Section 4B

Environmental Features, Management Measures and Impacts

This section describes the specific environmental features of the Mine Site and its surrounds that would or may be affected by the proposed Stage 2 Longwall Project. Information on existing conditions, proposed safeguards and controls and potential impacts the project may have after implementation of these measures is presented for those issues identified in Section 3 as being of greatest significance.

Where appropriate, proposed monitoring programs are also described.

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4B.1 SUBSIDENCE

The Mine Subsidence Predictions and Impact Assessment was undertaken by Ditton Geotechnical Services Pty Ltd. The full assessment is presented in Volume 1 Part 1 of the Specialist Consultant Studies Compendium, with the relevant information from the assessment summarised in the following subsections. The full assessment is referred to as DGS (2009) throughout this report. A peer review of the predicted subsidence was undertaken by Dr Bruce Hebblewhite. A copy of the review is included behind the subsidence assessment in the compendium.

4B.1.1 Introduction

Based on the risk analysis undertaken for the proposed Longwall Project (see Section 3.3 and **Table 3.5**), the potential environmental impacts related to subsidence requiring assessment and their unmitigated risk rating are as follows.

- Damage or destruction of structures / infrastructure (high risk).
- Alteration of local drainage resulting in ponding, realignment or other impacts on local drainage (moderate to high risk).
- Increased erosion along drainage lines and subsequent decrease in water quality (moderate risk).
- Change to structure or composition of vegetation communities and fauna habitat (high risk).
- Reduced availability of groundwater as a result of fracturing altering hydrogeological flow paths (high risk).
- Disturbance of, or damage to, Aboriginal sites or artefacts (moderate risk).

In addition, the Director-General's Requirements issued by DoP identifies subsidence as a key issue for consideration within the *Environmental Assessment*.

The following subsections present a summary of existing conditions and impacts associated with subsidence, the method of assessment, predictions of subsidence and subsidence related impacts, the proposed management of identified sites and an assessment of the significance of the residual impacts (once the proposed management measures are implemented).

4B.1.2 The Existing Environment

4B.1.2.1 Surface Features

An overview of the principal surface features relating to the proposed mine subsidence is outlined as follows.

As noted in Section 4A.3.2, the Mine Site comprises privately owned land, the majority of which is owned by the Proponent and related companies, ie. 3 825ha or approximately 75% of the total area of ML1609. A small proportion of the Mine Site, predominantly with the southwestern corner, occurs within NSW State Forests (Jacks Creek and Pilliga East Stage

Forests). The Mine Site is used primarily for livestock grazing with some cereal crop farming over the eastern half of the Mine Site. The western half of the Mine Site is covered by native woodlands and the Jacks Creek and Pilliga East State Forests.

As noted in Section 4A.1.2, the terrain of the Mine Site is generally flat to undulating in the east with two low-level ridges with moderate slopes (up to 18^{o}) in the west. Two ephemeral creeks (Kurrajong Creek and Pine Creek) and their tributaries drain towards the northeast across ML1609. Elevations above the mining area vary from 270m AHD above the eastern longwall panels to 370m AHD above the western longwall panels.

The maximum slope of approximately 18^{o} occurs along the northeast-southwest trending ridge, with the minimum slopes of $<1^{o}$ common in the northeast, on ridge crests, foot slopes, valley floors and creek channels. No cliff lines are present above the mining area. **Figure 4B.1** illustrates the elevations, slopes and drainage features of the Mine Site.

In order to accurately predict impacts related to subsidence, DGS (2009) assembled an inventory of significant surface, natural and archaeological features. DGS (2009) has identified the following features of significance on the Mine Site.

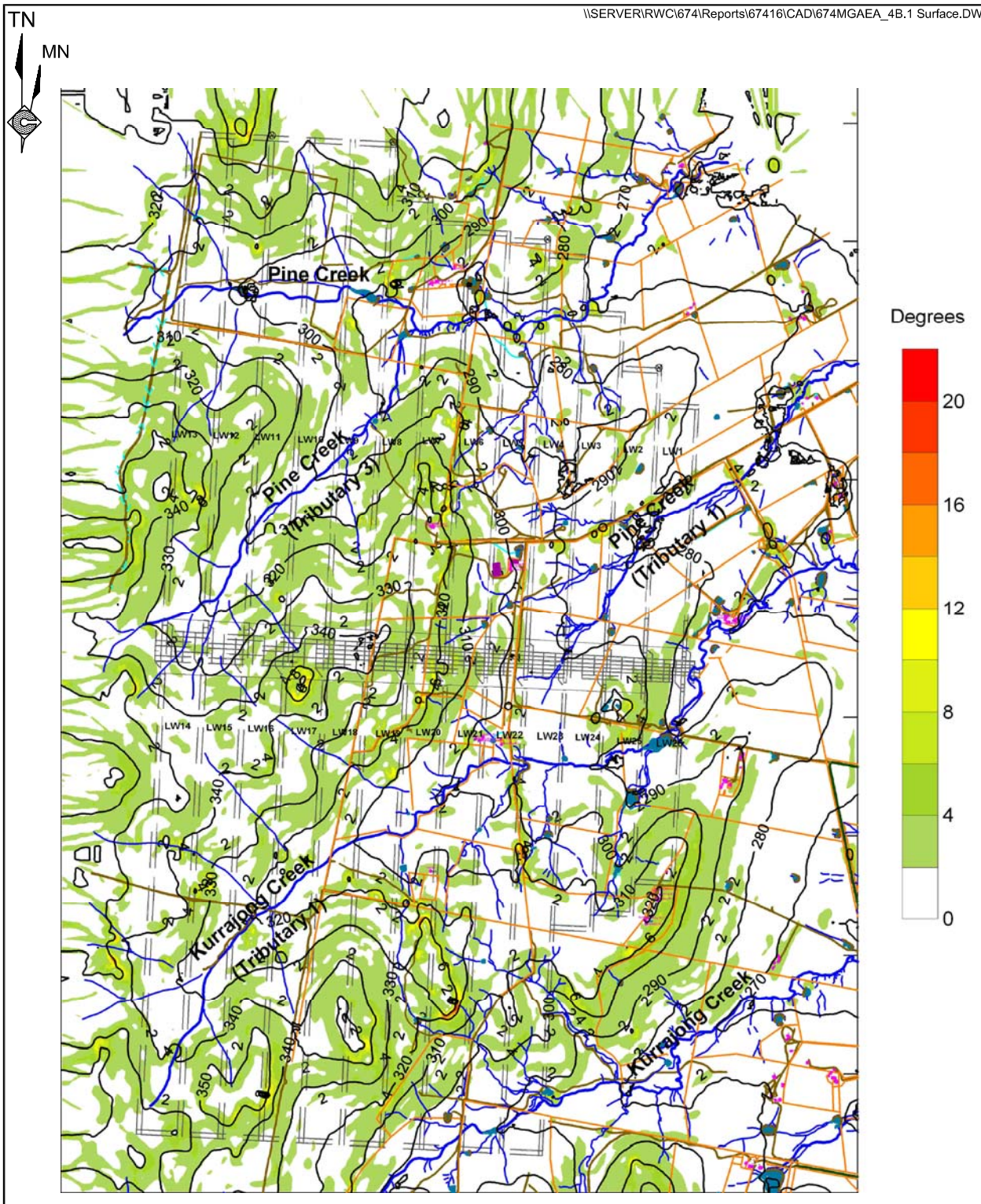
Natural Features

- The ephemeral tributaries that form the headwaters of Pine Creek (located above the northern longwalls) and Kurrajong Creek (located above the southern longwalls). All tributaries of the two creeks drain the Mine Site generally in a northeasterly direction.
- Sandy alluvial deposits (up to 15m deep) are present along the creek channels with virtually no rock exposures evident.
- The silty sand and sandy clay surface soils present on the Mine Site display moderate erodibility and may be susceptible to erosion if exposed to concentrated runoff.
- Vegetation over the relatively undisturbed western half of the underground mine area consists of low mallee woodland with a dense shrub layer to open forest with sparse shrub layer. This vegetation merges with the cleared agricultural land to form partially cleared and disturbed woodland dominated by species adapted to, or tolerant of drier conditions, with occasional inundation due to flooding. Riparian zones along creeks within the predominantly cleared agricultural land over the eastern two thirds of the Mine Site provide partially cleared but relatively intact open forest to woodland dominated by casuarinas and species adapted to higher water availability. Section 4B.4 provides further detail on the vegetation of the Mine Site.
- Notably, there is a lack of significant rock outcropping or rock features such as caves or overhangs on the Mine Site.

Archaeological Features

- Aboriginal heritage features that are present across the Mine Site include open scatters of up to 100+ artefacts, isolated artefacts, axe grinding grooves and scarred trees. Section 4B.5.3 provides greater detail on the type and distribution of Aboriginal Sites across the Mine Site.

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SCALE 1:50 000

0.5 0 0.5 1.0 1.5 2.0 2.5 km

Source: DGS (2009) - Figure 5

Figure 4B.1
MINE SITE SURFACE ELEVATIONS, SLOPES AND DRAINAGE FEATURES

Developed Features

Buildings, in particular residences, on the rural properties above the underground mine area. **Figure 4A.4** provides the locations of the three residences above the underground mine, all of which are owned by Narrabri Coal Pty Ltd.

- Soil conservation structures, eg. contour banks.
- Earth embankment dams for the watering of livestock.
- Unsealed gravel access roads and access tracks.
- Property boundary-line fences.
- Single-phase suspended power lines (for domestic power supply).
- Suspended Telstra telephone lines.

These features have all been considered in the assessment of subsidence-related impacts.

4B.1.2.2 Sub-Surface Conditions

Subsidence is influenced not only by the type and scale of longwall mining, but also by the type and condition of the geological strata above the area mined. The following considers the sub-surface conditions, specifically with respect to how these conditions may influence the prediction of subsidence.

As noted in Section 2.2.1, the Mine Site is situated within the Mullalley Sub-basin, which is in the northern part of the Gunnedah Basin. The sub-basin contains Permian to Jurassic Age sedimentary and igneous strata overlying the Hoskissons Coal Seam, which generally dips westwards at approximately 2^{o}. Several northwest to southwest and northeast to northwest trending normal and reverse faults, which have throws ranging from 1m to 5m, ie. less than half the coal seam thickness, have been identified within the mining area. A typical profile of the Mine Site stratigraphy is provided by **Figure 2.3**.

Typically, the geological strata above the Hoskissons Coal Seam comprises thin to medium bedded siltstone / sandstone laminite with minor claystone (Pilliga Sandstone, Purlawaugh Formation and Napperby Formation) between several massive 15m to 40m thick units of conglomerate (Digby Formation), basalt sills and lava flows (Garrawilla Volcanics). The depth of cover above the Hoskissons Coal Seam ranges from 160m to 380m with the depth of weathering typically varying from about 15m to 35m from the surface. Through a review of the available exploration data, DGS (2009) determined that the potential subsidence reducing 'massive' units in the overburden are the conglomerate of the Digby Formation, the intrusive basalt sill in the Napperby Formation and basalt lava flows of the Garrawilla Volcanics.

A summary of the thickness of the massive units in descending order from surface is presented in **Table 4B.1**.

Table 4B.1
Summary of Massive Strata Units of the Mining Area

Lithological Unit	Massive Unit Thickness (m)	Unit Distance Above the Mining Area (m)	Laboratory UCS Strength Range (Mean) (MPa)
Garrawilla Volcanics*	1 to 62	110 to 250	65 to 252 (140)
Basalt Sill of the Napperby Formation	7 to 27	44 to 80	91 to 189 (140)
Digby Conglomerate	13 to 25	0 to 34	21 to 42 (28)
Note *: The top 1m to 3m may be affected by weathering. Unit may have a maximum thickness of 20m			
Source: Modified after DGS (2009) – Table 1			

Each of the three geological units above the Hoskissons Coal Seam has been assessed for their potential for bridging behaviour. DGS (2009) determined (based on strength testing, empirical data base and an analytical Voussoir Beam model) that only the Garrawilla Volcanics has the potential to bridge the longwall panels and therefore reduce subsidence.

4B.1.3 Subsidence Development Mechanism

After the extraction of coal within a longwall panel, the immediate mine roof usually collapses into the void left by the removal of the coal. The overlying strata or overburden then sags down onto the collapsed material, resulting in settlement of the land surface. **Figure 4B.2** provides an illustration of this mechanism which is discussed in more detail, as follows.

As illustrated on **Figure 4B.2**, the maximum subsidence would occur in the middle of the extracted panel and would be dependent on the following.

- The height of the longwall panel which determines the height of the initial collapse. The longwall panels would be 4.2m high while the gate road headings and chain pillars between the panels would be 3.5m in height.
- The cover depth above each longwall panel influences rock fracture, swelling and bridging, all of which reduce the effect of the initial collapse with height. As noted in Section 4B.1.2.2, cover depths range from 160m in the east up to 380m in the west with a single row of chain pillars to be left between the extracted longwall blocks. The widths of the chain pillars would increase with cover depth from 24.6m in the east to 37.6m in the west.
- The geological properties of the strata above the collapsed section of mine including any massive structures above the longwall panel would influence the bulking characteristics of the collapsed strata, as well as any 'bridging' by the massive units over collapsed rock beneath it. As noted in Section 4B.1.2.2, only the Garrawilla Volcanics are likely to bridge over collapsed strata lower in the sequence.
- Features of surface geology and topography may exacerbate the impacts of surface subsidence through cracking or impacts on structurally vulnerable features such as creeks, caves, overhangs etc.

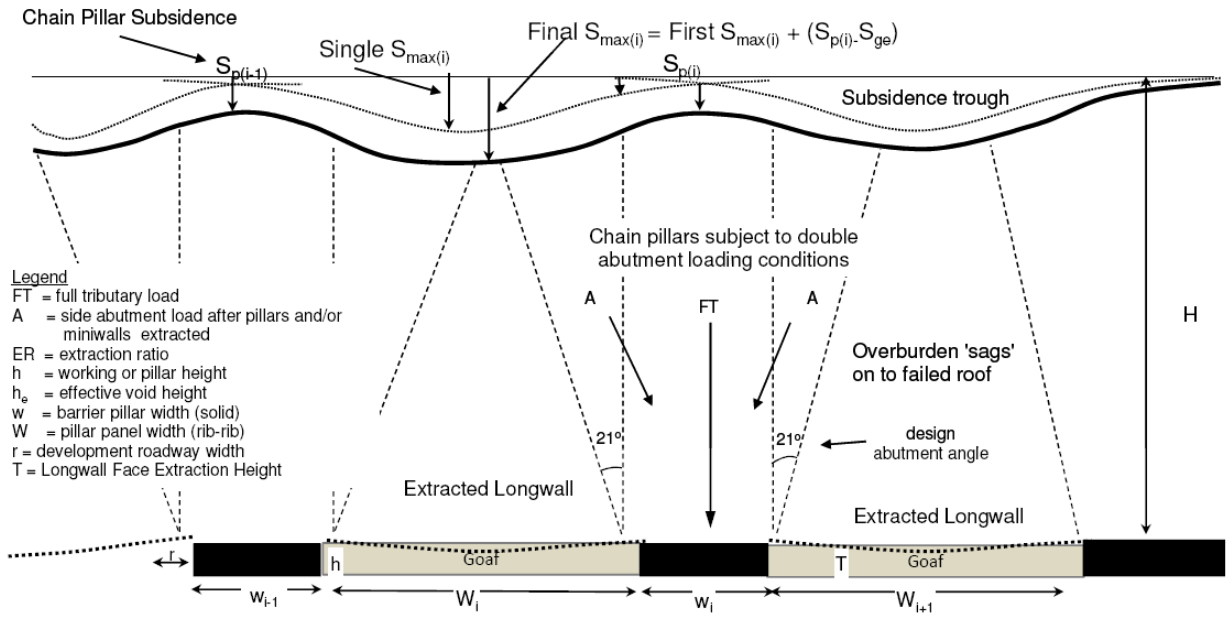


Figure 4B.2
LONGWALL PANEL SUBSIDENCE MECHANISM

Source: DGS (2009) – Figure 13

The combination of the above factors determines whether a single longwall panel would be sub-critical, critical or supercritical in terms of maximum subsidence. The terms sub-critical, critical or supercritical are defined as follows.

- Sub-critical subsidence refers to panels that are narrow and deep enough for the overburden to bridge or 'arch' across the extracted panel regardless of geology. It is also termed 'geometrical' or 'deep beam arching'.
- Critical subsidence refers to panels that are unable to arch without the presence of massive, competent strata, ie. the strata above the panel sags down onto the collapsed or caved roof strata immediately above the extracted seam. If relatively thick and strong massive strata exist, then 'critical arching' or 'shallow Voussoir beam' behaviour can occur for panel W/H ratios up to1.8.
- Supercritical panels refer to panels with widths that cause complete collapse of the overburden.

In Australian coalfields, sub-critical or (geometrical arching) behaviour generally occurs when the panel width (W) is <0.6 times the cover depth (H) and supercritical when W:H > 1.4. Critical behaviour usually occurs between W/H ratios of 0.6 and 1.4 and represents the transition between 'geometrical arching' to 'shallow beam bending' to 'complete failure' of the overburden. The maximum subsidence for sub-critical and critical panel widths is < 60% of the longwall extraction height and could range between 10% and 40% (of the extraction height).

With an ultimate panel width of 305m (including the gate road heading either side) and cover depth of between 160m and 380m, the W/H ratio varies from 0.8 in the west to 1.9 in the east and falls outside the sub-critical range. However, it is possible that the Garrawilla Volcanics may bridge over the collapsed lower strata creating sub-critical behaviour in some or all of the longwall panels. This assessment has considered both sub-critical and critical longwall behaviour.

The surface effect of extracting several adjacent longwall panels is dependent on the stiffness of the overburden and the dimensions of the chain pillars left between the panels. Invariably, 'extra' subsidence occurs above a previously extracted panel and is caused primarily by the compression of the chain pillars and adjacent strata between the extracted longwall panels.

A longwall chain pillar undergoes the majority of life-cycle compression when subject to double abutment loading, ie. the formation of goaf on both sides of it, after two adjacent panels have been extracted. Surface survey data indicates that an extracted panel can affect the chain pillars between three or four previously extracted panels. The stiffness of the overburden and chain pillar system would determine the extent of load transfer to the preceding chain pillars. If the chain pillars go into yield, the load on the pillars would be mitigated to some extent by load transfer to adjacent fallen roof material or goaf.

The surface subsidence would extend beyond the limit of underground mining for a certain distance (i.e. the angle of draw). The angle of draw distance is usually less than or equal to 0.5 to 0.7 times the depth of cover (or angles of draw to the vertical of 26.5^{o} to 35^{o}) in the NSW and Queensland Coalfields.

4B.1.4 Potential Impacts and Management Issues

As a result of subsidence, the following impacts could be expected. Each of these is considered in relation to the subsidence predictions of DGS (2009) in Section 4B.1.6.

Surface Cracking

The development of surface cracking above a longwall panel is caused by the bending of the overburden strata as it sags down into the newly created void in the coal seam. The sagging strata is initially supported by previously collapsed roof material (goaf), which then slowly compresses to a maximum subsidence.

The tensile fractures generally occur between the chain pillars and the point of inflexion, which is where convex curvatures and tensile strains would develop. Compressive shear fractures or shoving zones would generally also develop in the area above the longwall panel and inside the inflexion points.

Sub-surface Cracking

The caving and subsidence development processes above a longwall panel usually results in sub-surface fracturing and shearing of sedimentary strata in the overburden (see **Figure 4B.2**). The extent of fracturing and shearing is dependent on mining geometry and overburden geology. As illustrated on **Figure 4B.2**, sub-surface fracturing may be defined as either 'continuous' or 'discontinuous' hydraulic fracturing.

Continuous sub-surface fracturing refers to cracking above a longwall panel that would provide a direct flow-path or hydraulic connection to the workings if a sub-surface aquifer (or surface) were intersected. The presence of sub-surface aquifers above the workings and within the continuous fracture zone could therefore result in increased water inflow into the seam level during longwall extraction.

Discontinuous fracturing refers to the additional extent above a longwall to which there could be a general increase in horizontal and vertical permeability, due to bending or curvature deformation of the rock mass. This type of fracturing does not usually provide a direct flow path or connection to the workings, however, it is possible that they would interact with surface cracks, joints, or faults. This type of fracturing can also result in an adjustment of:

- surface and sub-surface flow paths; and
- rock mass conductivity and storage magnitudes, but may not result in a significant change to the groundwater or surface water resource in the long-term.

Slope Stability and Erosion

As a consequence of changes in surface slopes and drainage paths, erosion may be accelerated leading to possible en-masse sliding, ie. a landslip, of the ridges or hills of the Mine Site. The occurrence or scale of erosion and/or landslip is likely to be influenced by soil type and pre-subsidence slopes with dispersive soils and slopes >10º more susceptible to these impacts.

Valley Closure and Uplift

'Valley closure' (or opening) movements can be expected along cliffs and sides of deep valleys wherever longwalls are mined beneath them. Valley closure can also occur across broader drainage gullies where shallow surface rock is present.

When creeks and river valleys are subsided, the observed subsidence in the base of the creek or river is generally less than would normally be expected in flat terrain. This reduced subsidence is due to the floor rocks of a valley buckling upwards when subject to compressive stresses generated by surface deformation. This phenomenon is termed as 'valley uplift'. In most cases in the Newcastle and Southern NSW Coalfields, the observed uplift has extended outside steep sided valleys and included the immediate cliff lines and the ground beyond them.

Ponding and Other Impacts on Local Drainage

Surface slopes in the elevated areas of the Mine Site range between 1° and 18° and are unlikely to be affected by ponding caused by closed form depressions from subsidence trough development, ie. the net fall across the area would therefore be sufficient to allow surface drainage to continue unimpeded after mining is completed.

Some watercourses present within the Mine Site, however, occur where the surface slope is considerably less than 1º and these could be susceptible to potential ponding depths of between 0.5m and 1.5m. The actual ponding depths would depend upon several other factors, such as rain duration, surface cracking and effective percolation rates of the surface soils and fractured rock bars/outcrops along the creeks.

In some instances, the ponding effect could result in a change to the alignment of the creek or tributary. This could impact on local erosion processes and impact on the vegetation along the pre-subsidence and altered drainage line.

Far-Field Horizontal Displacements

Horizontal movements due to longwall mining have been recorded at distances well outside of the angle of draw in the Newcastle, Southern and Western Coalfields. Horizontal movements recorded beyond the angle of draw are referred to as far-field horizontal displacements.

This phenomenon is strongly dependent on:

- cover depth;
- distance from the goaf edges;
- the maximum subsidence over the extracted area;
- topographic relief; and
- the horizontal stress field characteristics.

An empirical model for predicting Far-field displacement (FFDs) indicates that measurable FFD movements, ie. 20mm, generally occur in relatively flat terrain for distances up to three to four times the cover depth. The direction of the movement is generally towards the extracted area, but can vary due to the degree of regional horizontal stress adjustment around extracted area and the surface topography.

Aboriginal Artefacts

As a consequence of the potential impacts identified above, in particular surface cracking, Aboriginal artefacts may be damaged or vertically or laterally displaced.

Surface Infrastructure

As a consequence of the changing elevation caused by subsidence, or the potential impacts such as surface cracking and erosion resultant from erosion, surface infrastructure such as houses and other buildings, roads, pipelines, services (eg. power / telephone) and water management structures such as dams and contour banks may be damaged.

4B.1.5 Subsidence Modelling

4B.1.5.1 Subsidence Prediction Methodology

Subsidence Models

DGS (2009) used two empirically based prediction models (ACARP, 2003 and SDPS®, 2007) to generate subsidence contours above the proposed longwall panels after mining is complete. A summary of these two models is as follows.

- **ACARP, 2003.** An empirical model originally developed for predicting maximum single and multiple longwall panel subsidence, tilt, curvature and strain in the Newcastle Coalfield. The model database included measured subsidence parameters and overburden geology data which have been back analysed to predict the subsidence reduction potential (SRP) of massive lithology in terms of 'Low', 'Moderate' and 'High' SRP categories.

- The model database also includes chain pillar subsidence, inflexion point distance / subsidence, goaf edge subsidence and angle of draw prediction models, which allow subsidence profiles to be generated for any number of panels and a range of appropriate confidence limits. The Upper 95% Confidence Limit (U95%CL) has been adopted in this study for predictions of the Credible Worst-Case values.
- The model has been recently updated by Ditton Geotechnical Services Pty Ltd to allow the original model to be applied to other Australian Coalfields (including the Gunnedah Basin) due to its generic nature. DGS (2009) provides the detail of the model modification undertaken to improve compatibility between the ACARP, 2003 prediction model and the SDPS®, 2007 model.
- **SDPS®, 2007.** Developed as an influence function model for subsidence predictions above longwalls or pillar extraction panels. The model requires calibration to measured subsidence profiles to reliably predict the subsidence and differential subsidence profiles required to assess impacts on surface features.
- The value of this model is that it includes a database of percentage of hard rock, ie. massive sandstone / conglomerate, that effectively reduces subsidence above super-critical and sub-critical panels due to either bridging or bulking of collapsed material.
- Subsidence, tilt, horizontal displacement, and strain contours were ultimately produced using the modelled results of the SDPS®, 2007 model.

Further detail on the use of both models for the proposed Longwall Project is provided by DGS (2009).

Modelling Methodology

Using the two empirical prediction models, DGS (2009) produced total and differential subsidence predictions across the Mine Site at the following time sequence intervals:

- after each longwall block has been extracted, and
- after mining of all of the proposed longwall panels is complete.

Without prior experience longwall mining the Hoskissons Coal Seam, the following parameters influencing subsidence were considered.

- The subsidence reduction potential (SRP) of the overburden and the influence of proposed mining geometry on single panel subsidence development, ie. whether the panels are likely to be sub-critical, critical or supercritical. As noted in Section 4B.1.2.2, the Garrawilla Volcanics displays spanning potential that may influence the development of subsidence impacts, although the level of this influence is not known.
- The behaviour of the chain pillars and immediate roof and floor system under double-abutment loading conditions when longwall panels have been extracted along both sides of the pillars.

- The combined effects of single panel and chain pillar subsidence to estimate final subsidence profiles and subsidence contours for subsequent environmental impact assessment.
- In order to account for these uncertainties in model parameters and subsidence development, DGS (2009) considered the modelling predictions of the following three cases.
  - Case 1: Non-spanning Garrawilla Volcanics and maximum chain pillar subsidence.
  - Case 2: Spanning Garrawilla Volcanics (where thick enough) and maximum chain pillar subsidence.
  - Case 3: Non-spanning Garrawilla Volcanics and minimum chain pillar subsidence.

DGS (2009) based maximum panel and chain pillar subsidence predictions for the three cases on 'Credible Worst Case' values derived from ACARP (2003). The term 'Credible Worst Case' infers that the predictions would be exceeded by 5% of panels mined with similar geometry and geology etc., and is identified as the Upper 95% Confidence Limit (U95%CL) value.

Minimum values have been based on the 'mean' values derived from the ACARP (2003). The term 'mean' infers that the predictions would be exceeded by 50% of panels mined with similar geometry and geology etc., and is identified as the 50% Confidence Limit value.

4B.1.5.2 Results of Subsidence Modelling

DGS (2009) predicts single panel, chain pillar, goaf edge and multi-panel subsidence values for each of the three modelled cases.

Single Panel Subsidence

Based on an assumed SRP of 'Low', 'Moderate' and 'High', and a longwall extraction height (T) of 4.2m, DGS (2009) provides the predicted single panel subsidence for each longwall panel. **Table 4B.2** provides the mean and U95%CL subsidence for Cases 1 and 2 predicted by DGS (2009).

Table 4B.2
Predicted Maximum Single Panel Subsidence

Page 1 of 2

Longwall Panel No.	Cover Depth (m)	W/H	Unit (m)	SRP	Case 1		Case 2	
					Mean	U95%CL	Mean	U95%CL
1	165	1.85	30	H	2.40	2.44	1.93	2.14
2	175	1.75	30	H	2.44	2.44	1.81	2.02
3	195	1.57	20	M	2.41	2.44	2.19	2.40
4	210	1.45	15	L	2.33	2.44	2.33	2.44
5	230	1.33	20	H	2.24	2.44	1.93	2.14
6	250	1.22	35	H	2.18	2.39	1.75	1.96
7	275	1.11	40	M	2.12	2.33	1.96	2.33
8	290	1.05	40	M	2.06	2.27	1.87	2.27
9	290	1.05	40	M	2.06	2.27	1.87	2.27
10	300	1.02	40	M	2.02	2.23	1.81	2.23

Table 4B.2 (Cont'd)
Predicted Maximum Single Panel Subsidence

Longwall Panel No.	Cover Depth (m)	W/H	Unit (m)	SRP	Case 1		Case 2	
					Mean	U95%CL	Mean	U95%CL
11	310	0.99	40	L	1.99	2.20	1.99	2.20
12	330	0.93	35	L	1.92	2.13	1.92	2.13
13	360	0.85	30	L	1.80	2.01	1.80	2.01
14	365	0.84	35	L	1.77	1.98	1.77	1.98
15	345	0.89	38	L	1.88	2.09	1.88	2.09
16	335	0.91	42	M	1.91	2.12	1.64	1.85
17	310	0.99	42	M	1.99	2.20	1.76	1.97
18	290	1.05	42	M	2.06	2.27	1.87	2.08
19	265	1.15	41	M	2.14	2.35	1.96	2.17
20	251	1.22	30	L	2.19	2.40	2.18	2.39
21	230	1.33	25	M	2.24	2.44	1.93	2.14
22	215	1.42	20	M	2.31	2.44	2.01	2.22
23	200	1.53	20	M	2.38	2.44	2.14	2.35
24	200	1.53	20	M	2.38	2.44	2.14	2.35
25	195	1.57	20	M	2.41	2.44	2.19	2.40
26	185	1.65	25	M	1.77	1.98	2.25	2.44

Source: Modified after DGS (2009) – Table 3

Chain Pillar Subsidence

The predicted mean and maximum subsidence values above the proposed chain pillars (under double abutment loading conditions and a mining height of 4.2m) predicted by the empirical modelling of DGS is summarised in **Table 4B.3**.

Table 4B.3
Predicted Chain Pillar Subsidence

Longwall Panel No.	Cover Depth (m)	Chain Pillar Width (m)	Chain Pillar Stress (MPa)	Pillar FoS under DA[1] Loading Conditions	Subsidence			
					Cases 1 and 2		Case 3	
					Initial Subsidence (U95%CL)	Final Subsidence (U95%CL)	Initial Subsidence (mean)	Final Subsidence (mean)
1	165	24.6	17.3	1.51	0.46	0.51	0.26	0.31
2	175	24.6	19.8	1.32	0.53	0.59	0.33	0.39
3	195	24.6	23.3	1.13	0.63	0.72	0.43	0.51
4	210	29.6	23.2	1.42	0.63	0.71	0.43	0.51
5	230	29.6	27.0	1.22	0.75	0.86	0.55	0.66
6	250	29.6	31.5	1.05	0.89	1.03	0.69	0.82
7	275	29.6	36.0	0.92	1.00	1.16	0.80	0.96
8	290	34.6	33.6	1.24	0.94	1.09	0.74	0.89
9	290	34.6	34.4	1.21	0.96	1.12	0.76	0.91
10	300	34.6	36.5	1.14	1.01	1.17	0.81	0.97
11	310	37.6	37.1	1.28	1.02	1.18	0.82	0.98
12	330	37.6	42.2	1.13	1.10	1.28	0.90	1.08
14	365	37.6	45.1	1.05	1.13	1.32	0.93	1.11
15	345	37.6	41.7	1.14	1.09	1.27	0.89	1.07
16	335	34.6	40.8	1.02	1.08	1.26	0.88	1.06
17	310	34.6	35.9	1.16	1.00	1.16	0.80	0.95
18	290	34.6	31.5	1.32	0.89	1.03	0.69	0.82
19	265	29.6	30.7	1.08	0.86	1.00	0.66	0.79
20	245	29.6	27.1	1.22	0.75	0.86	0.55	0.66
21	230	29.6	24.2	1.37	0.66	0.75	0.46	0.55

Table 4B.3 (Cont'd)
Predicted Chain Pillar Subsidence

Page 2 of 2

Longwall Panel No.	Cover Depth (m)	Chain Pillar Width (m)	Chain Pillar Stress (MPa)	Pillar FoS under DA[1] Loading Conditions	Subsidence			
					Cases 1 and 2		Cases 1 and 2	
					Initial Subsidence (U95%CL)	Initial Subsidence (U95%CL)	Initial Subsidence (U95%CL)	Initial Subsidence (U95%CL)
22	215	29.6	21.5	1.54	0.58	0.65	0.37	0.45
23	200	24.6	23.0	1.14	0.62	0.71	0.42	0.50
24	200	24.6	22.6	1.16	0.61	0.69	0.41	0.49
25	180	24.6	21.2	1.23	0.57	0.64	0.37	0.44

Notes:
1. DA = Double abutment loading conditions.
2. The chain pillars referred to in the above table are on the Maingate side. As LW13 and LW26 are the last panels mined in the northern and southern panel series, they would not be subject to double abutment loading conditions, because they are adjacent to solid coal

Source: Modified after DGS (2009) – Table 4

The predicted initial subsidence over the chain pillars between the extracted panels is estimated to range from 0.26m to 1.32m for the range of pillar sizes and geometries proposed. The final subsidence over the chain pillars (after mining is completed) is estimated to range from 0.31m to 1.58m (an overall increase of 20%).

Goaf Edge Subsidence

DGS (2009) reports the mean and maximum goaf edge subsidence to be 0.07m to 0.58m respectively.

Multiple Panel Subsidence

Based on the single panel, chain pillar and goaf edge subsidence predictions, **Tables 4B.4** and **4B.5** present the maximum (Credible Worst Case) first and final maximum multi-panel subsidence predictions (and associated impact parameters) for Cases 1 and 2.

Table 4B.4
Predicted Credible Worst-Case First and Final Maximum Panel Subsidence Parameters (Case 1)

Page 1 of 2

Longwall Panel No.	Cover Depth (m)	Panel Width: Cover Depth Ratio	Predicted Subsidence					Max Tilt T_{max} (mm/m)	Max Curvature, C_{max} (km^{-1})		Maximum Strain, E_{max} (mm/m)*	
			Final Goaf Edge (m)	Single Panel S_{max} (m)	First Pillar S_p (m)	First Panel S_{max} (m)	Final Panel S_{max} (m)		Convex	Concave	Tensile	Compressive
1	165	1.85	0.22	2.44	0.46	2.44	2.44	45	1.05	1.36	11	14
2	175	1.75	0.22	2.44	0.53	2.44	2.44	41	0.95	1.20	9	12
3	195	1.57	0.22	2.44	0.63	2.44	2.44	35	0.76	0.97	8	10
4	210	1.45	0.22	2.44	0.63	2.44	2.44	32	0.63	0.84	6	8
5	230	1.33	0.24	2.44	0.75	2.44	2.44	30	0.56	0.78	6	8
6	250	1.22	0.28	2.39	0.89	2.44	2.44	30	0.55	0.78	5	8
7	275	1.11	0.34	2.33	1.00	2.44	2.44	30	0.53	0.78	5	8
8	290	1.05	0.38	2.27	0.94	2.44	2.44	30	0.52	0.78	5	8
9	290	1.05	0.38	2.27	0.96	2.44	2.44	30	0.52	0.78	5	8
10	300	1.02	0.40	2.23	1.01	2.44	2.44	30	0.51	0.78	5	8
11	310	0.99	0.43	2.20	1.02	2.44	2.44	30	0.50	0.78	5	8
12	330	0.93	0.49	2.13	1.10	2.44	2.44	30	0.48	0.78	5	8
13	360	0.85	0.58	2.01	-	2.40	2.44	30	0.45	0.78	5	8

Table 4B.4 (Cont'd)
Predicted Credible Worst-Case First and Final Maximum Panel Subsidence Parameters (Case 1)

Longwall Panel No.	Cover Depth (m)	Panel Width: Cover Depth Ratio	Predicted Subsidence					Max Tilt T_{max} (mm/m)	Max Curvature, C_{max} (km^{-1})		Maximum Strain, E_{max} (mm/m)*	
			Final Goaf Edge (m)	Single Panel S_{max} (m)	First Pillar S_p (m)	First Panel S_{max} (m)	Final Panel S_{max} (m)		Convex	Concave	Tensile	Compressive
14	365	0.84	0.59	1.98	1.13	2.04	2.44	30	0.44	0.78	4	8
15	345	0.89	0.53	2.09	1.09	2.44	2.44	30	0.47	0.78	5	8
16	335	0.91	0.50	2.12	1.08	2.44	2.44	30	0.48	0.78	5	8
17	310	0.99	0.43	2.20	1.00	2.44	2.44	30	0.50	0.78	5	8
18	290	1.05	0.38	2.27	0.89	2.44	2.44	30	0.52	0.78	5	8
19	265	1.15	0.32	2.35	0.86	2.44	2.44	30	0.54	0.78	5	8
20	245	1.25	0.27	2.40	0.75	2.44	2.44	30	0.55	0.78	6	8
21	230	1.33	0.24	2.44	0.66	2.44	2.44	30	0.56	0.78	6	8
22	215	1.42	0.22	2.44	0.58	2.44	2.44	31	0.60	0.80	6	8
23	200	1.53	0.22	2.44	0.62	2.44	2.44	34	0.71	0.92	7	9
24	200	1.53	0.22	2.44	0.61	2.44	2.44	34	0.71	0.92	7	9
25	195	1.57	0.22	2.44	0.57	2.44	2.44	35	0.76	0.97	8	10
26	185	1.65	0.22	2.44	-	2.44	2.44	38	0.85	1.08	8	11

Notes:
Single Panel S_{max}: Maximum surface subsidence predicted for a single, isolated longwall panel.
Final Panel S_{max}: Estimated final subsidence for a given panel (including chain pillar compression effects) after all longwall panels have been extracted.
*: Predicted strains are for a surface with a deep soil cover and likely to have 'smooth' profile strains. A surface with rock exposures is likely to cause strain concentrations which are 2 x 'smooth' profile strains.

