0.5 | | | | | | |
| 7 | Woodville Road East of Cadia Road | Local | 6.00 am - 7.00 am | 19.0 | 2.0 | 18.3 | 3.3 | **3.5** | -0.4 | 0.9 | 0.5 | -8.7 | 0.9 | -0.5 |
| 8 | Cadia Road North of Panuara Road | Local | 6.00 am - 7.00 am | 12.8 | 1.5 | 4.5 | 0.0 | 0.5 | Compliance demonstrated in Year 2 - not assessed in Year 4 | | | -2.1 | 0 | -0.5 |
| 9 | Forest Road at Spring Hill (MR 245) | Sub-arterial | 10.00 pm - 7.00 am | 38.2 | 2.3 | 11.2 | 15.9 | **5.0** | -0.6 | 4.6 | 2.0 | -4.6 | 4.6 | 2.0 |
| 10 | Orange Road (MR 559) at Railway Overbridge | Sub-arterial | 10.00 pm - 7.00 am | 122.4 | 7.2 | 25.5 | 8.8 | 2.0 | Compliance demonstrated in Year 2 - not assessed further | | | | | |
| 11 | Panuara Road East of Four Mile Creek Road | Local | 6.00 am - 7.00 am | 1.0 | 0.7 | 4.5 | 0.0 | **7.0** | 0.0 | 0.0 | 0.0 | -0.7 | 0.0 | -1.5 |
| 12 | Cadia Road South of Woodville Road | Local | 6.00 am - 7.00 am | 12.8 | 1.5 | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA | 177.9 | 11.9 | **12.0** |

Source: After Appendix D.

LV = Light vehicle.
HV = Heavy vehicle.

[1] Existing traffic = Total traffic including non-Cadia Valley Operations traffic plus traffic associated with the existing average Cadia Valley Operations workforce of 950 employees.

[2] Project traffic increase relative to the existing traffic.

[3] Site 12 not assessed in Years 2 and 4 as this section of Cadia Road would not be significantly impacted until the new Cadia Hill access road is constructed in Years 5 and 6.

**Table 4-26**
**Offset Distance to Meet ECRTN Criteria – Years 2, 4 and 17**

| Site | Road | Type | ECRTN Assessment Period | ECRTN Traffic Noise Goals (dBA) $L_{Aeq(period)}$ | Offset Distance to meet ECRTN (m) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Existing | Project Year 2 | Project Year 4 | Project Year 17 |
| 4 | Orchard Road East of Cadia Road | Local | 6.00 am to 7.00 am | 50 | 85 | 160 | 110 | 100 |
| 7 | Woodville Road East of Cadia Road | Local | 6.00 am to 7.00 am | 50 | 50 | 110 | 60 | 45 |
| 9 | Forest Road at Spring Hill (MR 245) | Sub-arterial | 10.00 pm to 7.00 am | 55 | 5 | 25 | 15 | 10 |
| 11 | Panuara Road East of Four Mile Creek Road | Local | 6.00 am to 7.00 am | 50 | <5 | <10 | <10 | <10 |
| 12 | Cadia Road South of Woodville Road | Local | 6.00 am to 7.00 am | 50 | <10 | NA[1] | NA[1] | 250 |

Source: After Appendix D.
[1] Site 12 not assessed in Years 2 and 4 as this section of Cadia Road would not be significantly impacted until the new Cadia Hill access road is constructed in Years 5 and 6.

*CVO Dewatering Facility Road Noise*

Construction of the CVO Dewatering Facility would involve up to approximately 66 traffic movements (including 16 heavy vehicles) per day. Given that construction activities would be undertaken during the day, road traffic noise would not be expected to cause nuisance at nearby sensitive receivers. Road traffic associated with operations would be only 18 movements per day, which is not anticipated to cause significant increases in road traffic noise (Appendix D).

***Rail Noise***

Rail movements associated with the Project along the Main Western Railway would increase from approximately three movements to six movements per week. Typical operations would involve one rail movement from the CVO Dewatering Facility per day, although two rail movements may be undertaken during peak production or if congestion in the train timetable dictates the need. Given that typical operations would involve only one Project train movement, there would be a negligible increase in daily rail noise along the Main Western Railway compared with noise from existing rail movements (Appendix D).

***Blasting***

*Blasting Criteria*

For assessment of annoyance due to blasting, the DECC adopts the *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* (ANZECC, 1990). The DECC's Environmental Noise Control Manual (ENCM) (EPA, 1994) Chapter 154 *Noise Control Guideline – Blasting* also provides guidance with respect to blasting.

In order to maintain consistency with the existing criteria for the Cadia Valley Operations, criteria from the Ridgeway Development Consent (DA 134-04-00) has been adopted for this assessment. A summary of the blasting annoyance and discomfort criteria is provided in Table 4-27.

For assessment of potential property damage due to ground vibration, AS2187.2:1993 *Explosives – Storage, Transport and Use – Part 2 Use of Explosives* specifies recommended levels for vibration to protect typical buildings from damage. These are:

- "Structures that may be particularly susceptible to ground vibration" – 5 mm/s.
- "Houses and low-rise residential buildings; commercial buildings not included below" - 10 mm/s.
- "Commercial and industrial buildings or structures of reinforced concrete or steel construction" – 25 mm/s.

**Table 4-27**
**Blasting Criteria**

| Time of Blasting | 5% Exceedance Airblast Level (dBL) | 5% Exceedance PPV Ground Vibration (mm/s) |
|---|---|---|
| Monday to Saturday 10.00 am to 6.00 pm | 115 | 5 |
| Monday to Saturday 6.00 am to 10.00 am and 6.00 pm - 8.00 pm | 105 | 2 |
| Sunday, Public Holidays 6.00 am to 8.00 pm | 95 | 1 |
| Any Day – 8.00 pm to 6.00 am | 95 | 1 |

Source: Appendix D.

PPV = peak particle velocity.

In addition to the blasting criteria listed above, Condition 57(b)(ii) of the Ridgeway Development Consent (DA 134-04-00) requires:

> *For the Cadia Engine House, Crusher Room and Chimney structures within the State Heritage Register curtilage (SHR No. 779), the peak particle velocity for ground vibrations shall not exceed a limit of 15 mm/s, measured at the Chimney blast monitoring point, without anti-vibration strengthening.*

*Blasting Parameters*

The blasting assessment focused on blasting that would be undertaken underground to precondition ore for panel caving, because this would involve the highest MIC of Project-related blasting activities. Given that the blasting would take place underground at the Cadia East underground mine, it is not considered necessary to assess impacts from blast overpressure (Appendix D). Airblast overpressure (e.g. from ventilation shafts and decline portals) would be minimal due to the attenuation associated with the declines/shafts.

The preconditioning blasting technique would involve long, vertical drillholes from the undercut or extraction levels with a controlled and precise detonation. Estimated consumption of bulk emulsion explosive would be approximately 0.003 kg/t preconditioned ore up to a MIC of 1,500 kg of explosives per delay. Blasting would be undertaken 24 hours a day, seven days per week.

*Predicted Blasting Emissions*

Amenity

The vibration levels were calculated for the closest 20 sensitive receivers (Appendix D). The vibration levels predicted can be compared with the relevant criteria, as follows (Appendix D):

- Predicted 95% blast vibration levels are within annoyance criteria for blasting between 10.00 am and 6.00 pm Monday to Saturday.
- Predicted 95% blast vibration levels are generally within criteria from 6.00 am to 10.00 am and 6.00 pm to 8.00 pm Monday to Saturday (with the exception of sensitive receivers 24 [SR & AL De Gruchy], 22 [JL Gill & CA Jackson], 152 [PD & DL McKie], 176 [CL Suttie] and 177 [SW & KA Muno]).
- Blasting at night-time, on Sundays and Public Holidays should be conducted using reduced MICs to ensure that the criterion is met. Monitoring should be undertaken to ensure compliance and assist with the management of blasting vibration (Appendix D).

A summary of exceedances of the annoyance and discomfort vibration criteria is provided in Table 4-28.

Structural Damage

The blast emission levels are well below the building damage criteria at all dwellings (Appendix D).

**Table 4-28**
**Summary of Blasting Annoyance and Discomfort Criteria Exceedances**

| Time of Blasting | 5% Exceedance PPV Ground Vibration Criteria (mm/s) | Sensitive Receivers |
|---|---|---|
| Monday to Saturday<br>10.00 am to 6.00 pm | 5 | Nil |
| Monday to Saturday<br>6.00 am to 10.00 am and<br>6.00 pm to 8.00 pm | 2 | 24 – SR & AL De Gruchy<br>22 – JL Gill & CA Jackson<br>152 – PD & DL McKie<br>176 - CL Suttie<br>177 – SW & KA Munro |
| Sunday, Public Holidays<br>6.00 am to 8.00 pm<br>Any Day<br>8.00 pm to 6.00 am | 1 | All sensitive receivers assessed[1] |

Source: Appendix D.
[1] MICs to be reduced to ensure compliance with criterion.

Cadia Engine House and Chimney Vibration Assessment

An assessment of the potential impact of blasting on the Cadia Engine House and Chimney located within the Cadia Valley Operations was conducted.

Predicted blast vibration levels are within criteria at the heritage sites, with the highest predicted vibration being 2.5 mm/s at the heritage sites compared with the 15 mm/s criteria (Appendix D).

### 4.7.3 Mitigation Measures and Management

Noise mitigation and management measures for the existing Cadia Valley Operations are described in the NMP. The NMP includes the following mitigation measures:

- regular servicing of the mobile equipment fleet;
- regular maintenance of conveyor belt drives and rollers;
- regular maintenance of underground ventilation fans;
- regular maintenance of reversing alarms on mobile equipment; and
- notification of employees, contractors and visitors to the site of their responsibility to undertake work activities in an environmentally sensitive manner (including minimising noise while on-site or entering and leaving the site).

The NMP also describes the existing noise monitoring network (Figure 4-4). The current monitoring network comprises quarterly attended and unattended monitoring at the following locations:

- Triangle Park;
- Triangle Flat;
- Barton Park;
- Bonnie Glen;
- Eastburn;
- Argyle;
- Northwest;
- Mount Arthur;
- Mayfield;
- Endsleigh Park;
- Southlog;
- Mayburies; and
- Warrengong.

The NMP would be revised for the Project, where necessary. A noise monitoring protocol would be prepared for the Project and would include noise management strategies and a complaint response protocol. The noise monitoring protocol would be included in an update of the NMP.

During the noise impact assessment, a number of iterative steps were taken to develop noise mitigation measures for the Project, including:

- Preliminary noise modelling of scenarios representative of the maximum noise emissions from the mine to identify areas of noise management and noise affectation.
- Consideration of various combinations of noise management and mitigation measures to assess their relative effectiveness.
- Adoption by CHPL of noise management and mitigation measures to appreciably reduce noise emissions associated with the CVO Dewatering Facility, including:
  - optimising the mine equipment fleet and keeping equipment well maintained;
  - construction of a 3 m high panel fence around the CVO Dewatering Facility hardstand area to the east;
  - selection of quieter operational fleet at the CVO Dewatering Facility; and
  - loading of trains during daytime hours only.

Fixed plant and mobile equipment would be commissioned and maintained to remain below the specified maximum operating $L_{Aeq}$ sound power levels detailed in Appendix D.

As detailed in Table 4-22, the private dwellings where noise emissions are predicted to be above Project-specific noise assessment criteria can be divided into a noise management zone (1 to 5 dBA above Project-specific criteria) and a noise affectation zone (greater than 5 dBA above Project-specific criteria). Proposed noise management procedures for these zones are detailed below.

*Noise Management Zone*

Depending on the degree of exceedance of the Project-specific criteria, potential noise impacts in the noise management zone could range from marginal to moderate (in terms of the perceived noise level increase). In addition to the noise mitigation measures included in the predictive modelling, noise management procedures would include:

- noise monitoring on-site and within the community;
- prompt response to any community issues of concern and complaints;
- refinement of on-site noise mitigation measures and operating procedures where practicable; and
- implementation of reasonable and feasible acoustical mitigation at private dwellings (which may include measures such as enhanced glazing, insulation and/or air-conditioning) where noise monitoring shows noise levels which are 3 to 5 dBA above Project-specific noise criteria.

*Noise Affectation Zone*

Exposure to noise levels greater than 5 dBA above Project-specific criteria may be considered unacceptable by some landowners. Management procedures for the noise affectation zone would include:

- discussions with relevant landowners to assess concerns and define responses;
- implementation of reasonable and feasible acoustical mitigation at private dwellings (which may include measures such as enhanced glazing, insulation and/or air-conditioning) where noise monitoring shows noise levels from the mine which are greater than 5 dBA above Project-specific noise criteria; and
- negotiated agreements with landowners where required.

***Road Traffic Noise Mitigation Measures***

Traffic noise mitigation and management measures for the existing Cadia Valley Operations are described in the NMP, and are reproduced below:

- employees, contractors and visitors to the site are reminded of their responsibility to drive in a sensible manner while driving to and from the mine, a reduction in speed contributes to a reduction of noise; and
- the majority of heavy vehicle deliveries are scheduled to occur during daytime hours to avoid the night-time period.

The mitigation and management measures described in the NMP would not change as a result of the Project and would continue for the Project.

***Blasting Mitigation Measures***

Blasting management measures for the existing Cadia Valley Operations are described in the BVMP. The BVMP includes the management measures listed below:

- The driller and shotfirer will ensure that blastholes are positioned away from cracks and undercuts and are not too close to the face.
- Alter the charge distribution in the blasthole by means such as stem decks or air decks in areas where the face burden is insufficient.
- A maximum of seven rings per blast are fired or timing intervals set for individual blasts.
- If blasting near infrastructure, a thorough risk assessment is completed, controls identified and implemented in a planned manner.
- If a misfire occurs the blast supervisor will determine whether the blast is able to be safely recovered and fired. If refiring does not occur immediately, the blast will be cordoned off and will be fired at the next available blast time. At Ridgeway, the misfire is always cordoned off and fired at the next available blast time.

The BVMP would be revised for the Project, and would include a management protocol to ensure that MICs for evening and night-time blasts do not result in exceedances of vibration criteria. The BVMP includes a blast vibration monitoring programme which comprises vibration monitoring for each blast event at the following locations (Figure 4-4):

- Cadia Engine House and Chimney;
- Cornwall;
- Barton Park;
- Coorabin;
- Wire Gully; and
- Southern Lease Boundary.

## 4.8 ABORIGINAL HERITAGE

An Aboriginal Cultural Heritage Assessment for the Project has been undertaken by Colin Pardoe Bio-Anthropology & Archaeology (2009) and is presented in Appendix K. The assessment was conducted in accordance with the procedures outlined in the *draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* (DEC, 2005a) and the *Interim Community Consultation Requirements for Applicants* (DEC, 2004b). Surveys for the Project were undertaken in a staged manner for discrete portions of the Project disturbance areas including:

- Cadia East subsidence zone and zone of influence;
- STSF inundation areas;
- NTSF inundation areas;
- concentrate and return water pipelines;
- CVO Dewatering Facility; and
- the eastern margin of the Cadia East zone of influence and the Cadia Road re-alignment.

### 4.8.1 Existing Environment

***Regional***

Before European settlement, the Central West was located within the territory of the Wiradjuri-speaking people, who occupied an extensive tract of land on the western side of the Great Dividing Range and south beyond the Murrumbidgee and Lachlan Rivers (Kohen, 2000). The local clan names in the vicinity of Cadia Valley are not known, but the area would have been relatively rich in food resources for Aboriginal people.

***Local***

*Pre-European Contact*

Several microenvironments occur within the Cadia Valley, including high ridgelines and spurs, steep valley walls with small incised creeks, rock pools and platforms and flats where valleys widen out, terracing where stream flow decreases. The area is also on the edge of a more gently rolling countryside to the south, which contains riparian floodplain, basal slopes and sandy deposits (Lance, 1985; Navin Officer, 1996; Colin Pardoe Bio-Anthropology & Archaeology, 2005). The Cadia Valley would have been covered with open forest and woodland vegetation (Colin Pardoe Bio-Anthropology & Archaeology, 2005).

*Post-European Contact*

Several land development practices have taken place in the Project disturbance areas over the last 150 years that may affect the integrity of sites and features (Appendix K). These areas are described below:

- historical mining areas (e.g. Little Cadia Copper Mine and Wire Gully Gold Workings), including excavated areas, deposited waste rock and building ruins;
- deforested areas with substantial regrowth evident on slopes;
- road graded areas and exploration drill pads throughout the Cadia East area;
- erosion and soil loss as a result of tree clearance;
- pine plantation areas which feature tracks, graded areas and a covering of pine needles on the ground; and
- agricultural areas which have been subject to tree clearance, ploughing and/or grazing and fencing.