Source: Modified after DGS (2009) – Tables 6A and 6B

Table 4B.5
Predicted Credible Worst-Case First and Final Maximum Panel Subsidence Parameters <u>with</u> Spanning Garrawilla Volcanics (Case 2)

Longwall Panel No.	Cover Depth (m)	Panel Width: Cover Depth Ratio	Predicted Subsidence					Max Tilt T_{max} (mm/m)	Max Curvature, C_{max} (km^{-1})		Maximum Strain, E_{max} (mm/m)*	
			Final Goaf Edge (m)	Single Panel S_{max} (m)	First Pillar S_p (m)	First Panel S_{max} (m)	Final Panel S_{max} (m)		Convex	Concave	Tensile	Compressive
1	165	0.02	0.41	0.26	0.41	0.70	0.70	6	0.21	0.26	2	3
2	175	0.03	0.44	0.33	0.56	0.93	0.93	8	0.24	0.31	2	3
3	195	0.07	2.19	0.43	2.32	2.44	2.44	25	0.51	0.65	5	6
4	210	0.07	2.33	0.43	2.44	2.44	2.44	23	0.44	0.56	4	6
5	230	0.09	1.93	0.55	2.11	2.44	2.44	22	0.41	0.52	4	5
6	250	0.07	0.53	0.69	0.79	1.58	1.58	12	0.26	0.34	3	3
7	275	0.10	0.55	0.80	0.88	1.78	1.78	14	0.30	0.38	3	4
8	290	0.11	0.52	0.74	0.90	1.73	1.73	13	0.29	0.37	3	4
9	290	0.11	0.48	0.76	0.83	1.70	1.70	13	0.28	0.36	3	4
10	300	0.12	0.44	0.81	0.80	1.72	1.72	13	0.29	0.36	3	4
11	310	0.13	0.37	0.82	0.76	1.68	1.68	13	0.28	0.36	3	4
12	330	0.16	0.47	0.90	0.86	1.86	1.86	15	0.31	0.39	3	4
13	360	0.18	0.62	-	1.04	1.64	1.64	12	0.27	0.35	3	3
14	365	0.17	0.46	0.93	0.46	1.52	1.52	11	0.26	0.32	3	3
15	345	0.18	0.35	0.89	0.80	1.79	1.79	14	0.30	0.38	3	4
16	335	0.16	0.30	0.88	0.73	1.72	1.72	13	0.29	0.37	3	4
17	310	0.12	0.30	0.80	0.72	1.62	1.62	12	0.27	0.34	3	3
18	290	0.10	0.36	0.69	0.74	1.52	1.52	11	0.25	0.32	3	3
19	265	0.08	0.40	0.68	0.73	1.51	1.51	11	0.25	0.32	3	3
20	245	0.11	1.49	0.57	1.79	2.40	2.40	21	0.40	0.51	4	5
21	230	0.08	1.46	0.46	1.72	2.22	2.22	19	0.37	0.47	4	5
22	215	0.07	2.01	0.37	2.20	2.44	2.44	22	0.42	0.53	4	5

Table 4B.5 (Cont'd)
Predicted Credible Worst-Case First and Final Maximum Panel Subsidence Parameters with Spanning Garrawilla Volcanics (Case 2)

Longwall Panel No.	Cover Depth (m)	Panel Width: Cover Depth Ratio	Predicted Subsidence: Final Goaf Edge (m)	Predicted Subsidence: Single Panel S_{max} (m)	Predicted Subsidence: First Pillar S_p (m)	Predicted Subsidence: First Panel S_{max} (m)	Predicted Subsidence: Final Panel S_{max} (m)	Max Tilt T_{max} (mm/m)	Max Curvature, C_{max} (km^{-1}): Convex	Max Curvature, C_{max} (km^{-1}): Concave	Maximum Strain, E_{max} (mm/m)*: Tensile	Maximum Strain, E_{max} (mm/m)*: Compressive
23	200	0.07	2.14	0.42	2.29	2.44	2.44	24	0.48	0.61	5	6
24	200	0.07	2.14	0.41	2.31	2.44	2.44	24	0.48	0.61	5	6
25	195	0.07	2.19	0.37	2.36	2.44	2.44	25	0.51	0.65	5	6
26	185	0.03	0.67	-	0.85	1.02	1.02	8	0.24	0.30	2	3

Notes:
Single Panel S_{max}: Maximum surface subsidence predicted for a single, isolated longwall panel.
Final Panel S_{max}: Estimated final subsidence for a given panel (including chain pillar compression effects) after all longwall panels have been extracted.
*: Predicted strains are for a surface with a deep soil cover and likely to have 'smooth' profile strains. A surface with rock exposures is likely to cause strain concentrations which are 2 x 'smooth' profile strains.

Source: Modified after DGS (2009) – Tables 7A and 7B

The predicted multi-panel subsidence impacts are illustrated on **Figures 4B.3** and **4B.4** for Cases 1 and 2. Derived from the mean goaf edge subsidence predictions, DGS (2009) estimates the angel of draw to range from 10º to 26.5º, where the angle of draw (AoD) is the angle from the vertical of the line drawn between the tailgate edge of the longwall panel to the 20mm subsidence contour[1] at the surface. Based on these AoDs, DGS (2009) anticipates that subsidence would extend the following distances beyond the limit of mining.

- 150m to 220m beyond the western boundary (23^o to 31^o draw angle).
- 35m to 70m beyond the eastern boundary (12^o to 21^o draw angle).
- 130m to 200m beyond the northern and southern boundaries at the western end, reducing to 35m to 70m in the east (12^o to 31^o draw angle).

Section 4B.1.6 provides an assessment of these results.

Reliance would be placed upon the monitoring to confirm the angle of draw well ahead of the commencement of Panels LW9 to LW13 to ensure that subsidence exceeding 20mm is confined within the northern boundary of ML1609.

4B.1.6 Assessment of Impacts and Management

4B.1.6.1 Surface Cracking

Predicted Impacts

Surface cracks caused by tensile fractures generally occur between the chain pillars and the point of inflexion, which is where convex curvatures and tensile strains would develop. Based on the predicted panel subsidence and tilt (see **Tables 4B.4** and **4B.5**), the point of inflexion is assessed to be located 20m to 60m from the panel ribs for the range of mining geometries proposed. Tensile fractures can also develop above chain pillars that are located between extracted panels.

[1] The 20 mm subsidence contour is an industry defined limit and represents the practical measurable limit of subsidence.

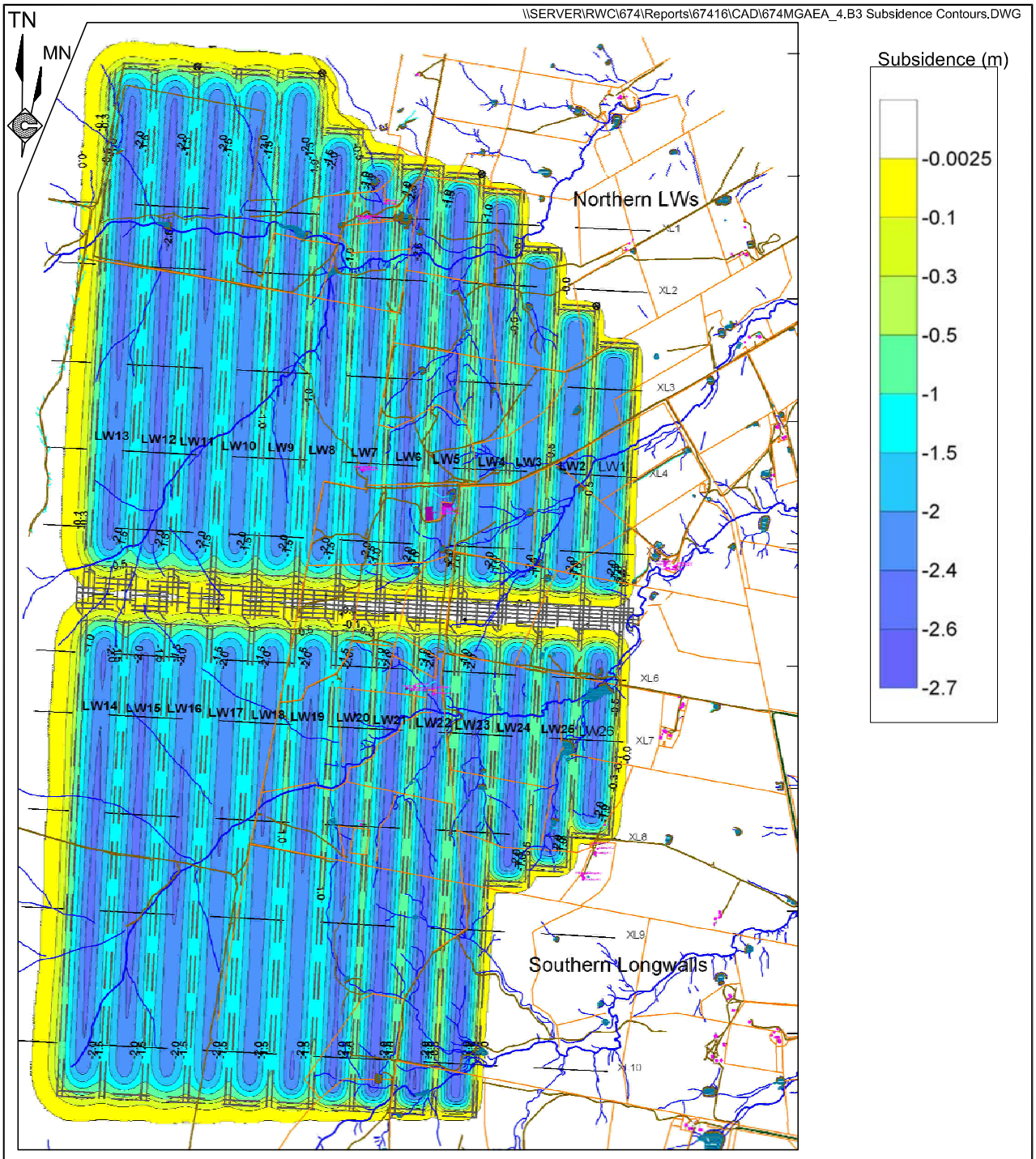
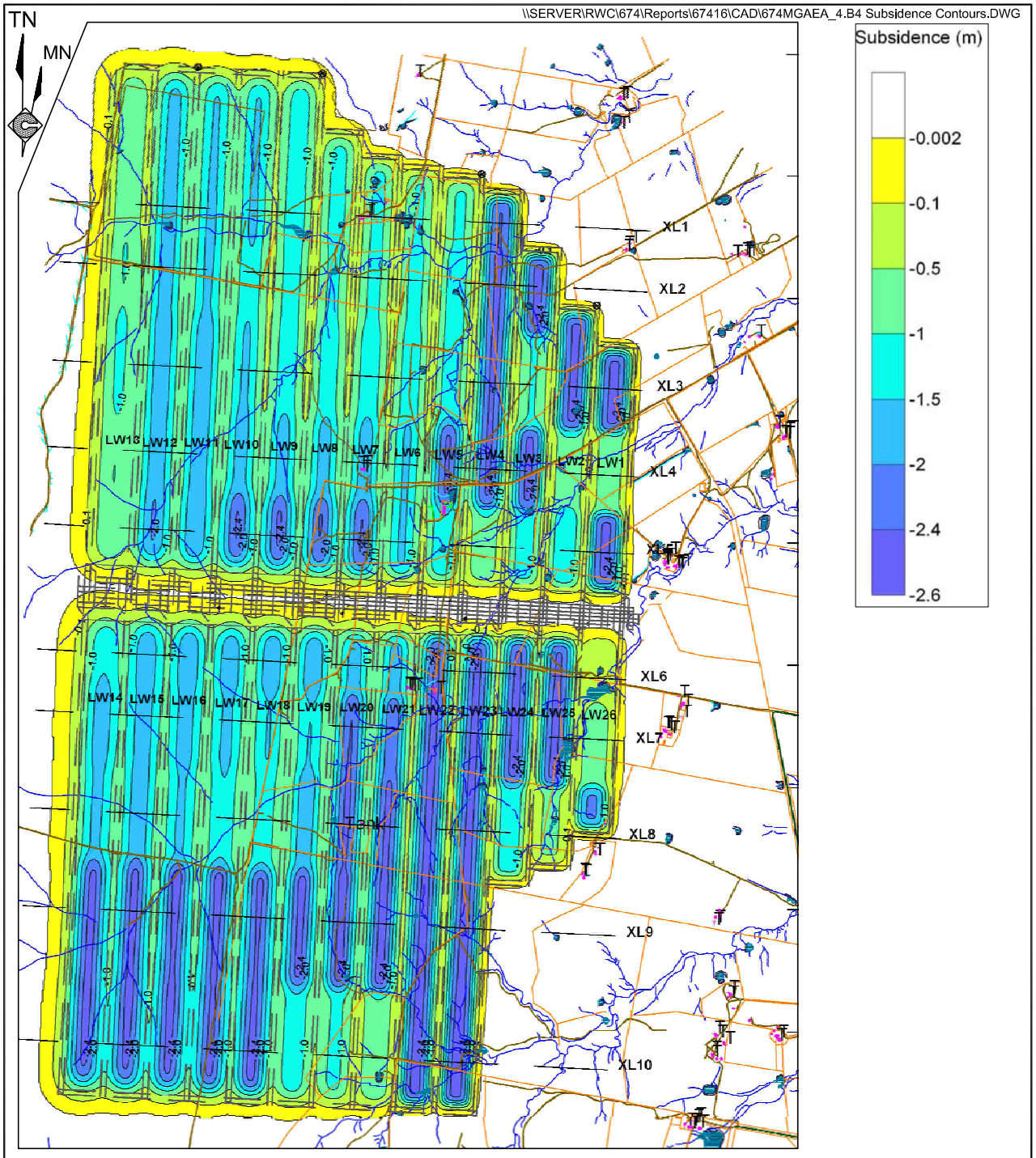


Figure 4B.3
PREDICTED MINE SUBSIDENCE CONTOURS (CASE 1)



Source: DGS (2009) - Figure 36

Figure 4B.4
PREDICTED MINE SUBSIDENCE CONTOURS (CASE 2)

The compressive shear fractures or shoving zones would generally develop in the area above the longwall panel and inside the inflexion points.

Surface crack widths (in mm) have been estimated by multiplying the predicted strains by 10 (and assuming a 10m distance between survey pegs). Therefore, based on the predicted range of maximum transverse tensile and compressive strains predicted by DGS (2009), ie. 19mm/m to 2mm/m, maximum surface cracking widths of between 20mm and 190mm may occur above the panels. It is acknowledged by both DGS (2009) and in the peer review by Dr Bruce Hebblewhite (see Volume 1, Part 1 of the *Specialist Consultant Studies Compendium*) that the crack widths could be greater than 190mm.

It is noted that the wider cracks would appear in the eastern side of the mining area and the narrower cracks would appear in the western side of the mining area. Strain concentrations in near surface rock, could also double the above crack widths to 40mm and 380mm respectively. The above crack width estimation method assumes all of the strain would concentrate at a single crack between the survey pegs. This could occur where near surface bedrock exists, but is more likely to develop as two or three smaller width cracks, over a tensile zone of 20m in width, in deep alluvial soil profiles. Therefore, the crack widths are expected to be wider on ridges than along sandy-bottomed creek beds.

The cracks in the tensile strain zones would probably be tapered and extend to depths ranging from 5m to 15m, and possibly deeper in near surface rock exposures and ridges. Cracks within compressive strain zones are generally low-angle shear cracks caused by failure and shoving of near surface strata. The cracks would probably have developed by the time the longwall face has retreated past a given location for a distance equal to 1 to 2 times the cover depth.

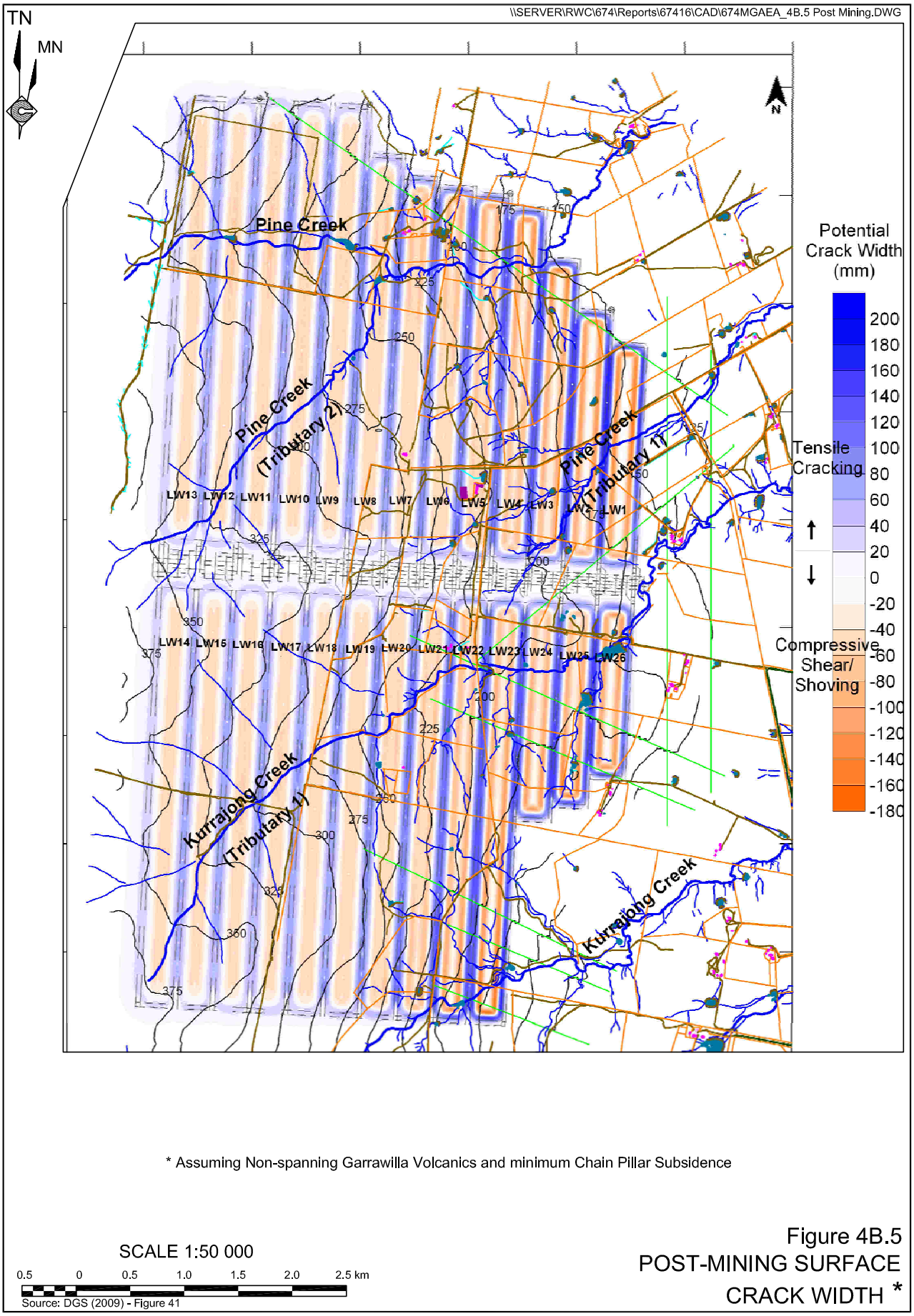
Figure 4B.5 presents the predicted subsidence crack width location zones associated with post-mining tensile and compressive strains for the worst-case scenario (Case 1 – Maximum chain pillar subsidence and non-spanning Garrawilla Volcanics). It is expected that the cracks would be orientated sub-parallel to the sides and ends of each panel, with diagonal cracking at the corners.

Undermining ridges can also result in surface cracks migrating up-slope and outside the limits of extraction for significant distances due to rigid block rotations. This phenomenon depends upon the slope angle, vertical jointing and the subsidence at the toe of the slope. There are few if any ridges within the Mine Site likely to enable upslope migration of cracking.

Proposed Management

The Proponent would regularly monitor areas of the Mine Site likely to be affected by surface cracking (see **Figure 4B.5**). This would involve inspection of the areas on foot, or where access is available by vehicle.

On identification of cracking, the location would be noted but no further action taken at that time as with many smaller width cracks, natural erosive forces are likely to result in these being in-filled naturally. For larger cracks (>100mm) or those persisting without being naturally in-filled, the Proponent would undertake remedial works involve the scarification or light ripping of surface over and both sides of the crack.



* Assuming Non-spanning Garrawilla Volcanics and minimum Chain Pillar Subsidence

Figure 4B.5
POST-MINING SURFACE CRACK WIDTH *

In the unlikely event that ripping alone is insufficient to fill in a deeper or wider crack, the Proponent would excavate the required volume of subsoil from stockpiles located at nearby gas drainage or ventilation sites or footprint of the Reject Emplacement Area, transfer it to the crack site and fill it in.

4B.1.6.2 Sub-Surface Cracking

Predicted Impacts

Two heights of fracturing models (A and B) were used by DGS (2009) to:

- ascertain the sensitivity of the predictions; and
- demonstrate which model is more conservative.

The predicted mean and U95%CL values for the continuous and discontinuous sub-surface cracking heights above longwall panels are summarised in **Table 4B.6**.

Table 4B.6
Summary of Predicted Sub-Surface Fracturing Heights

Longwall Panel No.*	Cover Depth (m)	Mining Height, T (m)	Single Panel S_{max} (mean) (m)	Predicted Fracture Heights (m)		
				Continuous (A Horizon)		Discontinuous (B Horizon) (mean - U95%CL)
				Model A (mean - U95%CL)	**Model B** 21T - 33T	
Northern Longwalls						
1	165	4.2	2.40	69 - 114	**88 - 139**	141 - *170*
2	175	4.2	2.44	69 - 116	**88 - 139**	147 - *177*
3	195	4.2	2.41	67 - 120	**88 - 139**	156 - *190*
4	210	4.2	2.33	64 - 120	**88 - 139**	161 - *198*
5	230	4.2	2.24	63 - 125	**88 - 139**	172 - *212*
6	250	4.2	2.18	68 - 135	**88 - 139**	186 - 230
7	275	4.2	2.12	**73 - 146**	88 - 139	204 - 252
8	290	4.2	2.06	**75 - 152**	88 - 139	213 - 264
9	290	4.2	2.06	**75 - 152**	88 - 139	213 - 264
10	300	4.2	2.02	**76 - 156**	88 - 139	220 - 272
11	310	4.2	1.99	**77 - 160**	88 - 139	226 - 280
12	330	4.2	1.92	**80 - 168**	88 - 139	239 - 296
13	360	4.2	1.80	**81 - 178**	88 - 139	256 - 319
Southern Longwalls						
14	365	4.2	1.77	**81 - 179**	88 - 139	259 - 323
15	345	4.2	1.88	**81 - 174**	88 - 139	248 - 308
16	335	4.2	1.91	**80 - 170**	88 - 139	242 - 300
17	310	4.2	1.99	**77 - 160**	88 - 139	226 - 280
18	290	4.2	2.06	**75 - 152**	88 - 139	213 - 264
19	265	4.2	2.14	**71 - 142**	88 - 139	197 - 243
20	245	4.2	2.19	67 - 132	**88 - 139**	183 - 226
21	230	4.2	2.24	63 - 125	**88 - 139**	172 - 212
22	215	4.2	2.31	62 - 120	**88 - 139**	163 - *201*
23	200	4.2	2.38	66 - 120	**88 - 139**	158 - *193*
24	200	4.2	2.38	66 - 120	**88 - 139**	158 - *193*
25	195	4.2	2.41	67 - 120	**88 - 139**	156 - *190*
26	185	4.2	2.44	69 - 118	**88 - 139**	152 - *184*

Notes:
*: Predictions determined along XL 4 and XL 7 (see **Figure 1** for cross line location)
T: Mining Height
Italics: Discontinuous fracturing may interact with surface cracks if B-Horizon within 15m of surface, resulting in surface flow re-routing.
Bold: Conservative modelling result
Source: Modified after DGS (2009) – Table 10

The results indicate that Model A is generally the more conservative model for cover depths >260m and less conservative for cover depths <260m. Model B predicts direct surface to seam fracturing could occur for cover depths between 88m and 139m.

The results indicate that continuous fracturing from seam to surface would not occur (given the predicted depth of continuous fracturing does not exceed the cover depth of any of the longwall panels). Subsurface aquifers within 110m to 180m above the proposed panels, ie. 50% to 70% of the cover depth, may however, be affected by direct hydraulic connection to the workings, with significant long-term increases to vertical permeability. DGS (2009) notes that the continuous fracture would not extend above the Garrawilla Volcanics, ie. not result in direct hydraulic connection between the groundwater of the Great Artesian Basin Intake Beds and the underground mine.

Table 4B.6 indicates that discontinuous sub-surface fracturing could interact with surface cracks where cover depths are <215m. This accounts for approximately 28% of the mining area. As a result, creek flows could be re-routed to below-surface pathways and re-surfacing down-stream of the mining extraction limits in these areas. DGS (2009) notes, however, that this phenomenon would normally only occur where shallow surface rock is present and is unlikely where deep soil profiles exist. Deep soil profiles occur over that area of the Mine Site where cover depth <215m (LW1 to LW4 and LW 23 to 26) and it is therefore considered unlikely that there would be any interaction between discontinuous sub-surface cracks and local creeks or their tributaries.

The potential impacts of the predicted sub-surface fracturing has been included in groundwater modelling undertaken by Aquaterra (2009), which is summarised in Section 4B.2.5.

Proposed Management

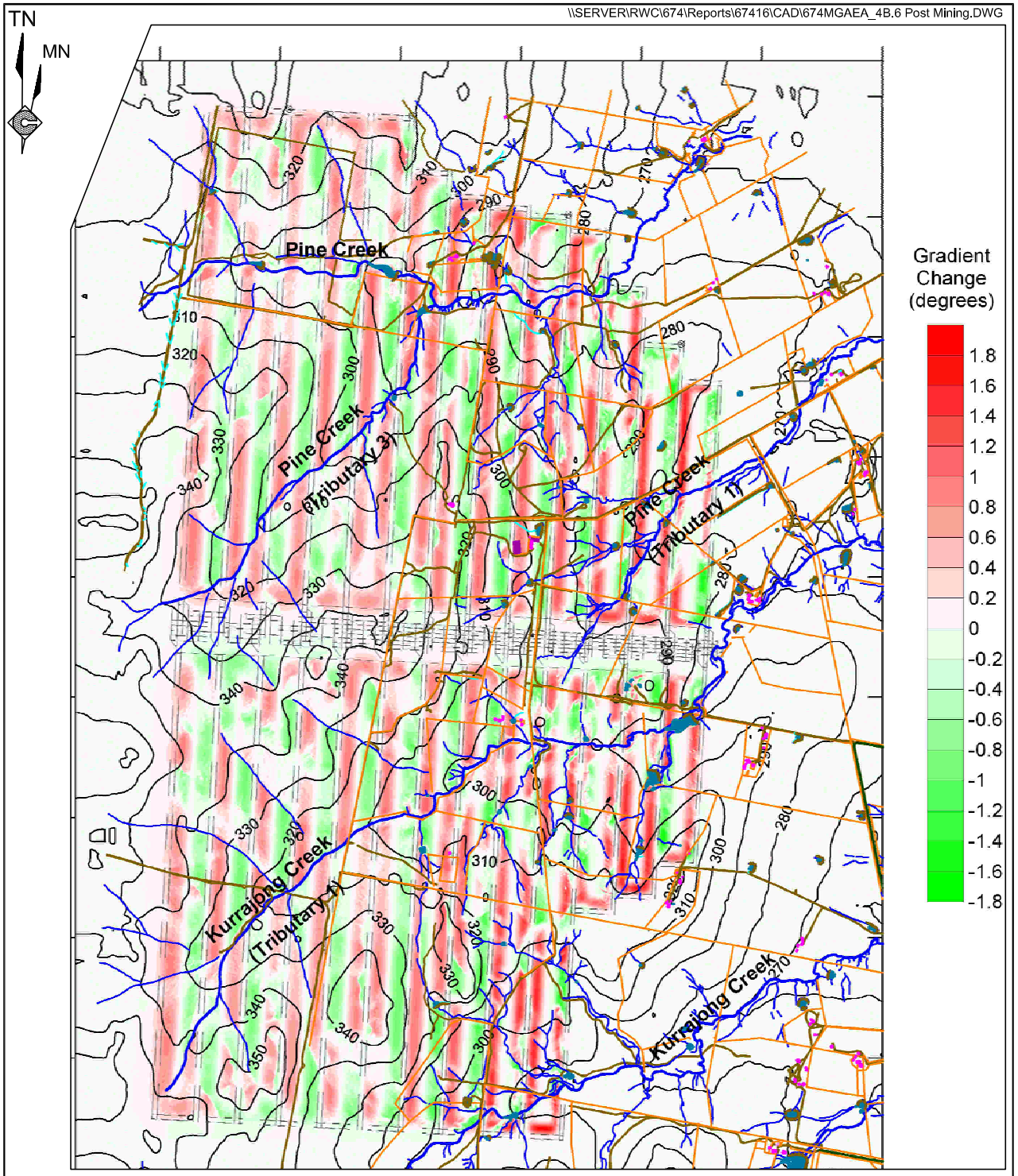
The management of sub-surface cracking impacts on local groundwater is considered as part of the Longwall Project groundwater assessment (see Section 4B.2.5).

4B.1.6.3 Slope Stability and Erosion

Predicted Impacts

The likelihood of en-masse sliding, ie. a landslip, of the ridges or hills over basal siltstone beds tilted by subsidence has been assessed based on landslide risk assessment terminology. The predicted post mining surface slope elevations and gradients for the proposed mining layout are presented in **Figure 4B.6**.

Based on the predictions presented in **Tables 4B.4** and **4B.5**, DGS (2009) indicates that the predicted tilts for the longwall panels are expected to change existing slopes by between 10mm/m and 45mm/m, ie. approximately 1° to 2° (see **Figure 4B.6**). This would indicate that any near surface creek beds might have their dip increased from about 3° to 5° to a range of 4° to 7° on east and west facing slopes within the Mine Site.



* Assuming Non-spanning Garrawilla Volcanics and minimum Chain Pillar Subsidence

SCALE 1:50 000

0.5 0 0.5 1.0 1.5 2.0 2.5 km

Source: DGS (2009) - Figure 47

Figure 4B.6
POST-MINING SURFACE LEVELS AND GRADIENT CHANGES *

Referring to Factors of Safety (FoS) against en-masse sliding of a natural slope, DGS (2009) calculated that the probability of the minimum recommended FoS for slopes with lower bound material strengths (1.2 to 1.3) being exceeded was 1% to 5%. That is, it is 'very unlikely' that a large scale instability or landslip would occur in the long-term due to the proposed longwall mining. Further, studies in terrain above the NSW coalfields to-date indicate longwall mining in undulating terrain with ground slopes up to 25^{o} has not resulted in any large scale, en-masse sliding instability due to mine subsidence (or other natural weathering processes etc.)

The predicted impacts of the tilts predicted by DGS (2009) and presented in **Table 4B.4** are also considered 'unlikely' (<10% probability) to cause localised surface slope instability unless mining-induced cracking and increased erosion rates also develop. The areas most susceptible to surface slope instability include any steeply eroded banks of Kurrajong and Pine Creeks and their tributaries on the Mine Site. These may slump or topple if cracks develop through them.

The rate of soil erosion is expected to increase in areas with exposed dispersive/reactive soils and slopes >10°. The topsoil layer of all soil types encountered on the Mine Site do not display significant dispersive tendencies and are therefore unlikely to be at significant risk of soil erosion (directly attributable to subsidence) (GCNRC, 2009). The subsoil layers of all soil types generally tend to display higher dispersion than the topsoil, with this especially evident in the soils derived from the Purlawaugh Formation (which represents less approximately 25% of the soils likely to be affected by subsidence – see **Figure 2.11**). However, as the subsoil layers are unlikely to be disturbed the erosion risk associated with the soils of the Purlawaugh Formation is likely to be minimal.

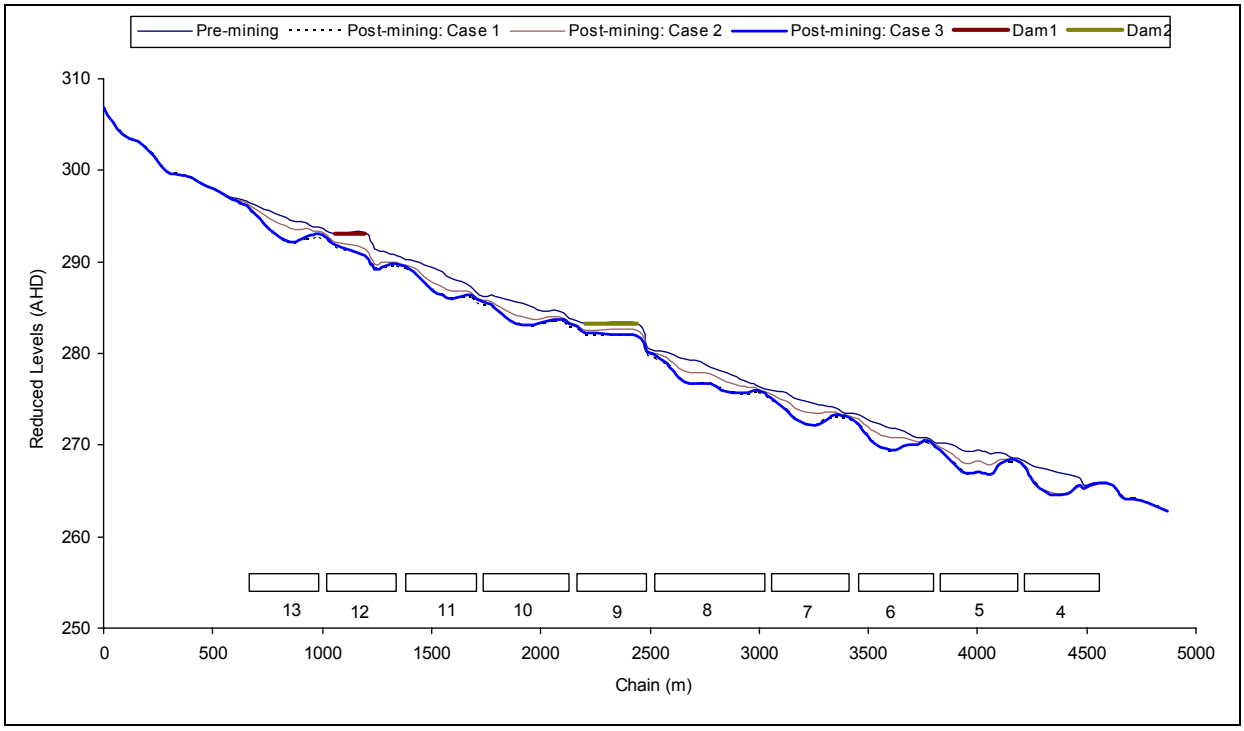
Areas with slopes <10° (see **Figure 4B.1**) are expected to have low erosion rate increases, except for the creek channels, which would be expected to re-adjust to any changes in gradient. **Figure 4B.7** provides a cross-section along Kurrajong and Pine Creeks illustrating the predicted gradient changes along these watercourses.

Proposed Management

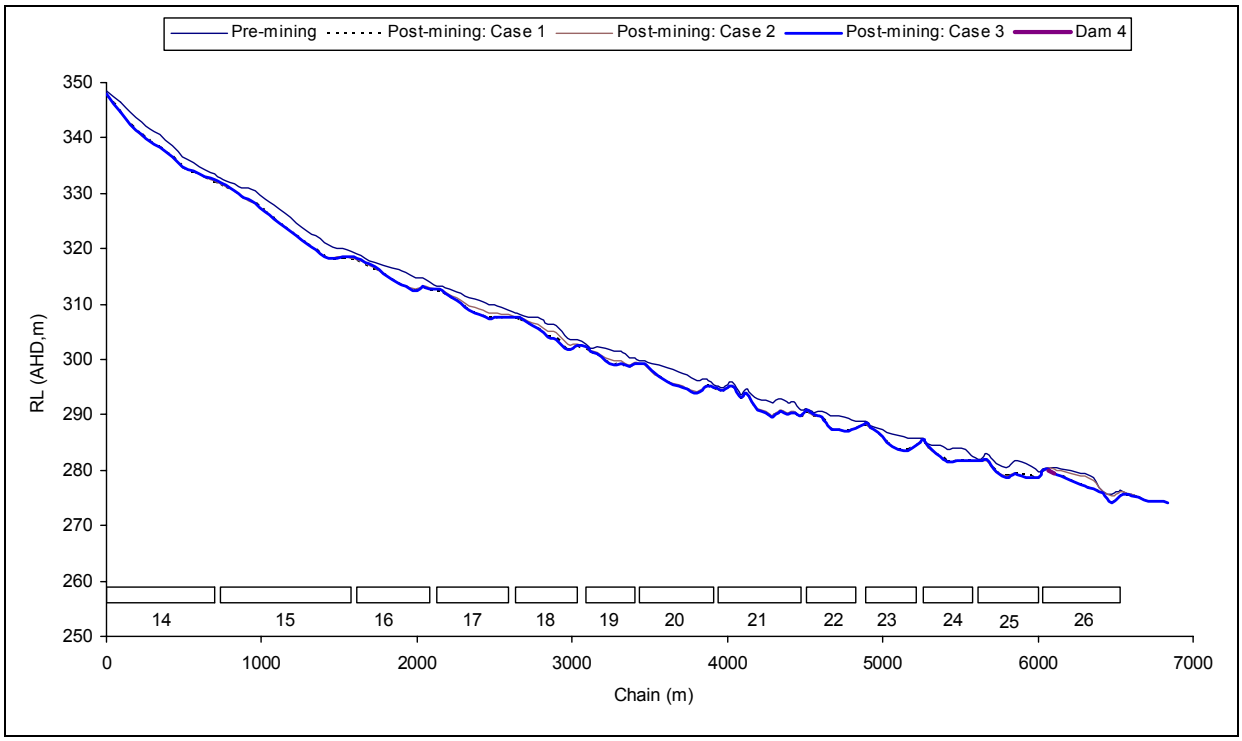
The Proponent would regularly inspect areas of the Mine Site susceptible to landslip of accelerated erosion, eg. drainage lines and steeply sloped areas of exposed Purlwaugh Formation derived subsoils.

While considered unlikely, should large-scale slope instability after mining be identified, the Proponent would undertake stabilisation works, such as the installation of deep sub-surface drainage trenches (to reduce pore pressures) and construct strategic catch drains along slope crests to improve surface run-off.

In the event erosion is identified, in particular along Kurrajong and Pine Creeks and their tributaries, the sections of damaged or steeply eroded banks would be stabilised. Any stabilisation works would be undertaken in accordance with an Erosion and Sediment Control Plan (ESCP) which would be prepared for the Mine Site. It is proposed that the ESCP be prepared in consultation with Narrabri Shire Council and relevant government agencies.



Pine Creek



Kurrajong Creek

Figure 4B.7
PRE-MINING AND PREDICTED POST-MINING SURFACE PROFILES ALONG PINE AND KURRAJONG CREEKS

Source: DGS (2009) – Figures 49 and 51

4B.1.6.4 Valley Closure and Uplift

Predicted Impacts

Valley closure and uplift movements are strongly dependent on the level of 'locked-in' horizontal stress immediately below the floor of the gullies and more importantly the bedding thickness of the floor strata, ie. thin to medium bedded sandstone is more likely to buckle than thicker beds. The influence of the aspect ratio, ie. valley width/depth, is also recognised as an important factor, with deep, narrow valleys having greater 'upsidence' than broad, rounded ones, due to higher stress concentrations.

As the valleys across the Mine Site are broad and there is a lack of thick, massive beds of conglomerate and/or sandstone units along the creeks / valleys, DGS (2009) concludes that the probability of 'upsidence' development and/or valley closure is likely to be negligible.

If 'upsidence' does occur, it may cause some minor, localised deviation of surface flows along ephemeral creek beds into sub-surface routes above the longwall panels. Failure and cracking of the near surface rocks due to tensile bending or compressive/shear strains would also contribute to the re-routing of surface flows. Re-routed surface flows would be expected to re-surface down stream of the damaged area.

Proposed Management

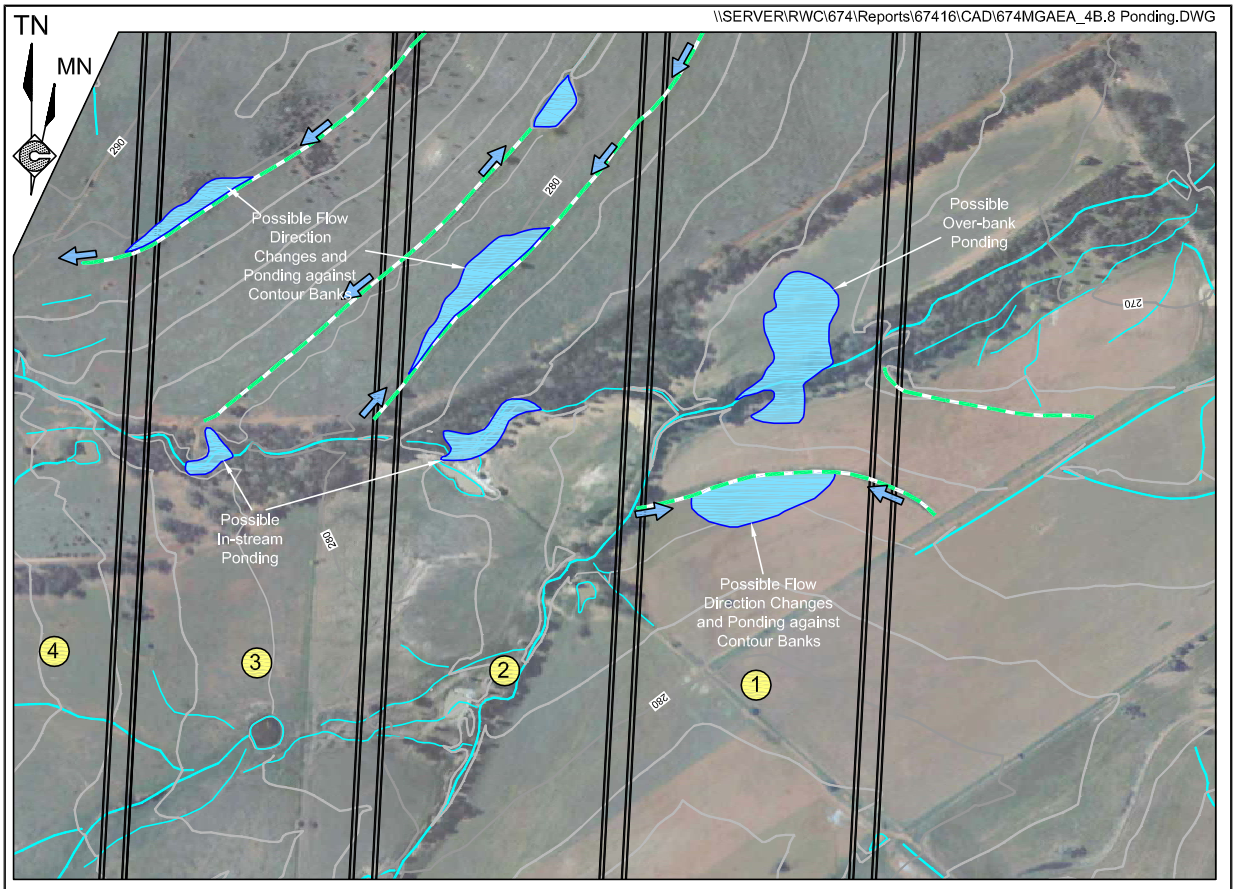
While the potential for 'upsidence' is considered negligible, the Proponent would undertake the following to manage the resultant impacts.

- Survey lines along ephemeral drainage gullies and along gully crests would be installed and monitored during and after longwall mining. This monitoring would be combined with visual inspections to identify any signs of cracking or 'upsidence'.
- The predictions of 'upsidence' and valley crest movements would be reviewed after each longwall is completed.
- In the event that 'upsidence' results in the appearance of large cracks, remedial works such as those identified for surface cracking (see Section 4B.1.6.1) and erosion (see Section 4B.1.6.3) would be implemented.

4B.1.6.5 Ponding on Tributaries of Kurrajong and Pine Creeks

Predicted Impacts

DGS (2009) suggests that some of the watercourses present within the Mine Site could be susceptible to potential ponding depths of between 0.5m and 1.5m, based on the predicted final surface level profiles of Pine and Kurrajong Creeks (see **Figures 4B.7**). Surface gradients may subsequently increase or decrease by up to 6% (3^{o}) along creeks. The actual ponding depths would depend upon several other factors, such as rain duration, surface cracking and effective percolation rates of the surface soils and fractured rock bars/outcrops along the creeks. An assessment of the possible ponding that may occur on and adjacent to Pine Creek Tributary 1 during the initial years of mining has been completed by WRM Water and Environment Pty Ltd (WRM, 2009) (see **Figure 4B.8**). Additional predictions of ponding within the creeks and their tributaries on the Mine Site is provided by WRM (2009 – *Figures 7.1 to 7.4*). Notably, the predicted ponding would generally be restricted to within the existing channel banks (in-stream), with only one additional area of possible overbank ponding identified on a tributary to Kurrajong Creek near the southeastern corner of the Mining Area (over LW22).





REFERENCE
280 Contour (m AHD)(Interval = 2m)
Creek / Drainage Line
Contour Bank
Underground Workings
Predicted Ponded Area
1 Longwall Panel No.

SCALE 1:10 000

100 0 100 200 300 400 500 m

Source: Modified after WRM (2009) - Figure 7.1

Figure 4B.8
PREDICTED PONDING ON PINE CREEK TRIBUTARY 1 OVER LONGWALL PANELS LW1 to LW3

The impacts within this area are likely to include the following.

- In-stream and over bank ponding over LW1 and in-stream ponding (limited to within the channel of Pine Creek Tributary 1) over LW2 and LW3. Ponding is most likely to occur when the tributary channel is perpendicular to the longwall panels (as the change in channel slope is more significant).
- Over bank ponding and possible flow re-direction along the contour banks north of Pine Creek Tributary 1 over LW2 and LW3. This would occur as the variable subsidence across the retained chain pillars would result in the contour banks no longer run along contour.
- The bed slope of the channels would increase on the downstream (eastern) side of the chain pillars, which may increase channel erosion along these areas.
- Increased in-stream sedimentation would occur on the downstream (eastern) side of the longwall panels in the areas of in-stream ponding. The source of the increased sediment would be due to the channel erosion on the upstream (western) side of the same long wall panel draining from the chain pillars.

Additional impacts associated with the ponding illustrated on **Figure 4B.8** may be as follows.

- The short term loss of riparian vegetation.
- Inundation of identified (and unidentified) Aboriginal sites.
- Increased salinity of downstream flows as a result of ponding over saline soils. Notably, some sub-soils derived from the Purlawaugh Formation have been identified as slightly to moderately saline (GCNRC, 2009) and if exposed as a result of subsidence could increase the salinity of the water discharged from the Mine Site.

Following inspection of the post mine subsidence contours predicted along the tributaries of Kurrajong and Pine Creeks, WRM (2009) determines that the impacts illustrated on **Figure 4B.8** are likely to be typical and repeated across all watercourses within the subsidence zone of the Mine Site. WRM (2009) concludes that major changes in channel geomorphology due to changes in channel location (avulsions) are unlikely.

In considering the impacts of ponding, it is worthy of note that the ponded water would also be likely to provide an additional source of drinking water for local fauna.

Proposed Management

WRM (2009) suggests that the continual action of erosion and sedimentation without mitigation measures is likely to 'self correct' the geomorphic characteristics of the waterways over time. Water would be regularly sampled (in accordance with a Surface Water Monitoring Procedure – see Section 4B.3.8) to confirm no increase in the salinity of water which may be attributable to ponding over saline soils.

The above notwithstanding, the Proponent would regularly inspect the watercourses over the subsidence zone of the Mine Site and implement the following mitigation strategy.

- If little vegetation of significance is impacted and water quality analysis confirms no increase in salinity, the ponding would be left to self correct over time.

- If significant areas of vegetation (or vegetation of conservation significance) occur within the ponded area, the channel across the chain pillars would be excavated to reduce the gradient change which causes the pond to form. If this occurs, appropriate management measures (in accordance with an Aboriginal Cultural Heritage Management Plan – see Section 4B.5.5 and vegetation clearing procedures – see Section 4B.4.5.1) would be followed to ensure that Aboriginal sites or significant vegetation is not impacted by the excavation.
- In the event that an increase in salinity is observed, the channel across the chain pillars would be excavated to reduce the gradient change which causes the pond to form (thereby reducing the time over which the salts can leach from the soil and enter the water).

4B.1.6.6 Far-field Horizontal Displacements

Predicted Impacts

DGS (2009) reports that Far-field Displacements (FFDs) generally only have the potential to damage long, linear features such as pipelines, bridges, railway and dam walls. Therefore, any surface features such as bridges or culverts within three or four times the cover depth, ie. approximately 600m from the proposed LW1 and LW26 on the eastern side would be monitored for FFD movements during mining. The deeper western side of the proposed Stage 2 Longwall Project mining area may affect a larger area of up to 1.5km away.

Notably, FFDs outside a distance equal to one cover depth from the longwall extraction limits are unlikely to generate significant strains or movement to cause cracking or damage to the surface (DGS, 2009).

DGS (2009) concludes that the closest linear structures to the mining area (the Main Western Branch Railway Line and the Kamilaroi Highway) would be beyond the area likely to be affected by far-field movements. Hence, no management strategies would need to be adopted.

4B.1.6.7 Aboriginal Artefacts

Section 4B.5.6.2 presents the results of the assessment of potential impact(s) upon the predicted subsidence on Aboriginal sites and artefacts.

4B.1.6.8 Other Surface Features and Infrastructure

4B.1.6.8.1 Unsealed Gravel Access Roads and Tracks

Predicted Impacts

The unsealed gravel access public and private roads and tracks above the proposed longwall panels are likely to be damaged by cracking and ‘shoving’ at tensile and compressive strain zones.

Proposed Management

Given the maximum crack width is unlikely to exceed 380mm in the eastern side of the mining area (see Section 4B.1.6.1), this could be effectively managed through regular inspection and maintenance of the roads and access tracks undertaken after each longwall block is mined or as required when the impacts occur. Particular attention would be paid to public roads maintained by Narrabri Shire Council.

4B.1.6.8.2 Water Storage Dams

Predicted Impacts

Non-engineered farm dams and water storages would be susceptible to surface cracking and tilting due to mine subsidence. The tolerable tilt and strain values for the dams would depend upon the materials used, construction techniques, foundation type and likely repair costs to re-establish the dam's function and pre-mining storage capacity.

The expected phases of tensile and compressive strain development may result in breaching of contour banks or dam walls or water losses through the floor of the dam storage area. Loss or increase of storage areas may also occur due to the predicted tilting. Damage to windmills and fences around the dams may also occur and require repair.

Proposed Management

Notably, the damage to water management structures on the Mine Site would be largely on properties owned by the Proponent. It is also highly likely that any damage caused to these structures could be remediated, or the structure replaced with a comparable one in an appropriate location. For impacts on dams, contour banks, or windmills on the limited number of properties not owned by the Proponent, the Proponent would re-instate or replace the damaged structure in a timely manner and in the case of dams or windmills provide an alternative supply of water during the interim period. DGS (2009) notes that dams similar to those across the Mine Site have been undermined by longwall mining elsewhere in Australia with any damage effectively managed in the manner proposed.

4B.1.6.8.3 Property Fences and Livestock

The impact of subsidence on the grazing of livestock would primarily require the management and repair of surface cracking and fences. Ponding is not expected to affect grazing or pasture areas.

4B.1.6.8.4 Residential Dwellings and Machinery Sheds

Predicted Impacts

It is estimated that there are seven buildings, two orchards and two water tanks present above longwall panels LW5, LW7, LW21 and LW22. These structures and features may be subject to subsidence of up to 2.44m. DGS (2009) considers that the predicted level of subsidence, and the associated tilts and strains, is likely to significantly damage these features. The ultimate impact cannot be predicted, however, it may result in the structures becoming structurally unstable and therefore uninhabitable. The only residential dwellings above the underground Mining Area are on land owned by the Proponent and only two are occupied. The Proponent has already made provision for these dwellings to be vacated well ahead of the predicted subsidence occurring.

Mine subsidence impacts on surface structures are expected to develop soon after a longwall retreats beneath each structure and would be expected to continue until the longwall face is one to two times the cover depth past the structure. Subsidence movements would also be expected to commence again as the subsequent longwall panel(s) pass, albeit at decreasing rates and magnitudes. It is considered likely that subsidence movements would affect undermined properties for periods of at least 2 years after mining.

Structures located outside the Mining Area, but within the angle of draw, may be subject to subsidence movements <200 mm, tilts <4mm/m and strains <1mm/m. Within this zone, and regardless of the type of structure, DGS (2009) predicts damage to these structures to be minor.

Structures that are further than distances of 0.5 to 0.7 times the cover depth (ie. at angles of draw of 26.5^{o} and 35^{o}) from the limits of longwall extraction are likely to be subsided < 20mm with negligible tilts (<1mm/m) and strains (<0.5mm/m). It is very unlikely that mining would cause any damage to these buildings. There are several structures (ie. residences, machinery sheds and tanks) on the "Kurrajong" property which are 80 to 350m south of LW26 and 135m to 155m southeast of the starting position of LW25. The cover depth of 170m gives an effective angle of draw of 25.5 to 64^{o} for these structures.

A detailed assessment of all structures would be undertaken during the development of the Subsidence Management Plan for the Longwall Project.

Proposed Management

A dilapidation survey and inspection of all structures not owned by NCOPL would be made by a qualified building consultant within the proposed angle of draw (+200m) before and after mine subsidence. The report could then be referred to in individual property subsidence management plans (IPSMP) to provide fair and reasonable outcomes between the land owner and the Proponent. The IPSMPs should address the following issues in consultation between the stakeholders (ie. land owners, mine, Council and Utilities).

- When mining impacts would occur and the predicted damage to property structures.
- The monitoring plan for the property during mining and safety/hazard management plan.
- The timing of disconnection of power supply etc.
- The post-mining inspection and reporting of property damage and repair works options.

Any repair works to internal/externals cracking or re-levelling of damaged structures on non-project related properties would be implemented to ensure the properties are safe and serviceable before allowing re-entry to the property.

4B.1.6.8.5 Narrabri Coal Mine Site and Other Infrastructure

No damage or impacts are expected to the proposed Mine Site infrastructure given it is located east of the subsidence zone or along the West Mains, which would cause negligible subsidence.

DGS (2009) reports that the Kamilaroi Highway and North Western Branch Railway Line are well outside the limits of subsidence impact, including impacts from far-field displacements. Notwithstanding this, DGS (2009) recommends, as a precaution, that risk management zones are defined around the mine site infrastructure, highway and railway line.

4B.1.7 Monitoring Program

DGS (2009) notes that measurable subsidence at a given location above the longwall panel centreline is likely to commence at a distance of approximately 50m to 100m ahead of the retreating longwall face and may develop at rates of 50mm/day to 300mm/day. The Proponent would undertake a subsidence and strain-monitoring program in order to provide adequate information to enable the design and implementation of appropriate subsidence impact management plans, as well as to provide pillar stability data for the gate road and main headings. A Subsidence Monitoring Program would be prepared as part of a Subsidence Management Plan for the Longwall Project, which would allow a comparison between predicted and measured subsidence parameters for a given feature. The Subsidence Monitoring Program would include the following elements.

- A transverse subsidence line across the northern and southern panels. The lines would be installed to at least the middle of the next adjacent longwall before undermining occurs.
- A longitudinal line extending in-bye and out-bye from the starting and finishing point of each panel, for a minimum distance equal to the cover depth.
- A survey line along the riparian management zone of Kurrajong and Pine Creeks and their tributaries over the Mine Site.
- A minimum of three monitoring pegs spaced 10m apart in a line or triangle at any feature of interest, eg. dam walls, archaeological sites, to measure subsidence, tilt and strain.
- Visual inspections and mapping of damage before, during and after mining.

In each case, monitoring survey pegs would be spaced between 10m and 20m apart with a minimum of two baseline surveys of subsidence and strain completed before mine subsidence effects occur. Survey frequency would be determined by mine management and be dependent upon requirements for subsidence development data in order to implement subsidence and mine operation management plans.

An alternative method of subsidence monitoring that may be undertaken is Aerial Laser Scanning (ALS). This technique allows a reduction in ground monitoring to key baseline monuments and provide subsidence data to within +/- 0.15m. ALS scans also provide a more thorough picture of the subsidence development along creeks and surface terrain generally and without the need for intrusive surveys or monitoring pegs (which can be a hazard to livestock and be lost by farming activities). The Proponent has already acquired ALS data across the entire mining area to enable comparisons to be made with post-mining data.

4B.2 GROUNDWATER

The groundwater assessment was undertaken by Aquaterra Consulting Pty Ltd (Aquaterra, 2009). The full assessment is presented as Part 2 of the Specialist Consultant Studies Compendium, with the relevant information from the assessment summarised in the following subsections. A peer review of the groundwater modelling was undertaken by Professor Noel Merrick. A copy of Professor Merrick's review is behind the groundwater assessment in the compendium.

4B.2.1 Introduction

Based on the risk analysis undertaken for the Longwall Project (see Section 3.3 and **Table 3.5**), the potential groundwater impacts requiring assessment and their unmitigated risk rating are as follows.

- Groundwater pollution as a result of leakage or spillage (low to moderate risk).
- Drawdown of groundwater resulting in:
  - reduced water levels within the aquifers of the Intake Beds to the Great Artesian Basin Groundwater Source (high risk);
  - reduced water levels within the aquifers of the Lower and Upper Namoi Alluvial Groundwater Source (moderate risk); and
  - reduced water levels within the aquifers of the Gunnedah Basin Groundwater Source (high risk).
- Reduction in the yield / saturated thickness of groundwater bores:
  - on the Mine Site or Proponent-owned land (high risk);
  - by <15% on non-project related properties (moderate risk); and
  - by >15% on non-project related properties (high risk).
- Impacts on groundwater-dependent ecosystems (high risk).

In addition, the Director-General's Requirements identify "soil and water" as a key issue for assessment and require the *Environmental Assessment* to pay particular attention to:

- any potential impacts on the Great Artesian Basin intake beds;
- the requirements of the *NSW Great Artesian Basin Groundwater Sources Water Sharing Plan* and the *Upper and Lower Namoi Groundwater Water Sharing Plan*;
- demonstrating how the Proponent would manage mine water, especially any mine water brought to the surface; and
- any potential subsidence-induced soil and stream erosion.

This section commences with a review of the existing regional and local hydrogeology, local availability and use of groundwater resources and current statutory framework for the management of groundwater. Potential sources of groundwater contamination are then identified and the operational safeguards, controls and mitigation measures described. The section concludes with an assessment of the residual impacts following the implementation of these safeguards, controls and mitigation measures.

4B.2.2 The Existing Environment

4B.2.2.1 Regional and Local Hydrogeology

4B.2.2.1.1 Regional Hydrogeology

Section 2.2.1 records the Mine Site is located within the Mullaley Sub-basin, which is part of the Gunnedah Basin. In the western part of the Mine Site, the Gunnedah Basin sequence is unconformably overlain by the Jurassic age Surat Basin sequence. The Jurassic and Triassic sequences are overlain in northern and western parts of the Mine Site by Quaternary sand and talus material. These alluvial channel and overbank deposits of gravels, sand, silt and clay are associated with the Namoi River and can reach a thickness of up to 120m.

Regional Aquifers and Groundwater Management Areas (GWMAs)

The Triassic, Jurassic and Quaternary sequences contain differentiated aquifers which have been defined by the former Department of Water and Energy (DWE) as groundwater management areas (GWMAs). These are described as follows, with reference to the relevant geological units within the Mine Site.

- The Intake Beds of the Great Artesian Basin (GAB) GWMA (601) which are defined by the easterly extent of the Surat Basin sequence. The Surat Basin is a large intra-cratonic basin covering approximately 270 000km^2 with the southern third of the basin occupying a large part of northern New South Wales. The Surat Basin sequence of the Mine Site includes the following formations.
  - The Pilliga Sandstone: which is a Jurassic age braided stream deposit consisting of very well sorted medium to very coarse grained, quartzose sandstone with very minor interbeds of mudstone and siltstone. This formation constitutes the major intake beds and aquifers for the Great Artesian Basin groundwater system and sub-crops across the western part of the Mining Area (see **Figure 4B.9**). Aquaterra (2009) concurs with GHD (2007) which reported that the Pilliga Sandstone is not saturated within the Mine Site. Aquaterra (2009) notes, however, that the Pilliga Formation becomes partly saturated to the west of (down-dip from) the Mine Site, as the formation dips below the regional water table level.
  - The Purlawaugh Formation: which consists of thinly bedded, lithic, fine to medium grained sandstone interbedded with siltstone and mudstone. Soils derived from the readily weatherable argillaceous sediments of this formation occur over the eastern half of the Mining Area (see **Figure 4B.9**). The sandstone of this formation is noted as having low porosity and permeability and are rarely considered as aquifers with bore yields generally less than 0.5 L/s.

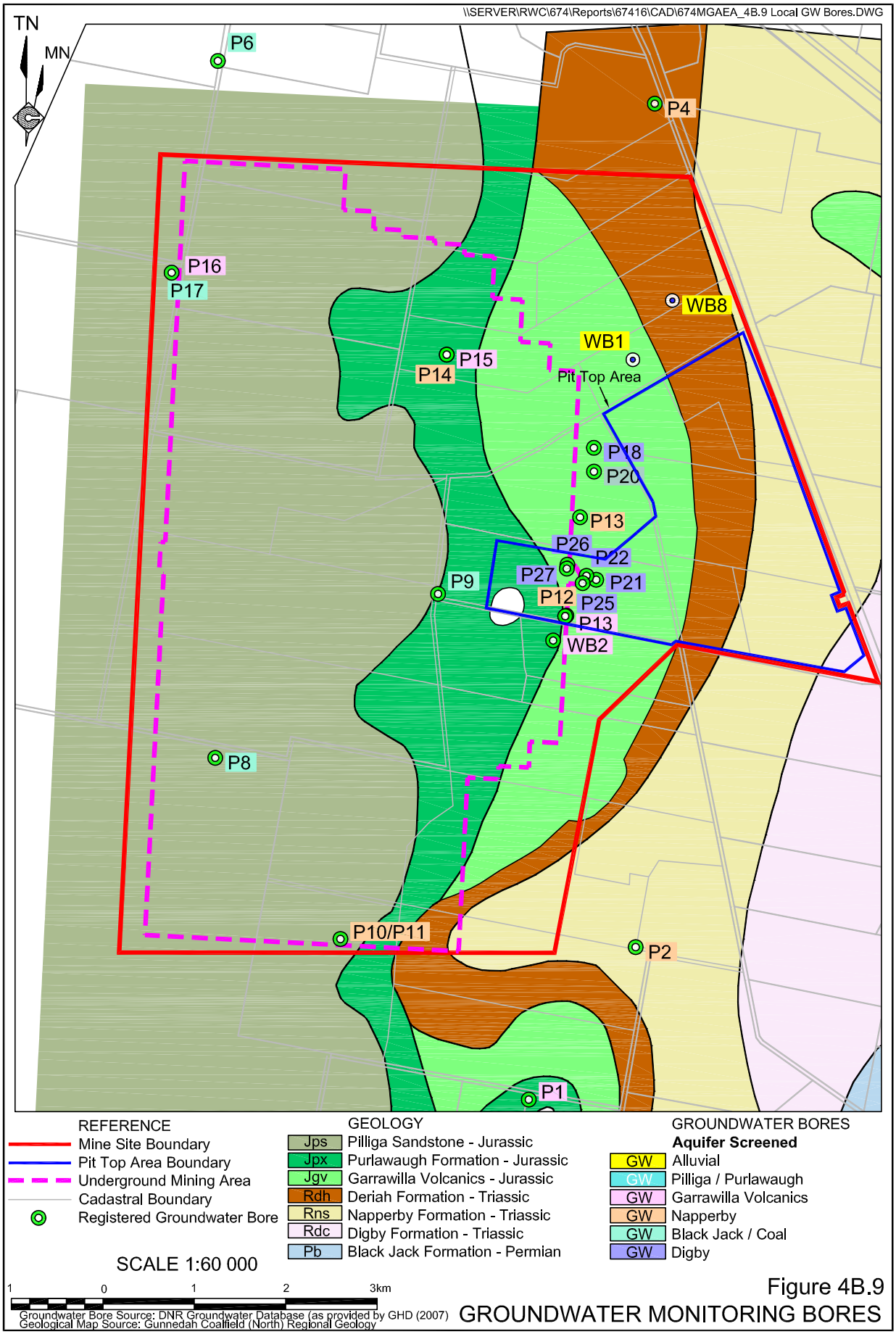


Figure 4B.9
GROUNDWATER MONITORING BORES

- The Garrawilla Volcanics: which consists of flows of basalt and trachyte and interbedded pyroclastics. Individual flows range in thickness from 1m to 8m and range from extremely vesicular to non-vesicular. The volcanics are found sub-cropping under alluvium generally to the east of the Mining Area (see **Figure 4B.9**) and represent the north-south trending boundary between the Surat Basin and Gunnedah Basin Sequence.

Aquaterra (2009) reports that no groundwater flows have previously been recorded from these units within the Mine Site, however, during construction of the box cut for the Stage 1 Narrabri Coal Mine, groundwater inflows were observed emanating from the base of the weathered profile. The groundwater observed was restricted to small amounts of perched water accumulating between the more permeable weathered profile and relatively impermeable fresh rock below and while in this instance was restricted to the box cut area, could occur elsewhere across the Mine Site. Aquaterra (2009) notes that as the Mine Site is located above younger geological units that are topographically higher than the Namoi River floodplain, the groundwater of the intake beds of the GAB is not hydraulically connected with alluvial groundwater associated with the Namoi River.

- Gunnedah GWMA (604) which comprises the Permo-Triassic Gunnedah Basin sequence and is found in the eastern part of the Mine Site. The Gunnedah Basin sequence of the Mine Site includes the following formations.
  - The Mid Triassic Napperby Formation which is a thick sequence of siltstone/sandstone laminite overlain by sandstone. This formation sub-crops under alluvium/talus material in the eastern part of the Mine Site (see **Figure 4B.9**).
  - The Early Triassic Digby Formation which is a poorly sorted lithic conglomerate alluvial fan deposit and has not been mapped as sub-cropping on the Mine Site.
  - The Late Permian Black Jack Group which includes the Hoskissons Coal Seam with subordinate layers of fine grained sandstone, carbonaceous siltstone and claystone. These layers have been classified as follows.
    - Arkarula Formation – Quartzose sandstone and siltstone, typically the upper 10m of the Black Jack Formation throughout the Mine Site.
    - Brigalow Formation – Coarse sandstone and conglomerate interbedded within the coal seam and grades laterally into the Arkarula Formation, thickening to the west across the Mine Site from 2m to 10m.
    - Pamboola Formation – Lithic sandstone, siltstone, claystone and coals. Continuous over the Mine Site below the Arkarula Formation and Brigalow Formation with a thickness of between 55m to 75m.
  - The Late Permian Millie Group, Early Permian Bellata Group and Gunnedah Basin sequence basement lie beneath the Black Jack Group but would not be intersected by the proposed underground workings.

- Aquaterra notes that the Gunnedah Basin sequence contains local groundwater flow systems in fractured rock. Bore yields within the Gunnedah GWMA on and surrounding the Mine Site are generally low and similar to the Purlawaugh Formation.

- The Upper Namoi GWMA (004) which is contained in the unconsolidated sediments of the Namoi River and its tributaries. The Upper Namoi GWMA is divided into 11 zones of which Zone 5 is found to the east of the Mine Site. The alluvium associated with the Namoi River valley can exist to depths in excess of 100m, as is seen in the palaeochannels to the north of Narrabri. The aquifer is considered to be stressed due to large over-allocations of groundwater extraction.

Elsewhere, alluvial / colluvial sediments form surface cover over the sub-cropping geological units (see **Figure 4B.9**), with thicknesses that can extend up to 30m.

4B.2.2.1.2 Local Hydrogeology

Local hydrogeological conditions have been identified based on the following investigations.

Groundwater Modelling of the Saturated Aquifer System of the Upper and Lower Namoi Valley Alluvium

Identified as a narrow palaeochannel 3km to 10km in width, the Namoi Valley contains a sequence of non-marine alluvial deposits (up to 120m thick) of Tertiary and Quaternary age. A numerical groundwater flow model (using MODFLOW), periodically revised since 1982, has been developed to simulate the behaviour of this aquifer system and has been incorporated into the model developed for the Mine Site and surrounds.

Groundwater Investigations Undertaken by GHD (2007) for the Stage 1 Narrabri Coal Mine

Through a review of the available literature and mapping of the hydrogeological properties of the various formations below the Mine Site, and site investigations which involved the construction and permeability testing of eight groundwater bores, GHD (2007) reported that the groundwater at the Mine Site is typically associated with fractures encountered in the consolidated sedimentary rocks and volcanics. In consolidated sandstones and shales, groundwater can occur both in the pore space in the rock matrix and within fractures and joints, whereas in the volcanics groundwater is generally only associated with fractures and joints. In the absence of fracturing, the inter-bedded and laminated nature of the Napperby and Purlawaugh Formations is likely to restrict vertical groundwater flow in these formations.

Shallow groundwater intersections at depths of 15m to 30m below surface are associated with the weathered and fractured strata of the Garrawilla Volcanics. Between 35m and 75m below surface, groundwater intersections within a confined to semi-confined fractured rock aquifer occur within the Purlawaugh, Napperby and Garrawilla Volcanics formations. Deeper groundwater intersections, typically associated with the fractures in the Basalt Sill and Napperby Formation, are encountered from 74m to 144m below surface. The pump testing of piezometers within the Hoskissons Coal Seam, Arkarula Formation and Pamboola Formation encountered groundwater, however, low permeability values and slow recharge rates suggest the three formations are unlikely to provide significant groundwater intersections.

Groundwater Investigations Undertaken by Aquaterra (2009) for the Stage 2 Longwall Project

Additional monitoring bores have been installed within and surrounding the Mine Site since the completion of the Stage 1 groundwater assessment. These additional installations bring the total dedicated groundwater monitoring bores within the monitoring network to 26. **Figure 4B.9** presents the location of the groundwater monitoring bores, targeting the principal

hydrogeological units of the Mining Area, on the Mine Site[2]. Monitoring of groundwater levels in 20 of the 26 piezometers (P1 to P20) and 12 existing registered bores (WB1 to WB12) indicates that groundwater levels in most bores have generally been very stable and are not influenced greatly by direct rainfall recharge.

Permeability testing undertaken by Aquaterra (2009) (by falling head slug tests) were conducted on the new monitoring bores (constructed since the Stage 1 testing) and a selection of Stage 1 monitoring bores. The test results for both the Stage 1 and Stage 2 Longwall Project tests are summarised in **Table 4B.7**.

Table 4B.7
Permeability Testing Results for Selected Monitoring Bores

Monitoring Bore ID[1]	Screen Interval (m bgl)	Hydraulic Conductivity(K) (m/day)			Target Formation
		Stage 1 Test Results[2]	Stage 2 Test Result[3]		
			Method		
P1	44 – 50	NT	Slug	0.11	Garrawilla Volcanics
P2	44 – 50	NT	Slug	0.057	Napperby Formation
P3	34 – 40	NT	Slug	0.03	Pamboola Formation
P4	24 – 30	NT	Slug	0.004	Napperby Formation
P5	24 – 30	NT	Slug	0.002	Pamboola Formation
P6	78 – 90	NT	Slug	0.029	Pilliga Sandstone
P7	78 – 90	NT	Slug	0.19	Pilliga Sandstone
P8	57 – 63	NT	Slug	0.017	Purlawaugh Formation
P9	24 – 30	0.41	NT	0.032	Purlawaugh Formation
P10	118 – 130	NT	Slug	0.049	Napperby Formation (no sill)
P11	44 – 50/ 24 – 40	0.0007	Slug	0.00055	Napperby Formation
P12	84 - 90	0.0016	Slug	0.09	Napperby Formation above sill
P13	24 - 30	0.068	Constant Rate -DD	0.44	Garrawilla Volcanics / Napperby Formation
			Constant Rate - Recovery	0.016	
			Slug	0.13	
P15	24 – 30	0.047	NT		Garrawilla Volcanics
P16	137 - 146	NT	Slug	0.003	Garrawilla Volcanics
P17	47 - 56	NT	Slug	0.0028	Purlawaugh Formation
P18	143 - 146	0.0086	Slug	0.013	Hoskissons Coal Seam
P19	184 - 187	0.0028	Slug	0.023	Pamboola Formation
P20	159 - 162	0.012	Slug	0.013	Arkarula Formation
GWB4S	57 – 63	0.0011	NT		Purlawaugh Formation
Claremont Bore	?	NT	Constant Rate - Recovery	2.0[4]	Garrawilla Volcanics

NT = No Test
Note 1: See **Figure 4B.9** Note 2: Recorded by GHD (2006) or RCA (2007) Note 3: Recorded by Aquaterra (2009)
Note 4: The calculated hydraulic conductivity was assessed to be approximately 2m/day based on a measure transmissivity of 75m^2/d and an aquifer thickness of 37m. This result indicates a higher permeability for the volcanic unit than normally encountered and is probably related to localised fracturing.

Source: Modified after Aquaterra (2009) – Table 3.2

[2] It is noted that several monitoring bores located to the west (P7), north (P5) and east (P3) of the Mine Site are beyond the coverage of **Figure 4B.9**.

On the basis of the hydraulic conductivity results presented in **Table 4B.7** the hydraulic conductivity within the geological units of the Mine Site has been summarised as follows.

- Several zones of elevated hydraulic conductivity occur within various formations (up to 0.44m/d in the Garrawilla Volcanics and the Pilliga Formation). Moderately high conductivity (0.09m/day) was also found in the Napperby Formation (above the basalt sill).
- Other units show a wide range of conductivities (0.0005m/d to 0.03m/d), with the higher conductivities generally in sub-crop areas. The mean conductivity of the Purlawaugh Formation and Basalt Sill is an order of magnitude lower (0.01m/d to 0.02m/d). All formations are assumed to be fractured and range from unconfined to semi-confined.
- The geological units underlying the Basalt Sill are characterised as being of low inherent permeability. The mean permeability of the Napperby Formation (below the sill) and the Digby Formation range from 1 x 10-4 m/d to 8 x 10-5 m/d.
- The mean permeabilities of the Black Jack Group, comprising the Hoskissons Coal Seam, Arkarula Formation/Brigalow Formation and the Pamboola Formation, ranged from 2 x 10^{-3} m/d to 3 x 10^{-2} m/d.

4B.2.2.1.3 Groundwater Systems and Flow Patterns

By reviewing the information gathered on local hydrogeology (see Section 4B.2.2.1.2), Aquaterra (2009) identifies two groundwater flow systems occur below the Mine Site, namely a shallow aquifer system and a deep aquifer system.