***Archaeological Surveys***

*Previous Surveys*

A number of archaeological studies have been undertaken in the Cadia Valley area. These have included studies by; Pearson (1979), Ross (1981), Huglund (1984a, 1984b), Kohen (1991, 1995, 1996, 2000), Colin Pardoe Bio-Anthropology & Archaeology (2005, 2007a, 2007b) and Kayandel Archaeological Services (2008a, 2008b). Previous research has established that Aboriginal sites are rare in the Orange area (Appendix K).

Ross (1981) found two isolated finds during a preliminary inspection of the Cadia Valley, and Kohen (1991) found one site and three isolated finds, all close to Cadiangullong Creek. The site, Cadia 1, located during the 1991 survey, consisted of seventeen artefacts exposed on a hill slope close to the confluence of Cadia Creek and Cadiangullong Creek, to the east of Ridgeway. An additional site was subsequently identified on Rodds Creek (Cadia 2) on flatter open ground (Kohen, 1995). Further sites were identified on Hoares Creek and Copper Gully. The 1999 survey conducted by Kohen (2000) found an artefact scatter during the survey of Ridgeway Hill, outside of proposed disturbance areas.

In mid 2002, five additional Aboriginal heritage artefacts (stone flakes) were identified during a programme of European heritage test excavations at the lower Cadia Village site being conducted in consultation with the NSW Heritage Office. A permit was obtained by NPWS and the artefacts collected in consultation with the OLALC and retained by them for safekeeping.

A scarred tree was identified by Kohen (2000) south of the Project area on a ridge to the north-east of the confluence of the Belubula River and Flyers Creek. More recently, Kayandel Archaeological Services noted a potential archaeological deposit along Cadiangullong Creek, between the Cadiangullong Creek diversion and Cadiangullong Dam (Kayandel Archaeological Services, 2008a).

*Cadia East Project Surveys*

Three archaeological surveys were conducted over the Project disturbance areas which had not been assessed in earlier surveys within Cadia Valley. These surveys are listed below (Appendix K):

- *Cadia East Study Area Cultural Heritage Survey* (Colin Pardoe Bio-Anthropology & Archaeology, 2005) which covered the Cadia East subsidence zone and zone of influence.
- *Cadia East Project Cultural Heritage Assessment of Extension to the Northern and Southern Tailings Storage Facilities* (Colin Pardoe Bio-Anthropology & Archaeology, 2007), which surveyed the proposed inundation areas associated with the NTSF and STSF.
- *Cadia East Project Aboriginal Cultural Heritage Assessment – Concentrate Pipeline Route and East Blayney Dewatering Facility* (Kayandel Archaeological Services, 2008b), which surveyed the concentrate and return water pipelines and the CVO Dewatering Facility site.

In addition to the above, a supplementary survey was undertaken by Kayandel Archaeological Services (2009) to survey the MLA area east of Cadia Road and south of Woodville Road, and the Cadia Road re-alignment. This survey was undertaken in the company of the OLALC.

Aboriginal cultural heritage sites or areas of interest identified as a result of these surveys include (Figure 4-33):

- A quartz flake fragment (Woodville 1) – located along the route of the concentrate and return water pipelines easement.
- Potential archaeological deposits:
  - PAD 1 – located near the STSF but outside the Project disturbance area; and
  - PAD 2 – located marginally within the eastern extent of the Cadia East zone of influence.
- Two artefact scatters (Woodville 2 and 3), located east of the Cadia East subsidence zone of influence. These sites consist of six and 11 artefacts, respectively and are considered to be of local archaeological significance because of the different types of raw materials present (Kayandel, 2009).
- Three scattered lithic items – located to the north of the Cadia East subsidence zone.

A detailed description of the surveys and their findings is provided in Appendix K.

Cultural heritage surveys of the upper Rodds Creek area and STSF conducted in 1998 and 1999 as part of the Ridgeway EIS (Kohen, 2000) did not identify any significant sites within these areas.

***Consultation***

The OLALC is the only known Aboriginal organisation with a heritage interest in the area and was the only organisation to register as an Aboriginal stakeholder for the Project. The OLALC has been involved in all surveys undertaken for the Project and was also involved in the majority of previous surveys undertaken in the Cadia Valley. Details of consultation with the OLALC in relation to the Project are provided in Appendix K.

### 4.8.2 Potential Impacts

One Aboriginal cultural heritage site (a quartz flake fragment – Woodville 1) was identified within the Project disturbance areas during the Project Aboriginal cultural heritage surveys (Figure 4-33). The site is located along the proposed concentrate and return water pipelines easement.

Areas of interest were identified that may have some potential for deposited archaeological material, including the Southern Sloping Plain and terraces within the Cadia East subsidence zone and zone of influence (Figure 4-33). Although the recorded location of Terrace 62 is outside the direct disturbance of the Project, it is possible that a portion of the terrace is within the zone of influence and could be disturbed as a result of the Project.

One potential archaeological deposit (PAD 2) would be located partially within the Cadia East zone of influence. It is likely that this area would be impacted by the proposed bund and fence to be constructed around the zone of influence to restrict future access to this area.

In addition, two sites (Woodville 2 and 3) were located by Kayandel (2009) on a track located adjacent to the proposed Cadia Road re-alignment (but outside of the Cadia East zone of influence). It is possible that this track would be used during construction of the road re-alignment, resulting in increased disturbance of these sites.

***OLALC Consultation***

The OLALC provided a written response to CHPL in regards to the Project and indicated that they have no concerns (Appendix K). The OLALC also provided comment in regards to the cultural significance of the Cadia Valley (Appendix K).

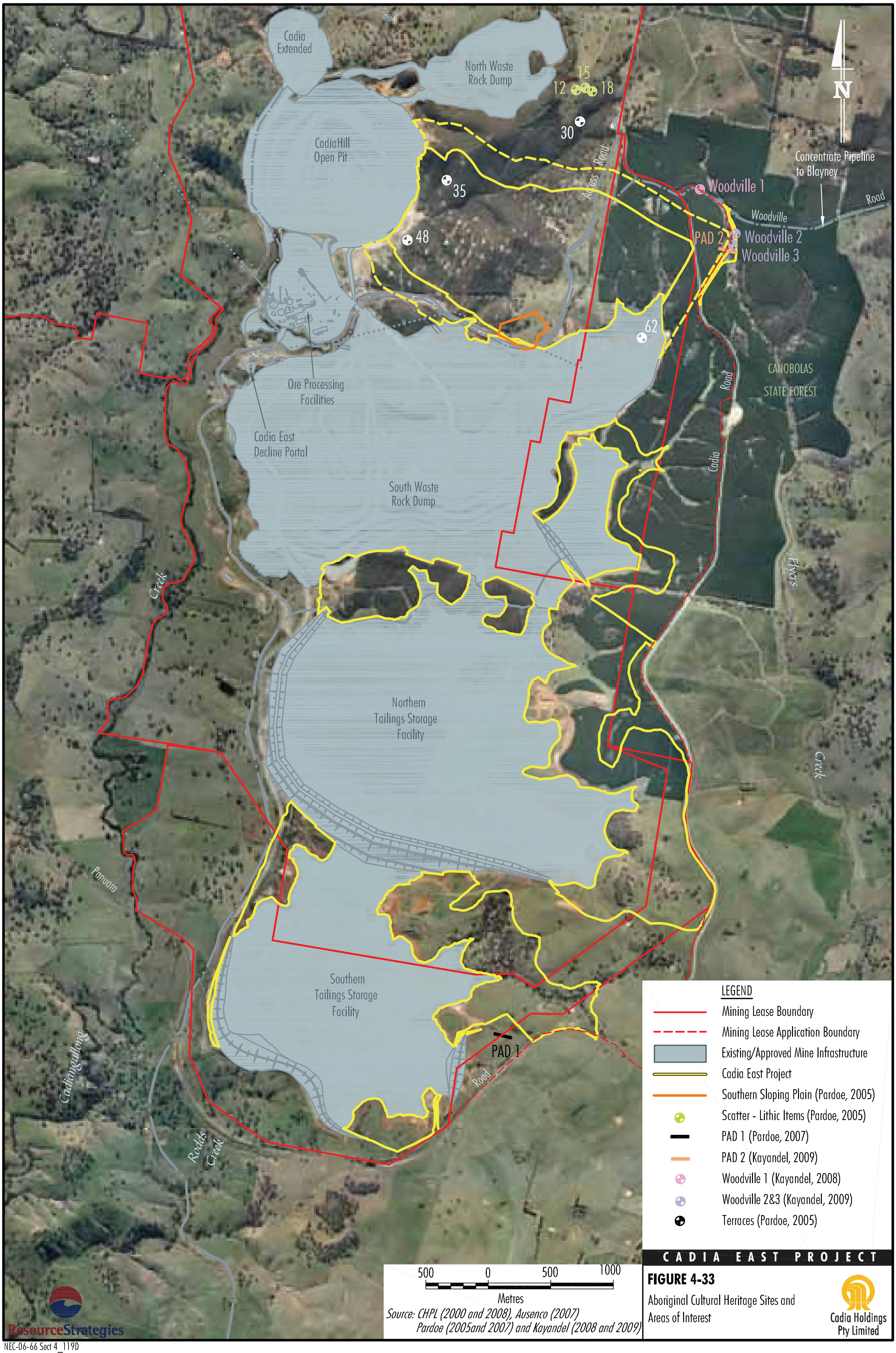
### 4.8.3 Mitigation Measures and Management

On the basis of the results of the Project cultural heritage surveys (Colin Pardoe Bio-Anthropology & Archaeology 2005, 2007; Kayandel Archaeological Services, 2008), previous archaeological surveys in Cadia Valley and the Orange area and input from OLALC, the mitigation measures described below would be employed for the Project.

***General Management Measures***

General Aboriginal cultural heritage management measures that would be implemented during the life of the Project are listed below:

- Consultation with the Aboriginal stakeholders would be ongoing over the life of the Project. Appropriate Aboriginal representation would occur during archaeological fieldwork (e.g. test pitting or collection of artefacts prior to construction).




CADIA EAST PROJECT

**FIGURE 4-33**

Aboriginal Cultural Heritage Sites and Areas of Interest

- CHPL would provide opportunities for Aboriginal community members to access identified Aboriginal sites located on CHPL owned land (e.g. for personal reasons or as part of scheduled field activities) in accordance with Occupational Health and Safety Requirements.
- Any new sites which may be identified during the development of the Project would be registered with the DECC in consultation with registered Aboriginal stakeholders.
- A record of known Aboriginal heritage sites, their status and location would be maintained by CHPL.
- Where practicable, known Aboriginal sites would be avoided during Project construction works at the Cadia Valley Operations, and demarcation of known Aboriginal sites would be undertaken where works are required in close proximity, to avoid accidental damage.
- In the event that avoidance of known sites is not practicable, artefacts would be collected for safekeeping by an archaeologist in consultation with registered Aboriginal stakeholders.
- Registered Aboriginal stakeholders would continue to be consulted regarding the storage of collected artefacts, management of artefacts at the completion of Project activities (e.g. artefact replacement onto the post-mining landscape) and the implementation of management measures for salvaged culturally modified trees (CMTs).

Additional specific management measures are described below.

***Aboriginal Cultural Heritage Site***

The mitigation and management measures proposed for ‘Woodville 1’ would include (Appendix K):

- salvage of ‘Woodville 1’ prior to construction of the concentrate and return water pipelines in consultation with the OLALC;
- ‘Woodville 1’ would be stored on-site at the Cadia Valley Operations in a locked cabinet or suitably secure location (“keeping place”) for the duration of construction works on the pipeline; and
- in general accordance with the wishes of the OLALC, the artefact would be placed within close proximity to its present location, after the completion of pipeline construction activities.

***Culturally Modified Trees***

In the event that any additional scarred trees of probable Aboriginal origin are identified in Project disturbance areas during the life of the Project, salvage of a section of the tree, or other suitable management measures would be implemented in consultation with registered Aboriginal stakeholders.

A suitable location for the storage (and/or display) of the salvaged sections of CMTs at the Cadia Valley Operations would be identified and managed in consultation with registered Aboriginal stakeholders.

***Areas Considered to have some Archaeological Potential***

Prior to any likelihood of subsidence propagating to the surface, a series of excavations would be conducted at the Southern Sloping Plain and Terraces 48 and 62 to determine the likely presence of archaeological material. A complete description of the proposed excavation works at the Southern Sloping Plain and Terraces 48 and 62 is provided in detail in Appendix K.

***Sites Located near the Cadia Road Re-alignment***

Two sites (Woodville 2 and 3) are located on an access track near the proposed Cadia Road re-alignment and may be impacted during construction, should this track be used during construction works. Kayandel (2009) recommends additional survey and salvage of these sites, along with some sub-surface testwork to better understand the extent of the sites. Further details on the recommendations are provided in Kayandel (2009).

## 4.9 EUROPEAN HERITAGE

A European Heritage Assessment for the Project was conducted by Edward Higginbotham & Associates (2009) and is presented in Appendix L. The assessment was prepared in accordance with the *NSW Heritage Manual* (NSW Department of Urban Affairs and Planning [DUAP], 1996). A description of the potential impacts (Section 4.9.2) and proposed management and mitigation measures applicable to the European heritage sites proposed to be disturbed by the Project (Section 4.9.3) are provided below.

### 4.9.1 Existing Environment

***Background***

Since European settlement the Cadia Valley has been associated with a combination of pastoral and mining activities. Pastoral settlement in the area commenced in the 1830s and copper was discovered at Cadia in 1851.

Mining activity in the Cadia Valley commenced by 1856 and was centred mainly on the upper Cadiangullong Creek Valley. Over the period from 1856 to the 1950s, a series of copper and iron ore mines were intermittently established in the Cadia Valley. Developments during this period included Cadia Village, Cadia School, engine house, smelters, aerial ropeway, bridges, railways and numerous underground and open pit mining ventures. In addition, gold mining was undertaken at Wire Gully and numerous small alluvial workings in the local area.

Of these extensive developments, limited physical evidence remains, as each successive era of mining tended to remove the traces of the previous developments and the majority of infrastructure was sold or salvaged following mine closures.

Godden Mackay (1992, 1995) conducted surveys and assessments of European heritage in Cadia Valley in 1992 and 1995 for the Cadia Hill EIS. These investigations concentrated on the historic mine workings and buildings within ML 1405. The surveys identified 153 sites within ML 1405 and the following six major heritage precincts:

- Cadia Engine House and Chimney;
- West Cadia;
- Iron Duke;
- East Cadia;
- Cadia Village; and
- Little Cadia Copper Mine (Little Cadia).

The Cadia Engine House and Chimney is the most significant surviving structure at Cadia and has been identified as being of State significance and is listed on the State Heritage Register.

***European Heritage within Project Disturbance Areas***

European heritage surveys have been conducted at the following Project disturbance areas:

- Cadia East subsidence zone and zone of influence;
- NTSF;
- STSF;
- concentrate and return water pipelines; and
- CVO Dewatering Facility.

Other Project disturbance areas (including Rodds Creek Water Holding Dam and Belubula River pipeline and pumping infrastructure) were included in previous European heritage surveys within the Cadia Valley.

A summary of the European heritage items that were identified during these surveys is provided below.

***Cadia East Subsidence Zone and Zone of Influence***

A portion of the Little Cadia heritage precinct would be located within the Cadia East zone of influence. Little Cadia was the first copper resource officially described at Cadia and vies with East Cadia (located on the east bank of Cadiangullong Creek, not to be confused with the Project) for the first place to be mined for copper in the locality (Appendix L). Mining works at Little Cadia commenced in 1859 and continued intermittently until the 1970s.

Edward Higginbotham & Associates (2009) conducted a survey of the Cadia East subsidence zone and zone of influence and identified 22 historical items (all associated with Little Cadia). A summary of these items and their level of significance is provided in Table 4-29.

Subsequent to the survey, archival recording and the archaeological investigation (including excavations) of Little Cadia were completed in April and September 2005, respectively. Following these excavations, site numbers 4 and 5 in Table 4-29 were regraded for archaeological significance, with elements of archaeological remains considered to be of moderate to exceptional significance (Appendix L).

The Little Cadia precinct is considered to have a Local level of significance (Appendix L).

**Table 4-29**
**Little Cadia Heritage Inventory**

| Site Number | Description | Level of Significance[1] |
|---|---|---|
| 1 | Small shed | Low |
| 2 | Shaft | Low |
| 3 | Remnants of dam or weir | Low |
| 4 | Chimney base | Moderate |
| 5 | Remnants of walls of structure | High |
| 6 | Miscellaneous timbers possibly a former pedestrian bridge | Low |
| 7 | Copper precipitation works | Low |
| 8 | Dam | Low |
| 9 | Blast furnace platform with remnants of timber building and pump or generator | Low |
| 10 | Timber lined wall | Low |
| 11 | Slag heap | Low |
| 12 | Blast furnace smelter site (engine hold down bolts and beams) | Moderate |
| 13 | Prospecting lease corner post | Moderate |
| 14 | Tramway remains | Low |
| 15 | Shaft E | Low |
| 16 | Shaft D | Low |
| 17 | Shaft B | Low |
| 18 | Shaft C | Low |
| 19 | Shaft | Low |
| 20 | Shaft A | Low |
| 21 | Site of former workings | None |
| R29 | Wood and metal box | Low |

Source: After Appendix L.
[1] In accordance with the *NSW Heritage Manual* (DUAP, 1996).

***Southern Tailings Storage Facility***

A portion of the Wire Gully Gold Workings would be located in the expanded STSF inundation area. Gold mining commenced at the Wire Gully Gold Workings in the 1880s and 1890s and continued intermittently until the late 1930s (Appendix L). Mining methods included both sluicing and the use of shafts.

The Wire Gully Gold Workings incorporate a Water Race, located to the east (Figure 4-34). These workings consist of alluvial and shaft mining remains, a dam and water race, and processing plant foundations. The Wire Gully Gold Workings and Water Race include 15 heritage items (Table 4-30).

**Table 4-30**
**Wire Gully Heritage Inventory**

| Site Number | Description |
|---|---|
| 1 | Shaft |
| 2 | Shaft |
| 3 | Mullock heap |
| 4 | Crusher plant |
| 5 | Machine bed |
| 6 | Machine bed and stone pillar or footing |
| 7 | Circular concrete footing |
| 8 | Mullock heap |
| 9 | Wheel and timber post structure |
| 10 | Dam and water race feeding into dam |
| 11 | Race below dam |
| 12 | Alluvial workings |
| 13 | Dam |
| 14 | Gully below dam |
| 15 | Pile of timber members |

Source: After Appendix L.

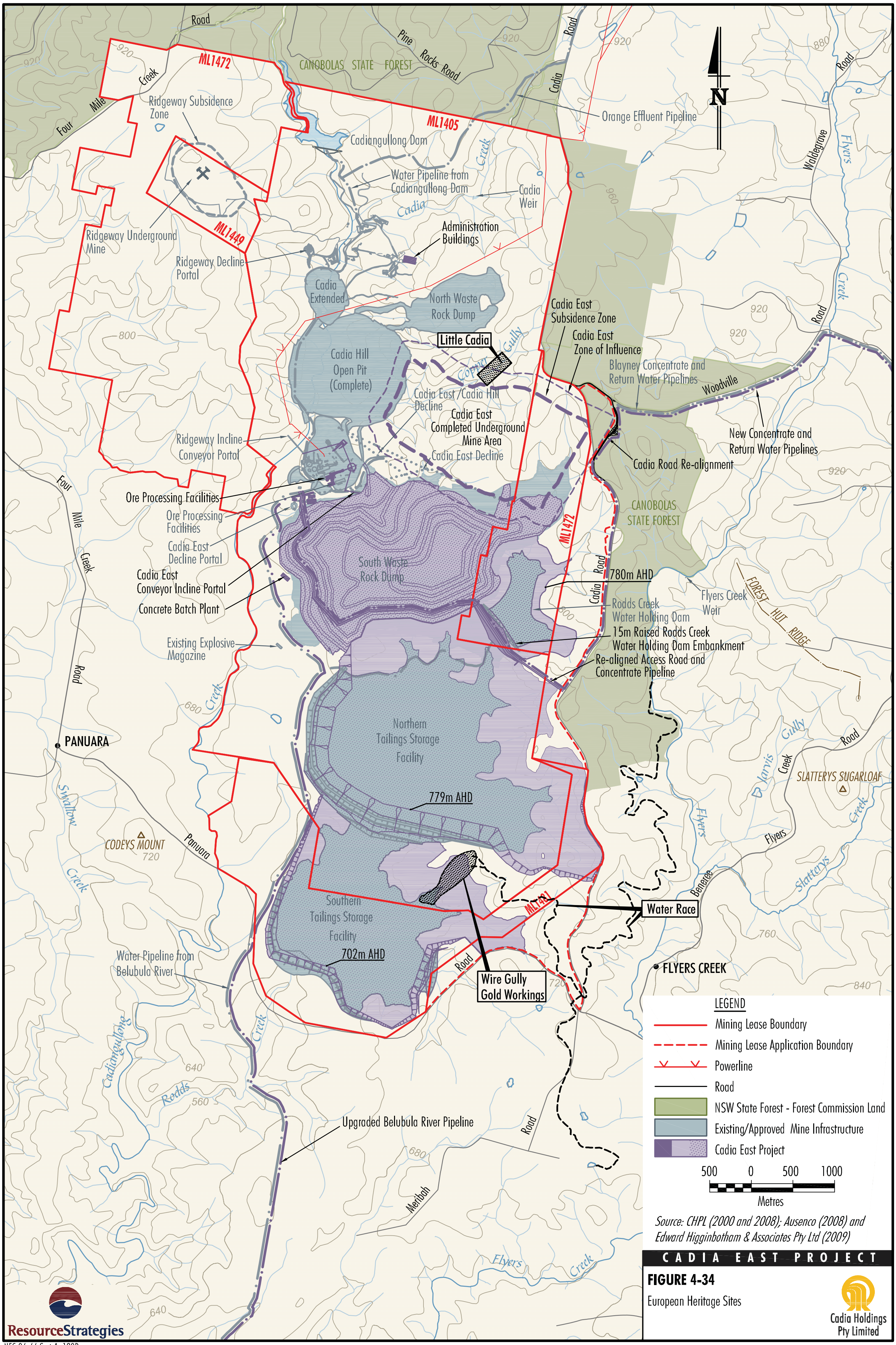



FIGURE 4-34
European Heritage Sites

NEC-06-66 Sect 4_120D

The Wire Gully Gold Workings are partially located in the currently approved STSF inundation area (Figure 4-34) and were therefore assessed in the Ridgeway EIS. The Project would result in an increased proportion of the Wire Gully Gold Workings being inundated by the STSF.

The Wire Gully Gold Workings and Water Race are considered to have a Local level of significance (Appendix L).

***Concentrate and Return Water Pipelines Easement***

A survey of the concentrate and return water pipelines was conducted and two heritage items were identified adjacent to the pipeline easement (Table 4-31) (Appendix L).

**Table 4-31**
**Summary of Heritage Items Identified in the Concentrate and Return Water Pipelines Easement**

| Site Number | Description | Level of Significance |
|---|---|---|
| 1 | Blayney Railway Station and Yard Group | - |
| 2 | Railway Culvert (with brick arch adjacent to the CVO Dewatering Facility) | Local |

Source: After Appendix L.

### 4.9.2 Potential Impacts

***Cadia East Subsidence Zone and Zone of Influence***

A portion of the Little Cadia precinct would be located within the zone of influence associated with the Cadia East subsidence zone. The zone of influence would experience some cracking but the ground is not expected to subside.

***Southern Tailings Storage Facility***

The expansion of the STSF would result in a larger proportion of the Wire Gully Gold Workings (up to approximately the northern-most dam) being inundated by tailings, including the dam to the south, the race below the dam, shaft and mullock tip and processing plant (Appendix L).

The Water Race is located at a higher elevation than the proposed inundation storage level and therefore would not be inundated by tailings associated with the Project (Appendix L).

***Concentrate and Return Water Pipelines Easement***

The concentrate and return water pipelines would be located on the northern side of the existing railway line and would therefore have no impact on the Blayney Railway Station and Yard Group (located on the southern side of the existing railway line) (Appendix L).

The concentrate and return water pipelines would be located south of the railway line near the railway culvert and as such would have minimal impact on the railway culvert.

### 4.9.3 Mitigation Measures and Management

Mitigation measures proposed for the heritage sites identified within the proposed Project disturbance areas are described in Appendix L and listed below:

- Access to the remains of Little Cadia, outside the Cadia East subsidence zone and zone of influence would be restricted via the erection of a fence.
- Archaeological excavation sites at Little Cadia would be backfilled and the archaeological remains in the excavated area would be conserved *in-situ*, in accordance with the recommendations outlined in Appendix L.
- Various relics that are visible at the Wire Gully Gold Workings would be salvaged in accordance with the recommendations outlined in Appendix L before disturbance.
- The alignment of the backbone water pipeline would avoid the site of Cadia Village.
- The concentrate and return water pipelines easement between the existing Blayney Dewatering Facility and the CVO Dewatering Facility would run along the northern side of the railway track at the Blayney Railway Station (i.e. avoid the Blayney Railway Station).
- The proposed concentrate and return water pipelines and the CVO Dewatering Facility would be designed and constructed to avoid disturbance to the brick arch railway culvert.
- The interpretation and display of those heritage items impacted by the Project would be completed in accordance with the *Cadia Interpretation Plan* which is presently under development in consultation with the DoP Heritage Branch and which would be revised for the Project if required.

## 4.10 ROAD TRANSPORT

A Road Transport Assessment for the Project was prepared by Traffix (2009) and is presented in Appendix I. A description of the existing traffic road network in the vicinity of the Project is provided in Section 4.10.1, and Section 4.10.2 describes the potential impacts of the Project on traffic. Section 4.10.3 outlines applicable mitigation, monitoring and management measures.

### 4.10.1 Existing Environment

***Road Hierarchy***

*Regional Roads*

The Mid Western Highway (State Highway 6) and the Mitchell Highway (State Highway 7) provide access to the Project area (Appendix I). The Mid Western Highway connects Bathurst to Hay in western NSW, via Blayney, and the Mitchell Highway connects Bathurst to Bourke in north-western NSW, via Orange. The Great Western Highway (State Highway 5) which connects Bathurst to Sydney provides access to Sydney.

Main Roads 245 and 559 provide a link between Orange and Blayney (Figure 4-32). Main Road 245 comprises Forest Road and links southern Orange with Main Road 559 to the east of Spring Hill (Figure 4-32). Main Road 559 links the Mitchell Highway in the north to Blayney in the south and comprises Millthorpe Road, Park Street at Millthorpe, Orange Road to Blayney and Church Street in Blayney. The eastern end of Main Road 559 intersects with the Mid Western Highway in Blayney (Figure 4-32).

*Local Roads*

Access to the Cadia Valley Operations from Orange, Blayney and regional roads is available via Forest Road, Cadia Road, Orchard Road, Long Swamp Road/Woodville Road and Panuara Road. However, the principal route used to access the Cadia Valley Operations is from Orange via Forest Road and Cadia Road (Appendix I). The existing Cadia Valley Operations access roads are located on Cadia Road.

The CVO Dewatering Facility would be located to the east of Blayney on Newbridge Road (Figure 1-3). Newbridge Road connects to the Mid Western Highway in Blayney via Burns Street (Figure 1-3).

***Existing Road and Traffic Conditions***

The following sections summarise existing road and traffic flow conditions in the vicinity of the Project and on key existing Cadia Valley Operations routes.

*Existing Road Conditions*

<u>Forest Road</u>

Forest Road (Main Road 245) is a sealed two lane rural road that has been upgraded as required under existing Cadia Valley Operations approvals (Appendix I). It has a good horizontal and vertical geometry and the pavement is in good condition. Forest Road is widened locally (i.e. a dedicated southbound right turn lane) at the intersection with Cadia Road. The east-west section of Forest Road east of Orchard Road is in generally satisfactory condition with a two lane sealed pavement.

<u>Cadia Road</u>

Cadia Road is a two lane rural road that is sealed with gravel shoulders between Forest Road and Woodville Road that was also upgraded as required under existing Cadia Valley Operations approvals (Appendix I). South of Woodville Road, Cadia Road continues as a gravel road to Panuara Road and is in generally good condition for a gravel road.

<u>Orchard Road</u>

Orchard Road is a sealed two lane rural road that connects Cadia Road to the east-west section of Forest Road and is relatively straight and sight distances are generally satisfactory (Appendix I).

<u>Woodville Road/Long Swamp Road</u>

Woodville Road/Long Swamp Road connects Cadia Road to Forest Reefs. Woodville Road consists of a two lane sealed surface. Long Swamp Road from Woodville Road through to Forest Reefs has a narrow sealed carriageway and follows a winding alignment typical of older country lanes and rural access routes (Appendix I).

<u>Forest Reefs Road</u>

Forest Reefs Road connects Forest Reefs with Millthorpe. It has a narrow sealed carriageway and follows a winding alignment typical of many older country lanes and rural access routes (Appendix I).

Panuara Road

Panuara Road provides a sealed route over its length and forms a southern/western perimeter route of the Project with Four Mile Creek Road (Appendix I).

Four Mile Creek Road

Four Mile Creek Road runs along the northern and western flanks of the Cadia Valley Operations from Panuara in the south to Cadia Road in the north and is sealed (Appendix I).

Newbridge Road and Burns Street

Newbridge Road and Burns Street (near Blayney) are in generally satisfactory condition and have a two lane sealed pavement (Appendix I).

*Existing Traffic Volumes*

Available traffic volume data were reviewed and additional traffic counts were conducted (i.e. to supplement available traffic volume data), where required (Appendix I). The Project traffic surveys were conducted in late March 2007. The relevant traffic counter locations are shown on Figure 4-32 and the existing traffic volumes (including traffic associated with the existing average Cadia Valley Operations workforce of 950 employees) and the associated Level of Service are summarised in Table 4-32.

AUSTROADS (1988) defines a Level of Service as a qualitative measure describing operational conditions within a traffic stream (in terms of speed, travel time, room to manoeuvre, safety and convenience) and their perception by motorists and/or passengers. A scale from A to F is used, with Level of Service A free flowing and F, queuing and delays. The roads listed in Table 4-32 all have a Level of Service of B or better. Level of Service B is described by AUSTROADS (1988) as:

> *…in the zone of stable flow and drivers still have reasonable freedom to select their desired speed and to manoeuvre with the traffic stream, although the general levels of comfort and convenience is a little less than with Level of Service A.*

*Peak Hour Intersection Performance*

The Traffix (2009) review of relevant traffic volume data indicated that the traffic peaks related to the existing Cadia Valley Operations occur between 6.00 am and 7.00 am and that general commuter (i.e. non-Cadia Valley Operations related traffic) peaks occur between 7.00 am and 8.00 am on the principal access routes (i.e. Forest and Cadia Roads) and Orchard Road (Appendix I).

**Table 4-32**
**Existing Traffic Volumes**

| Count Site[1] | Road | Daily Traffic Volume | Level of Service[2] |
|---|---|---|---|
| 1 | Forest Road (MR 245) South of Orange | 3,975 | B |
| 2 | Cadia Road South of Forest Road | 1,710[3] | A |
| 3 | Cadia Road South of Four Mile Creek Road | 935 | A |
| 4 | Orchard Road East of Cadia Road | 246 | A |
| 5 | Four Mile Creek Road West of Cadia Road | 190 | A |
| 6 | Four Mile Creek Road South of Ridgeway | 92[4] | A |
| 7 | Woodville Road East of Cadia Road | 254 | A |
| 8 | Cadia Road North of Panuara Road | 65[4] | A |
| 9 | Forest Road at Spring Hill (MR 245) | 760 | A |
| 10 | Orange Road (MR 559) at Railway Overbridge | 2,432 | B |
| 11 | Panuara Road East of Four Mile Creek Road | 63 | A |
| 12 | Cadia Road South of Woodville Road | 65[5] | A |
| 13 | Newbridge Road at Blayney | 468 | A |

Source: After Appendix I.

1 Refer to Figure 4-32.

2 *Guide to Traffic Engineering Practice: Part* 2: *Roadway Capacity* (AUSTROADS, 1988).

3 2005 and 2007 data were obtained from the OCC for Site 2, however as the 2005 traffic counts and percentage heavy vehicles were higher than the 2007 data, the 2005 data were conservatively used in the assessment.

4 2007 estimate based on 1999 data increased by the same growth rate that occurred at comparable sites.

5 Estimate based on Site 8 (i.e. Cadia Road north of Panuara Road) traffic count.

The performance of key intersections along the principal access route (i.e. Forest and Cadia Roads) and Orchard Road to the Cadia Valley Operations were assessed by Traffix (2009) using the intersection analysis computer program SIDRA (Signalised and unsignalised Intersection Design and Research Aid).

The performance of each intersection was assessed during its peak hour and the intersection turning volumes used in the assessment were estimated based on the traffic counts on surrounding roads. This analysis determined that the existing Levels of Service were good and with spare capacity (Table 4-33) (Appendix I).

**Table 4-33**
**Existing Daily Peak Hour Intersection Performance**

| Intersection | Control | Intersection Level of Service (Daily Peak)[3] |
|---|---|---|
| Cadia Road/ Forest Road[1] | Priority | A |
| Cadia Road/ Orchard Road[1] | Priority | A |
| Cadia Road/ Four Mile Creek Road[2] | Priority | A |
| Cadia Road/ Ridgeway Access Road[2] | Priority | A |
| Cadia Road/ Cadia Hill Access Road[2] | Priority | A |
| Cadia Road/ Woodville Road[2] | Priority | A |

Source: After Appendix I.
1 Peak period is 7.00 am to 8.00 am.
2 Peak period is 6.00 am to 7.00 am.
3 Level of Service as determined by SIDRA.