The shallow groundwater system occurs in the upper part of the Permo-Triassic sequence where it is weathered and locally fractured. This shallow aquifer effectively occurs within a range of geological units, due to the westerly dip on the strata. Groundwater in this aquifer is localised and influenced primarily by topography and local surface drainage, ie. flow is north to northeast towards the Namoi River. Recharge to the shallow aquifer system is believed to occur by infiltration of rainfall through the surficial alluvium and regolith (weathered material of the Surat Basin), with discharge occurring at the lower regional drainage lines.

The deeper aquifer system is influenced by regional features such as basin structure and regional recharge and discharge processes, and groundwater flow occurs primarily in fractures. Visual inspection of drill core suggests that the stratigraphic units are heterogeneous with aquifer properties varying depending on the nature and continuity of fractures and joints. The limited number of formation-specific monitoring points over the Mine Site makes it difficult to accurately map groundwater flow patterns. An analysis of temperature variations within the monitored bores indicates an increase in temperature at depths which correspond to the Hoskissons Coal Seam. This has been interpreted to correspond to increased groundwater flow within the coal seam.

4B.2.2.2 Surface Water – Groundwater Interaction

Groundwater Recharge

The main recharge mechanism for the groundwater within the Mine Site is local infiltration of rainfall with recharge rates a function of rainfall intensity, evaporation, vegetation coverage and density, topography and soil properties of the surficial aquifer material. Recharge occurs by direct infiltration of rainfall and local runoff into the unconsolidated surficial material, comprising alluvium/colluvium in low-lying areas, and the weathered zone of the bedrock (regolith layer) in more elevated areas. Water percolates downwards until reaching a zone of reduced permeability (top of fresh bedrock beneath the alluvium/colluvium, or the base of weathering), and then flows laterally above the less permeable aquitard layer.

The Permian and Triassic aquifers of the Mine Site are also recharged at the outcrop or sub-crop of the Surat Basin units (beneath the Quaternary alluvium or weathered 'regolith' layer). Where permeable areas of the Jurassic, Triassic and/or Permian formations sub-crop beneath alluvium, colluvium or highly weathered bedrock, recharge can also occur to these hard rock formations by downward percolation through the unconsolidated materials.

Natural groundwater discharge occurs through evapotranspiration, seepage and spring flow where the watertable intersects the ground surface, and through base flow contributions to creeks and rivers, including possible discharge to the alluvium in some locations. Local spring or seepage discharges may also occur wherever a permeable fractured zone within a hard rock unit crops out, such as on hillsides or the flanks of creeks and gullies, if the water level in that unit is higher than the ground surface.

Groundwater Discharge

With the possible exception of the area of the Mine Site around P13, where a perched groundwater aquifer was measured at 5m below surface (formed by the sub-crop zone of the Garrawilla Volcanics in a low lying area adjacent to a local drainage channel), Aquaterra (2009) reports that as groundwater generally occurs >15m below surface across the Mine Site, there is a very low likelihood for groundwater discharge to surface water systems.

To the south of the Mine Site, a spring discharging to surface (referred to as the "Mayfield Spring") has been identified and is utilised for stock watering (**Figure 4B.10**). It is believed to be derived from the Purlawaugh Formation with a flow rate not exceeding 0.1L/s. The Department of Environment, Climate Change and Water – NSW Office of Water (NOW) has also recorded the occurrence of an additional two groundwater derived springs further south of the Mine Site. **Figure 4B.10** identifies the locations of these groundwater dependent ecosystems to the south of the Mine Site referred to locally as Hardys Spring and Eather Spring.

More regionally, Aquaterra (2009) report that there is probably some discharge from the Jurassic-Permian formations to the Namoi Valley alluvium to the east of the Mine Site.

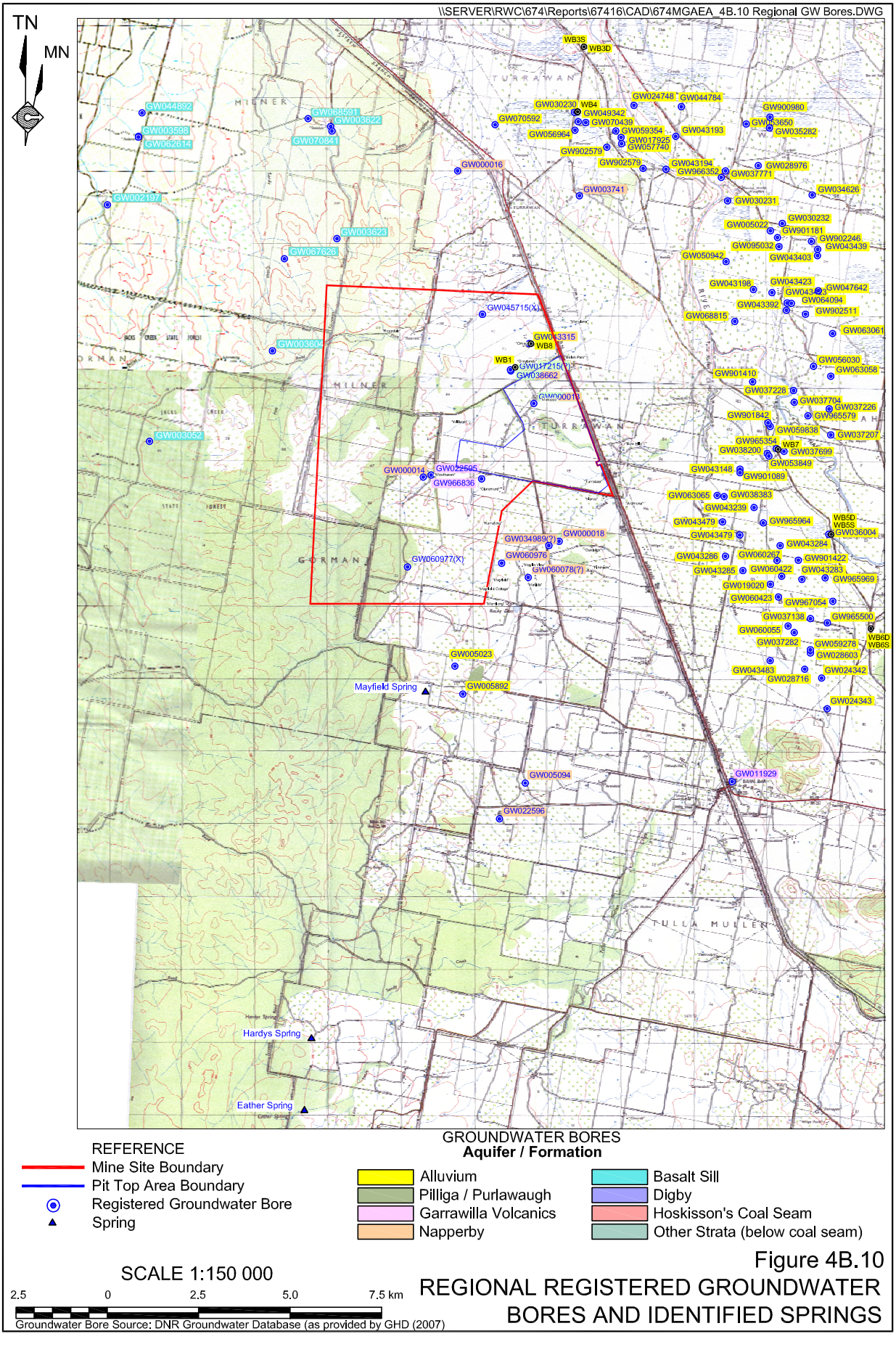


Figure 4B.10
REGIONAL REGISTERED GROUNDWATER BORES AND IDENTIFIED SPRINGS

4B.2.2.3 Groundwater Quality

Groundwater monitoring undertaken since the approval of the Stage 1 Narrabri Coal Mine has been analysed and compared to the groundwater quality analysis of GHD (2007) by Aquaterra (2009) to gain an understanding of the groundwater contained within the various geological units above the Hoskissons Coal Seam. Aquaterra (2009) reports that groundwater quality is variable, both in terms of key field parameters such as salinity and pH, and also in terms of major and minor hydrochemical constituents. The analytical testing of groundwater data collected from the geological units that would potentially be affected by the Longwall Project indicates the following.

- Groundwater pH is in the neutral to slightly alkaline range of 6.7 to 8.2.
- **Figure 4B.11** presents the distribution of salinity (as mg/L TDS) measured at various boreholes over the Mine Site. Groundwater salinity varies considerably, with recorded values of total dissolved solids (TDS) ranging from less than 100mg/L in the Garrawilla Volcanics and less than 500 mg/L within the Pilliga and Purlawaugh formations, to more than 16,000 mg/L in the Napperby Formation and the Basalt Sill.
- Limited sampling from the Hoskissons Coal Seam suggests that salinity within the coal seam would be around 2000mg/L (TDS), which is lower than overlying Triassic and Permian strata where salinities ranging from 6000mg/L to 8000mg/L TDS are typical. Aquaterra (2009) notes, however, that recent groundwater sampling and analysis from the SIS drilling program suggests that the TDS concentration within the Hoskissons Coal Seam may be up to 8000mg/L. Aquaterra (2009) suggests that the lower salinity determined from earlier monitoring may be limited to areas close to outcrop/subcrop.
- Laboratory analyses of groundwater samples indicate moderately elevated dissolved metals concentrations in groundwater. Notably, most sampled groundwater exceeded the ANZECC (2000) dissolved metal concentration guideline values for Cu, Pb, Ni and Zn. A number of groundwater samples (from bores P1, P2, P4, P5, P10 and P11) exceed the ANZECC (2000) guidelines for Mn as well.
- An analysis of major ions contained within the sampled groundwater identified that all groundwater was low in sulphate, but there is a broad distribution from bicarbonate to chloride dominance among the other anions. Chloride dominance occurs in the higher salinity waters from deeper intersections, particularly in the Pamboola Formation and the Napperby Formation. Bicarbonate dominance is normally associated with low salinity, and is typically an indicator of recent recharge or proximity to recharge in the flow system. An exception to this is found in the groundwater of the Hoskissons Coal Seam and Arkarula Formation where bicarbonate dominates despite relatively high salinity. In this case, the high bicarbonate is believed to be derived from some mineralisation source in the Permian sequence.

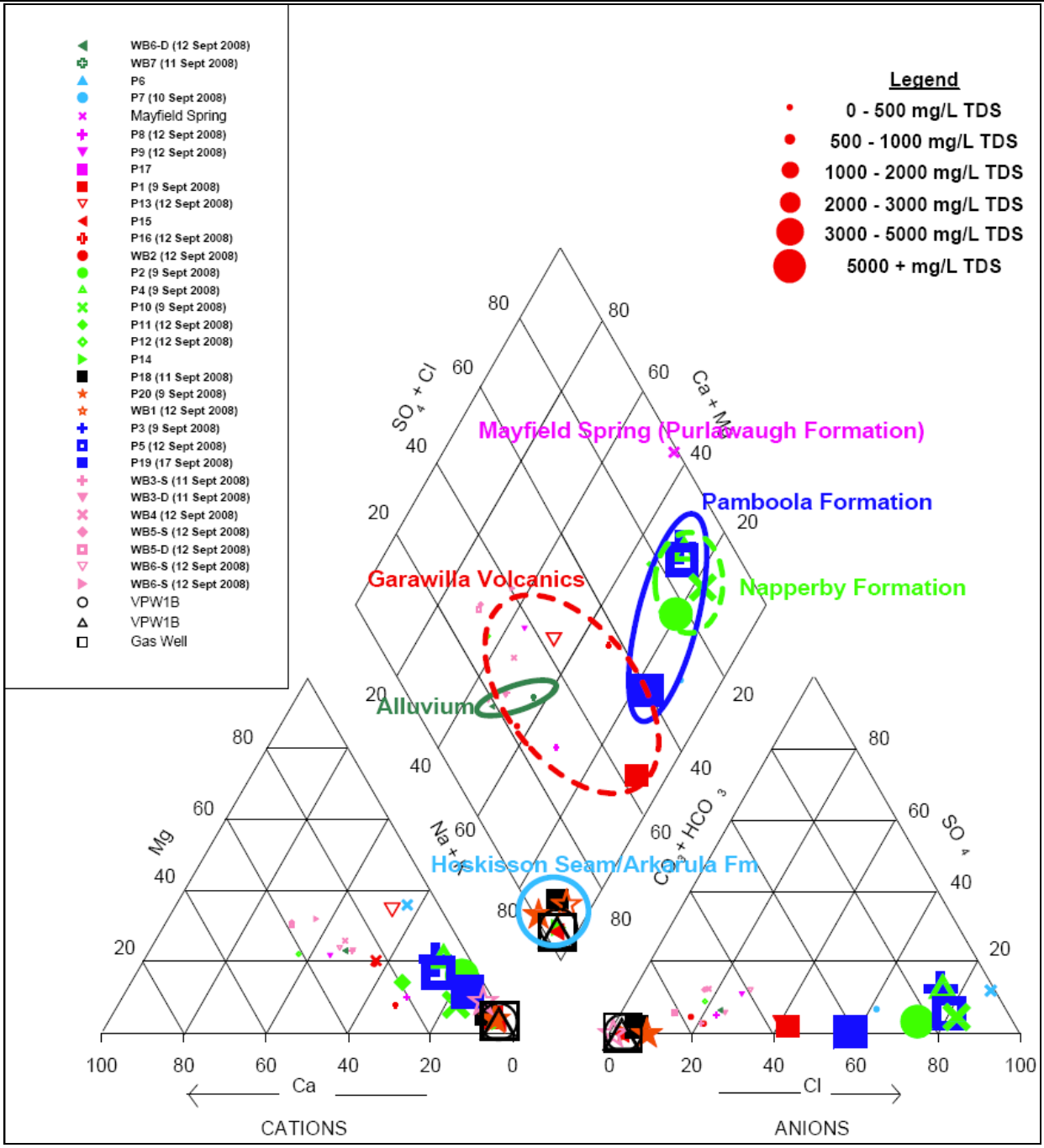


FIGURE 4B.11
GROUNDWATER QUALITY

Source: Aquaterra (2009) – Figure 4.9

4B.2.2.4 Water Use and Availability

Groundwater use within the boundaries of the Mine Site is restricted to a number of low yielding groundwater bores used for stock and domestic purposes. Surrounding the Mine Site, ie. within 5km of the Mine Site, groundwater is also used predominantly for domestic or agricultural purposes, with the extent of use invariably dependent on the quality of water and/or

yield available from the bore. A summary of groundwater use, based on consideration of the former DWE groundwater bore database and general liaison between the Proponent and local landholders, is as follows.

- Numerous bores are registered in the Quaternary alluvium of the Namoi River Valley (Lower and Upper Namoi Alluvial Groundwater Source) (see **Figure 4B.10**). These bores are typically shallow bores screened within the Quaternary alluvium and the pumped water used for domestic, stock and irrigation purposes. Some of the deeper irrigation bores are up to 80m deep and have yields of up to 90L/s.
- To the south, north and west of the Mine Site, some groundwater bores screen the Pilliga Sandstone and possibly other deeper Jurassic sediments. The groundwater of these bores is generally non-saline with bore yields of between 0.1L/s and 0.8L/s. The standing water levels vary between 50m to 80m below surface level close to the Mine Site to typically between 30m to 40m depth further to the northeast. Other groundwater bores on or surrounding the Mine Site with better quality water screen the Garrawilla Volcanics.
- A limited number of groundwater bores within 5km of the Mine Site are identified as screening the deeper formations of the Gunnedah Basin Groundwater Source. This water is generally more saline than water drawn from the geological units of the intake beds of the GAB, with yields less than 2L/s.

As noted in Section 4B.2.2.2, GDEs to the south of the Mine Site, occurring as groundwater derived springs, draw water from the Purlawaugh Formation.

It is noted that Narrabri Shire Council sources the town water supplies for both Narrabri and Boggabri from groundwater bores within the Upper Namoi Alluvial Groundwater Source. Discussions held with Narrabri Shire Council personnel indicate that while in recent times recovery times within these bores has increased slightly, groundwater draw from these bores remains well below their licenced and operational capacity.

4B.2.2.5 Regulatory Framework

Water sharing plans (WSPs), ie. statutory instruments under the *Water Management Act 2000*, have been prepared for the Great Artesian Basin Groundwater Sources (with the Mine Site located within the Southern Recharge (non-artesian) zone of the GAB) and the Upper and Lower Namoi Groundwater Sources (the Mine Site is located within the Upper Namoi Groundwater Source). These WSPs are designed to provide long term environmental protection and achieve a level of sustainability of the groundwater resources as well as directing how water would be allocated and shared among the different water users and apply the goals and principles of the State Groundwater Policy at the regional and local level.

The NSW EPA 2003 State of the Environment Report identified groundwater use in the Great Artesian Basin (GAB) Groundwater Sources exceeded 100% of the sustainable yield. In the Upper Namoi GWMA, groundwater use is 70% to 100% of sustainable yield (DEC, 2003). As a consequence, the Upper Namoi and GAB Groundwater Sources have been identified by the former Department of Water and Energy as high risk aquifers (DLWC, 1998).

4B.2.3 Potential Impacts on Groundwater Quality and Availability

4B.2.3.1 Potential Sources of Groundwater Contamination

The potential sources of groundwater contamination include:

- fuel, oil or other hydrocarbon spills or leaks;
- recharge of saline water and/or concentrated brine to fresh water aquifers; and
- explosives residues.

Based on experience elsewhere, explosives residues would be unlikely to have any measurable effect on the chemistry of the groundwater. In any event, negligible quantities of explosives would be used throughout the life of the mine. Potential contamination by fuel, oil or other hydrocarbons, and/or localised increases in the salinity of currently non-saline aquifers, are therefore the main issue that needs to be managed across the Mine Site.

4B.2.3.2 Potential Impacts on Groundwater Availability

Longwall mining would create a pressure gradient between the aquifers surrounding the underground mine (high pressure) and void (low pressure) resulting in the movement of groundwater flow into the underground void. This groundwater would be pumped from the underground mine resulting in the continuance of these mine in-flows. As water is drawn from the aquifers of the underground mine (Hoskissons Coal Seam) and immediately above, the vertical movement of groundwater from aquifers higher in the geological sequence downwards (from higher to lower pressure) may be accelerated. Ultimately, this movement of groundwater into the underground mine or accelerated vertical movement of groundwater would lead to a lowering of the water levels within the intercepted aquifers, which may subsequently impact on the yield of the groundwater bores on landholdings surrounding the Mine Site (see **Figure 4B.10**).

Continuous sub-surface fracturing resultant from mine subsidence may increase vertical movement of groundwater from the strata higher in the geological sequence by creating higher permeability flow paths along the cracks. This may increase the lowering of groundwater levels within affected geological units, thereby increasing the impact on groundwater availability and yield. Flow between geological units higher in the sequence, not directly connected to the underground mine, may also occur as a result of discontinuous sub-surface fracturing. The impact of this discontinuous fracturing would be less influential on groundwater levels and yields as the pressure gradient between the units linked by cracking would not be as great as that created by continuous cracking into the underground mine. The results of subsidence modelling provided in Section 4B.1.6 have been used to assess the impact of mine subsidence on mine in-flows and movement of groundwater between geological units, and subsequently groundwater levels and availability.

The potential lowering of shallow and non-saline aquifers which recharge the GAB and Upper Namoi Groundwater Sources also has the potential to affect groundwater dependent ecosystems (GDEs) which may be dependent to varying degrees on this water supply.

4B.2.4 Management Measures and Mitigation Measures

4B.2.4.1 Groundwater Contamination

Although it is not anticipated that the Longwall Project would have a significant or long-term impact on the level or quality of groundwater beneath landholdings surrounding the Mine Site, specific controls and mitigation measures have been proposed by the Proponent for surface hydrocarbon and saline water management. These measures are described in relation to the overall surface water management system in Section 4B.3.4.2.5.

It is currently proposed to re-inject concentrated brine solution into the completed underground workings following the cessation of mining. Transfer of the brine from the Brine Storage Area to the injection points (goaf gas drainage holes likely to be located over the western-most longwall panels) would be managed to minimise the risk of pipeline leakage or break. A HDPE pipe would be placed within an excavated channel such that should a leak occur, the discharged brine would remain within the channel. The length of the pipe would be regularly inspected to ensure no breaks or leaks. At the time of installation, additional monitoring controls would be considered, eg. flow meters linked by telemetry. In the event of a large spill or leak, the spill control measures outlined in Section 4B.3.4.2.5 would be implemented.

Based on modelling of the injection process, the brine would be re-injected over a 2 year period. This would ensure that groundwater levels do not rise to elevations which would have allowed saline water to enter the Garrawilla Volcanics via the subsidence zone. With a 2 year re-injection period, Aquaterra (2009) established that water levels in the goaf area would not rise above the top of the Napperby Formation during the re-injection period.

Finally, the Proponent is committed to continuing its ongoing investigations into alternative uses for the brine (see Section 2.14.4). Feasible and cost effective alternatives to brine re-injection will continue to be considered throughout the life of the mine.

4B.2.4.2 Groundwater Availability

Given the bulk of the groundwater in-flows would originate from the Gunnedah Basin Groundwater Source geological units which are saline and, with the possible exception of fractured zones, low in permeability, the likely impact on groundwater levels, bore yields and groundwater availability generally is predicted not to be significant. As such, emphasis in the management of groundwater availability (and groundwater quality) would be placed on the implementation of a groundwater monitoring program, as recommended by Aquaterra (2009). Section 4B.2.6.1 presents further detail on the preparation of the groundwater monitoring program while Parts 6 and 16 of **Table 5.1** present the details of commitments made in relation to this groundwater monitoring program.

4B.2.5 Assessment of Impacts

4B.2.5.1 Impact Assessment Criteria

Water Quality

Table 4B.8 presents the National Environment Protection Measure (NEPM) groundwater quality criteria (NEPC, 1999). Groundwater quality would be assessed predominantly against the NEPM livestock guideline levels, given this is the predominant use of groundwater in the vicinity of the Mine Site.

Impacts on the water quality parameters of pH, TDS, other anions and heavy metals (not considered by the NEPM criteria) would be based on comparisons to baseline monitoring of groundwater quality taken from all groundwater bores within the Mine Site.

Groundwater Levels and Water Availability

Groundwater levels and the saturated thickness within bores on neighbouring landholdings would be monitored with any variations over 15% considered a significant impact given these levels would be expected to naturally vary by this much. The criteria for groundwater level and saturated thickness has therefore been determined to be a >15% decrease in water level or saturated thickness.

Table 4B.8
Groundwater Quality Criteria

Analyte	Agricultural Irrigation (mg/L)	Livestock (mg/L)
Arsenic (total)	0.1	0.5
Cadmium	0.01	0.01
Chromium (Total)	1.0	-
Chromium (VI)	0.1	1.0
Copper	0.2	0.5
Lead	0.2	0.1
Manganese	2.0	-
Mercury (total)	0.002	0.002
Nickel	0.02	1.0
Zinc	2.0	20.0
Calcium	-	1 000
- No published values		
Source: Modified after NEPC (1999)		

4B.2.5.2 Assessment Methodology

4B.2.5.2.1 Groundwater Model Construction

The extent of mine in-flows into the underground workings and the effect the Longwall Project would have on groundwater levels, borehole yields, groundwater level re-establishment and availability of groundwater from existing surrounding bores has been predicted using the United States Geological Survey (USGS) finite-difference groundwater flow modelling code MODFLOW 2000 (Harbaugh et al., 2000) in conjunction with the SURFACT module (SURFACT Version 3, HydroGeoLogic, 2006 – cited in Aquaterra, 2009).

The MODFLOW package is the industry-leading groundwater modelling software, and has advanced modules for simulating surface water and groundwater interaction which allows for the assessment of impacts on creeks and rivers. Aquaterra (2009) has identified that MODFLOW has two notable limitations when simulating longwall mining.

- MODFLOW does not allow aquifer properties to change with time as mining progresses. In order to overcome this potential limitation, the model simulation has been run in a series of consecutive time slice models, with model hydraulic parameters changed from one time slice to the next to reflect the mining advance and associated subsidence.

- Standard MODFLOW cannot routinely simulate free draining conditions in rock layers above a longwall panel. By using the SURFACT module, saturated and unsaturated flow conditions can be simulated allowing for more stable drying and re-wetting of cells in thin model layers (such as coal seams and thin aquitards).

Aquaterra (2009) reports that the modelling and hydrogeological assessment generally was undertaken in accordance within the '*Guidelines for Management of Stream/Aquifer Systems in Coal Mining Developments – Hunter Region'* (DNR, 2005), and the modelling was undertaken in accordance with the best practice guideline on groundwater flow modelling (MDBC, 2001).

The extent of the model used for the Longwall Project extends that constructed by GHD (2007) to cover an area which includes the Boggabri Ridge extending west of the Mullaley Sub-basin and parts of the Gunnedah Basin, Upper Namoi and intake beds for the GAB Groundwater Sources. The model domain was also extended to capture the Namoi River alluvial aquifer system.

Similar to the GHD (2007) model, the Longwall Project groundwater model contains 11 active layers representing the major hydrogeological units of the Mine Site (see **Table 4B.9**) and differentiates between the Gunnedah Basin sequence (Gunnedah Basin GWMA), the Jurassic formations which comprise the Great Artesian Basin GWMA and Upper Namoi Alluvium GWMA.

A significant change made to the model of GHD (2007) was the direct physical disconnection of basal units, ie. Digby Formation and Blackjack Formation, from any direct connection with shallow alluvial sediments associated with the Namoi River. Aquaterra (2009) notes that this is in keeping with the geological model for the local stratigraphy, and in recognition that the Digby Formation and the Black Jack Formation have been partly truncated by the overlying Napperby Formation.

Table 4B.9
Conceptual Model Structure

Model Layer	Formation	Groundwater Source
1	Alluvium	Upper Namoi Alluvium
2	Pilliga Sandstone	Great Artesian Basin
3	Purlawaugh Formation	
4	Garrawilla Volcanics	
5	Napperby (above Sill)	Gunnedah Basin
6	Basalt Sill	
7	Napperby (below Sill)	
8	Digby Formation	
9	Hoskissons Coal Seam	
10	Arkarula Formation	
	Brigalow Formation	
11	Pamboola Formation	

Source: Modified after Aquaterra (2009) – Table 4.3

Values for the initial input parameters of the model were generated through a review of GHD (2007), historic literature and mapping available for the region and local area, as well as additional on-site testing conducted since the approval of the Stage 1 Narrabri Coal Mine. Aquaterra (2009) provides a detailed description of the on-site testing completed and historic literature reviewed.

The Aquaterra (2009) model was then calibrated, firstly in steady state mode to simulate long term average aquifer conditions and then in transient mode to improve the model calibration by means of a historic match to the observed groundwater levels during the period November 2007 to August 2008. The calibrated aquifer hydraulic parameters resulting from the steady and transient model calibration are summarised in **Table 4B.10**.

Table 4B.10
Calibrated Aquaterra (2009) Model Aquifer Parameters

Model Layer	Formation	Hydraulic Conductivity (m/day)		Storativity	
		Horizontal (Kh)	Vertical (Kv)	Unconfined Sy (-)	Confined S (-)
1	Alluvium	0.5-5.0	0.0005-0.005	0.1	$5x10^{-6}$
2	Pilliga Sandstone	0.001-0.5	0.000005-0.0005	0.1	
3	Purlawaugh Formation	0.001-0.3	0.000005-0.0003	0.1-0.2	$5x10^{-6}$
4	Garrawilla Volcanics	0.001-0.3	0.000002-0.0003	0.1	
5	Napperby Formation (above Sill)	0.001-0.05	0.000002-0.0001	0.1	$5x10^{-6}$
6	Basalt Sill	0.001-0.01	0.000002-0.00005	0.1	
7	Napperby Formation (below Sill)	0.001-0.01	0.000002-0.000008	0.1	$5x10^{-6}$
8	Digby Formation	0.001-0.01	0.000002-0.000005	0.1-0.15	
9	Hoskissons Coal	0.005-0.01	0.000002	0.1-0.15	$5x10^{-6}$
10	Arkarula Formation	0.001-0.01	0.000001	0.1	$5x10^{-6}$
11	Pamboola Formation	0.01	0.001	0.1	$5x10^{-6}$
Source: Modified after Aquaterra (2009) – Table 6.7					

In general, overall simulated transient hydrograph results coincided very well with the actual hydrographs, confirming the model as a good predictive tool to simulate the complex multi-layer Narrabri aquifer system.

Further detail on the design and calibration and running of the model is provided in Aquaterra (2009) (*Sections 6.2 to 6.5*).

4B.2.5.2.2 Predictive Modelling (Base Case)

Using the calibrated set of boundary and hydraulic properties identified in Section 4B.2.5.2.1 (and **Table 4B.10**), the impact of the Longwall Project on the hydrogeological conditions of the Mine Site was simulated. Specific impacts of the longwall mining on the following parameters were then measured.

- Mine in-flow rates.
- Regional changes in groundwater levels, both during mining and after mine closure.
- Changes in base flow contributions to surface watercourses, particularly the Namoi River system.

- Impacts of re-injecting concentrated brine into the underground void at the completion of longwall mining. Potential impacts on groundwater quality and local groundwater table recovery were considered.

The "Base Case" simulation of potential mining impacts involved a simulation comprising 14 time slices, with the first time slice representing 3 years (from commencement of the Longwall Project) and then at 2 yearly intervals for the remaining life of the mine. The Base Case model also provides for hydrogeological conditions 100 years post-completion of the Longwall Project.

The hydraulic properties of the model cells within the region above the progressively collapsed goaf of the completed longwall panels was changed progressively to reflect progressive effects of subsidence fracturing. As the longwall mine progresses, it is expected that mine in-flows would increase (as the total void space created increases). However, to simulate the fact that once longwall mining commences in the southern longwall panels (LW14 to LW26), in-flowing groundwater could be retained in the down-dip (western) section of the underground mine (and would not need to be dewatered), the drain cells of the model associated with the down-dip section of the mine were turned off.

Post-mining recovery was simulated for a period of 100 years from the completion of mining. The recovery modelling simulated the re-injection of brine stored within the Brine Storage Area over a two year period into 20 large diameter goaf gas drainage bores screened within the goaf zone of the Hoskissons Coal Seam. Based on a water balance for the Mine Site prepared by WRM (2009) (see Section 4B.3.5), approximately 2 000ML of brine would be re-injected. In order to ensure that groundwater levels would not rise to elevations which could allow saline water to enter the Garrawilla Volcanics (via the subsidence zone), a 2 year re-injection period was used modelled. The results from the end of re-injection were used as the initial conditions for modelling the remaining 98 year recovery period.

Further detail on the simulation of the changing model conditions associated with the progressive gate road headings, longwall mining and goaf collapse is provided in Aquaterra (2009) (*Section 6.5*).

4B.2.5.2.3 Predictive Modelling (Sensitivity and Uncertainty Analysis)

Sensitivity Analysis

In order to assess the sensitivity of the model calibration to the assumed input parameters and boundary conditions, Aquaterra (2009) has undertaken a sensitivity analysis by sequentially changing key input parameters or boundary conditions, and evaluating the impacts of the changes on the calibration statistics. Any parameter change that resulted in a significant change to the scaled root mean square (SRMS) value of the model was identified as a sensitive parameter in the model.

Sensitivity analyses were undertaken on the horizontal conductivity, vertical conductivity and recharge parameters of the model to determine the impact on the SRMS value of the model. Aquaterra (2009) found the model was not highly sensitive to either horizontal or vertical hydraulic conductivity of the in-situ rock strata. However, it was assessed that the model would likely be sensitive to the hydraulic properties that were assumed for the subsidence fracture zone extending from the goaf.

Uncertainty Analysis

Uncertainty analysis is an assessment of the impact that uncertainty in the assumed values of the input hydraulic parameters has on model predictions and model reliability. While the sensitivity analyses conducted by Aquaterra (2009) suggests that the model is not sensitive to changes in hydraulic parameter values, in the absence of prior experience with longwall mining in the Gunnedah Basin, Aquaterra (2009) undertook the following uncertainty analyses.

1. Accounting for the possibility that continuous fracturing could extend higher into the Garrawilla Volcanics.
2. Assuming higher and lower vertical hydraulic conductivities for the portions of Layers 5 to 8 within the longwall footprint.
3. Assuming the changed hydraulic parameters (of uncertainty analyses 2) within the fracture zone may reduce over time (lag factor of 1 to 2 years) to model the settling and/or redistribution of fines within the affected strata.

Detail on the parameter values incorporated into each uncertainty analysis model run are provided by Aquaterra (2009 – see *Table 6.14*).

4B.2.5.3 Predicted Impacts on Mine In-flows

Figure 4B.12 presents the predicted groundwater in-flow to the underground workings, for the base case and three uncertainty analyses of Aquaterra (2009), over the life of the Longwall Project. It is predicted that groundwater would initially in-flow at a moderate rate of 0.21ML/day (78ML/year), steadily increase to a peak rate of 3.89ML/day (1419ML/year) in about Year 18 before declining as water is allowed to recover into the goaf areas of completed longwall panels in areas down dip of the active mining.

When considering the uncertainty analyses, the modelling of Aquaterra (2009) indicates the following.

- If connected fracturing extends up into the Garrawilla Volcanics, a slight increase in the peak inflow rate to 3.85ML/day (1 409ML/year) may occur.
- In the unlikely event that vertical permeabilities are increased by a significantly greater amount than anticipated in the subsidence zones above the longwall goafs, inflow rates peaking at up to 5.23ML/day (1 914ML/year) may occur.

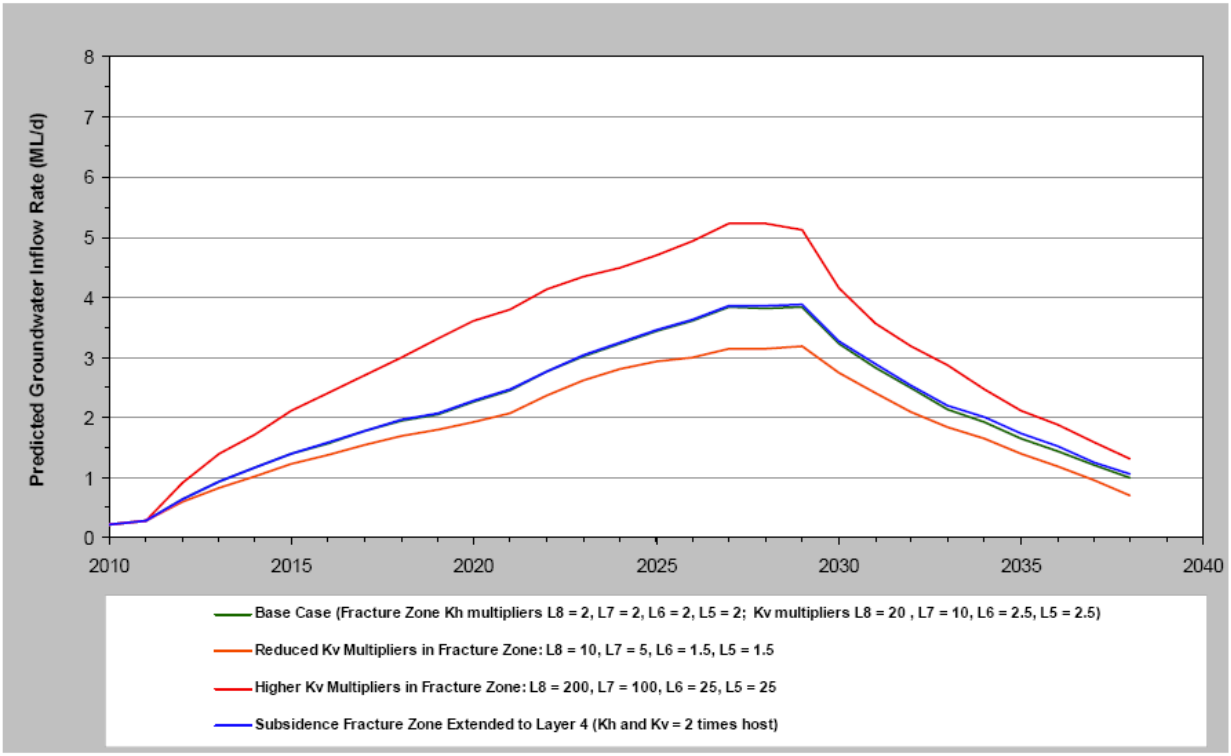


FIGURE 4B.12
PREDICTED MINE IN-FLOWS

Source: Modified after Aquaterra (2009) – Figure 6.27

Acknowledging the lack of prior experience of longwall mining in the Gunnedah Basin, the base case and uncertainty analyses 1 and 2 represent a conservative approach to parameter estimation, and therefore the prediction of possible in-flow rates. Elements of conservatism that have been built into the assessment of mine in-flows (and subsequently groundwater drawdown – see Section 4B.2.5.5) for the base case and uncertainty analyses 1 and 2 are as follows.

- The representative hydraulic properties assumed for each model layer may be too high. The values used have been influenced principally by the results of hydraulic testing, which is carried out preferentially on bores that intersected measurable groundwater inflows, ie. those bore holes which have no or very low in-flows are not included in the calculation of average hydraulic properties. Hence the dataset is skewed towards the more permeable locations, and ignores the numerous locations that are essentially impermeable.
- All model layers have been assumed to be regionally hydraulically continuous. It is likely that hydraulic barrier boundaries would be found to exist within the vicinity of the mine that would at least partly reduce the regional extent of drawdown and therefore groundwater in-flow. Aquaterra (2009) report that these hydraulic barriers are common in practice, but can only be identified under extended pumping or dewatering conditions. It is likely that some partial hydraulic barriers would be found to exist in the area of predicted impact that would lead to a reduction in actual in-flow rates.

- No allowance has been made for reduction in permeability or lateral flows of the subsidence affected strata over time. Aquaterra (2009) reports that some locations in the central Hunter Valley have shown signs of apparent "healing" or in-filling of subsidence fractures reasonably soon after subsidence occurs which leads to a reduction in ongoing drawdown and mine in-flow.