The Intersection Level of Service is a comparative measure which provides an indication of the operating performance of an intersection. An Intersection Level of Service A indicates good operation and an average vehicle delay of less than 14 seconds (Appendix I).

***Road Safety***

A review of road accident data has been undertaken for the Orange, Blayney and Cabonne LGAs over the period from 2002 to 2006. The data indicates that total accidents across all three of the local government areas have reduced by approximately 20% over the period (Appendix I).

In addition, detailed road accident data were obtained from the RTA for the period January 2003 to September 2008. The accident data were reviewed to identify accidents that had occurred on the key Project routes (e.g. Forest Road and Cadia Road). Review of the RTA data identified no particular accident pattern or causation factors along the key Project routes and that the number of accidents correlates to some extent with overall daily traffic flows (Appendix I).

***Car Parking***

Significant on-site car parking is available at the Cadia Valley Operations for staff, visitors and on-site contractors adjacent the Ridgeway and Cadia Hill administration buildings (Appendix I).

***School Buses***

During the 2008 school year there were approximately six school bus routes operating in the area surrounding the Cadia Valley Operations (Appendix I). These bus routes were used outside the Cadia Valley Operations' morning peak (i.e. 6.00am and 7.00am) and afternoon peak (i.e. 6.00pm and 7.00pm) traffic periods.

***Other Developments***

A traffic assessment was undertaken in 2006 (Masson Wilson Twiney, 2006) for the Orange Base Hospital Redevelopment, which was approved in 2008. The site is located on the eastern side of Forest Road. The assessment concluded that the hospital will not have a significant impact on the operation of surrounding streets (Appendix I).

An additional traffic assessment was undertaken in 2008 (John Coady Consulting, 2008) for the Orange Private Hospital Precinct development. The site will be located to the south of Orange on Forest Road opposite the Orange Base Hospital Redevelopment (Appendix I). The assessment indicated that approximately 8% of the traffic generated by the proposed Orange Private Hospital Precinct will travel south on Forest Road towards the Cadia Road intersection. John Coady Consulting (2008) also reported that it is unlikely that the Orange Private Hospital Precinct development will have any unacceptable traffic implications for key intersections along Forest Road.

Forests NSW conducts forestry operations at the Canobolas State Forest located to the east and north of the Cadia Valley Operations (Figure 4-32). During the life of the Project, Forests NSW will continue to periodically conduct harvesting/thinning campaigns in the Canobolas State Forest (Appendix I). It is expected that timber haulage trucks will predominately use Four Mile Creek Road and Cadia Road depending on the area of the Canobolas State Forest where the harvesting/thinning activities are occurring.

The potential cumulative effects of the above developments have been considered in the context of the predicted Project traffic flows.

### 4.10.2 Potential Impacts

Potential traffic impacts of the Project on road traffic movements and key intersection operation are assessed in Appendix I and summarised below.

***Cadia East Project Traffic Generation***

Table 4-34 summarises existing and predicted daily vehicle movements (traffic in both directions) generated by different phases of the Project. As described in Section 2.3, the Project would involve various periods of different levels of mining and construction activity (e.g. tailings storage facilities embankment lifts). Three traffic scenarios were investigated to determine the predicted impact of the Project traffic flows on the local road network during the Project life. The three scenarios were:

- Scenario 1 (Year 2) – includes the operation of Cadia Hill, Ridgeway, Ridgeway Deeps and the development/construction of the Cadia East underground mine (representative of the maximum Project related traffic movements).
- Scenario 2 (Year 4) – includes the operation of Cadia Hill, Ridgeway Deeps and the Cadia East underground mine.
- Scenario 3 (Year 17) – includes the operation of the Cadia East underground mine.

Table 4-35 presents the predicted impact of the Project traffic flows in the local road network for the three scenarios.

Scenario 1 (Year 1) represents the greatest potential traffic impact associated with the Project as it includes the operation of the two existing mines (i.e. Ridgeway and Cadia Hill) and the construction/development of the Project.

Project related employee traffic movements in Scenarios 2 and 3 (Years 4 and 17) would be lower than the traffic movements associated with the existing Cadia Valley Operations (although heavy vehicle movements keep the total traffic movements above the existing traffic volume in some cases [Table 4-35]) (Appendix I).

The existing Level of Service (Table 4-32) of all assessed roads is not expected to change as a result of the Project (Appendix I).

***Peak Hour Intersection Performance***

The peak hour performance of the key intersections along the principal access route (i.e. Forest, Orchard and Cadia Roads) to the Project site were assessed using the intersection analysis computer program SIDRA for Scenario 1 (i.e. the peak Project related traffic scenario) (Appendix I).

All of the intersections assessed would continue to operate very satisfactorily during the critical morning peak period, with an Intersection Level of Service A expected at all intersections (Appendix I).

***Cadia Road and Re-aligned Cadia Hill Access Road Intersection***

The existing Cadia Hill access road would be re-aligned to avoid the Cadia East subsidence zone (Section 2.12.2 and Figure 2-4c). The re-alignment of the Cadia Hill access road would require the construction of a new intersection with Cadia Road. The intersection would be constructed in accordance with *Guide to Traffic Engineering Practice - Part 5: Intersections at Grade* (AUSTROADS, 2005) and the *Road Design Guide* (RTA, 1999) and would reflect a similar geometric arrangement to that currently provided at the existing site access (Appendix I). This intersection would be designed to cater for the oversize vehicles that would access the Project.

***Cadia Road Re-alignment***

A 1.1 km section of Cadia Road would be re-aligned to avoid the subsidence zone (Section 2.12.3 and Figure 2-7). A section of Woodville Road would be incorporated into the Cadia Road re-alignment and therefore a new intersection at Cadia Road and Woodville Road would be required (Figure 2-7).

**Table 4-34**
**Existing and Predicted Cadia Valley Operations Traffic Volumes**

| Scenario | Project Year | Employee Trips (trips/day) | Operations Truck Trips (trips/day) | Construction Trucks (trips/day) |
|---|---|---|---|---|
| - | Existing[1] | 1,200 | 80 | 0 |
| 1 | 2 | 1,643 | 132 | 150 |
| 2 | 4 | 1,191 | 132 | 5 |
| 3 | 17 | 990 | 132 | 5 |

Source: After Appendix I.

1 Estimated average Cadia Valley Operations traffic generation (based on 950 employees), current Ridgeway Deeps construction traffic is higher (approximately 1,100 employees).

**Table 4-35**
**Predicted Peak Period Daily Traffic Flows on the Local Road Network**

| Count Site[1] | Road[1] | Existing Traffic Volume | Predicted Traffic Volume | | |
|---|---|---|---|---|---|
| | | | Scenario 1 | Scenario 2 | Scenario 3 |
| 1 | Forest Road (MR 245) South of Orange | 3,975 | 4,324 | 3,987 | 3,855 |
| 2 | Cadia Road South of Forest Road | 1,710 | 2,059 | 1,722 | 1,590 |
| 3 | Cadia Road South of Four Mile Creek Road | 935 | 1,419 | 971 | 820 |
| 4 | Orchard Road East of Cadia Road | 246 | 376 | 270 | 256 |
| 5 | Four Mile Creek Road West of Cadia Road | 190 | 195 | 190 | 185 |
| 6 | Four Mile Creek Road South of Ridgeway | 92 | 97 | 92 | 87 |
| 7 | Woodville Road East of Cadia Road | 254 | 393 | 266 | 226 |
| 8 | Cadia Road North of Panuara Road | 65 | 87 | 65 | 55 |
| 9 | Forest Road at Spring Hill (MR 245) | 760 | 890 | 784 | 770 |
| 10 | Orange Road (MR 559) at Railway Overbridge | 2,432 | 2,571 | 2,444 | 2,404 |
| 11 | Panuara Road East of Four Mile Creek Road | 63 | 85 | 63 | 53 |
| 12 | Cadia Road South of Woodville Road | 65 | 87 | 65 | 1,111 |

Source: After Appendix I.

1 Refer to Figure 4-32.

The road re-alignment would be constructed in consultation with BSC and CSC with consideration of the requirements of the *Guide to Traffic Engineering Practice – Part 5: Intersections at Grade* (AUSTROADS, 2005) and the *Road Design Guide* (NSW Roads and Traffic Authority [RTA], 1999) and would be similar to the existing sealed section of Cadia Road (Appendix I).

***Car Parking***

Additional temporary and permanent car parking facilities would be located on-site to cater for workforce and visitor parking. The car parking facilities would be constructed to appropriate standards.

***Heavy Traffic***

The Project would generate external heavy traffic associated with Project construction and operational deliveries as described in Appendix I. These heavy vehicles would include approximately six trips per week associated with the transport of molybdenum concentrate from the Project to Sydney (Appendix I). All heavy vehicle loads would be appropriately secured and covered, where necessary.

***Oversize Traffic***

A small number of overwidth, overheight, or overweight heavy loads would be generated during construction and operations. All such loads would be transported with the relevant permits, licences and escorts, as required by the regulatory authorities. The proposed route would be negotiated with the relevant local councils.

***School Buses***

The Project's morning peak (i.e. 6.00 am and 7.00 am) and afternoon peak (i.e. 6.00 pm and 7.00 pm) traffic periods are outside of the local school bus operational periods (i.e. between 7.35 am and 9.15 am, and between 3.10 pm and 4.35 pm) (Section 4.10.1). The potential for overlap between peak daily Project traffic and these school buses would therefore be minimal (Appendix I).

***Road Safety***

The traffic assessment did not identify any particular accident patterns or causation factors in the vicinity of the Project (Section 4.10.1). As the Project would not significantly alter traffic flows, or the type of vehicles on the key routes, Traffix (2009) considers that it is unlikely to significantly affect road safety performance (Appendix I).

***Cumulative Traffic Increases***

*Hospital Developments*

As described in Section 4.10.1, the Orange Base Hospital Redevelopment and the proposed Orange Private Hospital Precinct on Forest Road in Orange have some potential to influence traffic generation during the life of the Project.

Traffic generated from these developments would largely be limited to the urban areas of Orange (Appendix I). The peak period for general traffic generation in Orange, including the additional peak hour traffic associated with these hospital developments is after 7.00 am, and is therefore likely to have little influence on periods of peak Cadia Valley Operations traffic flows (i.e. 6.00 am to 7.00 am) and hence limited effect on key intersection performance during these periods.

The road network in the vicinity of the Cadia Valley Operations would generally be unaffected by the hospital operations. However, Forest Road, north of the hospital developments may experience some limited and short-term reduction in the Level of Service where the hospital developments overlap with peak Project construction (i.e. Year 2) (Appendix I).

Masson Wilson Twiney (2006) reported that at full development of the Orange Base Hospital Redevelopment (i.e. approximately ten years after commencement) the intersection of Forest Road and Huntley Road would have limited spare capacity during the hospital's afternoon peak hour. At this stage of the Project, light vehicle movements associated with workforce transport would be less than the current levels as the number of employees at the Cadia Valley Operations would reduce after the closure of Cadia Hill and Ridgeway in Years 4 and 8 respectively.

*Canobolas State Forest – Forestry Activities*

As described in Section 4.10.1, Forests NSW conducts forestry operations at the Canobolas State Forest located to the east and north of the Cadia Valley Operations. During the life of the Project, Forests NSW will continue to periodically conduct harvesting/thinning campaigns in the Canobolas State Forest (Appendix I). Forests NSW has advised that haulage operations will occur sporadically for short periods of time during the life of the Project. These operations may be conducted up to 24 hours per day.

Given the episodic and short-term nature of the Forests NSW harvesting/thinning activities and the relatively small number of movements (i.e. typically 30 timber haul truck movements per day), it is considered by Traffix (2009) that the continuation of existing forestry activities at the Canobolas State Forest would not result in significant cumulative impacts on the local road network during the life of the Project (Appendix I).

*Long-term Baseline Traffic Growth*

The Project would have a life of approximately 21 years (i.e. 2010 to 2030). During this period the volume of background traffic (i.e. non Project traffic) is expected to vary (i.e. increase/decrease). In order to conservatively consider the potential impacts of the Project in the context of potential background traffic growth, an annual baseline growth rate was used in the Road Transport Assessment (Appendix I).

In consultation with the RTA, a general 2% per annum (pa) baseline traffic growth rate was applied to the existing traffic volumes provided in Table 4-32 (Appendix I). The potential impact of the 2% pa baseline traffic growth was considered in the assessment of the three scenarios described above.

The performance of the local road network (including intersections) is not considered by Traffix (2009) to be particularly sensitive to baseline traffic growth rate over the life of the Project, as the Level of Service of the roads assessed would not change and peak hour intersection operation would remain satisfactory.

***CVO Dewatering Facility***

*Traffic Volumes*

The CVO Dewatering Facility would be located on Newbridge Road to the east of Blayney (Figure 1-3). Traffix conducted an assessment of potential traffic impacts of the construction and operation of the CVO Dewatering Facility (Appendix I).

The existing traffic volume on Newbridge Road is 468 vehicles per day (Table 4-32). The construction of the CVO Dewatering Facility would generate up to 25 employee and 16 truck trips each day (i.e. 11% increase in daily traffic volume on Newbridge Road) and would be constructed during Years 2 and 3. During operations, the CVO Dewatering Facility would generate up to six employee and six truck trips per day (i.e. 2% increase in daily traffic volume on Newbridge Road). Based on the above, the construction and operation of the CVO Dewatering Facility would not create any adverse traffic impacts and there is substantial spare capacity along Newbridge Road.

*Site Access Road and Newbridge Road Intersection*

A site access road would be required at the CVO Dewatering Facility (Figure 1-3). The site access road would require the construction of an intersection on Newbridge Road. The intersection would be constructed in accordance with *Guide to Traffic Engineering Practice - Part 5: Intersections at Grade* (AUSTROADS, 2005) and the *Road Design Guide* (RTA, 1999). The performance of this intersection is expected to be very good, with minimal traffic volumes and a Level of Service A (Appendix I). The intersection would be designed to cater for oversize vehicles.

### 4.10.3 Mitigation Measures and Management

The following roadworks/upgrades would be constructed in accordance with *Guide to Traffic Engineering Practice – Part 5: Intersections at Grade* (AUSTROADS, 2005) and the *Road Design Guide* (RTA, 1999):

- construction of a new intersection on Cadia Road with the re-aligned Cadia Hill access road; and
- construction of the CVO Dewatering Facility access road intersection on Newbridge Road.

Notwithstanding the fact that the Project is not predicted to significantly alter existing off-site road transport on the public road network, CHPL would implement the following mitigation measures:

- all oversized vehicles would have the relevant permits, licences and escorts, as required by the regulatory authorities and the proposed route would be negotiated with the relevant local councils;
- all oversize vehicles loads would be appropriately secured and covered, where necessary; and
- CHPL would continue to investigate the viability of providing an employee shuttle bus service from Orange and Blayney to the Cadia Valley Operations.

The Project would result in traffic increases on some roads, but would not cause any unacceptable capacity problems (Section 4.10.2). Therefore, no further improvements beyond those identified above would be required during either the construction or operational phases (Appendix I).

## 4.11 REGIONAL ECONOMY

A Socio-Economic Assessment (including a regional economic assessment) was prepared for the Project by Gillespie Economics and is presented in Appendix H. The Project is located in the Orange, Cabonne and Blayney (OCB) Statistical Local Areas (SLAs) which are approximately equivalent to the respective LGAs within the region.

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 economies (including the influence of the existing Cadia Valley Operations) is provided in Section 4.11.1.

The potential impacts and benefits of the Project on the regional and NSW economies are described in Section 4.11.2.

#### 4.11.1 Existing Environment

The regional economic assessment was based on a 2005-2006 input-output analysis for the OCB SLAs and NSW economies.

The Gross Regional Product (GRP) for the regional economy is estimated at $2,393 M, comprising $1,245 M to households as wages and salaries and $1,148 M 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 4-36.

The regional agriculture/forestry and fishing sector, mining sector and manufacturing sector (excluding employment) are of greater relative importance to the regional economy than they are to the NSW economy. The building and service sectors are of less relative importance to the regional economy then they are to the NSW economy (Appendix H).

The services sector is the most significant sector, with manufacturing being the second most significant sector, in terms of total employment, contribution to GRP and output for the region and NSW (Table 4-36) (Appendix H).

Important sectors to output are equipment manufacturing, ownership of dwellings, business services, food manufacturing, non-ferrous metal ores mining and retail trade (Appendix H).

In terms of gross regional output, important sectors include the equipment manufacturing, ownership of dwellings, business services, food manufacturing, non-ferrous metal ores mining and retail trade (Appendix H).

The retail trade sector is the greatest employer in the region followed by services sectors (predominantly health services, education, personal/other services, business services and public administration sectors). However in terms of income paid to employment, the highest income sectors across the region are consistent with the largest employers in the region with the addition of the equipment manufacturing sector (Appendix H).