Based on the above, it is assessed that the predicted mine in-flows presented for the base case and uncertainty analyses 1 and 2 in **Figure 4B.12** (in particular that representing the higher vertical permeabilities in Layers 5, 6, 7 and 8 of uncertainty analysis 2 - see **Table 4B.10**), are likely to over-estimate actual mine in-flows. The third uncertainty analysis, which accounts for some reduction in vertical conductivity and lateral flows, provides for a reduction in the predicted mine in-flow rate, peaking at up to 3.17ML/day (1 157ML/year) may occur. This may be the more likely of the four scenarios modelled, however, in the interest of conservatism, the Proponent has provided for water management of groundwater up to and exceeding that predicted by uncertainty analysis 2.

The Proponent has committed to monitoring mine in-flows throughout the life of the Longwall Project, to obtain the necessary operational experience such that the groundwater model can be refined and recalibrated to allow for greater confidence to be placed on forward predictions of inflow rates (and other impacts).

4B.2.5.4 Predicted Impacts on Groundwater Levels

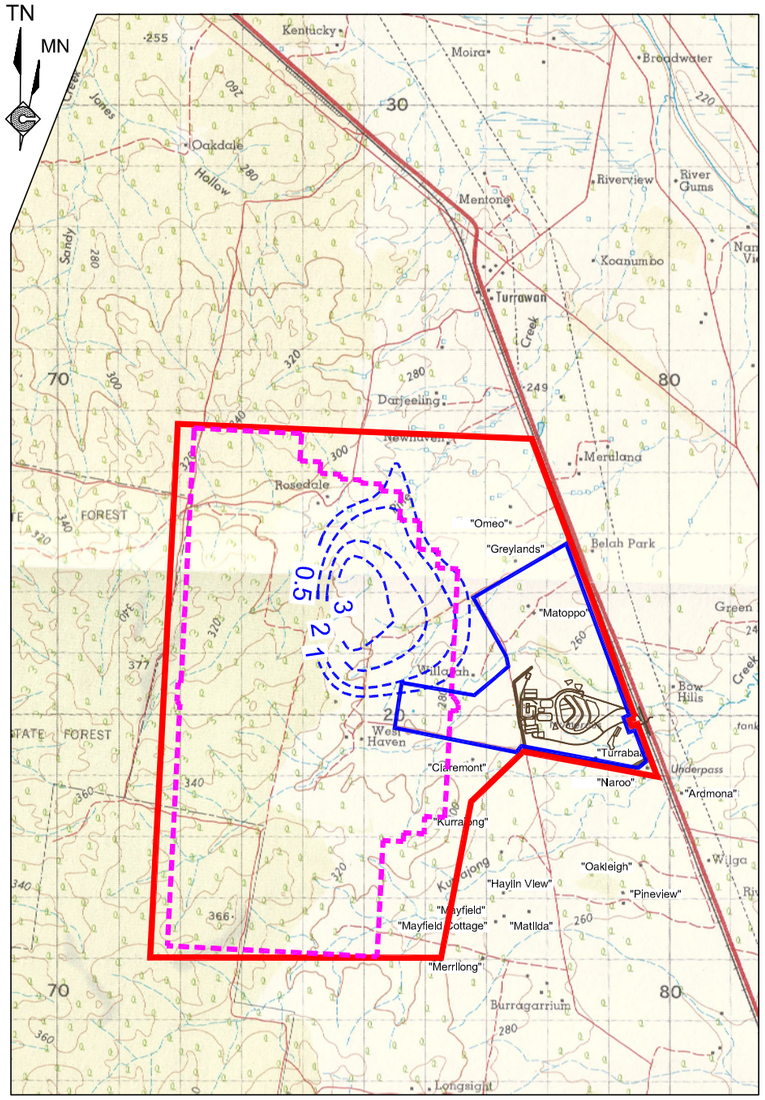
Figures 4B.13 to **4B.15** present the groundwater drawdown predicted by Aquaterra (2009) in the Alluvium (Layer 1), Garawilla Volcanics (Layer 4) and Hoskissons Coal Seam (Layer 9) after Year 15, the completion of mining (Year 29) and at the end of the recovery period (Year 129).

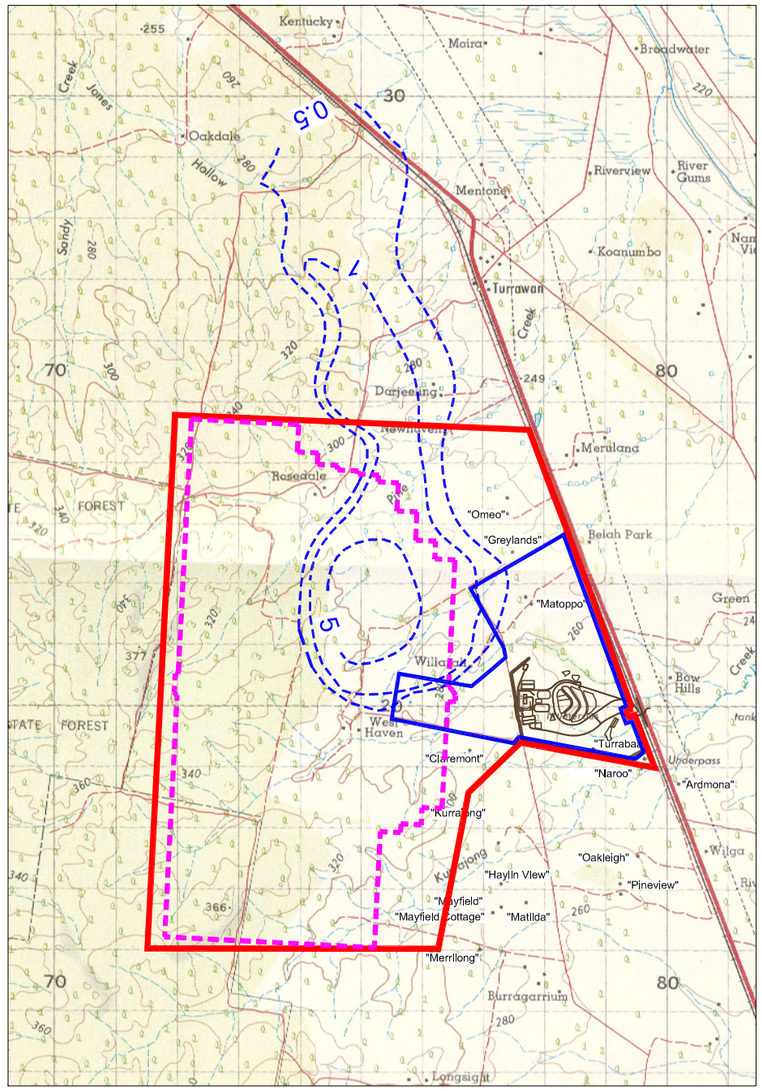
The most significant impacts on groundwater levels are predicted to occur within the Hoskissons Coal Seam (Layer 9). Groundwater in-flows would be induced laterally and from adjacent hydrogeological units, and subsidence fracturing above the goaf would allow increased drainage from the units above the longwall panels, extending up to the Napperby Formation, and possibly above into the Garrawilla Volcanics. Although the mine is not overlain by any significant aquifer, potential impacts on the aquifers that do exist are as follows:

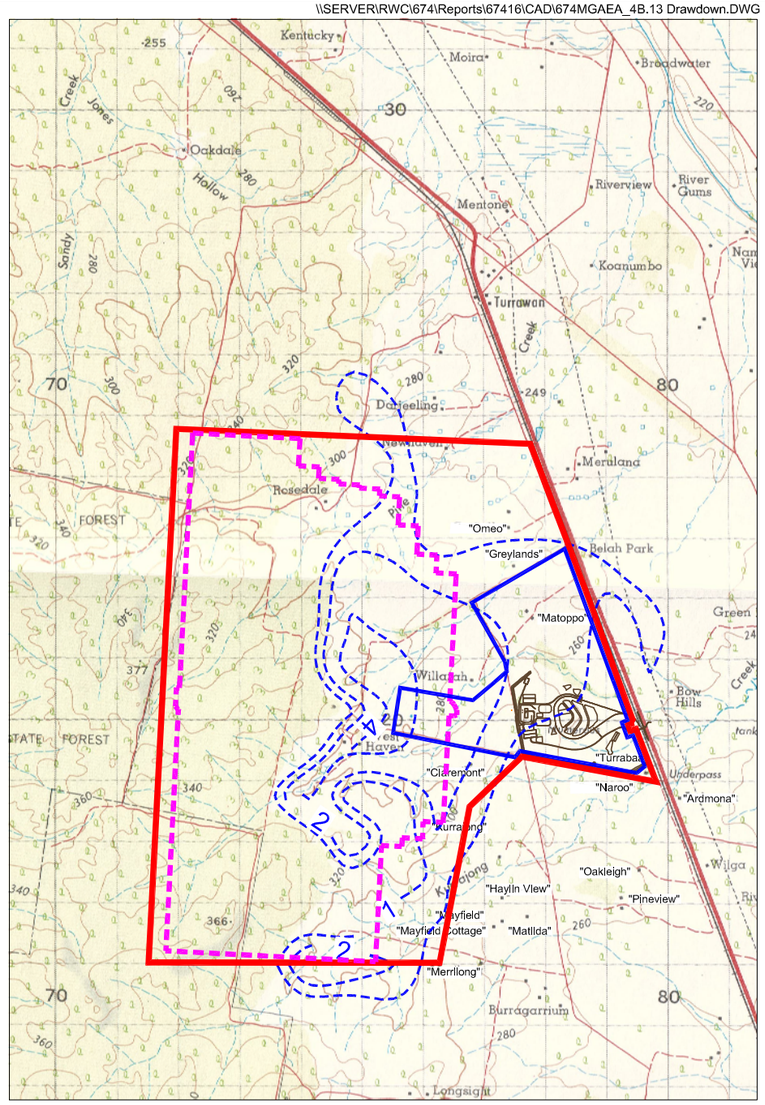
- A cone of depression centred on the Mining Area is evident in the Hoskissons Coal Seam, with a less pronounced cone of depression in the units above. A review of **Figures 4B.13** to **4B.15** indicates the following.
  - Within the Hoskissons Coal Seam, drawdowns of 5m or more extend to 15km from the Mine Site at the end of mining. Drawdowns of 1m or more are predicted to extend to a maximum of approximately 20km from the Mine Site to the southwest and northwest and 10km from the mined areas to the south. Drawdown to the east is limited by the truncation of the Hoskissons Coal Seam in sub-crop.

\\SERVER\RWC\674\Reports\67416\CAD\674MGAEA_4B.13 Drawdown.DWG

TN
MN







REFERENCE
- Mine Site Boundary
- Indicative Limit of Underground Workings
- Pit Top Area Boundary
- 3 Groundwater Drawdown Contour (m AHD)

SCALE 1:100 000

1 0 1 2 3 4 5 km

Source: Aquaterra (2009) - Figures 6.13, 6.14 & 6.21

Figure 4B.13
PREDICTED GROUNDWATER DRAWDOWN IN ALLUVIUM, COLLUVIUM AND REGOLITH

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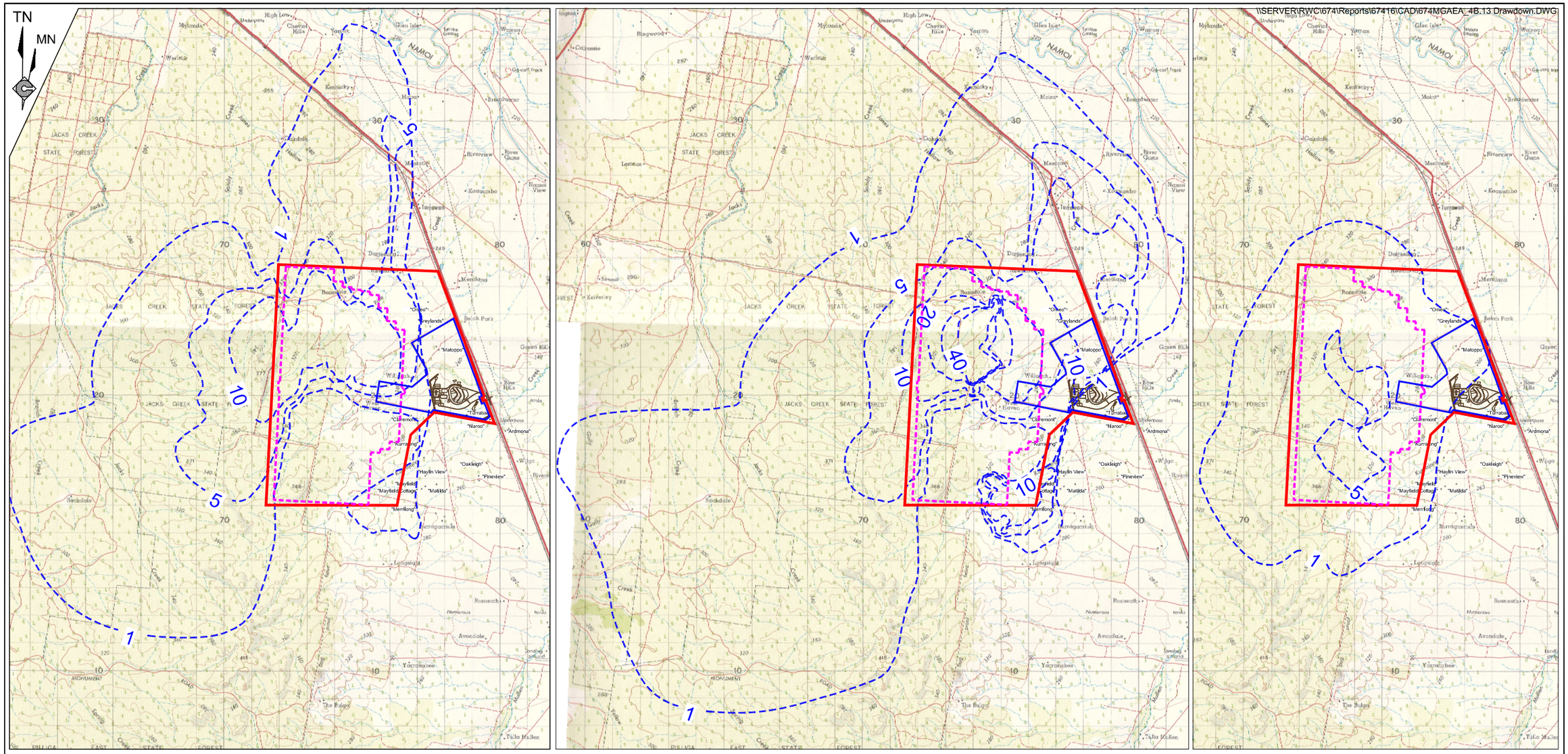


Figure 4B.14
PREDICTED GROUNDWATER DRAWDOWN IN GARRAWILLA VOLCANICS

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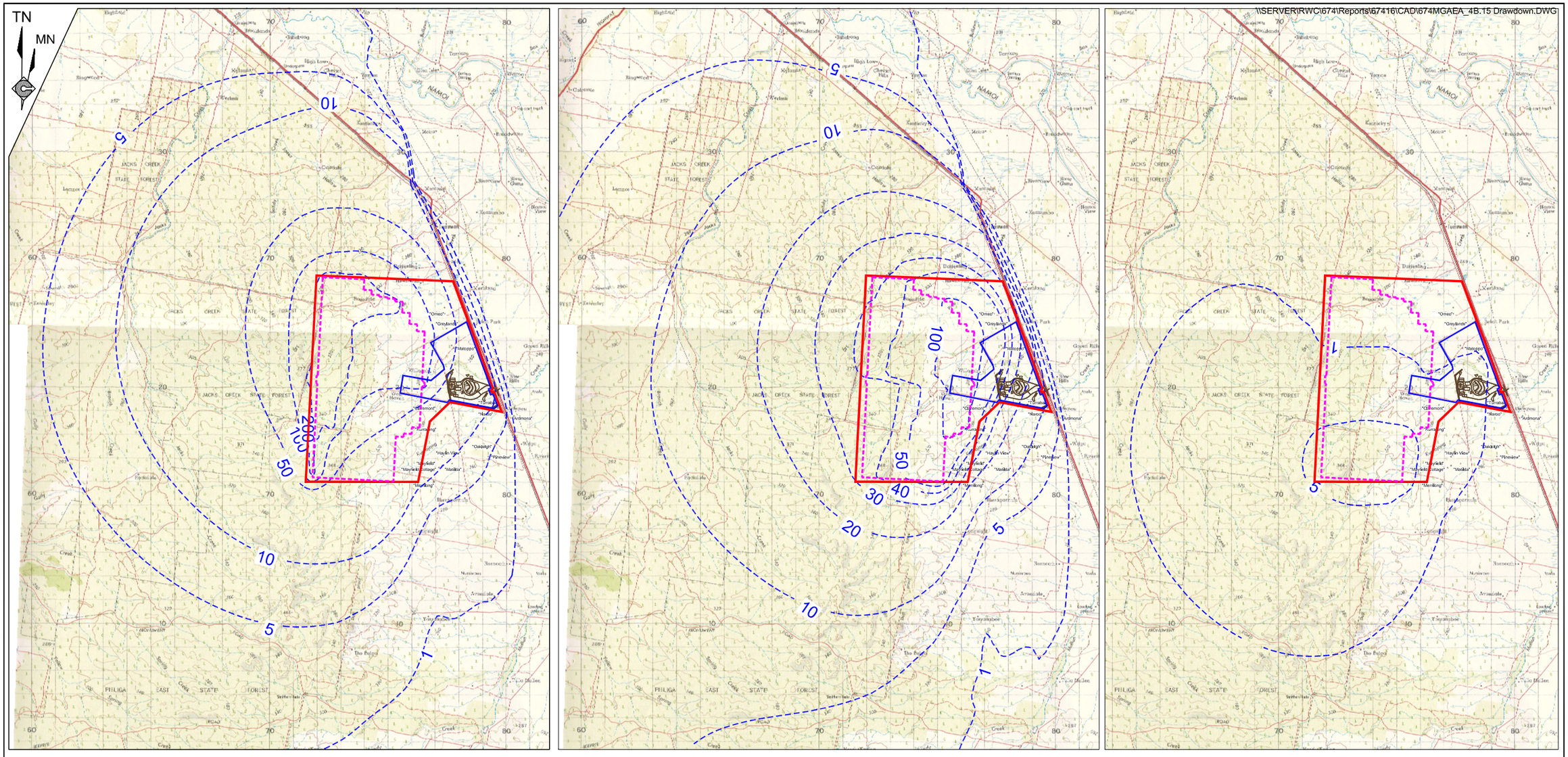


Figure 4B.15
PREDICTED GROUNDWATER
DRAWDOWN IN HOSKISSONS
COAL SEAM

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- Within the Garrawilla Volcanics, a drawdown of generally less than 5m is predicted adjacent to the mine at the end of mining. A 1m drawdown is predicted to extend between 5km and 8km to the west of the Mine Site.
- Drawdown in the water table within the regolith (Layer 1) at the end of mining is predicted to be less than 1m outside the Mining Area and limited to areas close to the mine. Maximum drawdown is limited to around 5m, and these only occur in the immediate vicinity of the Mining Area.
- Drawdown in the Namoi Valley alluvium (Layer 1) is predicted to be less than 0.1m.

- Aquaterra (2009) reports no drawdown in the Jurassic sediments of the Great Artesian Basin, ie. Purlawaugh Formation and Pilliga Sandstone.
- At the end of the 100 year recovery period, water levels in all the main hydrogeological units are predicted to have recovered to levels almost equivalent to those recorded at the start of mining.

The impact associated with the predicted drawdowns is further considered in the following sub-sections.

- Section 4B.2.5.6 considers the impact of the predicted drawdown on the three GWMAs which occur within the Mine Site.
- Section 4B.2.5.7 considers the impacts associated with the predicted drawdown on local groundwater availability and use.
- Section 4B.2.5.8 considers the impacts associated with the predicted drawdown on base flows to the Namoi River.
- Section 4B.2.5.9 considers the impacts associated with the predicted drawdown on groundwater dependent ecosystems.

4B.2.5.5 Predicted Impacts on Groundwater Quality

4B.2.5.5.1 Mine Dewatering

The average water quality of mine inflows would be a composite blend of the water qualities from all groundwater sources contributing to inflows. Aquaterra (2009) notes, however, that groundwater quality would initially be dominated by the groundwater from the Hoskissons Coal Seam and the underlying Arkarula Formation. Over time, as proportionally more groundwater flows from the higher units and from more distant parts of the area of predicted drawdown impact, the groundwater quality would change to reflect an increased contribution from those areas.

Aquaterra (2009) calculates the contribution from each unit by identifying the change in groundwater storage within each layer for each 1 year time step in the base case model, and multiplying this volume change by the average salinity for that layer, summing the totals and dividing by the total mine inflow volume for that time step to determine an average salinity value. This method gives equal weight to both close and distant changes in storage in the model, and hence may underestimate the proportional effect of salinity in the Hoskissons Coal Seam and the other Permian units close to the workings.

Aquaterra (2009) modelled the change in water quality within the underground void based on an initial groundwater salinity (TDS) of 6 000mg/L (which provides an average of all salinity measurements for the Hoskissons Coal Seam, ie. including one low salinity measurement of 2000mg/L) and 8 000mg/L (which weights the average in favour of the higher salinity measurements). Aquaterra (2009) suggests that the actual average salinity of inflows is likely to be between these two calculations.

Figure 4B.16 presents the results of this modelling which predicts that an initial average inflow salinity of between 6 500mg/L to 8 000mg/L, decreasing to around 4 500mg/L (Year 20) before steadily rising again to around 6000mg/L by the end of mining. Aquaterra (2009) notes that while some variation in the salinity of water flowing into the underground mine is expected each year due to periodic short-term inflows of higher or lower salinities, the salinity of day to day in-flows is not expected to vary dramatically.

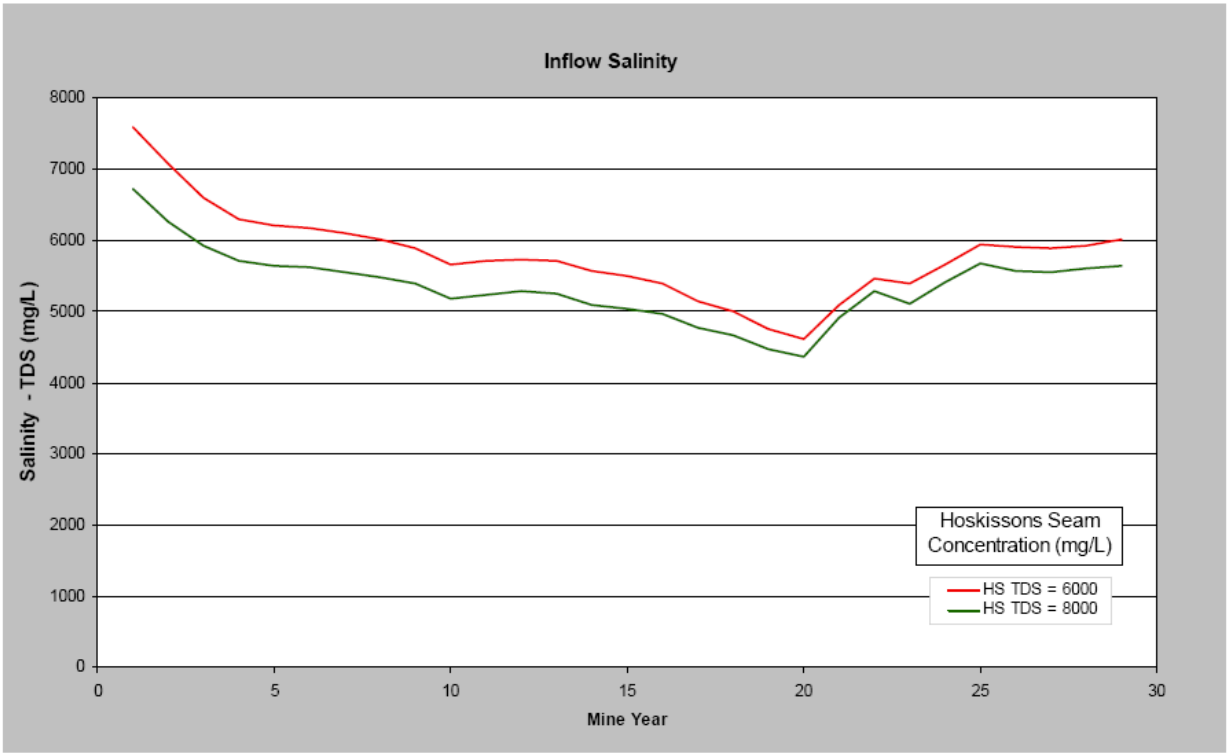


FIGURE 4B.16
PREDICTED CHANGES IN GROUNDWATER SALINITY

Source: Modified after Aquaterra (2009) – Figure 7.1

Further review of **Figure 4B.16** suggests that the groundwater quality of the Mining Area would be generally improved as lower salinity water is drawn from the units higher in the geological sequence into the void space of the underground mine.

4B.2.5.5.2 Brine Re-injection

Aquaterra (2009) undertook a particle tracking exercise on the recovery model to assess the potential for re-injected brine to migrate from the goaf to hydrogeological units of the Gunnedah Basin, Great Artesian Basin and/or Namoi Alluvium Ground Water Management Areas. The particle tracking considers that at the completion of mining and dewatering ceases, groundwater will start to flow back into the drawdown zone created by the 29 years of dewatering. Hence, groundwater will flow radially towards the mine area from the outer edges of the drawdown "cone". However, as the groundwater levels become elevated within the goaf area during the 2 year brine re-injection period, there will also be an inner region where groundwater will have the potential to initially flow outwards from the goaf area into the drawdown zone. The particle tracking concentrated on this inner region, looking at the distances travelled by particles, and also whether there is any upward migration to higher model layers. (Further detail on the particle tracking methodology and modelling is provided by Aquaterra (2009) – *Section 6.5.9*).

The results of the particle tracking indicate the following.

- Groundwater flow directions within the Jurassic strata will generally trend away from the Mining Area. The distance predicted to be travelled by particles in the simulated 100 year recovery period is limited to less than 1km from the Mining Area in all directions.
- Groundwater flow directions within the Permian – Triassic strata, initially trend away from the goaf area. The distance predicted to be travelled by particles in the simulated 100 year recovery period is limited to less than 2km from the Mining Area to the north and less than 1km elsewhere.
- In most cases, the particle tracking shows that particles stay within the layer from which they started. Where interchange between geological units does occur, the movement is downward to the underlying layer. No upward migration to a higher layer occurs.

On the basis of the above, it is predicted that the migration of brine would be restricted to less than 2km, and in most cases less than 1km from the Mining Area, in 100 years after cessation of mining. Importantly, there would be no upward migration to the higher quality aquifers of the formations of the Great Artesian Basin GWMA.

4B.2.5.6 Predicted Impacts on Groundwater Management Areas

Potential Impacts on the Upper Namoi Alluvium GWMA

As discussed in Section 4B.2.5.4, the Longwall Project would result in negligible drawdown in the Quaternary Alluvium due to the presence of a significant barrier of low permeability strata between the Namoi River alluvium and the proposed mine footprint. There would be no measurable impact in the volume of water held within the Upper Namoi Alluvium GWMA.

Section 4B.2.5.8 considers the impacts of the Longwall Project on base flows to the Namoi River.

Potential Impacts on Intake Beds of the Great Artesian Basin GWMA

The groundwater modelling of Aquaterra (2009) predicts minimal change (<0.03ML/day) in outflow to the GAB. Furthermore, the Pilliga Sandstone, recognised as a major intake bed to the GAB, is believed to be dry within the Mine Site and therefore, even in the highly unlikely event that continuous sub-surface cracking from longwall mining does extend beyond the floor of the underlying Purlawaugh Formation, which is recognised as a major regional aquitard, the intake beds would be insulated from groundwater depressurisation occurring within the underlying Permian coal measures.

On the basis of the above, the Longwall Project would have no measurable impact on the volume of water held within the intake beds of the Great Artesian Basin GWMA. In order to account for any theoretical loss in water availability within the geological units which make up the intake beds of the GAB (0.03ML/day), as a result of the minor drawdown predicted within the Jurassic sediments, and in accordance with the Water Sharing Plan which requires any removal of water to be licensed, the Proponent holds WAL AL811436 for 248MLpa within this GWMA.

Particle tracking has confirmed that saline water (brine) would not migrate from the goaf upward into the GAB formations following brine re-injection.

Potential Impacts on Intake Beds of the Gunnedah Basin GWMA

The groundwater modelling of Aquaterra (2009) predicts that impacts associated with the Longwall Project would be largely restricted to the hydrogeological units of the Gunnedah Basin GWMA. As illustrated by **Figure 4B.15**, the most significant impact on groundwater levels would be observed within the Hoskissons Coal Seam (measurable drawdown predicted up to 20km from the Mine Site at the completion of mining). Aquaterra (2009) also predicts that there would be measurable drawdown in the overlying hydrogeological units of the Gunnedah Basin (as changing hydraulic gradients draw water vertically and horizontally towards the void space of the underground workings). The drawdown in the Triassic units of the Gunnedah Basin GWMA are less pronounced than those within the coal seam and are typified by those predicted within the Napperby Formation. A measurable drawdown (of ≥1m) is predicted to extend to approximately 10km from the Mining Area, however, the level of drawdown quickly reduces from a maximum of 20m immediately adjacent to the Mining Area.

As a consequence of drawdown impacts being predominantly restricted to the hydrogeological units of the Gunnedah Basin GWMA, and the negligible impact of the predicted drawdowns on the volume of water held within the Upper Namoi Alluvium, and intake beds of the Great Artesian Basin GWMAs, it is concluded that the vast majority of mine in-flows would originate from the Gunnedah Basin GWMA. Therefore, the Longwall Project is predicted to reduce the volume of water held within the Gunnedah Basin GWMA each year.

To account for the predicted annual reduction in the volume of groundwater held within the Gunnedah Basin GWMA, the Proponent is currently finalising the acquisition of an Aquifer Interference Licence No. 90BL254679 under the *Water Act 1912* with an allocation of 818MLpa. Based on the groundwater modelling of Aquaterra (2009), this allocation would be sufficient for the predicted mine in-flows up to Year 11 of the Longwall Project (see **Figure 4B.12**). Prior to Year 11, the Proponent would have had opportunity to validate the measured actual mine in-flows and compare these to the predicted in-flow rates. In the event

that the actual in-flow rate equals or exceeds that predicted, the Proponent would obtain additional allocation or an additional water access licence for the extraction of the groundwater as mine in-flow.

4B.2.5.7 Predicted Impacts on Water Use and Availability

Drawdown associated with the Longwall Project is predicted in the fractured rock aquifers above the mine up to the base of the Garrawilla Volcanics, with greatest impacts in geological units close to the Hoskissons Coal Seam, and less impact on higher units. Yields and available drawdown may therefore be affected at any existing groundwater bores close to the mine which are screened in the formations predicted to be affected by groundwater drawdowns.

A search of the database of registered groundwater bores revealed a number of registered bores within the predicted impact zone, however a field inspection undertaken by Aquaterra (2009) identified that many are either non-existent, abandoned or destroyed. As there would be no drawdown within the Namoi Alluvium, within which the majority of the bores of the region are screened, the potential for impact on groundwater users would be limited to the small number of bores screening the lower units of the geological sequence, eg. Napperby Formation, Digby Formation and Hoskissons Coal Seam.

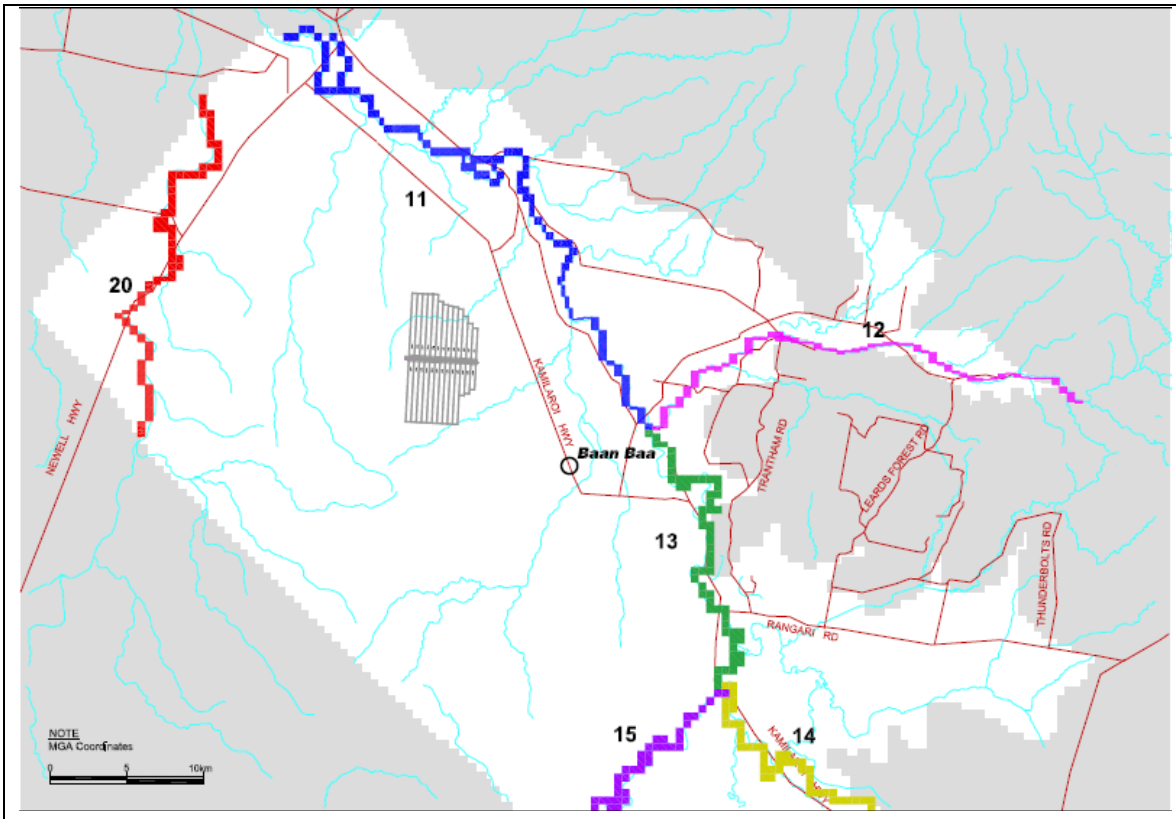
The potential for impact on the small number of bores screening the aquifers of these lower geological units has to a large degree been mitigated by the Proponent's acquisition of properties within the anticipated zone of impact. However, in the event that drawdown associated with the Longwall Project is determined to impact on the yield of a non-project related bore, the Proponent has committed to mitigating these impacts (or compensating the bore holder). Assessment of potential impacts would be undertaken on a case by case basis, with possible mitigating measures discussed with each affected bore holder.

4B.2.5.8 Predicted Impacts on Namoi River Base Flows

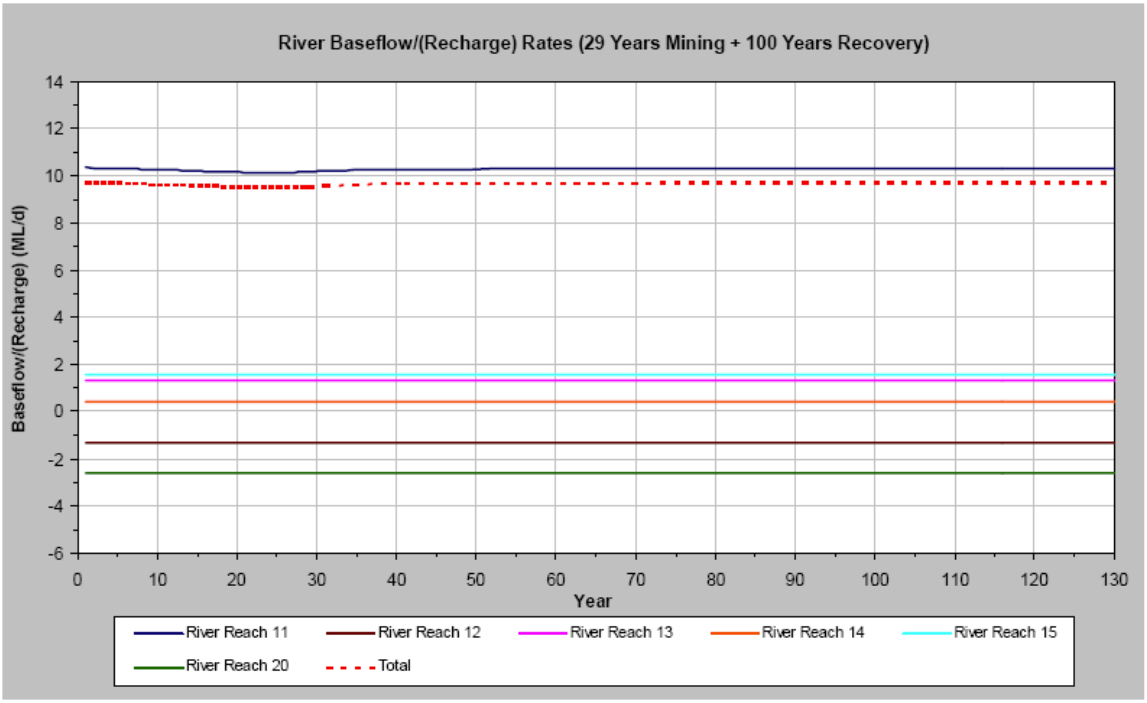
The impacts of the Longwall Project on the groundwater base flow discharges to Namoi River (Reaches 11, 13 and 14), Maules Creek (Reach 12) and Jacks Creek (Reach 20) have been assessed by Aquaterra (2009) for each of six river reaches designated on **Figure 4B.17**. Most of the river reach base flows remain stable during the mining period with a very minor reduction predicted in Reach 11 of the Namoi River (increasing to a maximum of 0.22ML/day at the completion of mining). The maximum predicted base flow impact during mining represents about a 2% reduction in the pre-mining base flow in Reach 11, but an insignificant percentage of total stream flow in the Namoi River (Aquaterra, 2009).