Non-ferrous metal ore mining, equipment manufacturing and food manufacturing were the major sectors responsible for exports from the region, with the latter two predominantly responsible for regional imports (Appendix H).

***Community Impact Review***

In 2006/2007 Gillespie Economics completed a Community Impact Review for the Cadia Valley Operations (Gillespie Economics, 2007) that included a community attitudes survey and business and stakeholder surveys focussing on perceptions of Cadia Valley Operations' socio-economic contributions to the local region and any effects on community infrastructure.

A survey of business in Orange, Blayney and Molong (Gillespie Economics, 2007) found that 71% considered that their business directly or indirectly benefits from the Cadia Valley Operations (Appendix H).

When asked about the extent to which their business benefits, the majority of respondents (67%) considered that they benefit by up to 5% of business turnover. Some businesses (2%) considered that they benefited by greater than 15% turnover (Appendix H).

**Table 4-36**
**Contributions to Employment, the GRP and Output by Industry Sector – Regional Economy (2005 to 2006)**

| Sector | Total Employment (%) | | Contribution to GRP[1] (%) | | Contribution to Output (%) | |
|---|---|---|---|---|---|---|
| | OCB Region | NSW | OCB Region | NSW | OCB Region | NSW |
| Agriculture/Forestry and Fishing | 9 | 3 | 6 | 2 | 6 | 2 |
| Mining | 4 | 1 | 10 | 2 | 8 | 2 |
| Manufacturing | 11 | 11 | 14 | 11 | 26 | 19 |
| Utilities | 1 | 1 | 2 | 2 | 4 | 3 |
| Building | 5 | 7 | 4 | 6 | 6 | 9 |
| Services | 70 | 77 | 59 | 71 | 51 | 65 |

Source: After Appendix H.

1 Percentages may not add to 100% as only intermediate sectors have been included.

A total of 93% of businesses surveyed considered that the local economy benefits from the Cadia Valley Operations, with 97% of these considering that the benefit to the local economy from the Cadia Valley Operations is medium to high (Appendix H).

A community attitudes survey (Appendix H) also examined the extent to which the local economy benefits from the Cadia Valley Operations. A total of 93% of respondents agreed or strongly agreed that the local economy benefits from the Cadia Valley Operations (Appendix H).

Of those community respondents that agreed, 97% considered that the benefit to the local economy from the Cadia Valley Operations is medium to high (Appendix H).

All stakeholders interviewed at the time considered that the Cadia Valley Operations has had a positive impact on the local economy (Appendix H). CHPL was considered to have stimulated existing businesses and also resulted in a number of new businesses setting up to service the mine. The expenditure of employees was also seen as stimulating businesses, particularly retail in the main street of Orange. OCC confirmed increased interest in retail development and improvement within the Orange area due to the Cadia Valley Operations (Appendix H).

The Cadia Valley Operations was seen as instrumental in the diversification of the regional economy, reducing the reliance on Electrolux which was previously Orange's largest employer, but which has been decreasing in size (Appendix H).

The strong growth in Orange was considered to have also spilled into rural settlements, unlike growth in other areas such as Dubbo which were seen to come at the expense of surrounding rural settlements (Appendix H).

### 4.11.2 Potential Impacts

The types of positive regional economic impacts and business impacts associated with the existing Cadia Valley Operations described in Section 4.11.1 would continue with the development of the Project (Appendix H).

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 H includes consideration of the average potential incremental economic impacts of the Project on the OCB SLAs.

***Project Operations***

The Project is predicted to have the following impacts on the OCB SLAs (Appendix H):

- $1,025 M in annual direct and indirect regional output or business turnover;
- $557 M in annual direct and indirect regional value-added;
- $165 M in annual household income; and
- 1,889 direct and indirect jobs.

The main sectors of the OCB SLAs regional economy likely to be affected by the output, value-added and income flow-on impacts from the Project are likely to be wholesale trade, electricity supply, retail trade, hotels, cafes, restaurants, scientific and technical services, other business services, law, accounting and marketing, banking, ownership of dwellings, health services, personal services and road transport (Appendix H).

The Project would directly generate a long-term (i.e. following the cessation of operations at Cadia Hill and Ridgeway) average annual workforce of approximately 783 employees (Appendix H). Production-induced employment impacts would mainly occur in the mining sectors and services sectors. Consumption-induced employment flow-ons would mainly occur in the services sectors and wholesale and retail trade sectors.

***End of Project Life***

The Project would enable at least part of the stimulus to the regional economy currently provided by the Cadia Valley Operations to continue into the future (Appendix H). Cessation of the Project would, however, lead to a reduction in regional economic activity in the OCB SLAs.

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 (Appendix H).

The OCB region has a history of mining and it is therefore possible 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 (Appendix H).

Ultimately, the significance of the economic impacts of cessation of the Project would depend on the economic structure and trends in the regional economy at the time (Appendix H). For example, if cessation of the Project takes place in a declining economy the impacts might be relatively significant. Alternatively, if cessation of the Project takes place in a growing diversified economy where there are other development opportunities, the ultimate cessation of the Project may have less effect on the regional economy.

CHPL would develop a Mine Closure Plan before Project closure. The plan would be prepared in consultation with OCC, CSC, BSC, DoP and the community and would include consideration of amelioration of potential adverse socio-economic effects due to the reduction in employment at Project closure.

## 4.12 EMPLOYMENT, POPULATION AND COMMUNITY INFRASTRUCTURE

For the purposes of the employment, population and community infrastructure component of the Socio-Economic Assessment (Appendix H), the OCB SLAs were used as the local region.

A summary in relation to the background demographics, employment and community infrastructure is provided in Section 4.12.1. 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 4.12.2. Relevant mitigation measures are described in Section 4.12.3.

### 4.12.1 Existing Environment

***Population Profile***

Table 4-37 compares population growth experienced in the OCB SLAs and NSW as a whole. As shown in Table 4-37 the total population of the OCB SLAs increased from 51,933 in 1996 to 53,550 in 2001 at a rate lower than that for NSW (Table 4-37). The population growth rate in the OCB SLAs slowed to 0% between 2001 and 2006 (Table 4-37). However, the population growth remained positive in the Cabonne and Blayney SLAs (Table 4-37).

*Demographics*

Table 4-38 provides a summary of the age distribution of the OCB SLAs for the years 1996 to 2006 and the age distribution for NSW in 2006.

Table 4-38 indicates that the proportion of people under the age of 44 has been decreasing. The proportion of aged 45 years and older is increasing.

***Employment Profile***

The unemployment rate in the OCB SLAs has been declining over time (Table 4-39).

Health and social assistance is the principle industry sector in the OCB region in terms of employment, followed by retail trade, manufacturing, agriculture and education and training (Appendix H).

***Housing***

Table 4-40 provides a summary of housing in the OCB SLAs. There were approximately 19,804 private dwellings in the OCB SLAs in 2006. The dominant housing type was separate houses (90.3%). The number of occupied semi-detached and other dwellings has been declining.

***Education***

There is a range of private and public primary schools available in Orange and surrounding settlements (Appendix H). Generally at public primary school level there is considered to be overall excess capacity, although a couple of individual schools may be considered at or close to capacity (Appendix H).

Reflecting the declining OCB SLAs population in the younger age groups, attendance at most education establishments has declined between 2001 and 2006 (Table 4-41). The exception is preschool where attendances increased while the population of this age group declined (Table 4-41) (Appendix H).

***Health***

The Greater Western Area Health Service (GWAHS) administers the following health and community services in the OCB SLAs (Appendix H):

- Blayney Hospital and Health Service;
- Bloomfield Hospital;
- Orange Base Hospital;
- Canowindra Health Service;
- Cudal Health Service; and
- Molong Health Service.

**Table 4-37**
**OCB Observed Population Growth Rates**

| Year | 1996 | 2001 | 2006 |
|---|---|---|---|
| **Orange** | | | |
| Population | 33,964 | 35,521 | 34,969 |
| Population Growth Rate (pa) | | 4.6% | -1.6% |
| **Cabonne** | | | |
| Population | 11,944 | 11,888 | 12,215 |
| Population Growth Rate (pa) | - | -0.5% | 2.8% |
| **Blayney** | | | |
| Population | 6,025 | 6,141 | 6,364 |
| Population Growth Rate (pa) | - | 1.9% | 3.6% |
| **Total** | | | |
| Population | 51,933 | 53,550 | 53,548 |
| Population Growth Rate (pa) | - | 3.1% | 0.0% |
| **NSW** | | | |
| Population | 6,038,696 | 6,371,745 | 6,585,732 |
| Population Growth Rate (pa) | - | 5.5% | 3.4% |

Source: After Appendix H.

**Table 4-38**
**Distribution of the OCB SLAs Population by Age**

| Proportion of Total Population | OCB SLAs | | |
|---|---|---|---|
| | 1996 | 2001 | 2006 |
| Aged 0-4 years | 7.7% | 7.4% | 7.0% |
| Aged 5-11 years | 11.5% | 11.1% | 10.7% |
| Aged 12-17 years | 9.9% | 9.7% | 9.6% |
| Aged 18-12 years | 2.6% | 2.7% | 2.5% |
| Aged 20-24 years | 6.3% | 5.6% | 5.5% |
| Aged 25-34 years | 13.2% | 12.8% | 11.4% |
| Aged 35-44 years | 14.7% | 14.3% | 13.8% |
| Aged 45-54 years | 12.3% | 13.3% | 13.5% |
| Aged 55-64 years | 9.0% | 9.6% | 11.3% |
| Aged 65-74 years | 7.2% | 7.2% | 7.8% |
| Aged 75-84 years | 4.0% | 4.4% | 5.1% |
| Aged 85 years and over | 1.3% | 1.6% | 1.8% |

Source: After Appendix H.

Note: Percentages may not add to 100% due to rounding.

**Table 4-39**
**Unemployment in the OCB SLAs**

| Year | 1996 | 2001 | 2006 |
|---|---|---|---|
| Total Number in the Labour Force | 23,705 | 24,916 | 25,097 |
| As Percentage of People over 15 Years | 60.4% | 60.9% | 60.5% |
| Total Employment | 21,825 | 23,238 | 23,731 |
| Total Unemployment | 1,880 | 1,678 | 1,366 |
| Unemployment Rate | 7.9 | 6.7 | 5.4 |

Source: After Appendix H.

**Table 4-40**
**Housing Stock in the OCB Region**

| Year | 1996 | 2001 | 2006 |
|---|---|---|---|
| Total Private Dwellings | 18,261 | 19,190 | 19,804 |
| Percentage Separate Houses | 88.3% | 88.5% | 90.3% |
| Percentage Semi Detached | 4.4% | 4.7% | 2.5% |
| Percentage Flat, Unit, Apartment | 4.9% | 5.1% | 6.1% |
| Percentage Other Dwelling | 1.6% | 1.2% | 1.1% |
| Percentage Not stated | 0.8% | 0.6% | 0.1% |

Source: After Appendix H.

Note: Percentages may not add to 100% due to rounding.

**Table 4-41**
**Education in the OCB SLAs**

| Year | 1996 | 2001 | 2006 |
|---|---|---|---|
| Pre-school | 782 | 822 | 1,012 |
| Infants/Primary | 5,788 | 5,690 | 5,234 |
| Secondary | 4,242 | 4,326 | 4,100 |
| Technical or Further Educational Institution | 1,544 | 1,964 | 1,344 |
| University or other tertiary Institution | 909 | 1,050 | 984 |
| Other type of Educational Institution | 144 | 190 | 186 |

Source: After Appendix H.

In addition, the Orange Base Hospital Redevelopment and the Orange Private Hospital Precinct were approved by the DoP in October 2008 and November 2008, respectively.

According to the 2006 population census there were 3,221 people employed in the health and community services industries in the OCB SLAs (Table 4-42). Health and community services are a relatively large sector in the OCB SLAs economy, accounting for 14.4% of all employment in the region in 2006, compared to a figure of 10.7% for NSW (Appendix H).

**Table 4-42**
**Employment in Health and Community Services in the OCB SLAs**

| Industry | 2006 |
|---|---|
| Health care and social assistance (not further defined) | 130 |
| Hospitals | 1,323 |
| Medical and other health care services | 771 |
| Residential care services | 450 |
| Social assistance services | 547 |
| **Total** | **3,221** |

Source: After Appendix H.

### 4.12.2 Potential Impacts

The primary potential impact of the Project on community infrastructure relates to population growth and related effects on housing and community facilities.

*Workforce*

As described in Section 2.14, the total operational workforce at the Cadia Valley Operations (including mining contractor's personnel and employees at the Blayney Dewatering Facility) currently averages approximately 950. The current workforce is approximately 1,100, which includes Ridgeway Deeps construction. It is anticipated that an average of 880 employees (i.e. over the 21 year life of the Project) and a maximum of approximately 1,300 employees would be required for the Project. Maximum employment occurs in year two of the Project, during peak construction/development activity.

*Population Effects*

The additional 204 direct jobs are predicted to be associated with a population of 414 migrating into the OCB region (Appendix H). Flow-on jobs of up to 240 are estimated to be associated with a population of 393 migrating into the OCB (Appendix H). Hence, in total the maximum increase in population associated with the Project is 807 (Appendix H). After three years, the Project employment levels (and associated population levels) would return to current levels and thereafter decline to a long-term average of approximately 783 (Appendix H).

*Community Infrastructure Effects*

Demand would be generated for a peak of up to 280 residences by the migrating direct and indirect workforce (Appendix H). Short-term accommodation is expected to meet this housing demand and would largely be for detached housing in Orange and a lesser extent in Blayney, Millthorpe, Forest Reefs and Molong.

The region has considerable short-term accommodation and private unoccupied dwellings (Appendix H). It is expected that the demand for housing generated by employees of Cadia Valley Operations would actually decline after three years to below current levels. Any cumulative impact of the Project on housing in the OCB region is therefore only likely to be short-term (Appendix H).

During operation of the Project, any incoming flow-on workers would be expected to exhibit average family structures and hence there is some potential for increased demand for education facilities within the region. The population of school aged children and attendance at primary school, secondary school, TAFE and university in the OCB SLAs has been decreasing (Section 4.12.1). The estimated population profile of children associated with the peak migrating direct and indirect workforce would generally only partially offset the reduction in school attendance at primary school, secondary school, TAFE and university between 2001 and 2006 (Appendix H).

Demand for preschool places increased between 2001 and 2006 despite a reduction in the regional population of children in this age group. The Project is predicted to add demand for up to 21 preschool places (Appendix H).

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 OCB region is well serviced by the health sector already and with the development of the Orange Base Hospital Redevelopment and the Orange Private Hospital Precinct, the region would continue to be well serviced (Appendix H).

***Social Considerations***

*Employment*

The Project would create direct jobs and indirect employment across a range of sectors. The generation of temporary employment for the unskilled during construction may provide experience to help secure future permanent employment.

***End of Mine Life***

Potential socio-economic impacts associated with the end of mine life are described in Section 4.11.2.

### 4.12.3 Mitigation Measures and Management

As described in Section 4.12.2, little or no impacts to the local population or community infrastructure are predicted as a result of the Project.

CHPL would continue to consult with the local community through the CCC which provides a forum for discussion between representatives of the mine and the local community on issues directly relating to CHPL'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 CCC, OCC, CSC, BSC and/or the relevant State Government department.

## 4.13 VISUAL CHARACTER

This sub-section presents an assessment of the potential visual impacts of the Project. The sub-section reviews the existing visual character of the Cadia Valley and the Blayney locality and qualitatively assesses potential visual impacts using methodology developed by the United States Department of Agriculture – Forestry Service (USDA-FS) (1974). Visual simulations are also provided for key viewsheds.

### 4.13.1 Existing Environment

Previous studies have established that scenic quality increases as topographic ruggedness and relative relief increase (Leonard and Hammond, 1984; Burns and Rundell, 1969; Anderson *et al*, 1976 in EDAW, 2006). Scenic quality can also increase as the patterning of vegetation increases.

The Cadia Valley and surrounds and site of the CVO Dewatering Facility in Blayney are comprised of a number of distinct landuse types and landscape units of varying levels of landscape quality. These landuse types and landscape units are described below in the context of regional, sub-regional and local settings. Existing landuse patterns are discussed in Section 4.1.1.

The visual settings are based on distance as follows:

- Regional Setting – greater than 5 km from the Project or the CVO Dewatering Facility;
- Sub-regional Setting – 1 to 5 km from the Project or CVO Dewatering Facility; and
- Local Setting – up to 1 km from the Project or CVO Dewatering Facility.

***Regional Setting (>5 km)***

The major geographical features within the region include Mount Canobolas and Mount Towac to the north, and Black Rock Range to the west. Mount Canobolas and Mount Towac are situated within Canobolas State Forest, and Black Rock Range is a steep and rugged landform with natural vegetation cover (FloraSearch, 2006). To the south, the Cadia Valley opens out to gently undulating land extending to the Belubula River. Major water storages in the region include Carcoar Dam and Lake Rowlands.