4B.2.5.9 Predicted Impacts on Groundwater Dependent Ecosystems

It is anticipated that the Purlawaugh Formation would insulate shallow groundwater from any mining-induced groundwater depressurisation of the underlying Permian coal measures. Therefore it is not anticipated that there would be significant impact to groundwater dependent ecosystems due to the Longwall Project.



Defined Reaches of the Namoi River



Modelled Impacts on Base Flows

FIGURE 4B.17
PREDICTED CHANGES TO NAMOI RIVER BASE FLOWS
Source: Modified after Aquaterra (2009) – Figures 6.7 & 6.25

It is acknowledged that shallow surface cracking may impact locally upon shallow groundwater such as the sporadic perched systems that exist at the base of the weathered zone, eg. "Mayfield Spring". It is likely, however, that these effects would not be permanent as the surface cracking would not be continuous to the underground workings. Any storage that is drained would be rapidly restored by recharge from rainfall, as the discontinuous fractures close up or become in-filled with fine sediment.

4B.2.5.10 Regulatory Compliance

An embargo currently exists on the issuing of new industrial bore licences within the intake beds of the Great Artesian Basin GWMA. In compliance with the Water Sharing Plan for this GWMA, the Proponent holds a Water Access Licence (WAL AL811436 for 248MLpa) for any incidental draw of groundwater. The licenced quantity of 248MLpa far exceeds the predicted incidental drawdown in the intake beds of the GAB.

An embargo also currently exists on the issuing of new industrial bore licences within the Upper Namoi Alluvium GWMA. However, the predictive modelling of Aquaterra (2009) has shown that there would be a negligible impact on the alluvium associated with the Namoi River and therefore the purchase of a Water Access Licence is not considered necessary.

Mining activities would be undertaken beneath the existing groundwater table in the Permian Coal Measures. An Aquifer Interference Licence has been obtained by the Proponent for 818MLpa for the incidental groundwater make of the underground mine which would be dewatered over the life of the Longwall project. The mine inflows are predicted to be below the 818MLpa level for at least 11 years. The Proponent would monitor flows and would purchase additional licences to cover the then predicted upper quantity of groundwater inflow.

4B.2.6 Groundwater Monitoring and Contingency Plans

4B.2.6.1 Groundwater Monitoring

The current baseline monitoring program of groundwater quality and standing water level would be continued, with a modified network of monitoring points finalised prior to commencement of mining.

An updated groundwater monitoring program would be prepared following the receipt of project approval. Monitoring to be included in this updated program would include.

- The volume of groundwater pumped to surface from all extraction bores, sumps within the underground workings and the box cut sump would be measured/recorded at least weekly.
- The volumes of water introduced to the mine for longwall mining operations would be measured/recorded at least weekly.
- Dewatered groundwater quality. The EC and pH of samples collected from each groundwater extraction point would be measured on a monthly basis.

- In-situ groundwater quality. More detailed chemical analyses would be undertaken of the groundwater of each extraction point measuring the following parameters:
  - Physical parameters: EC, TDS, TSS and pH;
  - Major cations: calcium, magnesium, sodium and potassium;
  - Major anions: carbonate, bicarbonate, sulphate and chloride;
  - Dissolved metals: aluminium, arsenic, boron, cobalt, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, selenium, zinc;
  - Nutrients: ammonia, nitrate, phosphorus, reactive phosphorus; and
  - Other: fluoride, cyanide.
- Quarterly manual monitoring, or continuous automated monitoring, of water levels from the network of monitoring bores.
- Quarterly monitoring of the spring discharges.

All monitoring results would be reviewed annually and summarised/evaluated in each Annual Environmental Management Report together with an assessment of the need to modify the parameters measured or monitoring frequency. It is fundamental that only meaningful data is collected.

In addition to the above, which is designed to assess general impacts of drawdown, the Proponent would implement a comprehensive monitoring program to investigate the subsidence impacts as they develop above longwall panels LW1 to LW3. Several multi-level vibrating wire piezometers are already in place, strategically placed within proposed chain pillars between LW1 and LW2 and just outside LW1, to enable ongoing monitoring. Additional multi-level vibrating wire piezometers and extensometers are proposed and monitoring of these would be conducted in conjunction with the subsidence monitoring recommended by DGS (2009).

4B.2.6.2 Contingency Plans

The Proponent is committed to addressing and mitigating impacts on groundwater as they occur. The following contingency plans, which build on those already in place for the Stage 1 Narrabri Coal Mine, would be implemented.

Water Levels

In the event that groundwater level drawdown in any bore in the alluvium, regolith or the Garrawilla Volcanics exceed predicted drawdown by 15% or more for any consecutive three month period, the monitoring data would immediately be referred to an approved hydrogeologist for review. The reviewer would then assess the data to establish the nature of the exceedance and the reasons for it, and recommend an appropriate response action plan for implementation in consultation with the relevant government agency.

In the event that an existing water supply is deemed by the hydrogeologist to be adversely affected drawdown generated by the Longwall Project, the Proponent would mitigate, or compensate for this impact through the provision of a replacement water supply.

The exact nature of impact mitigation or compensation would be developed on a case by case basis and would be referred to the relevant government agency in the event that mitigation or compensatory measures are unable to be negotiated.

Groundwater Quality

Should the water quality of the mine inflows or dewatering discharge indicate an inflow salinity of more than 20% above that predicted by the Aquaterra (2009) modelling (see **Figure 4B.16**), all relevant monitoring data would be provided to an approved experienced hydrogeologist for review and assessment of the impact on other users or the environment. If remedial action is recommended by the reviewer on the basis of the water quality, the recommended action would be implemented in consultation with the relevant government agency(ies) as appropriate.

4B.3 SURFACE WATER

The surface water assessment was undertaken by WRM Water & Environment Pty Ltd. The full surface water assessment is presented as Part 3 of the Specialist Consultant Studies Compendium, with the relevant information from the assessment summarised in the following subsections. The assessment is referred to as WRM (2009) throughout this document. A peer review of the water balance modelling component was undertaken by Mr Lindsay Gilbert, Director of Gilbert and Associates Pty Ltd. A copy of Mr Gilbert's review is included behind the surface water assessment in this compendium.

4B.3.1 Introduction

Based on the risk analysis undertaken for the project (see Section 3.3 and **Table 3.5**), the potential surface water impacts requiring assessment and their unmitigated risk rating are as follows.

- Discharge of sediment-laden or turbid water from the Mine Site (high risk).
- Temporary degradation of downstream water quality through discharge/spill of saline or contaminated water (high risk).
- Long term contamination of downstream water quality through major or repeated discharge/spill of saline or contaminated water (extreme risk).
- Altered flooding patterns and indirect impacts on native vegetation communities and ecosystems (moderate risk).
- Erosion of natural drainage lines (moderate risk).
- Erosion of rehabilitated final landform (moderate risk).
- Reduced flows to downstream agricultural land (low risk) and native vegetation (low risk).

In addition, the Director-General's Requirements issued by the DoP require that the assessment of surface water demonstrate "*how the company would manage mine water, especially any mine water brought to the surface*" and refer to the following policies, guidelines and plans:

- *Australian Guidelines for Fresh and Marine Water Quality (ANZECC/ ARMCANZ);*
- *Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ ARMCANZ);*
- *Namoi Catchment Action Plan (DPI);*
- *Managing Urban Stormwater: Soils & Construction (Landcom);*
- *Technical Guidelines: Bunding and Spill Management (DECC); and*
- *Environmental Guidelines: Use of Effluent by Irrigation (DECC).*

The following sub-sections describe and assess the existing drainage and surface water environment, identify the surface water management issues, proposed surface water controls, safeguards and mitigation measures and an assessment of the residual impacts following the implementation of these safeguards and mitigation measures.

4B.3.2 The Existing Environment

4B.3.2.1 Regional Drainage

The Mine Site is located in the Namoi River catchment and within the catchments of its tributaries, namely Kurrajong Creek, Pine Creek and Tulla Mullen Creek. The Namoi River flows in a northwesterly direction approximately 3km to 5km to the east of the eastern boundary of the Mine Site.

The Namoi River catchment has been used extensively for agricultural activities for over 100 years and is one of Australia's most developed irrigation areas, supporting significant cotton and broadacre cropping (mainly sorghum, sunflower and wheat) as well as other crops, and some sheep and cattle grazing. There are a number of major storages in the Namoi River catchment, namely the Keepit, Chaffey and Split Rock Dams located on the Namoi, Peel and Manilla Rivers, to provide water for the licensed water users in the region (**Figure 4B.18**).

The Mine Site is located within the catchments of Kurrajong and Pine Creeks. Pine Creek and its tributaries traverse the northern part of the Mine Site, before entering the Namoi River, while Kurrajong Creek and its tributaries originate in the southwestern corner of the Mine Site and traverse the southern part of the Mine Site, draining to Tulla Mullen Creek, which in turn drains into the Namoi River. The total catchments areas of Pine and Kurrajong Creeks are 76km^2 and 62km^2 respectively. The local catchment boundaries and drainage paths draining the Mine Site are shown in **Figure 4B.19**.

Pine and Kurrajong Creeks are ephemeral, generally flowing for short periods after significant rainfall events or protracted wet periods. Base flows in these creeks are insignificant. Sections of the local creeks are quite 'active' and are susceptible to high levels of erosion. The drainage paths of the smaller tributaries are poorly defined along some reaches through the Mine Site. Further detail on the structure and hydrological properties of these streams is provided by WRM (2009) – Section 2.2.

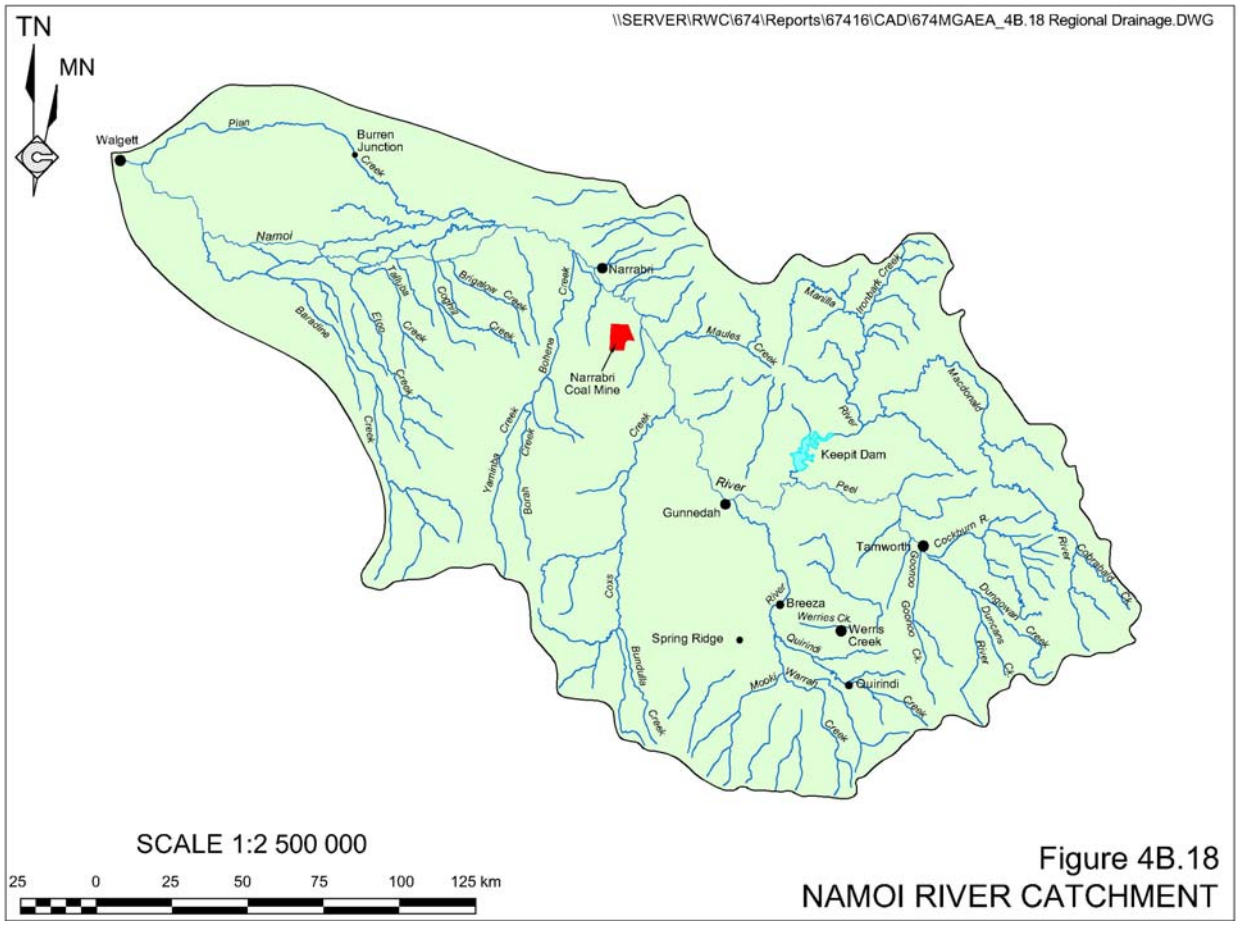


Figure 4B.18
NAMOI RIVER CATCHMENT

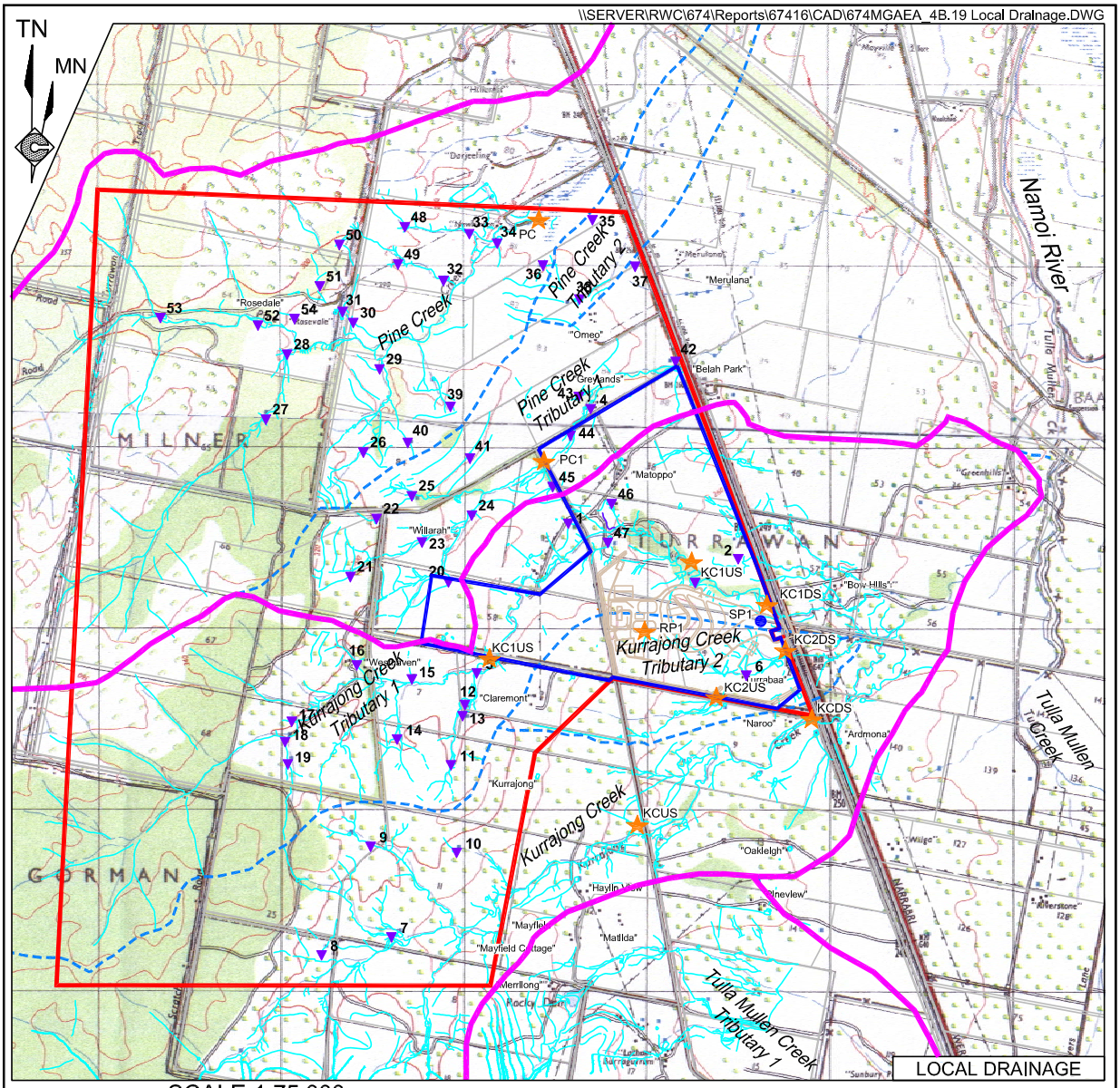
4B.3.2.2 Mine Site Drainage

Figure 4B.19 depicts the Mine Site, the location of the Pit Top Area and the local catchment boundaries whilst **Figure 4B.20** presents greater detail of the Pit Top Area and the local drainage paths and catchments within that area.

Table 4B.11 lists the proportions of the Mine Site and Pit Top Area that currently drain to each of the local sub-catchments. **Table 4B.12** lists the existing cleared and forested areas within the Project Site in each of the local sub-catchments.

Table 4B.11
Mine Site and Pit Top Areas Draining to Local Sub-Catchments

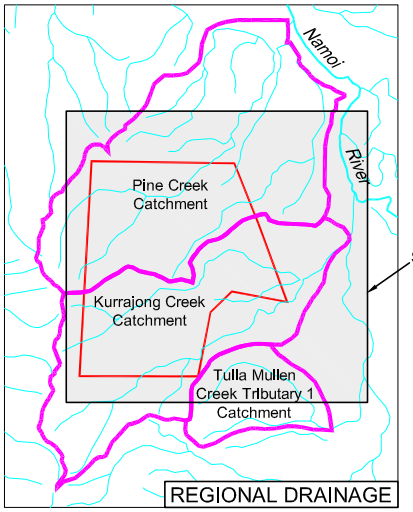
Sub-Catchment	Mine Site Area Within Catchment	
	Area (ha)	Area (%)
Pine Creek	1743	33.5
Pine Creek Trib 1	761	14.6
Pine Creek Trib 2	80	1.5
Kurrajong Creek	830	15.9
Kurrajong Creek Trib 1	1562	30.0
Kurrajong Creek Trib 2	234	4.5
Total	5210	100
Source: Modified after WRM (2009) – Table 2.1		



SCALE 1:75 000

1 0 1 2 3 4km

Source: WRM (2007) - Figure 3-1



REFERENCE
- Mine Site Boundary
- Pit Top Area Boundary
- Dividing Catchment Boundary
- Internal Catchment Boundary
- 10 ▼ Farm Dam (Approximate Position)
- ★ Surface Water Monitoring Location

Figure 4B.19
LOCAL DRAINAGE

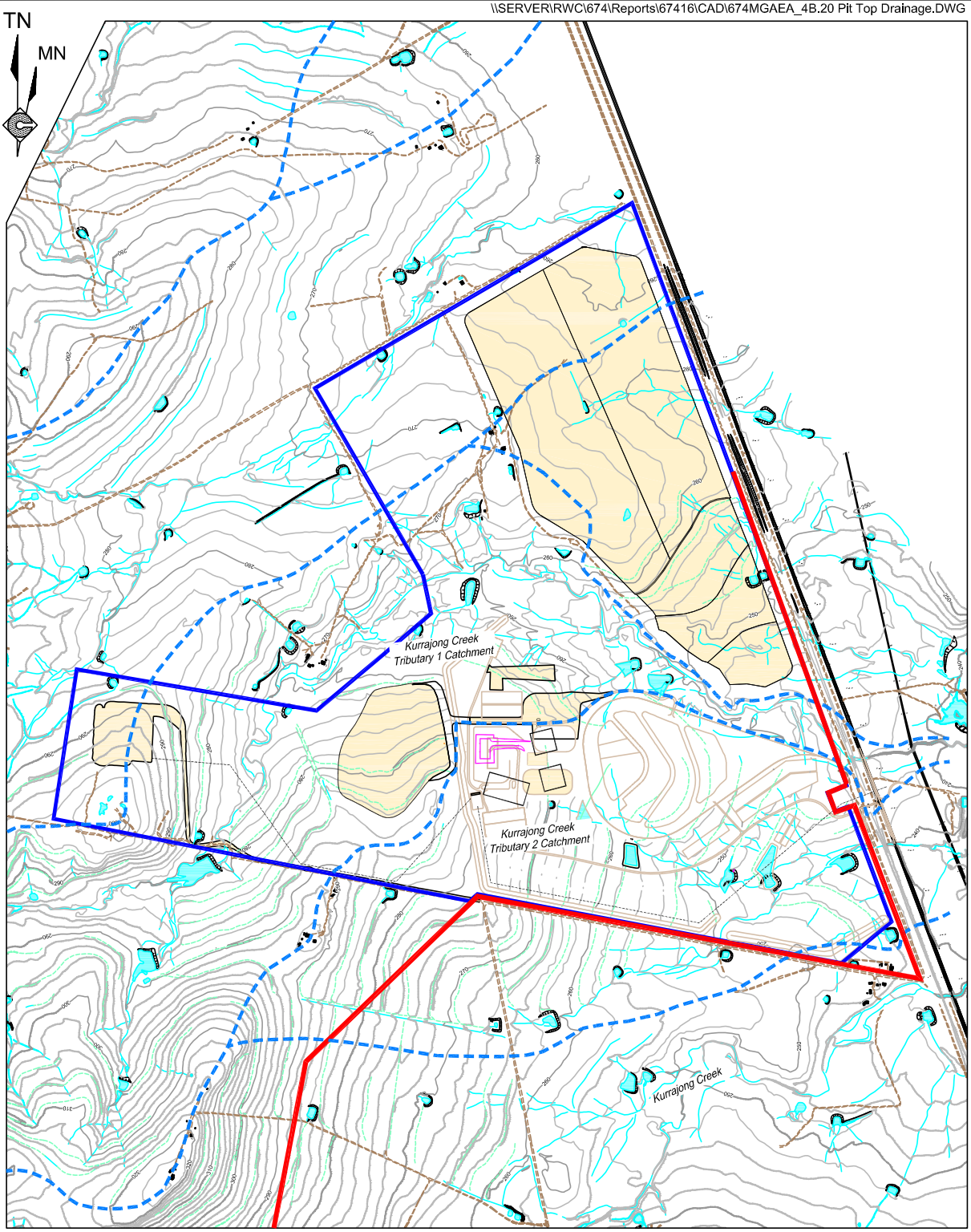


Figure 4B.20
PIT TOP AREA DRAINAGE

Table 4B.12
Cleared and Forested Areas within the Project Site in Each Local Sub-Catchment

Sub-Catchment	Cleared Area		Forested Area	
	Area (ha)	Area (%)	Area (ha)	Area (%)
Pine Creek	655	12.6	1088	20.9
Pine Creek Trib 1	708	13.6	53	1
Pine Creek Trib 2	80	1.5	-	-
Kurrajong Creek	592	11.4	238	4.6
Kurrajong Creek Trib 1	846	16.2	716	13.7
Kurrajong Creek Trib 2	234	4.5	-	-
Total	3115	59.8	2095	40.2
Source: WRM (2009) – Table 2.2				

4B.3.2.3 Existing Local Water Storages

There are 54 farm dams within the Mine Site, the locations of which are shown on **Figure 4B.19**. 34 of these dams, with a total capacity of 60.7ML, are located within Pine Creek catchments and the remaining 20, with a total capacity of 60.5ML, within Kurrajong Creek catchments. A total of 35 farm dams, with a combined capacity of 88.7ML, are located within the Proponent's landholdings. The individual storage capacities of these dams vary from approximately 0.5ML to 22.5ML.

4B.3.2.4 Existing Local Water Use

Existing (pre-mining) surface water use on the Mine Site and in the local area is primarily stock watering. There is no large scale irrigation infrastructure on the Mine Site to suggest that crops on the Mine Site were ever irrigated from the existing dams. There are two small dams on Pine Creek downstream of the Mine Site from which water is used for stock watering. There are also no farm dams on Kurrajong Creek and its tributaries or Pine Creek Tributary 1 downstream of the Mine Site.

The major towns of the Narrabri Shire all draw town water supply from groundwater bores within the Upper Namoi Alluvial Groundwater Source, ie. there is no reliance on surface water flows within the Namoi River Catchment. The small village of Baan Baa has no town water supply with rainwater and water captured within a dam to the south of the village the only source of water to residents of the town. Notably, the catchment for this dam would not be affected by activities on the Mine Site, nor dependent on runoff from the Mine Site catchments.

4B.3.2.5 Surface Water Quality

Regional Water Quality Data

Water quality data is available for the Namoi River at the Turrawan gauging station (Station No. 419023), located between the Kurrajong Creek and Pine Creek confluences with the Namoi River (see **Figure 4B.19**), for the period 1976 to 1986. **Table 4B.13** presents a summary of available water quality data for the Namoi River at Turrawan gauging station.

Table 4B.13
Water Quality Data, Namoi River at Turrawan

Parameter	Years of Data	Mean	Median	Min	Max	10th %ile	80th %ile	ANZECC (2000) Trigger Value	
								Upland	Lowland
Electrical Conductivity (µS/cm)	10	545	538	275	1 720	330	716	30 - 350	125 – 2 200
pH	10	8.0	8.0	7.4	8.8	7.6	8.4	6.5 – 8.0	6.5 – 8.0
Temperature (°C)	10	19.6	20.5	10	30	11.0	26.5	NA	NA
Turbidity (NTU)	9	15.6	5.4	2	130	2.0	40.4	NA	NA
Source: Modified after WRM (2009) – Tables 3.3 and 3.5									

Over the 10 year monitoring period, the ANZECC (2000) default trigger values were exceeded 87% of the time for electrical conductivity (EC), 50% of the time for pH and 17% of the time for turbidity. Similar results in relation to the ANZECC (2000) default trigger values were recorded following monitoring undertaken at 22 sites throughout the Namoi River catchment during 2000 and 2001 (DLWC, 2002b) (WRM, 2009).

Continuous water quality data, measuring electrical conductivity, was collected between 1995 and 2005 at the Gunnedah Station (63km upstream of the Mine Site). WRM (2009) reviewed this data and identified the following relationship between river flow and electrical conductivity.

- Electrical conductivity varies between 200µS/cm and 1 200µS/cm with the majority of elevated values occurring when flows are lower than 1 000ML/day.
- There is a strong relationship between flow rate and electrical conductivity with high flows, associated with floods, measuring lower electrical conductivity values.
- Higher electrical conductivity tends to occur when there are limited releases from Keepit Dam to supply the downstream irrigation demand and the majority of the flow is being generated from the downstream catchments of the Peel and Mooki Rivers (generally during the winter months).
- Elevated electrical conductivity values can occur for many months during low flow periods.

Local Catchment Water Quality Data

Water quality data has been obtained from locations upstream and downstream of the Pit Top Area on the tributaries of Kurrajong Creek following four storm events in July 2006, September 2008, December 2008 and February 2009. **Figure 4B.19** identifies the sites sampled in August 2006 (following sustained rainfall in the area at this time) which have not been affected by the construction activities on the Mine Site and are therefore representative of background data. **Table 4B.14** presents a summary of the water quality results.

Table 4B.14
Water Quality Data for the Local Catchments of the Mine Site

Parameter	No. Samples	Mean	Median	Min	Max	10th %ile	80th %ile	ANZECC (2000) Trigger Value	
								Upland	Lowland
Electrical Conductivity (µS/cm)	23	227	125	55	1300	65	301	30 - 350	125 – 2 200
pH	23	7.2	7.1	6.5	8.2	6.7	7.6	6.5 – 8.0	6.5 – 8.0
Total Suspended Solids (mg/l)	23	76	38	6	320	14.2	139	NA	NA
Oil & Grease (mg/l)	<2	<2	<2	<2	<2	<2	<2	NA	NA
Source: Modified after WRM (2009) – Tables 3.4 and 3.5									

The results presented in **Table 4B.14** suggest that local surface water is of generally neutral pH, fresh with a relatively high suspended sediment level reflecting the ephemeral nature of these drainage lines. When compared to the ANZECC (2000) Trigger Values, WRM (2009) concludes the following in relation to water quality.

- Electrical conductivity in the local creeks is lower than in the receiving waters of the Namoi River and generally lower than the default ANZECC (2000) trigger values. The upland rivers electrical conductivity trigger value of 350µS/cm was exceeded in the local creeks four times over the monitoring period.
- pH is generally within the bounds of the ANZECC (2000) trigger values.
- ANZECC (2000) does not specify trigger values for oils and greases or Total Suspended Solids and no data is currently available for turbidity (which can be used to indicate likely acceptable TSS values).

4B.3.2.6 Flooding Potential

WRM (2007) completed a flood study of Kurrajong Creek Tributary 1 to the north of the Pit Top Area for the approved Stage 1 Narrabri Coal Mine. The infrastructure developed for Stage 1 was generally outside the 100 year Average Recurrence Interval (ARI) flood extent for Kurrajong Creek Tributary 1 except for a small section of the rail adjacent to the Kamilaroi Highway. The impact of the constriction caused by the rail loop was not significant.

The additional Pit Top Area infrastructure required for the Longwall Project, including the Brine Storage Area is also outside the modelled 100 year ARI flood extent. The Mine Site is not susceptible to flooding from the Namoi River as it is located some 20m in elevation above the Namoi River floodplain.

On the basis of the above, the potential impacts of flooding are not considered further in the *Environmental Assessment*.

4B.3.2.7 General Sensitivity of the Namoi River Catchment

The surface water flows on and around the Mine Site provide a very minor contribution to the overall flows within the Namoi River catchment. This water is important to local landowners that use the water from local creeks for stock watering and/or crop irrigation purposes, with any changes in water availability potentially detrimental to the existing land uses. The impact on

Namoi River catchment flows during periods of floods and low flows would be negligible given the level of regulation and the size of the upper catchment in relation to the Project Site. The surface water flows are also important to the ecological health of the Namoi River, ie. the fauna and flora which rely on good quality water. A release of contaminated water from the Mine Site could significantly impact on the health of flora and fauna, as well as downstream water users.

In assessing the potential impacts of the Longwall Project on the Namoi River catchment, the management targets for surface and ground water ecosystems of the Catchment Action Plan for the Namoi River (NCMA, 2007) are considered.

1. From 2006, there would be an improvement in riverine structural stability, and the condition and extent of native riverine vegetation in priority riverine areas.
2. From 2006, maintain or improve surface and ground water quality suitable for irrigation, raw drinking water and aquatic ecosystem protection at Gunnedah, Narrabri and Goangra (near Walgett). Target values are as determined by:
   a) ANZECC (2000) guidelines for:
      - Irrigation Water - Electrical conductivity range of 650 –1300µS/cm; and
      - Aquatic Ecosystem Protection - mean values of Total Endosulphan <0.03µS/L and Atrazine <0.7µS/L.
   b) MDBC; River Salinity of 550µS/cm 50% of the time and <1 000µS/cm 80% of the time at Goangra (at time of writing the CAP).
3. From 2006, protect and assist the recovery of threatened or priority native aquatic species in identified priority areas.
4. From 2006, oversee and review water management planning and other processes under the *Water Management Act 2000*, so that Water Management Plans, including Water Sharing Plans (WSPs), result in fair and reasonable access to surface and ground water sources for the environment (water dependant ecosystems), economic uses (agricultural, industrial, town water supply) and social values (recreation, cultural).

The Longwall Project has been designed to operate within the framework outlined in NCMA (2007) to achieve these targets on the Mine Site and thereby assist in the achievement of these across the catchment.

4B.3.3 Surface Water Management Issues

4B.3.3.1 Introduction

The Longwall Project has the potential to impact upon both the quality, quantity and hydrology of surface water flowing from the Mine Site. The following sub-sections identify the potential impacts that have been considered in the design of surface water management controls and measures for the Mine Site. Section 4B.3.4 then addresses the controls to be implemented to avoid or maintain these impacts at an acceptable level.

4B.3.3.2 Potential Sources of Water Pollution

The potential sources of water pollution from the proposed activities within the Mine Site are as follows.

- Runoff from areas disturbed during construction within the Pit Top Area and progressive development of gas drainage and ventilation infrastructure.
- Runoff from stockpiles of topsoil, subsoil and mined rock.
- Surface runoff from ROM coal and coal product stockpiles.
- Runoff from hardstand areas including roads, coal crushing/sizing area and surface buildings.
- Surface runoff from rehabilitated areas prior to full stabilisation.
- Sedimentation generated by increased or accelerated erosion within the Mine Site.
- Uncontrolled discharge of dewatered mine in-flows (which are anticipated to be of elevated salinity).
- Leakage or spillage of saline groundwater stored within Dam A1.
- Leakage or spillage of brine stored within Dams A2, A3, B or BR1 to BR5.
- Leakage or spillage of hydrocarbons.

Based on the potential sources of pollution, suspended solids, ie. sand, silt, clay or coal particles in water, saline water and hydrocarbons are likely to be the major sources of surface water pollution.

i) The Longwall Project also has the potential to pollute the Namoi River as a result of the discharge of raffinate. Based on the proposed treatment of mine in-flows pumped to the surface and treated in the Water Conditioning Plant, the most likely source of pollution would be elevated salinity (measured by electrical conductivity).

4B.3.3.3 Potential Changes to Surface Water Quantity

Development of the Longwall Project would necessitate the clearing of some areas, mainly agricultural in nature and construction of hardstand areas which would potentially result in increased surface water run-off within the affected catchment and subsequently from the Mine Site. It is more likely, however, that the volume of water leaving the Mine Site would decrease marginally as a result of surface water being captured within water storages constructed on the Mine Site to provide for operational water requirements.

4B.3.3.4 Potential Impacts of Subsidence

As illustrated on **Figure 4B.7**, mine subsidence would result in a variable change in the gradient of the watercourses that traverse the Mine Site. Those likely to be affected are:

- Pine Creek;
- Pine Creek Tributary 1;
- Kurrajong Creek; and
- Kurrajong Creek Tributary 1.

These creeks and their tributaries range from first order water courses at the upstream (western end) of the mine subsidence zone to third order watercourses at the downstream (eastern end) under the Strahler stream ordering system (Strahler, 1957). All four have little to no capacity, are ephemeral and are therefore likely to be Schedule 1 streams in accordance with DIPNR (2005). Further detail on the structure and hydrological properties of these streams is provided by WRM (2009 – Section 2.2). The altered channel gradients within these creeks and their tributaries may result in the following impacts (which have previously been discussed in the Section 4B.1.6.5).

- Ponding, which may or may not be confined to the creek channel (in-stream or over bank ponding). **Figure 4B.8** illustrates the predicted ponding resultant following mining of LW1 to LW3.
- Ponding and possible flow direction changes against contour banks.
- Increased or accelerated in-stream erosion and sedimentation generated by the altered channel gradients.
- Increased water salinity as a result of increased storage time over saline soils.
- Degradation of riparian vegetation as a consequence of inundation.

Riparian Risk Management Zones have been defined through consideration of existing channel slopes and location in relation to the retained chain pillars of the underlying longwall panels (where the change in channel gradient is likely to be most affected – see **Figure 4B.7**).

- High Risk Management Zones, ie. those areas highly likely to be affected by one or more of the above impacts, are generally those higher order watercourses at the downstream (eastern) end of the mine site that are highly likely to be affected by one or more of the above impacts outlined.
- Moderate Risk Management Zones are those sections of the Mine Site creeks and tributaries which cross the retained chain pillars of the underlying longwall panels but have steeper existing channel slopes ($\geq 5^{o}$) (the steeper the channel is, the less the area of potential ponding).
- Low Risk Management Zones are those sections of the Mine Site creeks and tributaries which are located off the Mining Area.

Based on the existing drainage patterns of the Mine Site and the longwall panel design, **Figure 4B.21** provides the locations of the expected Riparian High Risk Management Zones across the Mine Site. The moderate risk management zones are defined as those sections upstream of the high risk management zones. The low risk management zones are downstream of the Mining Area.