The major geographical features provide elements of moderate scenic quality, while the patterned vegetation of Canobolas State Forest provide elements of high scenic quality. The contrast between the vegetation and ridgelines, and adjacent agricultural areas adds to the visual interest.

The majority of the native vegetation has been cleared from the region for agricultural purposes. Areas covered by native woodland are now largely restricted to areas unsuitable for agriculture.

The regional setting around Blayney is characterised by cleared agricultural areas surrounding the town of Blayney. The major geographical features are a series of elevated ridges between Carcoar Dam and Mount Macquarie (1,203 m AHD) to the south of Blayney (where the Blayney windfarm is situated).

***Sub-regional Setting (1-5 km)***

*Cadia Valley*

The sub-regional setting of the Project comprises similar features to that found within the regional settings. These features include elements of low to high scenic quality such as cleared agricultural lands, undulating topography and patterned vegetation of Canobolas State Forest. Codey's Mount (720 m AHD) is located near Panuara Road to the south-west and has previously been identified as a potential lookout for the public to view the mining operations (Newcrest, 1995). Several localities occur within the sub-regional setting including Panuara, Errowanbang, Flyers Creek, Forest Reefs, Carbine and Four Mile Creek.

*CVO Dewatering Facility*

The sub-regional setting of the CVO Dewatering Facility contains elements of low to moderate scenic quality due to the presence of cleared agricultural land, gently to moderately undulating topography, the township of Blayney, and the tree lined Belubula River.

Church Hill (935 m AHD) lies to the north of Blayney and provides panoramic views of the township and surrounding countryside. The Main Western Railway passes various industrial developments such as the disused Blayney abattoir and saleyards.

***Local Setting (<1 km)***

*Cadia Valley*

The Cadia Valley has been modified over time for agricultural and mining purposes. The Cadia Valley is characterised by undulating hills, cleared open grassland and scattered native vegetation remnants. The Cadia Valley is bounded by a series of rolling hills which form ridgelines to the east and west of Cadiangullong Creek.

As noted in Section 4.1.1, several mine landforms have modified the topography within the Cadia Valley. In general, views of the existing mining operations are restricted to the lower parts of the Cadia Valley, as ridgelines and Canobolas State Forest effectively screens most views of the northern parts of Cadia Valley. Vegetation screens were also planted during the Cadia Hill and Ridgeway developments to further obstruct views from the local surrounds.

*CVO Dewatering Facility*

The local setting of the CVO Dewatering Facility is considered to have elements of low to moderate scenic quality due to the presence of cleared agricultural land, flat to gently undulating topography, and existing industrial developments (i.e. the Blayney Cold Storage and Distribution warehouses). The Newbridge Road and Main Western Railway pass along and the southern and northern boundaries of the CVO Dewatering Facility area, respectively.

***Night Lighting***

The use of safety operational night lighting at the existing Cadia Valley Operations are generally associated with the following sources:

- overhead lighting of the ore processing facilities and administration area;
- fixed lights or mobile plant lighting on top of the South Waste Rock Dump;
- mobile equipment and work vehicle-mounted lights; and
- lighting for stockpiling and rail loading activities at the existing Blayney Dewatering Facility.

The night lighting from the existing mining activities is visible as a glow from the wider area, however views are primarily restricted to dwellings and public roads in the lower Cadia Valley to the south of the Cadia Valley Operations.

***Existing Sensitive Visual Settings***

Views of the existing Cadia Valley Operations landforms are available from some privately owned rural dwellings to the east, west, and south. Potential intermittent views from the surrounding road network to the existing Cadia Valley Operations are available, including: Cadia Road to the east; Panuara Road to the south (including Codey's Mount); and Lawson Road, Four Mile Creek Road and Wallaces Road to the west.

Views of the CVO Dewatering Facility site are available from some nearby private dwellings, the Newbridge Road and Main Western Railway.

### 4.13.2 Potential Impacts

Visual impact assessments have been conducted for the Cadia Hill EIS (Newcrest, 1995) and for the Ridgeway EIS (CHPL, 2000b). Visual impacts were also considered in modifications to Cadia Valley Operations in the Cadia Extended Modification SEE (CHPL, 2002), the South Dump Modification SEE (CHPL, 2004c), the Ridgeway Deeps SEE (CHPL, 2004a) and the South Waste Rock Dump Modification SEE (CHPL, 2008h). The previous assessments determined that views of the mining operations would be limited to a relatively low number of public vantage points and dwellings, and will be mitigated by rehabilitating the mine landforms and creating visual screens.

The methods used to assess the potential visual impacts as a result of the Project are described below.

***Assessment Methods***

*Zone of Visual Influence Analysis*

The Zone of Visual Influence (ZVI) is the area from which views of a particular development may be possible. Its primary purpose is to identify locations from which a development may be visible (EDAW, 2008).

The ZVI does not take into account the screening effect of vegetation and aspects of the built environment (e.g. sheds) and therefore shows a greater extent of viewshed identified than would actually exist (i.e. is considered 'worst-case'). However, the pine plantation to the east of the Project was included in this ZVI model due to its uniformed height and well defined boundary.

*Qualitative Visual Impact Assessment*

The potential visual impacts from the Project were qualitatively assessed using the techniques employed by EDAW Australia Pty Ltd (EDAW) (2006) which were developed by the USDA-FS (1974). The potential visual impacts from the Project were assessed by evaluating the level of visual modification of the development in the context of the visual sensitivity of relevant surrounding landuse areas from which the Project may be visible.

The level of visual modification of a development can be measured as an expression of the visual interaction, or the level of visual contrast between the development and the existing visual environment. Visual (viewer) sensitivity is a measure of how critically a change to the existing landscape is viewed from various use areas, and is a function of both landuse and duration of exposure (i.e. individuals generally view changes to the visual setting of their dwelling more critically than changes to the visual setting of the broader setting in which they travel or work) (EDAW, 2006). The visual impact resulting from the combination of visual modification and viewer sensitivity is shown in Table 4-43.

**Table 4-43**
**Visual Impact Matrix**

| Visual Modification | Viewer Sensitivity: H | M | L |
|---|---|---|---|
| H | H | H | M |
| M | H | M | L |
| L | M | L | L |
| VL | L | VL | VL |

**VL = Very Low**
**L = Low**
**M = Moderate**
**H = High**

Source: EDAW (2006).

For the purposes of the visual assessment, landuse areas in the vicinity of the Cadia Valley Operations were characterised in terms of low, moderate or high visual sensitivity, as follows:

- Low visual sensitivity – local roads (e.g. Cadia Road, Panuara Road).
- Moderate visual sensitivity – public vantage points (e.g. Codey's Mount and Church Hill).
- High visual sensitivity – rural dwellings and natural/recreation areas.

The extent to which the viewer may have become accustomed to the existing approved Cadia Valley Operations was also considered.

***Visual Impact Assessment***

Potential visual impacts as a result of the Project would be from the following key components (Figure 2-4d):

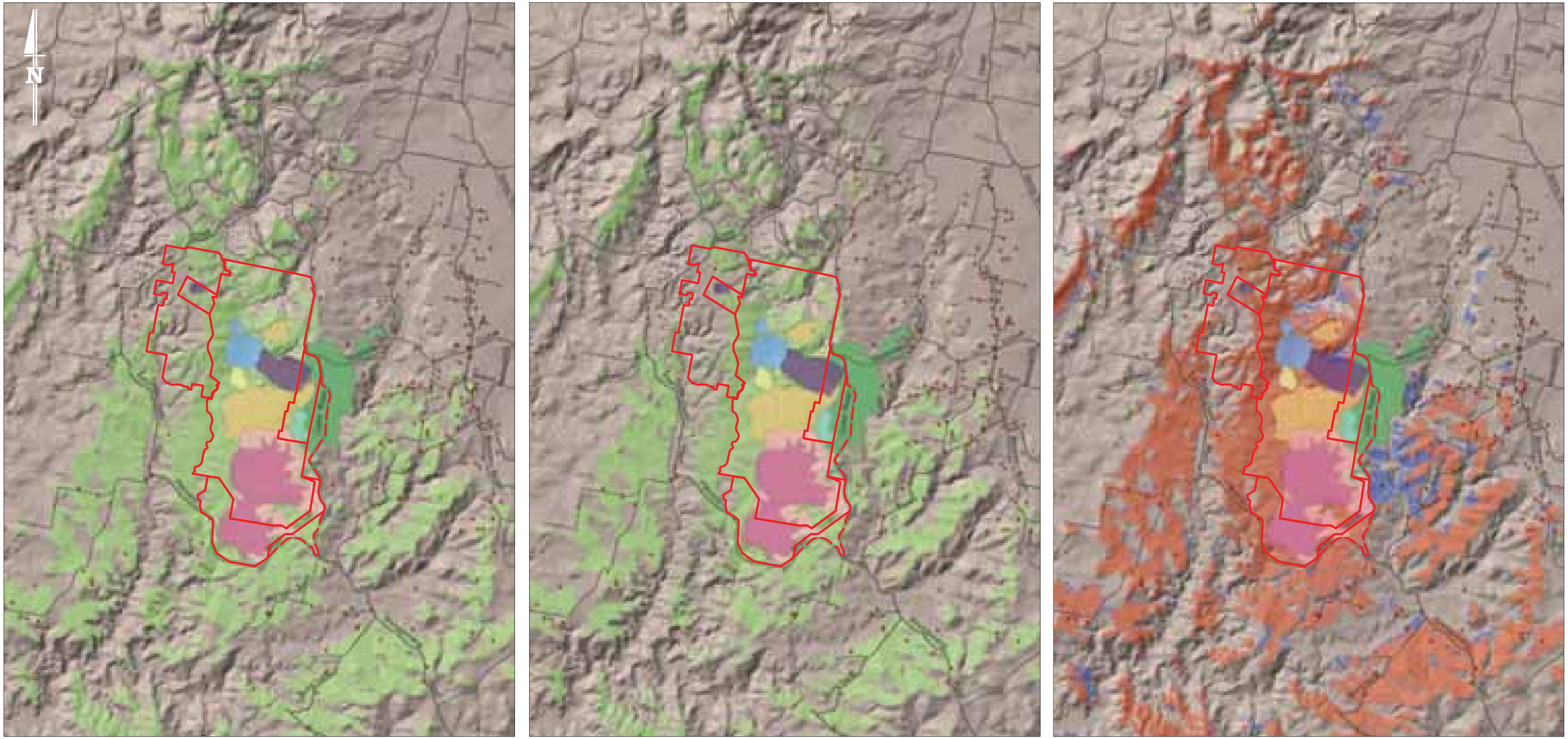
- lifting the NTSF embankment by approximately 38 m and the STSF embankment by approximately 20 m;
- creation of the Cadia East subsidence zone to the east of the existing Cadia Hill open pit; and
- the CVO Dewatering Facility located near Blayney.

The Project would not require an expansion of the disturbance area for the existing South Waste Rock Dump, nor would it to extend the dump higher than that currently approved (i.e. 880 m AHD). The post-mining landform would be designed to blend in with the surrounding natural topography of the area.

*Zone of Visual Influence Analysis*

The ZVI for the existing mine components, the Project components, and the combined existing and Project components are shown on Figure 4-35. The ZVI for the existing approved Cadia Valley Operations is primarily from the lower Cadia Valley and distant ridgelines to the east and west. The ZVI analysis for the proposed Project shows that dwellings with potential views of the Project landforms are primarily those with existing views to the mining operations.

Areas with views to the new Project components only are limited to the higher ridges surrounding the site of which is primarily private agricultural land (Figure 4-35).




Existing Zones of Visual Influence

Proposed Zones of Visual Influence

Existing and Proposed Zones of Visual Influence

LEGEND

- Main Road
- Road
- Existing Visible
- Not Visible
- Cadia Hill and Cadia Extended Open Pit
- North and South Waste Rock Dump
- Ridgeway/Ridgeway Deeps Subsidence Zone
- Northern and Southern Tailings Storage Facilities (Existing)
- Northern and Southern Tailing Storage Facilities (Proposed)
- Rodds Creek Water Holding Dam
- Infrastructure Area
- Mature Pine Plantation
- Dwelling

LEGEND

- Existing Visible
- Proposed Visible
- Combined Visible
- Not Visible

0 1 2 3 4 5

Kilometres

*Source: Urbis Pty Ltd (2009)*

CADIA EAST PROJECT

**FIGURE 4-35**

Visual Simulations of Visual Influence

Cadia Holdings Pty Limited

ResourceStrategies

NEC-06-66 Sect 4_122C

*Qualitative Visual Impact Assessment*

Assessment of the potential visual impacts focused on areas and dwellings to the south, west and east of the Project in accordance with the outcomes of the ZVI analysis. Potential visual impacts have been determined in accordance with the matrix presented in Table 4-43.

Visual simulations were prepared to show the existing views as well as simulations of the Project landforms at full development (i.e. Year 21 of operations), when the landforms would be at their maximum heights, representing the greatest potential for visual impact.

A post-mining simulation was also developed to illustrate the conceptual landform following completion of mining and rehabilitation activities. The locations of visual simulations for the mining operations are shown on Figure 4-36. Visual simulations for the mining operations are provided in Figures 4-37 to 4-42, and for the CVO Dewatering Facility on Figure 4-43.

***Mining Operations***

*Views from the South of the Project Disturbance Areas*

Views to the existing South Waste Rock Dump are available from a limited number of dwellings and the local public road network to the south of the Project (i.e. Cadia Road and Panuara Road). The existing tailings storage facilities are primarily screened by intervening topography and vegetation, however their embankments are visible from some locations along the public roads and private dwellings closer to the Cadia Valley Operations.

Potential visual impacts from the Project when viewed from the south would be restricted to the expansion of the tailings storage facilities, as the subsidence zone would be screened by the existing South Waste Rock Dump. The embankments of the expanded tailings storage facilities would rise above the intervening topography from some locations, however they would not rise above the existing mine landforms (i.e. South Waste Rock Dump) or the natural landforms to the north. Visual sensitivity of local public roads and public vantage points is low to moderate and the visual modification is generally considered to be low, resulting in a low potential visual impact.

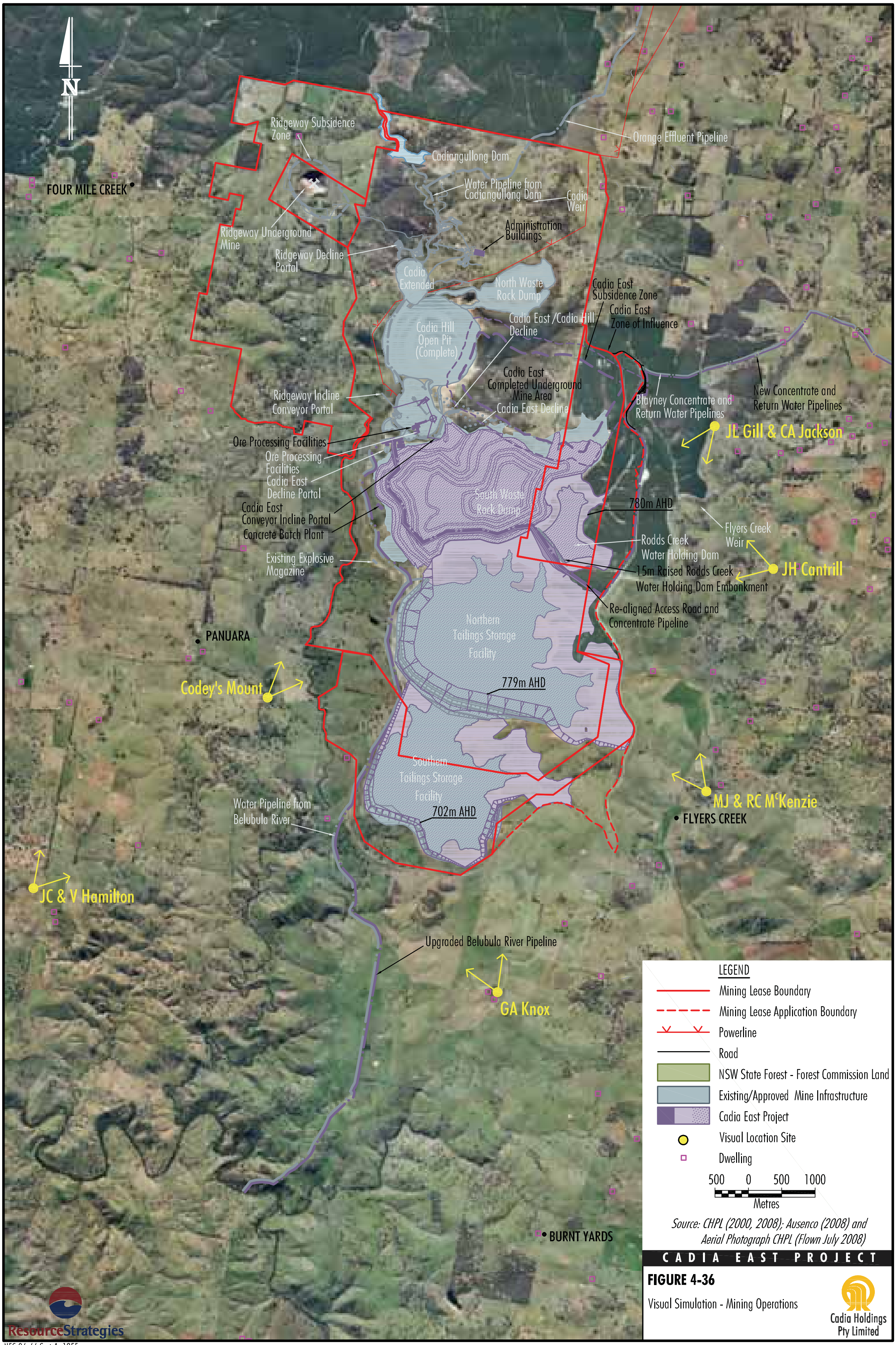
The GA Knox dwelling (171) is situated approximately 1.6 km to the south of the existing STSF (Figure 4-36). Clear views are available to the existing South Waste Rock Dump from this dwelling, however the existing Cadia Hill open pit is screened by the dump and the existing tailings storage facilities are not visible due to the intervening topography. The expansion of the NTSF would rise above the intervening topography and clear views of it would be available from the GA Knox dwelling (171) (Figure 4-37). However, because views of the South Waste Rock Dump are already available from this viewshed, the visual modification as a result of the expansion of the NTSF is considered to be low. The high viewer sensitivity would result in a moderate potential visual impact.