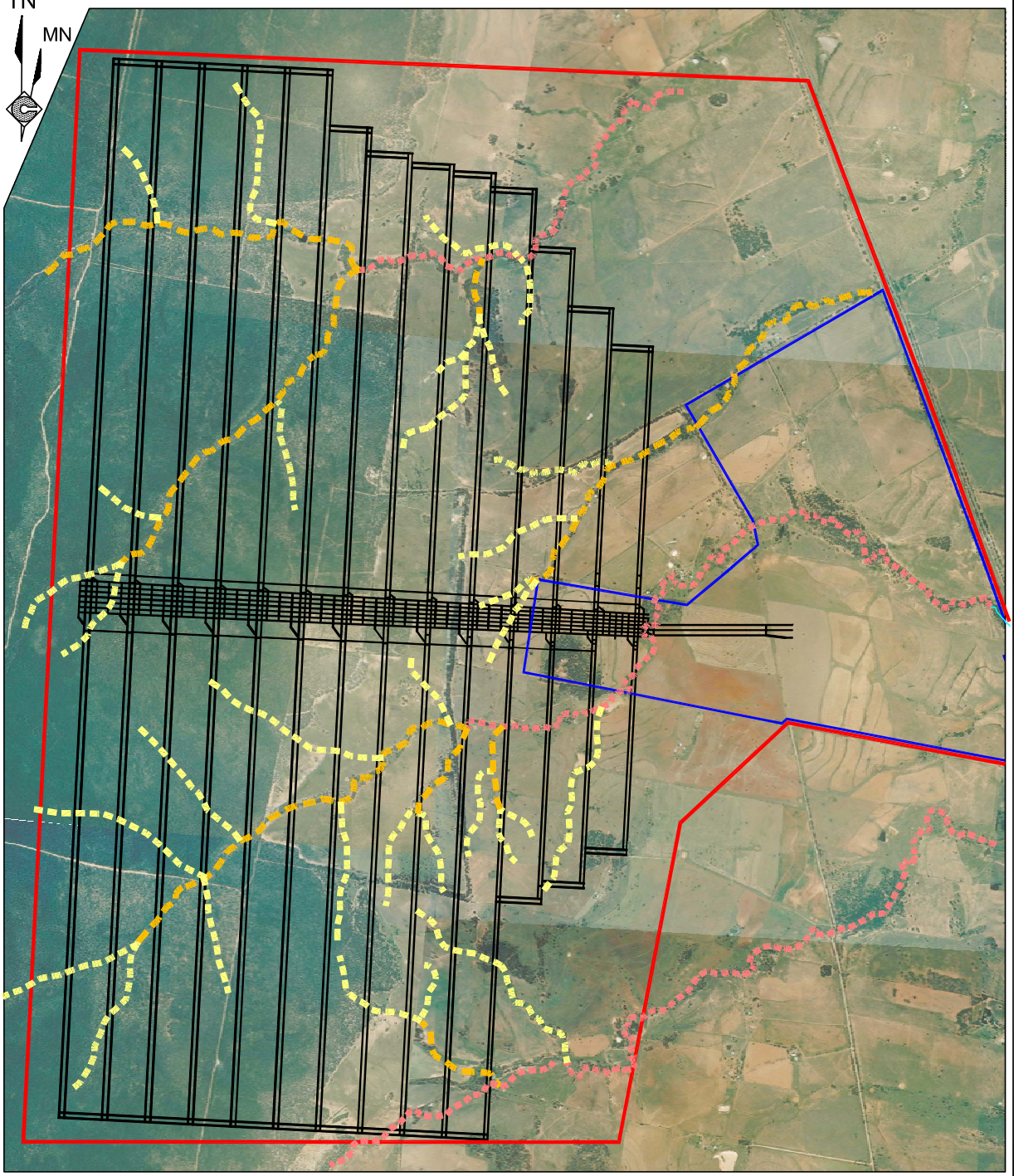


Figure 4B.21
MINE SITE STREAM ORDER

4B.3.3.5 Potential Impacts on Aquatic Habitat

Changes to water quantity and quality within the creeks and tributaries of the Mine Site could potentially affect aquatic habitat and species (should these occur on the Mine Site). Ecotone (2009) completed a comprehensive field survey of the ecology of the Mine Site and did not identify aquatic habitat or species (as distinct from Riparian vegetation). No further assessment of potential impacts on aquatic habitat has been undertaken, although it is noted that future ecological surveys to be undertaken on the Mine Site as mining progresses beyond LW7 would consider the potential for aquatic habitat or species.

4B.3.3.6 Dryland Salinity

Dryland salinity which is the accumulation of salts within the soil profile has been recognised as an issue of concern within the Namoi Valley for some time. The potential of the Longwall Project to increase dryland salinity has been considered given the necessity to store dewatered groundwater and brine within the Pit Top Area. However, as the ponds would be constructed with an impermeable liner (permeability < 1 x 10^{-14}m/sec), and recognising the bulk of the deep rooted vegetation of the Mine Site is located outside of the proposed area of disturbance, the potential for dryland salinity is considered minimal.

4B.3.3.7 Regional Drainage

As noted in Section 2.4.8.3, raffinate surplus to the storage capacity of Dams C and D would be discharged to the Namoi River. Whilst the volume of water discharged would represent a very minor contribution to the total flow within the river, the potential for this to impact on water quantity and quality more regionally requires consideration. In particular, the impact on the salt load within the river requires consideration (especially in relation to the management objectives of the Namoi River CAP).

4B.3.4 Water Management Measures and Operational Safeguards

4B.3.4.1 Introduction

For management purposes, the surface water within the proposed areas of disturbance has been divided into four categories, namely:

- **"Clean"** - surface runoff from rehabilitated catchments and catchments undisturbed or relatively undisturbed by construction, mining or related activities;
- **"Dirty"** - surface runoff from areas disturbed by construction or activities such as soil, overburden and coal stockpiling, and rehabilitation (until stabilised), all of which could contribute suspended solids to the surface water;
- **"Saline"** - water containing concentrations of total dissolved solids (TDS) greater than the ANZECC (2000) trigger level (see **Table 4B.22** Section 4B.3.7.6); or
- **"Contaminated"** - surface water containing hydrocarbons or any other contaminant other than suspended solids.

The key principles in managing surface water within and around the Mine Site would be to:

- divert clean water away from disturbed areas;
- capture dirty water and treat it so that it could be discharged in accordance with relevant criteria;
- prevent the leakage or spillage of groundwater dewatered from the underground workings and brine generated by the Water Conditioning Plant;
- capture and treat contaminated water prior to discharge from and/or re-use on the Mine Site;
- maintain as much vegetation cover (particularly grass) as possible; and
- manage the direct and indirect affects of mine subsidence on the hydrology of the Mine Site.

The water management controls identified for both the management of impacts associated with the surface operations of the Longwall Project and mine subsidence related changes to local hydrology have been drawn from WRM (2009) (see Part 3 of the *Specialist Consultant Studies Compendium*).

It should be noted that, whilst comprehensive in its assessment of Mine Site surface water flow and the design of water management structures, the proposed water management remains conceptual in terms of the positioning and number of structures. As the development and operation of the Longwall Project progresses, some variation to the structures may be required. The design of any variations would reflect, however, the overall objectives and principles included in the Site Water Management Plan for the Longwall Project.

4B.3.4.2 Water Quality

4B.3.4.2.1 Pit Top Area Surface Water Management Infrastructure

The locations of the existing and proposed water management control structures on the Pit Top Area are presented in **Figure 4B.22**. The general features of the surface water management infrastructure for the Pit Top Area remain consistent with those constructed and currently operating for the Stage 1 Narrabri Coal Mine and are as follows.

- A sediment basin (SB1) to collect dirty and contaminated runoff from the stockpiling and crushing/sizing area.
- A sump in the box cut to collect rainfall/runoff and seepage from the walls of the box cut.
- A series of sediment basins (SD1, SD2, SD3, SD4 and SD5) to collect and treat runoff from the southern part of the Pit Top Area, disturbed during Pit Top Area construction.
- A series of drains to collect runoff from the Pit Top Area and divert it to the various water management dams.

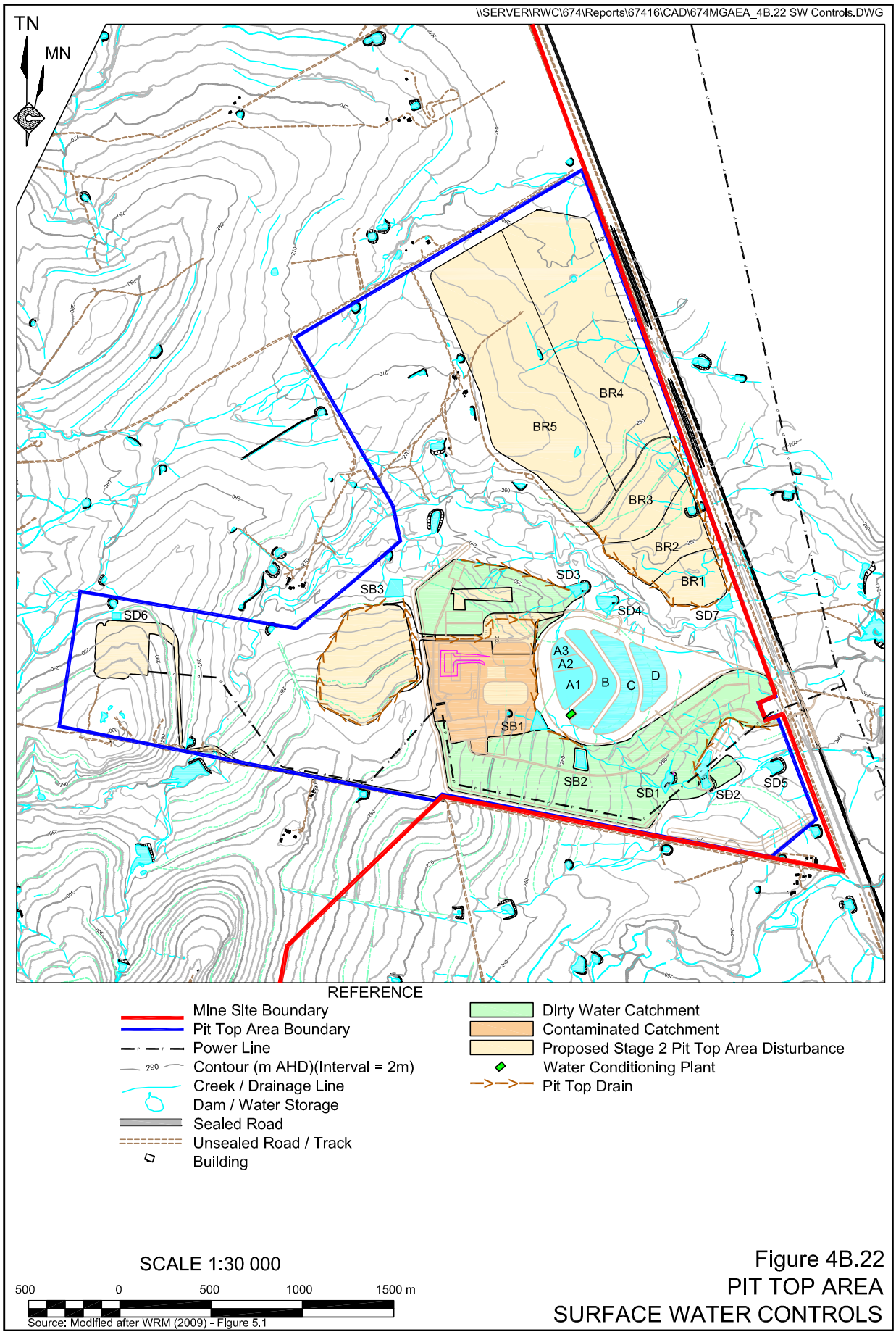


Figure 4B.22
PIT TOP AREA
SURFACE WATER CONTROLS

- A series of ponds within the rail loop for the storage of dewatered groundwater (Dam A1), treated raffinate (Pond D) and waste brine (Ponds A2, A3, B and C). Water would continue to be drawn from Dam A1, Dam C or D for operational purposes (depending on the quality requirements of the operation[3]).
- A Water Conditioning Plant to treat dewatered groundwater to a sufficient quality for Mine Site use (in underground, coal washing etc), increasing environmental flows in the Namoi River and potentially for use off site**.**

The following additional (or modification to existing) controls is proposed as part of the Longwall Project (see **Figure 4B.22**).

- The capacity of SB1 would be increased and an additional sediment basin (SB2) would be constructed immediately downstream of SB1 to provide additional capacity for the collection and storage of dirty runoff from the coal processing area.
- A new sediment basin (SB3) would be constructed to collect potentially dirty runoff from the proposed Reject Emplacement Area.
- A new storage dam (SD6) would be constructed to collect potentially dirty runoff from the initial ventilation shaft area.
- Additional brine storage ponds (identified as BR1 to BR5 on **Figure 4B.22**) would be progressively constructed within the Brine Storage Area to the north of Kurrajong Creek Tributary 2 to contain the brine generated by the Water Conditioning Plant. A description of the design, construction and operation of these brine storage ponds is provided in Sections 2.4.8.4 and 2.4.9.14.
- A new sediment dam (SD7) would be constructed to collect potentially dirty runoff from the construction of the proposed Brine Storage Area
- An underground pipe would be constructed from Dam C to the Namoi River to enable the extraction of additional water from the Namoi River or discharge of surplus raffinate to the Namoi River.

4B.3.4.2.2 Pit Top Area Sediment Basins and Dams

Storage Basins (SB1, SB2 and SB3)

SB1 would accept the dirty and potentially contaminated runoff from the coal processing area with any overflow, as well as runoff from the small area downstream of SB1, flowing to SB2. The water collected in SB1 and SB2 would be regularly pumped to Dam A1 to be used for dust suppression and other activities within the Pit Top Area that does not require clean water.

SB3 would collect runoff from the proposed Reject Emplacement Area. Only direct rainfall on the Reject Emplacement Area would flow to SB3 as a paired diversion bank / catchment bank arrangement would be constructed to the east and south of the structure to capture runoff from the slopes of the structure, as well as divert clean runoff from the east and south around the structure and into Kurrajong Creek Tributary 2.

[3] Water for underground dust suppression in the vicinity of the longwall unit is required to have a TDS of ≤500mg/L, whereas saline water is able to be used for most activities on the surface.

There would be no discharge from SB2 or SB3 (effectively there would be discharge from SB1 as any overflow from this storage basin would be captured by SB2) with the water collected in SB1, SB2 and SB3 periodically pumped to Dam A1 to supplement the Longwall Project water supply.

Table 4B.15 provides the proposed design capacities of the four storage basins on the Pit Top Area.

Table 4B.15
Storage Basin (SB) Design Capacities

Structure*	Catchment Area (ha)	Storage Volume (ML)
SB1	29.7	20.0
SB2	0.0	30.0
SB3	25.0	15.0
* See **Figure 4B.22**		
Source: Modified after WRM (2009) – Tables 6.3 and 6.4		

Sediment Dams (SD1 to SD7)

SD1, SD2, SD3, SD4 and SD5 are all currently active and contained within the Site Water Management Plan for the Stage 1 Narrabri Coal Mine. SD1 and SD2 collect runoff from the disturbed catchment of the Pit Top Area downstream of SB2, as well as any runoff from SB2 should this overflow. SD3 collects runoff from the disturbed catchment to the north of the coal processing area and box cut (which would include the longwall assembly laydown area), while SD4 collects any overflow from SD3. SD5 collects clean runoff from Kurrajong Creek Tributary 1.

SD6 would accept the dirty runoff from the initial ventilation shaft area (similar sediment basins would be constructed within the additional ventilation shaft areas and gas drainage sites to be constructed over the life of the Longwall Project). SD7 would accept the dirty runoff from the construction zone of the Brine Storage Area.

The Pit Top Area sediment dams have been designed to store runoff received from rainfall up to the 5 day 95th %ile rainfall event for the region (in accordance with the recommended design standards of *Soils and Construction – Managing Urban Stormwater, Volumes 1 and 2,* [Landcom, 2004, and DECC, 2008]). To maintain capacity within the sediment dams, and in accordance with DECC (2008), the settled water would be released to the downstream creeks within 5 days of the runoff event. During the initial years of the Longwall Project, water captured within the sediment dams would be pumped to Dam D to supplement the Mine Site water supply, however, as dewatering rates increase, this practice would cease and water would be released downstream after settlement in the structure.

Table 4B.16 provides the minimum design capacity of SD1 to SD7 (to provide sufficient water settlement and sediment storage zones to contain the 5 day 95%ile storm event (DECC, 2008)) and the proposed design capacity. The minimum design capacity has been calculated by WRM (2009) assuming a 5 day 95%ile storm event of 52mm and runoff coefficient of 0.74.

Table 4B.16
Sediment Dam (SD) Design Capacities

Structure*	Dirty Water Catchment Area (ha)	Minimum Storage Volume (ML)	Storage Volume (ML)
SD1	32.3	12.4	5.9
SD2	31.5	12.1	55.2
SD3	25.2	9.7	4.7
SD4	4.5	1.7	35.0
SD5	0	0	11.2
SD6	7.2	2.8	4
SD7	38.2	TBC	TBC

TBC: The design capacity would be determined prior to construction following confirmation of the individual brine storage pond specifications.
* See **Figure 4B.22**

Source: Modified after WRM (2009) – Tables 6.3 and 6.4

When comparing the nominated minimum design capacity and proposed design capacity, the following is noted.

- SD1 overflows to SD2. Excess storage is provided in SD2 to contain the minimum storage requirements for SD1.
- SD5 is not strictly a sediment dam because it primarily collects clean runoff from Kurrajong Creek Tributary 2.
- SD3 overflows to SD4. Excess storage is provided in SD4 to contain the minimum storage requirements for SD3.
- The design capacity of SD7 would be determined prior to construction of the first brine storage pond, at which point the Proponent will have a better understanding of the ultimate storage volume required of the Brine Storage Area to accommodate groundwater dewatering and brine generation.
- The spillway of each sediment dam would have sufficient capacity to pass the 100 Year ARI critical duration design flood.

4B.3.4.2.3 Management of Groundwater, Raffinate and Brine Storages

Figure 4B.22 identifies the locations of the existing water storages constructed to manage the dewatered groundwater, treated raffinate and brine. Each pond is approximately 5m deep, has 1:3 (V:H) side slopes and 5m wide crests. The storage volumes and surface areas of the evaporation ponds at full supply level are given in **Table 4B.17.**

As described in Sections 2.4.8.4 and 2.4.9.14, a series of additional storages to contain the additional brine generated by the treatment of dewatered groundwater would be constructed within the Brine Storage Area as required (see **Figure 4B.22**). Based on the results of the groundwater modelling (base case), and the anticipated water demand of the Longwall Project, WRM (2009) have calculated that between 2 200ML and 2 730ML of additional brine storage would be required. Brine storage ponds BR1 to BR3 would provide storage capacity for this volume of brine with **Table 4B.17** providing the surface area and storage volumes of these ponds. Brine storage ponds BR4 and BR5 would provide for contingency storage areas in the event that groundwater in-flows are much higher than predicted by the groundwater modelling of Aquaterra (2009).

Table 4B.17
Groundwater, Raffinate and Brine Storages

Pond*	Storage	Surface Area (ha)	Storage Volume (ML)
Existing Storages			
A1	Dewatered groundwater and dirty water from Pit Top Area storage basins	3.17	129.8
A2	Brine	0.98	30.6
A3	Brine	0.93	30.8
B1	Treated Raffinate	1.0	40.0
B2	Brine	4.85	165.0
C	Treated Raffinate or Water harvested from Pit Top Area SB's and SD's	6.63	218.3
D	Water harvested from Pit Top Area SB's and SD's	4.15	128.4
	Total	**21.71**	**742.9**
Additional Storages			
BR1	Brine	8.5	470
BR2	Brine	13.7	748
BR3	Brine	16.2	898
BR4	Brine (if required)	~55.0	>2 500
BR5	Brine (if required)	~65.0	>3 000
	Total	**158.4**	**>8 350**
* See **Figure 4B.22**			

The storages identified in **Table 4B.18** would be managed as follows.

- Groundwater pumped from the underground mine, along with all potentially contaminated runoff from the storage dams SB1, SB2 and SB3, would be discharged into Dam A1. Dam A1 is lined with HDPE with a maximum permeability of 1 x 10^{-14}m/sec.
- Concentrated brine produced by the Water Conditioning Plant would be discharged into Dam A2 and Dam A3, which are lined with HDPE. Overflow from Dam A3 would spill to Dam A2.
- Overflow from Dam A2 would spill to Dam B2, via a pipe. Dam C would be lined with HDPE (permeability <1 x 10^{-14}m/sec), if and when it is required to store the excess concentrated brine from the Water Conditioning Plant.
- BR1, BR2 and BR3 would be constructed if and when required to store the excess concentrated brine from the Water Conditioning Plant. These would be lined with HDPE and receive brine pumped from the Water Conditioning Plant.
- Dam B1 is clay lined and would be the primary storage for treated raffinate from the Water Conditioning Plant. This water would be used preferentially for underground operational requirements and as potable water after further treatment. Water may also be 'shandied' with water in Pond A1 or from Pond D for use in surface coal handling and site dust suppression.
- The clay lined Dams C and D would be the primary storage for clean or potentially dirty water harvested from the sediment dams of the Pit Top Area. The maximum permeability of the clay would be <1 x 10^{-9}m/sec. Ponds C and D could also store the excess raffinate from the Water Conditioning Plant in preference to discharge of this water.

- Water in excess of the storage capacity of Dams B1, C and D would be released to the Namoi River via the water pipeline described in Section 2.4.9.15. Section 4B.3.4.2.7 provides further detail of the proposed discharge of raffinate from the Pit Top Area.
- To prevent any of the brine storage dams from overflowing, each dam would maintain a 0.5m freeboard, which would be sufficient to contain the 100 year 72 hour storm event (0.26m) and any wave run up.
- The spillway for each brine storage dam or pond would be sufficient to convey the 10,000 year ARI critical duration storm event without overtopping the dam wall.

Section 4B.3.5.3 considers the operational behaviour of these storages over the life of the Longwall Project.

4B.3.4.2.4 Management of Progressive Surface Disturbance over the Mining Area

Surface water flows within each gas drainage or ventilation shaft area would be managed in accordance with a general Erosion and Sediment Control Plan (ESCP) (in accordance with the requirements of Landcom, 2004). The ESCP would provide for the following management.

- Prior to disturbance, the area would be marked out and 'no-go' zones identified.
- If located on or adjacent to a natural drainage line, a diversion bank would be constructed up-slope of the area to be disturbed and in accordance with Standard Drawing (SD) 6-4 of Landcom (2004).
- Based on the area to be disturbed, soil type and local topography, the requirement for a sediment basin would be determined, using the Revised Universal Soil Loss Equation (RUSLE).
- If a sediment basin is required, ie. soil loss >200t/ha/year, the sediment basin design capacity would be calculated.
- Vegetation and soil would be cleared and stripped and stockpiled away from natural drainage lines for future use in rehabilitation of the site.
- Sediment fencing would be installed along the down-slope boundaries of the disturbed areas.
- The function of the sediment fencing (and diversion bank or sediment basin if constructed) would be regularly inspected and remedial works undertaken immediately if not performing at optimum capacity.

4B.3.4.2.5 Contaminated Water Management

Runoff containing hydrocarbon contamination may be generated by:

- washdown area(s);
- workshop(s);
- fuel, oil and grease storages; and
- refuelling pads.

These areas would be managed as follows.

- Runoff would be drained to a triple interceptor (or similar) to reduce hydrocarbon concentration to acceptable levels before draining to SB1. The oily fraction would enter a containment system for removal as necessary.
- All oil, grease, fuel and hydrocarbon products would be securely stored on an impermeable surface within a bund capable of containing 110% of the largest tank's capacity.
- Refuelling, oiling and greasing would be restricted to designated areas, away from drainage and where spill kits are readily available.

In the event of a major hydrocarbon spill, the following actions would be undertaken.

- The contaminated soil at the site of the spill would be collected and transported to an approved waste depot or remediated safely on the Mine Site.
- Pits would be constructed around the spill with sufficient hydraulic gradient to capture seepage water and contaminated material, enabling the pits to be pumped out.
- The local groundwater would be monitored for signs of further contamination.

4B.3.4.2.6 Maintenance of Vegetation

The maintenance of vegetation, particularly ground cover, would be an important factor in reducing the velocity of surface water flows and maintaining acceptable surface water quality. By reducing flow velocity, the potential for soil erosion is reduced as would be the potential for further sediment to be entrained by the runoff. The vegetation itself would also act to filter any suspended solids contained within the water. As a general rule, all groundcover would be maintained on the Mine Site beyond the planned areas of disturbance. Importantly, the Proponent would undertake progressive revegetation of all completed landforms in order to maintain a ground cover of vegetation at 70% or better, although this value may fluctuate with seasonal conditions.

The areas where the retention and management of vegetation is of highest priority would be those subjected to large quantities of diverted water. This water is likely to be sediment-laden or potentially dirty.

Vegetation, particularly trees, also reduce the risk of dryland salinity by reducing the depth of the water table relative to the root zone of plants. By maintaining and/or enhancing as much vegetation on the Mine Site as possible, particularly trees, the potential for dryland salinity would be reduced.

4B.3.4.2.7 Water Discharge

No saline water would be discharged from the Mine Site. Dams A1, A2, A3, C and BR1 to BR5 would be lined with a impermeable HDPE (or equivalent) liner with a permeability of $\leq 1 \times 10^{-14}$m/sec and have been designed to have sufficient capacity to accept and store the predicted groundwater and brine make of the Longwall Project.

Within the Pit Top Area, water collected within SB1 to SB3 would not be discharged from the Mine Site. As these structures fill, the water contained would be pumped to Dam A1, from where it would be processed through the Water Conditioning Plant.

The discharge points from the Pit Top Area would be from SD2, SD4, SD5, SD6 and SD7. Based on the design of the sediment dams meeting the requirements of Landcom (2004) and DECC (2008) for a 5 day 90th %ile rainfall event, any release would achieve the water quality compliance criteria provided in Section 4B.3.6.

Discharged water would be sampled within 24 hours of a discharge event and assessed against DECCW water quality criteria. Contingency measures in the event of an exceedance of water quality criteria have been prepared and are discussed in Section 4B.3.5.

Finally, it is proposed to discharge raffinate from Dam D to the Namoi River. **Table 4B.18** presents the predicted annual discharge volumes based on the base case (most likely) groundwater modelling results.

Table 4B.18
Predicted Life of Mine Raffinate Discharge

Year	Predicted Discharge	
	ML/day	ML/year
8	0.3	98.1
9	0.6	209.3
10	0.7	241.4
11	0.8	301.6
12	1.0	355.3
13	1.2	445.8
14	1.4	521.7
15	1.6	588.6
16	1.8	647.3
17	1.9	696.9
18	2.1	761.2
19	2.1	758.4
20	2.1	758.3
21	1.6	583.1
22	1.3	466.3
23	1.0	371.9
24	0.7	261.9
25	0.6	203.5
26	0.3	118.8
27	0.2	64.5
28	-	-
29	-	-
Source: Modified after WRM (2009) – Table 8.6		

The pipeline would be fitted with a leak detection system such that any leak is able to be immediately detected, pumping ceased and the leak repaired before any significant impact on the surrounding soil and/or vegetation occurs.

4B.3.4.3 Water Quantity

The goals of the Proponent in relation to managing the quantity of water captured/discharged within the Mine Site are as follows.

- To ensure that sufficient water is available for operational requirements.
- To minimise the volume of clean water captured from natural (undisturbed) catchment on the Mine Site.
- To minimise the volume of treated raffinate discharged to the Namoi River.

Measures to Ensure Certainty of Water Supply

Transfer of surface water captured within the storage basins and sediment dams of the Mine Site has now been included in the water balance for the Mine Site. However, in the event that the commencement of the Longwall Project coincides with several years of low or average rainfall, the water captured on the Mine Site would be supplemented by water extracted from the Namoi River and pumped to the Mine Site via the proposed pipeline. It remains the Proponent's intent to only pump water to the Mine Site from the Namoi River when there are insufficient/reliable supplies on site.

Measures to Minimise Clean Water Capture

Only Dam SD5 captures clean water on the Mine Site for a combined dam capacity of 54.2ML (see **Figure 4B.22**). This is well within the maximum harvestable right dam capacity (MHRDC) for the Proponent's landholding which is calculated as follows.

MHRDC = Catchment Area of Proponent-owned land x Multiplier Value
= 3 825ha x 0.07
= 267.75ML

The above MHRDC calculation is based on guidelines provided by the former Department of Water and Energy (DWE) using the folder supplied by Department of Land and Water Conservation (DLWC) titled *Rural Production and Water Sharing Landholders Information Package*. It is noted that the maximum harvestable right does not include storages that are used on a Mine Site for environmental management purposes, eg. capture of 'dirty', saline or sediment-laden water.

Measures to Minimise Raffinate Discharge

In order to minimise the volume of groundwater treated, and therefore raffinate generated by the Water Conditioning Plant, raw groundwater (stored in Dam A1) would be used for all on-site dust suppression and coal processing operations within the Pit Top Area. Where the use of saline water will not adversely impact on equipment, this water would also be used for underground operations, eg. cooling, dust suppression away from the longwall unit.

Considering these management measures, the anticipated water requirements of the Mine Site and the predicted dewatering requirements of the underground mine a Site Water Balance has been prepared for the Longwall Project by WRM (2009). A summary of this water balance, which assesses the availability of water to supply the Longwall Project as well as capability of the nominated structures to store all water on the Mine Site is presented n Section 4B.3.5.

4B.3.4.4 Subsidence-related Impacts

The general principles involved in managing the impact of mine subsidence of the various watercourses that cross the Mine Site are as follows.

- Maintain stream stability where subsidence occurs.
- Minimise stream fracture where possible.
- Maintain stream channels with minimal incision from bed grade change.
- Minimise stream bed grade change to provide stable stream length.
- Maintain stream stability through soft controls, such as vegetation, where possible.

Figure 4B.8 illustrated that the potential impacts of mine subsidence may be significantly different at each creek crossing of each longwall panel. Based on the variable nature of impact, mitigation strategies would be tailored to each individual location, considering the geomorphic characteristics, vegetation and soil types of each individual location. The Proponent would inspect the creek channels of the Mine Site within 6 months of being crossed by a longwall panel. The inspection would consider, local ponding, erosion impacts on vegetation, with a water sample taken from ponded areas to assess water salinity and pH. In the event that significant erosion, ponding which inundates significant areas of vegetation, increased salinity or water pH outside the target range of ANZECC (2000) is identified, the Proponent would develop an impact mitigation strategy. The impact mitigation strategy may include the following strategies.

- Visible cracks in the bed of the creek will be in-filled.
- Contour banks that cross chain pillars would be removed and reconstructed if appropriate for the ongoing land use (noting that the Proponent owns the majority of the land over the mine subsidence zone which would have lower stocking rates and higher vegetation cover).
- If significant ponded areas are identified, the following assessment and mitigation would be made.
  - If little vegetation is impacted and minimal salt producing soils are evident, the ponding would be retained.
  - If larger areas or more significant vegetation is affected or salt producing soils are evident within the ponded area, the channel across the chain pillars may be excavated to reduce the extent of ponding.

Further to the above, the creek channels draining into the mine subsidence zone and on the downstream side of the chain pillars would be monitored for erosion following each runoff-producing storm event. Specific attention would be paid to those within the Riparian Risk Management Zones identified on **Figure 4B.21**. Any erosion would be repaired and remedial measures, such as check dams or drop structures, would be constructed, if necessary.

4B.3.4.5 Post-Mining Management

With the exception of the established perimeter bund wall, the rail loop and Mine Access Road which are intended to be retained, the final landform would be constructed to effectively recreate the landform disturbed by the surface facilities activities. Contour banks would be reconstructed along appropriate contour lines to allow for erosion protection of the land.

It is anticipated that over time, the process of erosion and sedimentation would re-instate the pre-subsidence channel gradients of the creeks and their tributaries that traverse the Mining Area. In accordance with the proposed approach to managing the affects of subsidence on local hydrology, channel excavation would be undertaken to mitigate larger ponds, or those which affect local vegetation and/or water quality. The Mine Site hydrology of the final landform would therefore be equivalent to that of the pre-mining landform.

Monitoring of the final landform and surface water flows on the Mine Site would be included in post project monitoring until such time as a stable landform could be demonstrated.

4B.3.5 Site Water Balance

4B.3.5.1 Introduction

Based on the proposed water management system described in Section 4B.3.3, WRM (2009) prepared a daily and annual water balance for the various water management dams on the Mine Site.

The daily water balance model was used to determine:

- the reliability of the various storages to supply the Mine Site water requirements during the initial years of the Longwall Project; and
- the frequency and volume of potential discharges from the storage basins and sediment dams under two scenarios:
  - during the second year (Year 2) of the Longwall Project when water is being pumped from the storage basins and sediment dams to Dam D;
  - during that period of the Longwall Project when the maximum volume of groundwater is predicted to be dewatered from the underground mine and therefore the maximum volume of raffinate is being produced for on-site consumption, ie., no water from the storage basins and sediment dams would be pumped back to Dam D (Year 18).

The Mine Site water demands for Year 2 and Year 18, with the dewatering rates of 0.28ML/day and 3.83ML/day respectively, are given in **Table 4B.19**.

Table 4B.19
Annual Operational Water Demand

Activity	Annual Demand (ML)	
	Year 2	Year 18
Supply		
Underground Dust Suppression and Other Uses	337	465
Coal Processing (Surface)	56	100
Pit Top Area Dust Suppression	27	27
Potable Water Supply	20	20
Recycle		
Underground Capture and Storage	-89	-284
Pit Top Area Capture and Storage	-5	-5
Total	**346**	**323**

Source: Narrabri Coal Operations Pty Ltd

The annual water balance of the major Pit Top Area water storages was used to determine:

- the frequency and volume of clean water releases from the Pit Top Area to the Namoi River; and
- the design requirements and behaviour of the brine storage ponds.

4B.3.5.2 Daily Water Balance Model

WRM (2009) used the AWBM rainfall runoff model (Boughton, 2003 [cited in WRM, 2009]) to determine the runoff volume from the various catchments on the Mine Site. Catchment parameters were based on the recommendations of Boughton (2003). WRM (2009) then used the IQQM water balance model (NSW DWE, 2007 [cited in WRM, 2009]) to assess the behaviour of the various storages on the Pit Top Area. The model was run over the 105 year period of daily rainfall data collected from 1900 to 2004 (inclusive). The use of such a long period of continual data provides a good indication of the behaviour of the various storages over extended dry and wet periods.

WRM (2009) provides further detail on the assumptions used in the development of water balance models and calibration of the water balance models. The following provides a summary of the water balance model results for Pit Top Area water storage behaviour during periods of low groundwater in-flow (potential surface water supply deficit) and high groundwater inflow (potential surface water supply surplus).

Reliability of Supply During Year 2 (potential surface water supply deficit)

The water balance model results for the Year 2 scenario were considered by WRM (2009) for a range of wet and dry years representing:

- 10^{th}%ile wet year (1 year in 10 are expected to produce more runoff);
- median (50^{th}%ile) year (1 year in 2 are expected to produce more runoff);
- 90^{th}%ile dry year (9 years in 10 are expected to produce more runoff); and
- 99^{th}%ile driest year (99 years in 100 are expected to produce more runoff).

Table 4B.20 summarises the results of the water balance model under the above rainfall conditions.

Table 4B.20
Annual Operational Water Demand

Rainfall Year	Water Supply from Pit Top Area Water Storages (ML)	Percentage of Demand Supplied by Pit Top Area Water Storages (%)
10th%ile wet year	438	99
Median (50th%ile) year	302	68.6
90th%ile dry year	205	46.6
99th%ile driest year	142	38.4
Source: Modified after WRM (2009) – Table 8.4		

The results show that the Pit Top Area water storages would be sufficient to supplement the groundwater inflows only during the wettest (10%ile) years. Therefore, during the majority of years, when rainfall is less than the 10th%ile year, there is an elevated potential for the water contained in the Pit Top Area water storages to be insufficient to supplement the groundwater in-flows. Based on the results presented in **Table 4B.20**, the Proponent would be required to source additional water from either licensed groundwater or river water supplies.

Potential Water Storage Discharges During Year 2 and 18 (potential surface water supply surplus)

Table 4B.21 presents the predicted probability and volume of discharges from the Pit Top Area water storages for Year 2 and Year 18 of the Longwall Project.

The following is of note with respect to the water balance modelling results.

- There are no uncontrolled spills from any of the dams constructed to store saline groundwater, brine or treated raffinate. This indicates that the proposed operating strategy is adequate for groundwater inflows up to 3.84ML/day.
- There are no uncontrolled spills from the four potentially contaminated storage basins of the Pit Top Area. Therefore, the proposed storage volume and operating strategy is deemed to be appropriate.
- Uncontrolled spills from SD1 to SD4 occur only once or twice when low groundwater in-flows (Year 2) are simulated, ie. when water is being harvested to supplement water supplies for the Longwall Project .
- WRM (2009) predicts no uncontrolled spills during Year 18 as all water would be released to the downstream creeks within 5 days of the rainfall event. At this stage, the water quality collected within the sediment dams is expected to achieve the water quality compliance criteria.
- Sediment Dam SD6 at the Vent Shaft spills on average of 1 year in 3. This satisfies the average annual sediment basin overflow frequency criteria given in DECC (2008).
- For the Year 18 scenario, controlled releases of the raffinate water are made from Dam D at a rate of 2.1ML/day to prevent uncontrolled spills. When less groundwater is dewatered to the surface, the volume of releases made to the Namoi River will be less.

Table 4B.21
Mine Site Water Storage Overflows and Uncontrolled Releases

Water Storage	Groundwater In-flow (ML/day)	
	0.28 (Year 2)	**3.83 (Year 18)**
Dam A1		
Years of Uncontrolled Spills (%)	0	0
Median Volume of Spill (ML)	0	0
Brine Storage Ponds		
Years of Uncontrolled Spills (%)	0	0
Median Volume of Spill (ML)	0	0
Raffinate Storages (B&D)		
Years of Uncontrolled Spills (%)	0	0
Median Volume of Spill (ML)	0	0
Years Controlled Release (%)	0	100
Median Volume of Release (ML)	0	763[1]
Storage Basins SB1& SB2		
Years of Uncontrolled Spills (%)	0	0
Median Volume of Spill (ML)	0	0
Storage Basin SB3		
Years of Uncontrolled Spills (%)	0	0
Median Volume of Spill (ML)	0	0
Sediment Dams SD1 & SD2		
Years of Uncontrolled Spills (%)	2	0
Median Volume of Spill (ML)	2	0
Sediment Basin SD3 & SD4		
Years of Uncontrolled Spills (%)	1	0
Median Volume of Spill (ML)	1	0
Sediment Basin SD6		
Years of Uncontrolled Spills (%)	31.5	31.5
Median Volume of Spill (ML)	2	2
Note 1: Includes constant Namoi River release of 2.1 ML/day		
Source: Modified after WRM (2009) – Table 8.5		

4B.3.5.3 Annual Water Balance Model

An annual spreadsheet water balance was developed by WRM (2009) to consider the behaviour and performance of:

- Dam A1 (saline groundwater storage);
- Brine storage ponds A2, A3, B2and BR1 to BR3; and
- Raffinate storage dams B1, C and D.