The batters of the embankments of the tailings storage facilities would be rehabilitated with grasses, trees and/or shrubs reducing the bare soil appearance in the long-term as the vegetation establishes (Figure 4-37). With progressive and final rehabilitation the level of visual impact would be reduced to low.

*Views from the West of the Project Disturbance Areas*

Clear views from the west of the existing South Waste Rock Dump and portions of the Cadia Hill open pit are available from a limited number of dwellings and the local public road network to the west of the Cadia Valley (i.e. Panuara Road, Four Mile Creek Road, Wallaces Road and Lawson Road). Views of the existing tailings storage facilities are available from some locations where there are gaps in the intervening topography and vegetation.

Potential visual impacts from the Project would be in relation to the expansion of the tailings storage facilities and the Cadia East subsidence zone. Views of the expanded tailings storage facilities would primarily be from locations that have existing views of the facilities. Where visible, the subsidence zone would appear as an escarpment similar to the adjacent Cadia Hill open pit highwall. Visual sensitivity of local public roads is low and the visual modification is generally considered to be low, resulting in a low potential visual impact.




CADIA EAST PROJECT

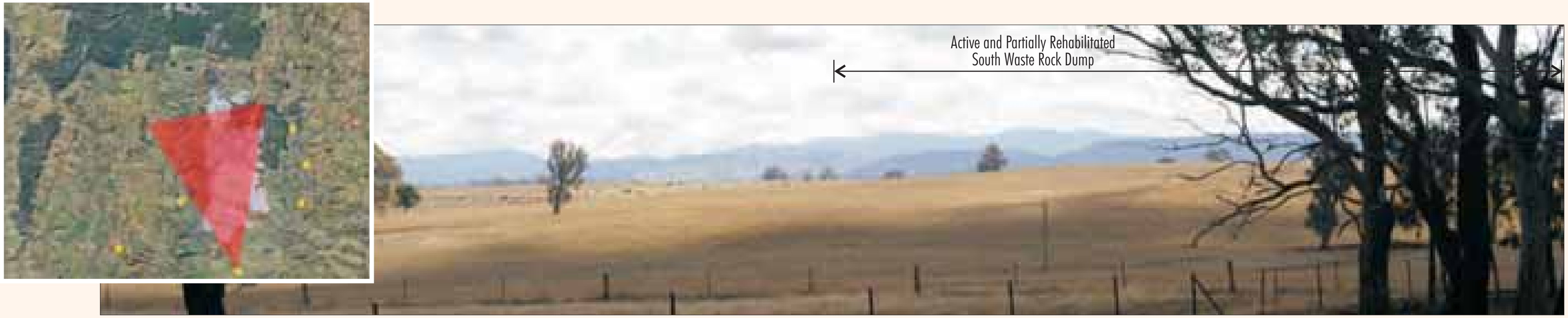
**FIGURE 4-36**

Visual Simulation - Mining Operations

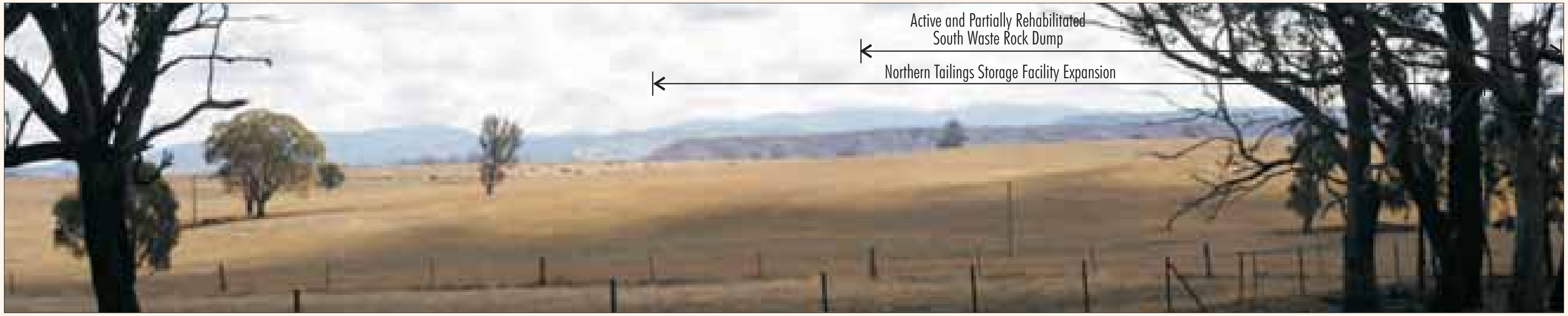
Cadia Holdings Pty Limited

ResourceStrategies

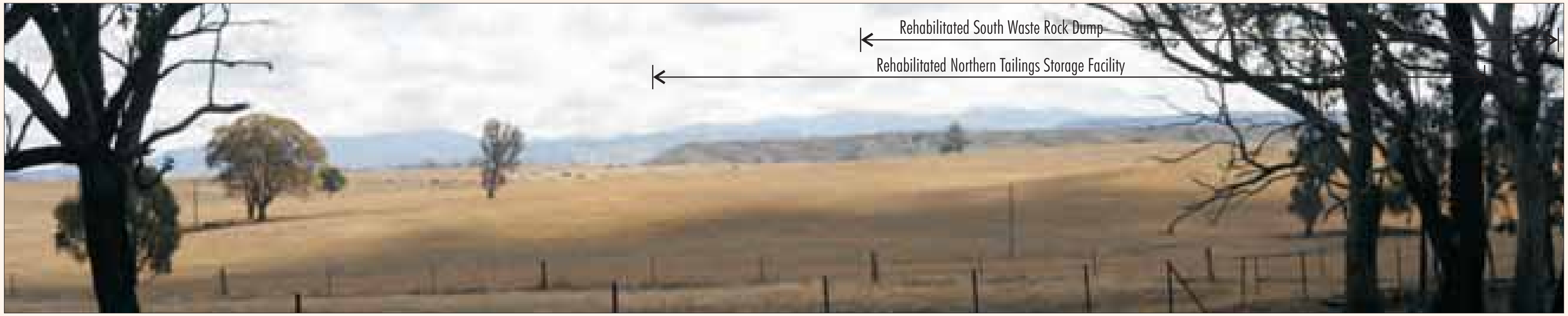
NEC-06-66 Sect 4_125E




Existing View




Full Development Simulation (Year 21)




Post-Mining Simulation

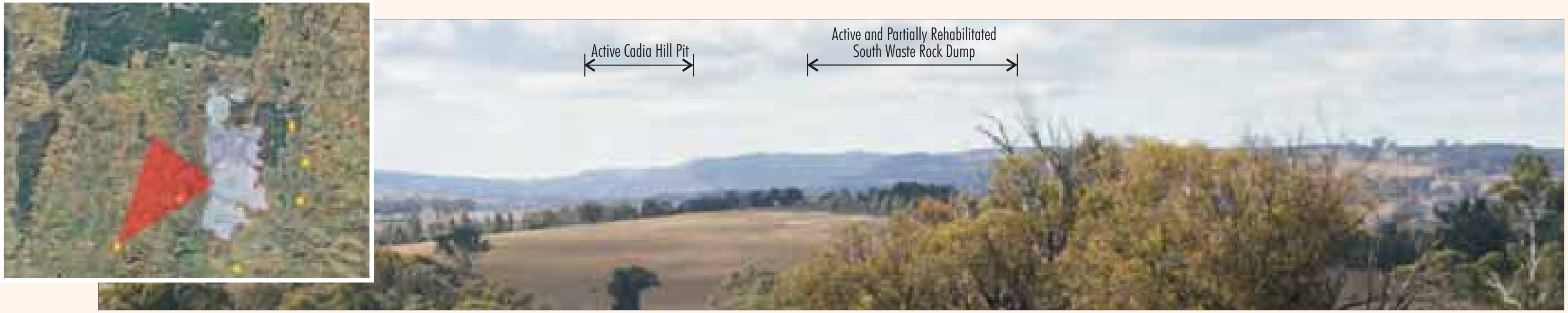
ResourceStrategies

CADIA EAST PROJECT

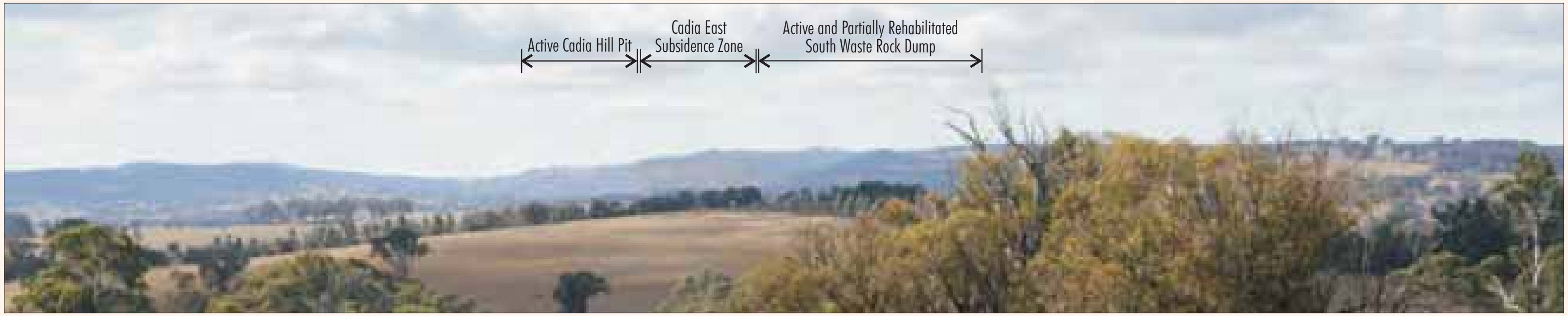
**FIGURE 4-37**

Existing View and Visual Simulations - GA Knox Dwelling

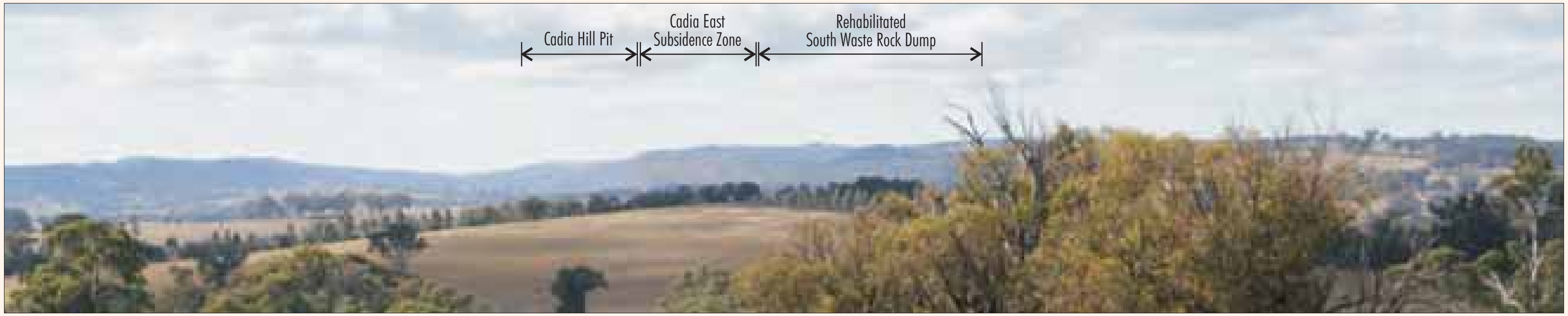
Cadia Holdings Pty Limited




Existing View




Full Development Simulation (Year 21)




Post-Mining Simulation

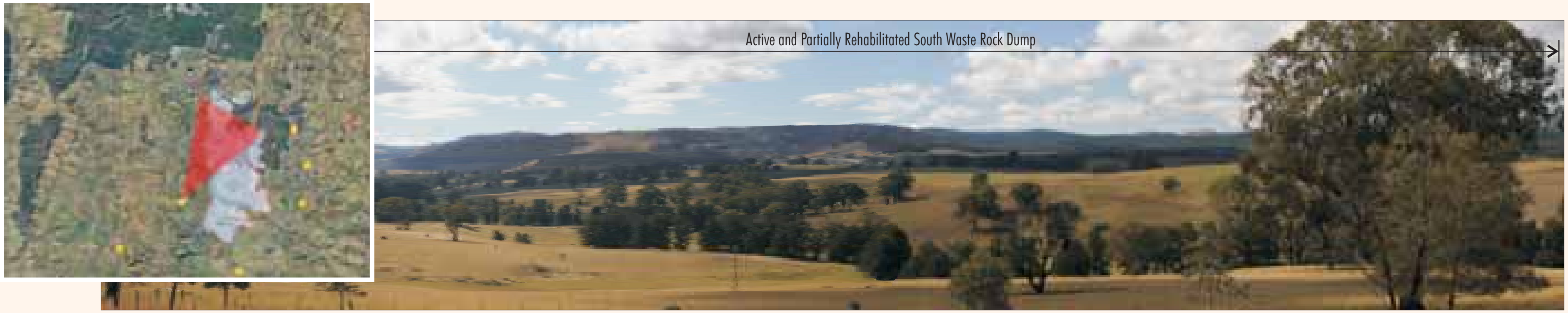
ResourceStrategies

CADIA EAST PROJECT

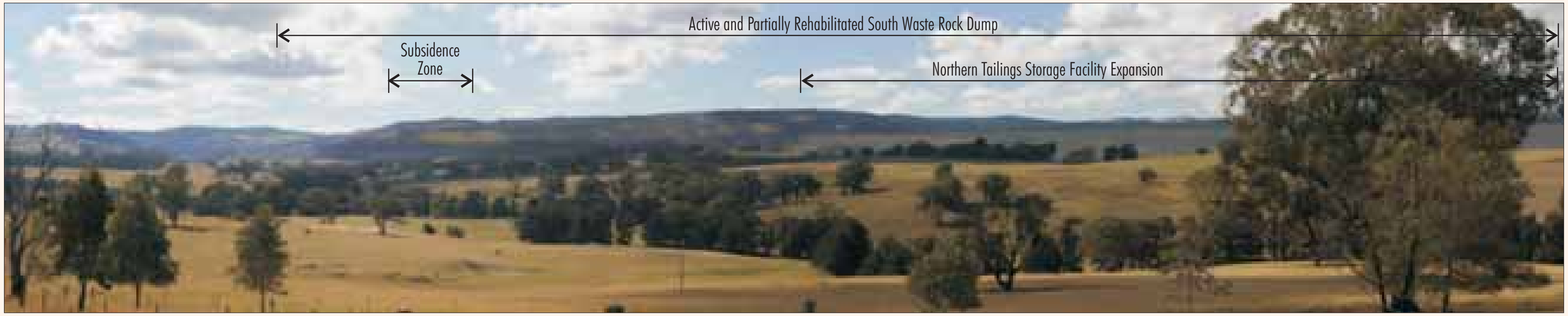
**FIGURE 4-38**

Existing View and Visual Simulations - JC & V Hamilton Dwelling

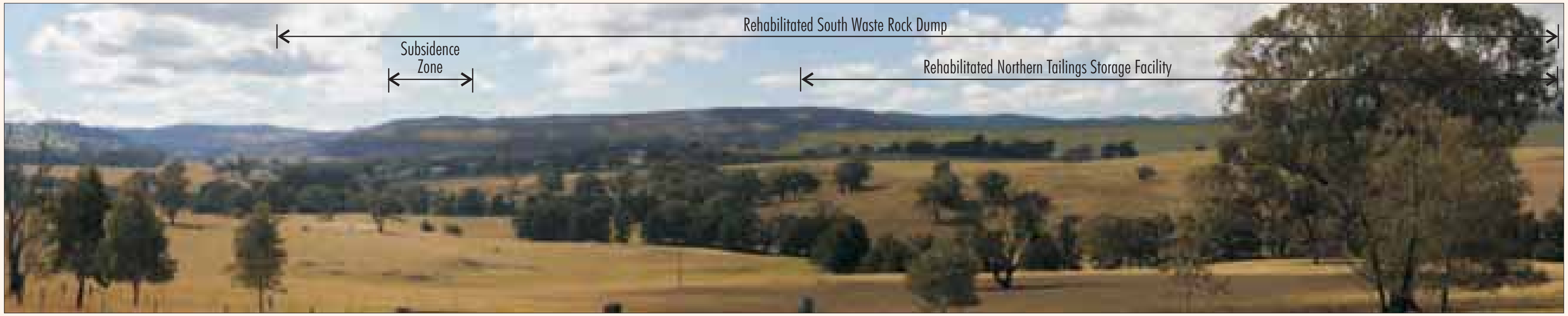
Cadia Holdings Pty Limited




Existing View




Full Development Simulation (Year 21)




Post-Mining Simulation

ResourceStrategies

CADIA EAST PROJECT

**FIGURE 4-39**

Existing View and Visual Simulations - Codey's Mount

Cadia Holdings Pty Limited

NEC-06-66 Sect 4_ 005C

Existing View


Full Development Simulation (Year 21)


Post-Mining Simulation

ResourceStrategies

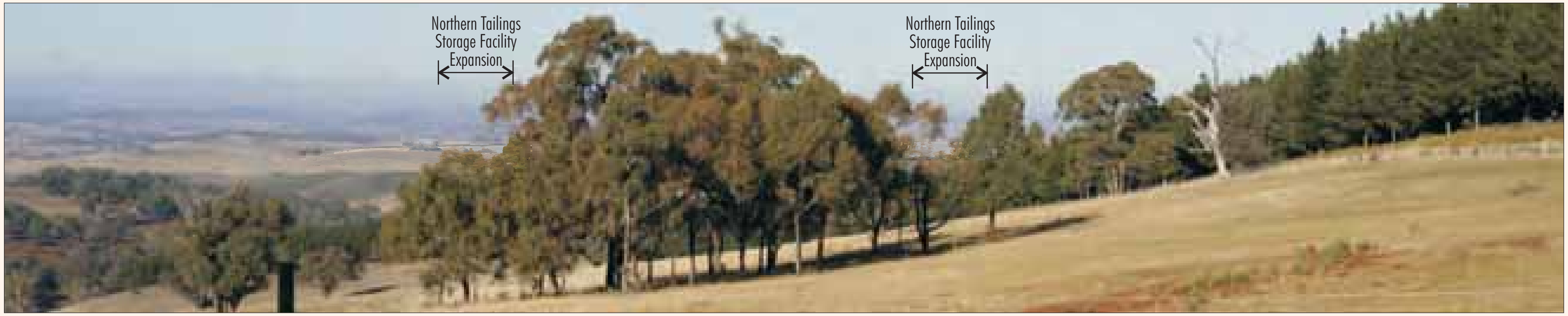
CADIA EAST PROJECT

**FIGURE 4-40**

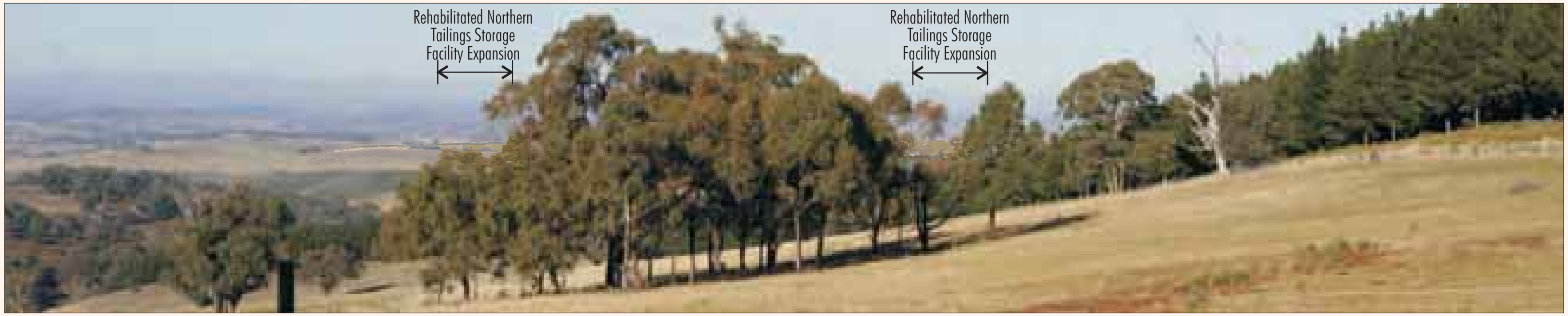
Existing View and Visual Simulations - MJ & RC McKenzie Dwelling

Cadia Holdings Pty Limited

Existing View




Full Development Simulation (Year 21)




Post-Mining Simulation

ResourceStrategies

CADIA EAST PROJECT

**FIGURE 4-41**

Existing View and Visual Simulations - JL Gill and CA Jackson Dwelling

Cadia Holdings Pty Limited

NEC-06-66 Sect 4_ 007C


Existing View


Full Development Simulation (Year 21)


Post-Mining Simulation

ResourceStrategies

CADIA EAST PROJECT

**FIGURE 4-42**

Existing View and Visual Simulations - JH Cantrill Dwelling

Cadia Holdings Pty Limited

Existing View

Full Development Simulation

CADIA EAST PROJECT

**FIGURE 4-43**

Existing View and Visual Simulation - CVO Dewatering Facility

Cadia Holdings Pty Limited

ResourceStrategies

NEC-06-66 BS VA_009C

The JC & V Hamilton dwelling (147) is located approximately 4.8 km to the south-west of the existing STSF and 9.5 km from the Cadia Hill open pit (Figure 4-36). Distant views of the existing South Waste Rock Dump and the Cadia Hill open pit are available from this dwelling (Figure 4-38). Potential visual impacts of the Project would occur later in the Project life from the subsidence zone, which would appear as an escarpment similar to the adjacent Cadia Hill open pit highwall (Figure 4-38). It is considered that the visual modification would be very low given the distance from the Project and the similarity to the existing potential visual impacts. The high viewer sensitivity would result in a low potential visual impact.

Codey's Mount is located approximately 1.5 km to the south-west of the existing STSF (Figure 4-36). Clear views of the existing South Waste Rock Dump and the NTSF embankment are available from this location (Figure 4-39). Views to the existing Cadia Hill open pit are screened by the South Waste Rock Dump (Figure 4-39).

The expansion of the tailings storage facilities would appear as a rise in the current embankment and a portion of the subsidence zone would appear as an escarpment above the level of the existing South Waste Rock Dump (Figure 4-39). The visual modification as a result of the expanded tailings storage facilities and visible portion of the subsidence zone is considered to be low. The moderate viewer sensitivity would result in a low potential visual impact. As noted in Section 4.13.1, Codey's Mount was originally nominated as a potential public lookout to view the mining operations.

The potential visual impacts would be further reduced by rehabilitating the embankments of the tailings storage facilities as shown in Figure 4-39.

*Views from the East of the Project Disturbance Areas*

Views of the existing mining operations from dwellings and the local public road network (i.e. Cadia Road) to the east are generally screened by a ridgeline and intervening vegetation, including the Canobolas State Forest.

Potential visual impacts from the Project would be in relation to the expansion of the tailings storage facilities, as the subsidence zone would primarily be screened by the intervening topography and vegetation. Glimpses of the expanded tailings storage facilities would be available where the embankments rise above the intervening topography, through gaps in the vegetation.

The MJ & RC McKenzie dwelling (2072) is situated approximately 2.3 km to the east of the existing NTSF in the Flyers Creek valley (Figure 4-36). The existing mining operations cannot be viewed from this dwelling due to the intervening topography (Figure 4-40). The top of the embankment of the expanded NTSF would appear slightly above the intervening topography where there are gaps in the surrounding vegetation (Figure 4-40). The visual modification is considered to be very low given the small portion of the embankment that could potentially be viewed. The high viewer sensitivity would result in a low potential visual impact. The potential visual impacts would also be low given the rehabilitation of the embankments of the tailings storage facilities as shown in Figure 4-40.

The JL Gill & CA Jackson dwelling (22) is situated in an elevated position approximately 1.6 km to the east of the existing South Waste Rock Dump (Figure 4-36). The existing mining operations are generally screened from this dwelling by the intervening topography and Canobolas State Forest with only distant and interrupted views of the existing tailings storage facilities through the surrounding vegetation possible from this dwelling (Figure 4-41). The potential visual impacts of the Project would be restricted to the expansion of the tailings storage facilities, of which a small portion of the NTSF would be visible in the distance to the south of the surrounding vegetation and through gaps in the surrounding vegetation. The level of visual modification is considered to be very low, with the high viewer sensitivity resulting in a low potential visual impact. The potential visual impacts would also be low given the rehabilitation of the embankments of the tailings storage facilities as shown in Figure 4-41.

The JH Cantrill dwelling (35) is situated approximately 2.6 km to the east of the existing Rodds Creek Water Holding Dam (Figure 4-36). Views of the top of the existing South Waste Rock Dump are possible from the dwelling, however the intervening topography and gardens screen views to other existing mine components (i.e. Cadia Hill open pit, NTSF and STSF) (Figure 4-42). Given that the height of the South Waste Rock Dump would not change and it would be progressively rehabilitated, the potential visual impact of the Project would be negligible (Figure 4-42).

***CVO Dewatering Facility***

Views of the CVO Dewatering Facility from the region (including Church Hill) would blend in with buildings and other infrastructure within and nearby Blayney. Views to the CVO Dewatering Facility from Blayney would be obstructed by the line of trees along the Belubula River and the Blayney Cold Storage and Distribution warehouses.

Newbridge Road and the Main Western Highway pass along the property boundary of the location of the CVO Dewatering Facility (Figure 1-3). Views from the railway line and road would be restricted to the time of passing traffic and intermittent along the road due to the intervening vegetation. Where visible, the CVO Dewatering Facility would appear similar to the existing adjacent Blayney Cold Storage and Distribution warehouses in that they would both have a large, ‘industrial’ appearance.

The junction of Newbridge Road and the Main Western Railway line is located approximately 500 m to the east of the CVO Dewatering Facility. Figure 4-43 shows that the CVO Dewatering Facility would be clearly visible from this location. However, it would appear similar to the existing Blayney Cold Storage and Distribution warehouses located approximately 150 m to the west. The level of visual modification is considered to be low given existing rail infrastructure and similar industrial buildings adjacent to the CVO Dewatering Facility. The moderate viewer sensitivity would result in a low potential visual impact.

The MC & PA Ewens dwelling is located approximately 500 m east of the CVO Dewatering Facility (Figure 1-3). The views from this dwelling would be similar to the visual simulation (Figure 4-43), however, the visual sensitivity would be high, resulting in a moderate potential visual impact.

Views to the CVO Dewatering Facility from the D Somervaille, GP Nixon & Sons Pty Ltd, and ML Gardner dwellings (Figure 1-3) would be generally obstructed by surrounding vegetation, landforms and the existing buildings at the Blayney Cold Storage and Distribution warehouses.

***Night Lighting***

Night-time mining activities for the Project would be located underground and would not be visible from the surface. Waste rock dumping activities on the South Waste Rock Dump would reduce during the life of the Project, which would reduce night lighting emissions from the dump.

However, the re-aligned Cadia Hill access road would be partially located on the South Waste Rock Dump. This has the potential to increase vehicular light emissions, particularly to the south of the Cadia Valley.

The upgraded ore processing facilities, concrete batch plant and heavy vehicle workshop would be located in the same area as the existing infrastructure. Overhead night lighting from the new Project components is not expected to noticeably increase the existing glow emitted from the area.

The CVO Dewatering Facility would require some night lighting for walkways and external stockpiling activities. The lighting is expected to be similar to that emitted from the existing Blayney Dewatering Facility.

### 4.13.3 Mitigation Measures and Management

Potential visual impacts are currently managed in accordance with the LMP (CHPL, 2009a) and the Lighting Management Plan (CHPL, 2009f). Current management measures include progressive rehabilitation, vegetation screens, architecture, and night lighting management, which would continue to be implemented for the Project.

***Progressive Rehabilitation***

Progressive rehabilitation would be undertaken throughout the life of the Cadia Valley Operations. Rehabilitation of the tailings storage facilities, South Waste Rock Dump, and other mine infrastructure areas (e.g. ore processing facilities, workshops, etc.) would include revegetation with pasturelands and woodlands. Further details of proposed rehabilitation activities are provided in Section 5 and Appendix P.

***Vegetation Screens***

Maintenance of the existing vegetation screens (e.g. addition and replacement of plants where required) would continue to be undertaken. An increase in screening effect over time as plants grow would continue as a result.

If required, additional vegetative screens would be planted at nearby dwellings and/or along public roads and vantage points in consultation with landholders and community groups. For example, it is envisaged that a screen would be planted along the western perimeter fence at the CVO Dewatering Facility to screen potential views from the west.

Further details of proposed revegetation activities are provided in Section 5 and Appendix P.

***Architecture***

The architectural detailing of proposed buildings is important in moderating potential visual impacts of the facilities and their relationship with the surrounding environment. Although largely obscured from view from public access points, the application of consistent detailing and colour selection (as for existing Cadia Valley Operations buildings) would assist in assimilating these buildings into the adjoining landscape.

***Night Lighting***

The lighting for the Project would have limited additional visual impact due to the use of a common infrastructure area and the use of underground mining methods.

Lighting for the Project would seek to minimise light emissions by means of shrouding and reflectors whilst ensuring that operational safety is not compromised.

Specifically, measures that would be employed to mitigate potential impacts from night lighting would include one or more of the following, where practicable:

- restriction of night lighting to the minimum required for operations and safety requirements, where appropriate;
- use of unidirectional lighting techniques;
- use of light shields to limit the spill of lighting;
- provision of curtains, cladding and/or screens at nearby dwellings to help screen any potential night-time lighting impacts, in consultation with the landholder; and
- planting of trees at nearby dwellings to help screen any potential night-time lighting impacts, in consultation with the landholder.

## 4.14 HAZARD AND RISK

A PHA was conducted to evaluate the hazards associated with the Project (Appendix M). The PHA is a requirement of SEPP 33 (Attachment 3) and was conducted in accordance with the general principles of risk evaluation and assessment provided in the DUAP *Multi-Level Risk Assessment Guidelines* (1999).

### 4.14.1 Existing Measures

A number of hazard prevention and mitigation measures are described in the following existing Cadia Valley Operations management documents and systems:

- Major Hazard Management Plan;
- Safety Management Plans;
- Contractor Management Plan;
- IESCP;
- BMP;
- Chemalert (a system that contains details of chemicals stored on-site);
- Emergency Management Plan; and
- Farm Safety Management Plan and Farm Safety Manual.

### 4.14.2 Hazard Identification and Risk Assessment

Potentially hazardous materials required for the Project include hydrocarbons (diesel, oils, greases, degreaser and kerosene), explosives, reagents, chemicals and gas cylinders. The 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 M) and potential incidents were identified and divided into generic classes for each operational area including:

- leaks/spills;
- fire/explosions;
- accident;
- contamination;
- power failure; and
- theft.

Other classes of incidents identified included:

- subsidence zone;
- earth tremor;
- dam failure; and
- sediment dam failure.

The potential risks identified in the PHA related to the following Project elements/activities:

- transport to site;
- on-site usage;
- construction/development;
- underground mining operations;
- waste rock management;
- ore treatment and processing;
- concentrate slurry transport;
- CVO Dewatering Facility operations;
- off-site rail of product;
- tailings management;
- water management; 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 construction and operation of the Project was undertaken (Appendix M).

An assessment of the combination of the consequence and probability rankings concluded that the overall risk rankings for the identified hazards would be low, and therefore tolerable.

Proposed preventative and control measures to address potential hazards are discussed in Section 4.14.3.

#### 4.14.3 Hazard Prevention and Mitigation Measures

The management plans described in Section 4.14.1 would be revised where necessary to address the Project requirements. Specific hazard treatment and mitigation measures would also be described in new management plans for the Project, where required.

In addition, the following hazard mitigation and/or preventative measures would be adopted by CHPL to reduce the likelihood and/or consequences of potentially hazardous incidents associated with the Project:

- **Maintenance** – Ongoing and timely maintenance of all 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 CHPL would be required to operate in accordance with the relevant Australian Standards, NSW Legislation and CHPL'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.