The annual water balance model provides an indication of the annual volume of clean water that would be released from Dam D to the Namoi River each year of operation. It also provides an approximate timeframe as to when BR1 to BR3 would be required and an estimation of the volume of brine that may need to be re-injected back into the underground void at the end of the Longwall Project. WRM (2009) provides additional detail on the assumptions made in the development and operation of the annual water balance model, which was run both for the predicted base case and upper bound groundwater in-flows of Aquaterra (2009).

The results of the annual water balance are summarised in Tables 8.6 and 8.7 of WRM (2009). The results show the following.

- For both the base case and upper bound groundwater in-flow scenarios, BR1, BR2 and BR3 would be required. BR4 would be required if groundwater in-flows are equivalent to those predicted by the high in-flow uncertainty analysis of Aquaterra (2009), however, BR5 is unlikely to be required unless in-flows are significantly higher than predicted by Aquaterra (2009) or the Proponent reduces the depth of each brine storage pond (to increase evaporation from these).
- For both cases, Dam B2 would be required for brine storage by Year 2 and would therefore be lined with HDPE prior to Year 2.
- BR1 would be required in Year 4 for both the base case and upper bound groundwater in-flow scenario.
- BR2 would be required by Year 7 to Year 9 and BR3 by Year 13 to Year 16.
- Pumping would cease from the sediment dams to augment Mine Site supplies in Year 3 or Year 5. The rehabilitation program from these catchments would be completed by this stage and the runoff quality would therefore be acceptable.
- Releases of raffinate water are expected to commence in Year 8 for the base case groundwater in-flow scenario or Year 6 for the upper bound groundwater in-flow scenario.
- Release of raffinate water is expected to peak in Year 18 at 761ML/yr for the base case groundwater in-flow scenario and in Year 19 at 1 171ML/yr for the upper bound groundwater in-flow scenario. Notably, the off site releases estimated in the base case scenario are very similar to the peak off site release estimated using the daily water balance model (see Section 4B.3.5.2).
- At the end of mine life, there would be 1 989 ML to 2 237 ML of brine left in storage that would be re-injected back into the underground void.

4B.3.6 Impact Assessment Criteria

The current environmental protection licence for the Stage 1 Narrabri Coal Mine (EPL 12789) requires the Proponent to comply with Section 120 of the *Protection of the Environment Operations Act 1997*, ie. the Proponent must not discharge water which contains concentrations of potentially polluting material greater than that of the accepting environment. It is proposed that this condition be retained for the Longwall Project. Alternatively, water quality criteria in line with the ANZECC (2000) trigger levels for lowland rivers apply.

The Proponent also proposes measurable water targets for the release of treated raffinate water to the Namoi River as presented in **Table 4B.22** (see Section 4B.3.7.5).

4B.3.7 Assessment of Impacts

4B.3.7.1 Introduction

Following the adoption of the water management controls and mitigation measures identified in Section 4B.3.4, the impacts on surface water within and beyond the Mine Site have been assessed as follows.

4B.3.7.2 Surface Water Catchments

The final landform created following the completion of the Longwall Project and rehabilitation of the Mine Site would be equivalent in topography and vegetation to that of the pre-mining landform (see **Figure 2.18**). There may be minor changes to the total catchment areas to the creeks and tributaries traversing the Mine Site, however, any change would be minimal and have no impact on the total catchments of Kurrajong and Pine Creeks.

No other catchment would be significantly effected by the Longwall Project.

4B.3.7.3 Subsidence Related Impacts on Local Drainage

Impacts associated with mine subsidence on local drainage is provided in Section 4B.1.6.5 and **Figure 4B.8**.

4B.3.7.4 Surface Water Quantity

The water balance modelling undertaken by WRM (2009) illustrates that during the initial years of the Longwall Project, additional water would have to be sourced from either groundwater or river sources. Supply from these sources would have to be licensed in accordance with either the *Water Act 1912* or *Water Management Act 2000*.

Importantly, the capture of clean water would not exceed the harvestable right of the Mine Site and as such it is assessed that the minor reduction in environmental flows to the Kurrajong Creek catchment is acceptable. As discussed in Section 4B.3.7.5, the Longwall Project would actually provide for a net increase in flows to the wider Namoi River catchment.

4B.3.7.5 Surface Water Quality

Pit Top Area

The proposed operating strategy for water management on the Pit Top Area has been designed to capture all "dirty" and "contaminated" water and direct it to sediment dams and storage basins, via a number of diversion banks and culverts. The design of these storage structures was reviewed by WRM (2009) with each determined to meet the requirements of Landcom (2004) and DECC (2008).

Notably, those structures constructed to accept runoff from the potentially contaminated catchments have been designed to contain all water with these structures, with the stored water ultimately processed through a Water Conditioning Plant to remove any contaminants before either used on the Mine Site or discharged to the Namoi River.

All storages constructed to contain saline water would be lined with HDPE plastic, which is effectively impermeable (permeability of $< 1 \times 10^{-14}$m/sec). The dam and liner would be inspected by an appropriately qualified person prior to the inflow of any saline water or brine. Shallow piezometers would be installed and monitored to identify if any leakage from these storages occurs and appropriate remedial measures completed as required and in consultation with the relevant government agency.

Impacts on water quality of the Namoi River (as a result of discharged raffinate) is considered in Section 4B.3.7.6.

Based on the above, it is concluded that the Longwall Project would not result in any unacceptable impact on local water quality. A surface water monitoring program (see Section 4B.3.8.1) would be updated and implemented to ensure impacts on the water quality of local catchments are as predicted and acceptable.

4B.3.7.6 Raffinate Discharge to the Namoi River

The water balance modelling, see Section 4B.3.5.3, indicates that discharge to the Namoi River is likely to be required after about 7 to 10 years. Considering the impact of the proposed volume of the discharge on the overall flow rate of the Namoi River, flow rate historic daily recorded flows in the Namoi River at Boggabri over the period 1990 to 2009 were reviewed by WRM (2009). The 1990 to 2009 period of record was selected because the majority of the irrigation infrastructure in the catchment would have been constructed by then and the Murray Darling Basin Commission cap on diversions had been imposed.

The 'base line' flow rates and the flow rate including the addition of up to 3ML/day from the Longwall Project was considered by WRM (2009) and the following conclusions made.

- Over 70% of daily 'base line' flows exceed 100ML/day and therefore the minor increase in flow resulting from the mine discharge is insignificant.
- The mine discharges could potentially increase the frequency of low flows, which could increase the reliability of stock and domestic users and improve environmental flows in the catchment.

Considering water salinity specifically, a plot of salinity levels against flow rate within the Namoi River at Gunnedah was prepared by WRM (2009) and is reproduced as **Figure 4B.23**.

Notwithstanding the varied and at times elevated salinity levels within the Namoi River, the Proponent would treat any water to be released sufficiently to comply with the water quality criteria provided by **Table 4B.22**.

Notably, at flow rates exceeding 100ML/day, background salinity levels in the Namoi River vary between 250µS/cm and 650µS/cm, with the salinity of the discharged raffinate (<250µS/cm) at the lower end of this range. It is also notable that during lower flow periods (flow < 100ML/day), salinity levels generally exceed the nominated water quality compliance requirement (see **Table 4B.15**). Therefore, the releases are expected to reduce the salinity concentrations during periods of low flows.

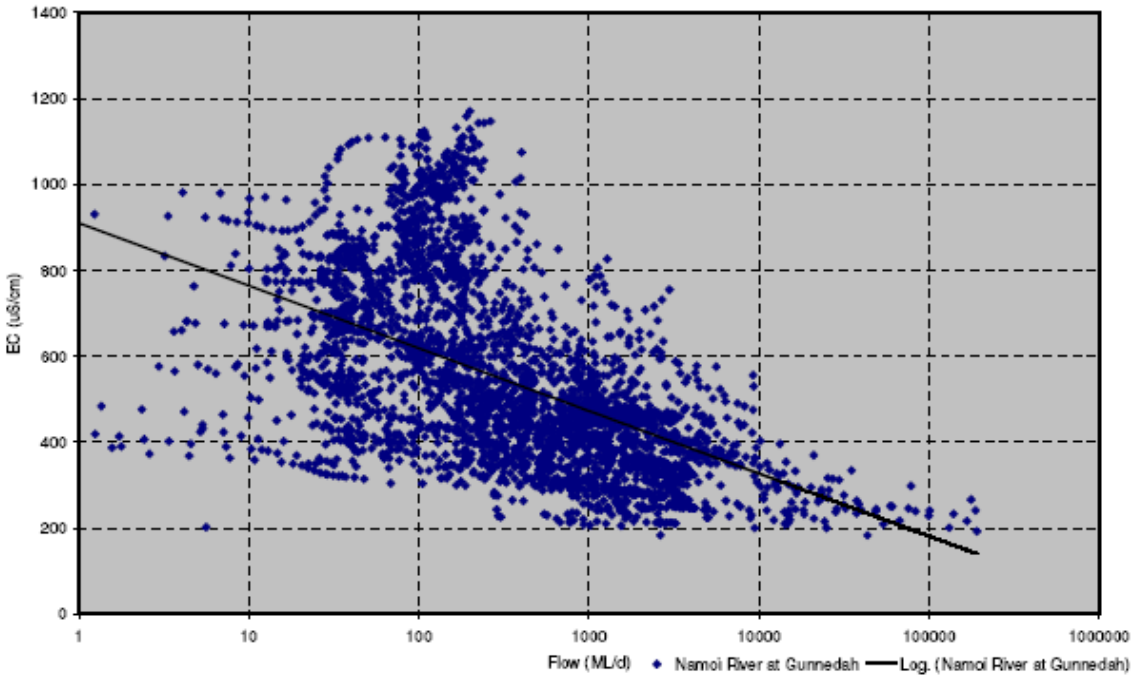


Figure 4B.23
Daily Flow and Electrical Conductivity Comparison, Namoi River at Gunnedah

Source: WRM (2009)

Table 4B.22
Water Quality Compliance Targets

Parameter	Unit	Target
pH		5.5 - 8
TDS	mg/L	350
Aluminium[1]	µg/L	55
Ammonia (as N)	µg/L	900
Antimony	µg/L	9
Arsenic[1]	µg/L	13
Boron[1]	µg/L	370
Beryllium[1]	µg/L	0.13
Cadmium[1]	µg/L	0.2
Chromium[1]	µg/L	1
Cobalt[1]	µg/L	1.4
Copper[1]	µg/L	1.4
Fluoride[1]	µg/L	2000
Iron[1]	µg/L	300
Lead[1]	µg/L	3.4
Manganese[1]	µg/L	1900
Mercury[1]	µg/L	0.1
Molybdenum[1]	µg/L	34
Nickel[1]	µg/L	11
Selenium[1]	µg/L	5
Uranium[1]	µg/L	0.5
Vanadium	µg/L	6
Zinc[1]	µg/L	8
Note 1: ANZECC (2000) default trigger values for slightly-moderately disturbed catchments		

4B.3.8 Monitoring Program and Contingency Planning

4B.3.8.1 Monitoring Program

A comprehensive monitoring program is already in place across the Mine Site that incorporates:

- the collection of rainfall and meteorological data;
- the collection of water quality and water level data in the water storages and creeks.

Table 4B.23 summarises the proposed surface water monitoring program for the Longwall Project. All samples would be collected in a manner consistent with the "*Approved Method for Sampling and Analysis of Water Pollutants in NSW*" (DEC, 2004).

Table 4B.23
Surface Water Monitoring Program

Location [1]	Parameters	Frequency
Site (Meteorological Monitoring)	- Rainfall - Wind speed and direction - Temperature - Relative humidity - Solar Radiation	Recording every 15 minutes
Rail Loop Water Storages and Brine Storages Ponds	- Water Level - EC - pH - Turbidity - TDS - TSS - Metals - Anion and Cations	Monthly (until baseline is established) and then quarterly
Sediment Dams and Storage Dams	- Water Level - EC - pH - TSS - TDS - Turbidity - NFR - Total Organic Carbon - Grease and Oil - Nutrients	Daily during runoff events
PC, PC1, KC1US, KC1DS, KC2US, KC2DS, KCUS, KCDS[1]	- Water Level - EC - pH - TSS - TDS - Turbidity - NFR - Total Organic Carbon - Grease and Oil - Nutrients	Daily during runoff events
Note 1: see **Figure 1.4**		
Source: Modified after WRM (2009) – Table 10.1		

The existing monitoring program would also be extended to include the monitoring of the impact of mine subsidence on the various watercourses that cross the mine subsidence zone. The monitoring would include the following components.

- Each creek traversing a longwall panel would be surveyed at regular intervals to determine the ultimate level of the area.
- Photographs of the creek would be taken prior to mine subsidence and after mine subsidence following significant rainfall events to assess whether erosion has occurred.
- A log of when inspections occur (and photographs taken) would be kept together with an assessment of the changes in erosion.

The Proponent proposes to review the frequency of monitoring and range of parameters analysed after the first two years of the Longwall Project.

4B.3.8.2 Contingency Planning

Polluting Discharge from Pit Top Area Water Storages

Whilst the water management structures of the Mine Site have been designed to collect and store runoff generated by rainfall events up to the 5 day 95th %ile, it is still possible that rainfall events of greater magnitude may occur which result in water with elevated levels of sediment discharging from the designed water storages (SB4, SD2 or SD4). The Proponent would sample water discharging from the final discharge structures as licenced in EPL 12789 by DECCW (Currently SD2, SD4 and SD5) within 24 hours of discharge and analyse the water for suspended solids, turbidity, electrical conductivity, oil and grease, and pH. In the event that monitoring confirms elevated concentrations of any of these parameters (in comparison to Environment Protection Licence criteria or ANZECC, 2000 trigger levels), one or more of the following measures would be adopted.

- The relevant government agencies would be advised. Salient preceding weather information would also be provided.
- Additional flocculants would be used to expedite settlement of sediments.
- The sediment basins would be enlarged or additional sediment basins constructed.
- An additional storage dam would be constructed downstream which would become the new site discharge point and monitoring location. DECCW would be advised to enable amendment to any Environment Protection Licence.

Polluting Discharge from Groundwater or Brine Storage Ponds

In the event that one of the groundwater or brine storage ponds or other saline water transfer or storage structure is breached, one or a combination of the following measures would be implemented.

- Dewatering from the underground workings would be transferred to an intact and lined storage structure along with any water remaining in the breached pond. As a last resort and in the event no suitable storage facility is available, the underground workings would be evacuated and dewatering ceased until a suitable storage area is identified.

- The breached pond or pipe would be repaired immediately and inspected by a suitably qualified person prior to re-integration into the saline water management system.
- The water cart would be used to transfer non-saline water to the area of the spill to flush and dilute the water discharged. As far as practical, at least four times the volume of the spilled water would be used to flush the downstream environment.
- Downstream vegetation would be monitored for any impacts of increased salinity and treated appropriately.

4B.4 ECOLOGY

The ecological assessment was undertaken by Ecotone Ecological Consultants Pty Ltd. The full assessment is presented as Volume 1, Part 4 of the Specialist Consultant Studies Compendium, with the relevant information from the assessment summarised in the following subsections. The full assessment is referred to as Ecotone (2009) throughout this document.

4B.4.1 Introduction

Based on the risk analysis undertaken for the project (see Section 3.3 and **Table 3.5**), the potential ecological impacts requiring assessment and their **unmitigated** risk rating are as follows.

- Disturbance to native vegetation / habitat within nominated areas (high risk).
- Disturbance to native vegetation / habitat outside nominated areas (moderate risk).
- Disturbance to threatened flora / fauna and endangered ecological communities (high risk).
- Disturbance leading to local population reduction (high risk).
- Disturbance leading to local extinction(s) (high risk).
- Reduced local biodiversity (moderate risk).
- Reduced regional biodiversity (high risk).

In addition, the Director-General's Requirements issued by the DoP identified "Biodiversity" as one of the key issues requiring assessment. The assessment of biodiversity is required to include:

- accurate estimates of any vegetation clearing associated with the Longwall Project;
- a detailed assessment of the potential impacts of the Longwall Project particularly from subsidence impacts on threatened species, populations, ecological communities or their habitat; and
- a description of any measures that would be implemented to maintain or improve biodiversity values in the region.

In accordance with the DGRs, the assessment of Ecotone (2009) was undertaken in accordance with the draft *Guidelines for Threatened Species Assessment under Part 3A of the Environmental Planning and Assessment Act 1979* (DEC, 2005) and has considered the following guideline documents and planning policies.

- "The NSW State Groundwater Dependent Ecosystem Policy" (DLWC, 2002).
- "Policy and Guidelines – Fish Friendly Waterway Crossings" (NSW Fisheries, undated).
- State Environmental Planning Policy No. 44 – Koala Habitat Protection.

The following subsections describe and assess the existing threatened species and their habitat, identify the ecological management issues, proposed controls, safeguards and mitigation measures for the threatened species and their habitat.

4B.4.2 Study Methodology and Outcomes

4B.4.2.1 Desktop Assessment

The desktop component of the ecological assessment, completed in satisfaction of Step 1 of the *Draft Guidelines for Threatened Species Assessment* (for projects assessed under Part 3A of the *Environmental Planning and Assessment Act 1979*) (DEC / DPI, 2005) (hereafter referred to as the Part 3A Guidelines), involved a review of flora and fauna surveys and assessments that have previously been conducted in the vicinity of the Mine Site and a web-based search of the documented records held on the Department of Environment and Climate Change, Atlas of NSW Wildlife Database and the Rare or Threatened Australian Plants (ROTAP) database (Briggs & Leigh 1996). In particular, Threatened flora and fauna species recorded within the Baan Baa, Narrabri, Boggabri and Horton 1: 100 000 map sheets were identified (hereafter referred to as "the region").

Subsequently, the records of the region were considered over a reduced area within a 20km radius from the centre of the Mine Site (hereafter referred to as "the locality").

Lists of threatened species known or predicted to occur within the Liverpool Plains (Part B), Pilliga (Part A) and Pilliga Outwash Catchment Management Authority (CMA) subregions of the BIOCLIM model were also reviewed (Busby, 1991). This modelling is based on areas of suitable climate for a species, although this does not mean that its required habitat would necessarily be present within the study locality.

4B.4.2.2 Field Surveys

4B.4.2.2.1 Introduction

In satisfaction of Step 2 of the Part 3A Guidelines, field surveys were completed by Ecotone across the Mine Site on 19 January 2009 and between 20 and 23 January 2009.

4B.4.2.2.2 Flora Surveys

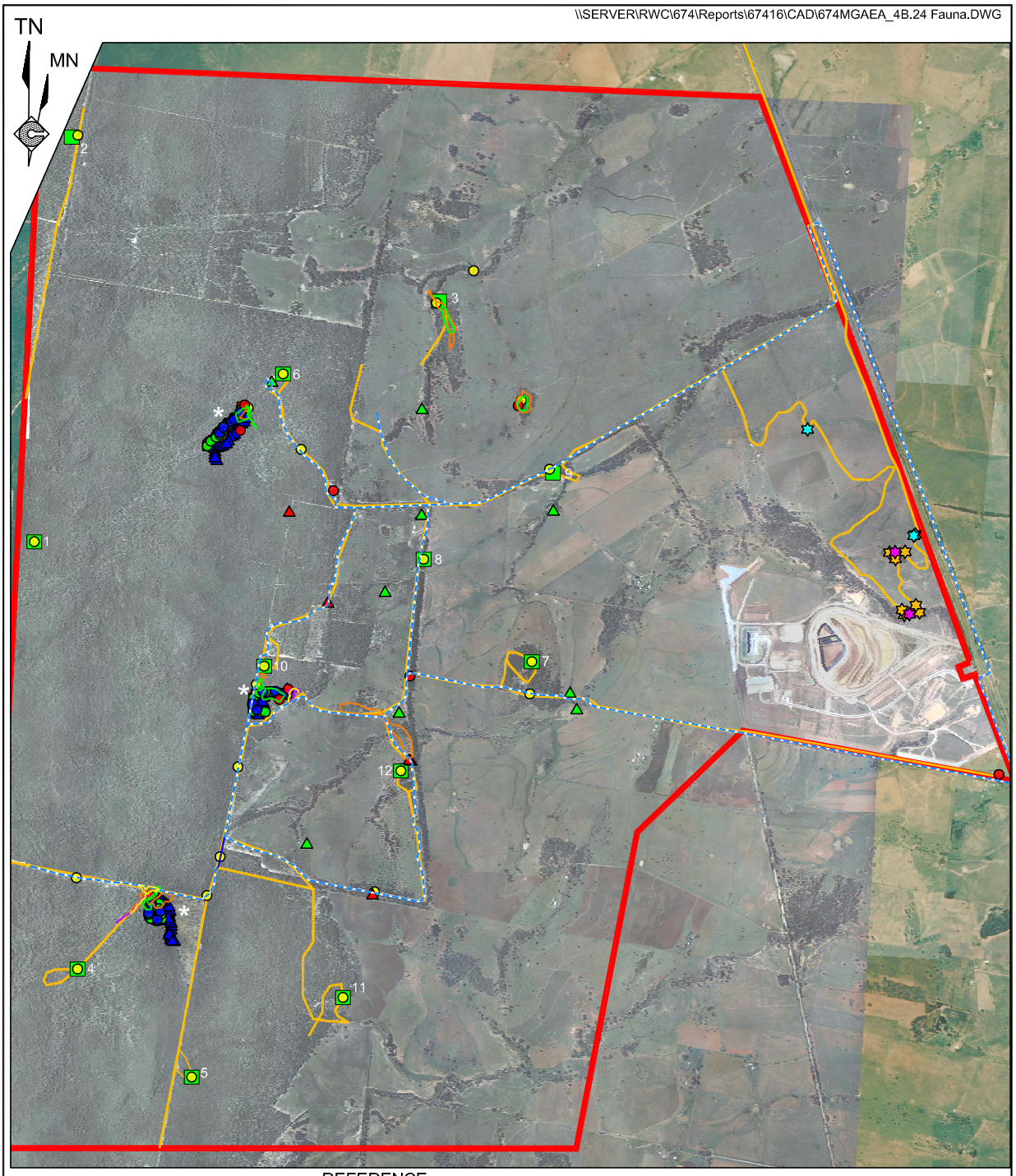
An initial and general site inspection of the Mine Site was undertaken on 19 January 2009, followed by four full days of field survey between the 20 to 23 January 2009 to document the flora and vegetation communities of the Mine Site. A total of 12 survey sites were selected, chosen to ensure that representative vegetation communities were sampled, for detailed survey and sampling. **Figure 4B.24** identifies the locations of the 12 vegetation survey sites. The methodology at each survey site involved the following components.

- A 'loop' transect on foot ranging in length from approximately 600m to 1km within which all vascular flora species were recorded and the variation in the structure and condition of the vegetation generally was noted.
- One 20m x 20m flora quadrat at a representative point along the loop transect within which vegetation structure (strata, heights and cover), soil type, topography, extent of modification, disturbance, weed invasion and condition of the vegetation generally was recorded. All vascular flora species were recorded within the quadrat.
- A targeted search, using the random meander method (Cropper, 1993), for any Threatened flora species listed under the *Threatened Species Conservation Act 1995* (TSC Act) or *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) for which potential habitat was available and which were considered to have at least a moderate likelihood of occurring and being detected at the time of the survey.

The survey sites were supplemented by general traverses over the entire Mine Site, mainly by vehicle, with some short random meanders on foot to assess the general vegetation type and condition throughout the study area in locations other than the survey sites.

A supplementary flora survey was undertaken over the Brine Storage Area (not included in the original field surveys) and proposed Water Pipeline Route between the Mine Site and Namoi River on 6 and 7 August 2009. A total of five survey sites were selected, chosen to ensure that representative vegetation communities were sampled, for detailed survey and sampling. The methodology at each survey site involved the same components as described for the 12 sites of the January 2009 field survey. **Figure 4B.25** identifies the locations of the five additional vegetation survey sites.

The survey methodology broadly complied with current best practice flora survey guidelines for a full impact assessment where practically possible, such as the *Draft Threatened Biodiversity Survey and Assessment Guidelines* (DEC, 2004). **Table 4B.24** outlines the level of compliance with the DEC (2004) recommended level of survey effort, based on the area covered by each vegetation community identified on the Mine Site (Stratification Unity).



REFERENCE

- Mine Site Boundary
- Anabat Detector
- Arboreal Elliot B Trap
- Cage Trap
- Habitat Assessment
- Harp Trap
- Nocturnal Farm Dam Frog Search
- Paired Hair Tube
- Pitfall Trap
- Terrestrial Elliot B Trap
- Farm Dam Fauna Habitat Assessment
- Koala Scat Search
- Woodland Fauna Habitat Assessment
- Bird Survey
- Diurnal Reptile Search
- Driving Spotlight
- Nocturnal Reptile and Amphibian Search
- Walking Spotlight
- Flora Quadrat
- Walking / Vehicle Transect

Note: More detail on survey effort at locations identified with * is provided by Figures 5,6 & 7 of Ecotone (2009).

SCALE 1:50 000

0.5 0 0.5 1.0 1.5 2.0 2.5 km

Source: Ecotone (2009) - Figure 4

Figure 4B.24
FLORA AND FAUNA FIELD SURVEY
(MINE SITE)

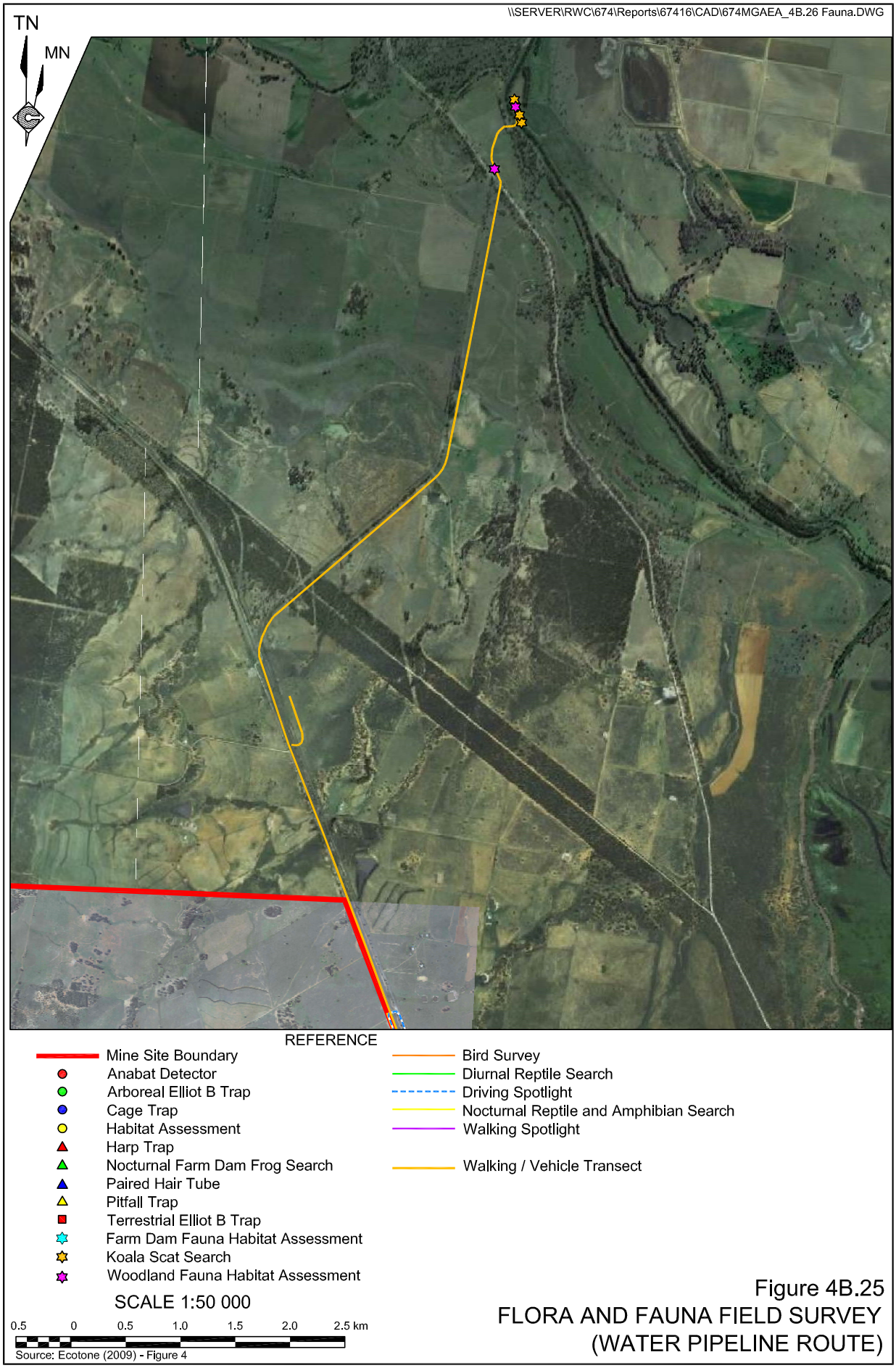


Figure 4B.25
FLORA AND FAUNA FIELD SURVEY
(WATER PIPELINE ROUTE)

Table 4B.24
Compliance with Suggested Flora Survey Effort

Method	Suggested Minimum Effort[1]		As Carried Out
Transects (or Traverse)	Community 1[2]	20 traverses of 100m each = 2200m total traverse length	6 traverses of average 800m each = 4800m total traverse length
	Community 2[2]	3 traverses of 100m each = 300m total traverse length	3 traverses of average 800m each = 2400m total traverse length.
	Community 3[2]	2 traverses of 100m each = 200m total traverse length	2 traverses of average 800m each = 1600m total traverse length.
	Community 4[2]	1 traverse of 100m	1 traverse of approx. 800m
Random Meander	30 minutes for each quadrat sampled within the same stratification unit as the quadrat		Done
Plot-based (Quadrat) Survey	Community 1[2]	20 quadrats	6 quadrats[3]
	Community 2[2]	3 quadrats	3 quadrats
	Community 3[2]	2 quadrats	2 quadrats
	Community 4[2]	1 quadrat	1 quadrat
Note 1: Community = Stratification Unit Note 2: Distribution of identified Community types are presented on **Figures 4B.26** and **27** Note 3: Due to uniformity of stratification, greater survey effort was allocated to transect length than quadrat number			
Source: Modified after Ecotone (2009) – Table 5			

4B.4.2.2.3 Fauna Surveys

Mine Site

Field surveys for fauna were undertaken between 19 and 23 of January 2009. A summary of the survey methods and strategies is provided as follows.

Habitat Assessment

The type and condition of potential habitat for fauna species was investigated and recorded. Habitat features identified included:

- topographic features;
- the dominant vegetation community composition, structure and condition at all strata levels, ie. from ground to canopy cover;
- groundcover type and percentage cover;
- presence, location and quality of water sources;
- type and size of tree hollows;
- presence, number and condition of unique habitat features (such as caves, crevices, loose tree bark, rocks on rock and mistletoe); and
- level of disturbance.

During the habitat assessment, all opportunistic observations of fauna or faunal activity were recorded, including visual and auditory recognition of fauna species and identification of evidence of faunal activity (eg. nests, diggings, scratch marks, droppings).

Trapping Sites

Three trapping sites were established in the woodland areas of the western half of the Mine Site (see **Figure 4B.24**). The trapping sites were selected to sample the representative woodland vegetation types present and to cover the area of the Mine Site.

At each of the three trapping sites, the following trapping effort was undertaken.

- 25 terrestrial Elliott A and 10 arboreal Elliott B traps.
- Five terrestrial cage traps.
- One 30m pitfall fence with three buckets.
- 20 terrestrial medium, 20 terrestrial small and 10 arboreal small hair tubes.

Bird Surveys

Each survey comprised one person hour of survey, ie. either by a single observer for one hour or by two observers for 30 minutes with birds identified either visually or by call. Where possible, bird surveys were undertaken during early morning or late afternoon. Two bird surveys were completed at each of the trapping sites and three additional bird surveys were completed at opportunistic habitat locations (see **Figure 4B.24**). Bird sightings were also recorded opportunistically during all other survey activities.

Reptile and Amphibian Searches

Each survey comprised one person hour of survey, ie. either by a single observer for one hour or by two observers for 30 minutes, both during the day and at night. The nocturnal searches included both terrestrial and aquatic habitats. Where possible, diurnal searches were undertaken during early to mid morning or mid to late afternoon and nocturnal searches between early and mid evening. Two diurnal and one nocturnal search were completed at each of the trapping sites and two additional diurnal searches were completed at opportunistic habitat locations (**Figure 4B.24**).

Spotlight Surveys

Both walking and driving spotlight surveys were undertaken between dusk and 1:00am over a single person hour (two observers) on each occasion. Both walking and driving spotlight surveys were undertaken at each of the three trapping sites, with driving spotlight surveys also undertaken across most of the Mine Site while travelling to and from trapping or other survey sites (**Figure 4B.24**).

Call Playback

Call playback for the following species was undertaken at dusk or during early evening at each of the trapping sites (see **Figure 4B.24**).

- Squirrel glider (*Petaurus norfolcensis*).
- Koala (*Phascolarctos cinereus*).
- Barking owl (*Ninox connivens*).
- Masked owl (*Ninox novaehollandiae*).
- Powerful owl (*Ninox strenua*).

Anabat Survey

Anabat detectors were used to record the echolocation calls of micro-bats at the three trapping sites for two nights and an additional opportunistic location for an additional night (see **Figure 4B.24**).

Brine Storage Area and Water Pipeline Route

A supplementary fauna survey was undertaken over the Brine Storage Area (not included in the original field surveys) and proposed water pipeline route between the Mine Site and Namoi River on 6 and 7 August 2009. The survey involved opportunistic fauna survey over the entire footprint of the proposed Brine Storage Area and water pipeline route including:

- recording of species sighted or heard;
- koala scat searches at the base of trees (1m radius);
- the opportunistic rolling of rocks and logs; and
- the identification of species presence from signs and traces such as scats and scratch marks.

Ecotone (2009) reports that the survey effort complied with that recommended by DEC (2004). The survey area for the supplementary survey is depicted on **Figure 4B.25**.

4B.4.3 Results of the Flora Surveys

4B.4.3.1 Regional Threatened Flora

Ecotone (2009) identified 17 threatened flora species as being known to occur within the region. Of these, only two have been recorded within the study locality (see **Table 4B.25**).

Table 4B.25
Rare or Threatened Flora Previously Recorded Within the Study Locality

Scientific Name	Status		Records (Region)	Records (Locality)
	TSC Act	EPBC Act		
Bertya opponens[1]	V	V	5	4
Boronia ruppii	E1	~	1	0
Bothriochloa biloba	U	V	3	0
Cadellia pentastylis	V	V	41	9
Cyperus conicus	E1	~	2	0
Dichanthium setosum	V	~	1	0
Digitaria porrecta	E1	E	3	0
Hakea pulvinifera	E1	E	9	0
Haloragis exalata	V	V	2	0
Homopholis belsonii	U	V	4	0
Lepidium aschersonii	V	V	28	0
Philotheca ericifolia	V	V	2	0
Polygala linariifolia	E1	~	1	0
Pomaderris queenslandica	E1	~	1	0
Pterostylis cobarensis	V	V	1	0
Rulingia procumbens	V	V	3	0
Swainsona murrayana	V	V	1	0

Note 1: *=Bertya sp. A Cobar-Coolabah*

Status (TSC Act): refers to the NSW *Threatened Species Conservation Act* 1995 (TSC)
E1 Schedule 1, Part 1: Endangered Species
V Schedule 2: Vulnerable Species
U Unprotected (not listed in Schedule 13 of the NPW Act 1974 or in the TSC Act 1995)
Status (EPBC Act): refers to the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC)
E Endangered Species
V Vulnerable Species

Source: Modified after Ecotone (2009) – Table 2

One NSW Wildlife Atlas record of *Bertya opponens* occurs within the Mine Site, although it is noted that its position was only given to an accuracy of 1 000m. In recognition of this record, the noted location was used as the basis for the location of Flora Quadrat 1 (see **Figure 4B.24**), and this species was particularly targeted during the survey at this site.

A total of 27 additional species previously recorded in the region are listed on the ROTAP database but are not protected under either the TSC Act or EPBC Act.

Two additional known or predicted flora species were identified following a review of the BIOCLIM database, namely:

- *Thesium australe* (Austral Toadflax): known from Liverpool Plains (Part B) subregion; and
- *Tylophora linearis:* Predicted to occur in Pilliga (Part A) and Pilliga Outwash subregions

4B.4.3.2 Existing Vegetation

4B.4.3.2.1 Vegetation Communities of the Mine Site

Six broad natural or predominantly native vegetation community types occur within the Mine Site and water pipeline route (see **Figures 4B.25** and **4B.26**). These communities also reflect types of faunal habitat, with both listed as follows.

- Community 1 - Brown Bloodwood / Pilliga Grey Box / Red Ironbark Woodland (Sandstone Slopes Woodland).
  Occurring on the undulating sandstone slopes and ridgetops of the Mine Site on sandy / sandy loam or rocky soil, this community ranges from low mallee woodland with dense shrub layer to open forest with sparse shrub layer. The tree layer is mostly sparse and dominated by Brown Bloodwood, Pilliga Grey Box and Red Ironbark. A dense shrub layer of tall wattles is often present.
- Community 2 – Inland Grey Box / Bimble Box / Blakely's Red Gum Woodland (Lower Flats and Floodplain Woodland).
  This modified, partially cleared and disturbed woodland community is dominated by adapted to or tolerant of drier conditions, with occasional inundation due to flooding. Tree species include Bimble Box, Western Grey Box and Blakely's Red Gum. Most areas of this community have been modified by agricultural activities with partial clearing of the shrub layer and at least occasional grazing of the groundcover.
- Community 3 – River She Oak / Belah / Inland Grey Box Forest (Riparian Forest).
  This community has been partially cleared but remains a relatively intact open forest to woodland dominated by casuarinas and species adapted to higher water availability including River She Oak, Belah, Blakely's Red Gum, Spiny Mat Rush over very dense shrub and sparse ground cover.

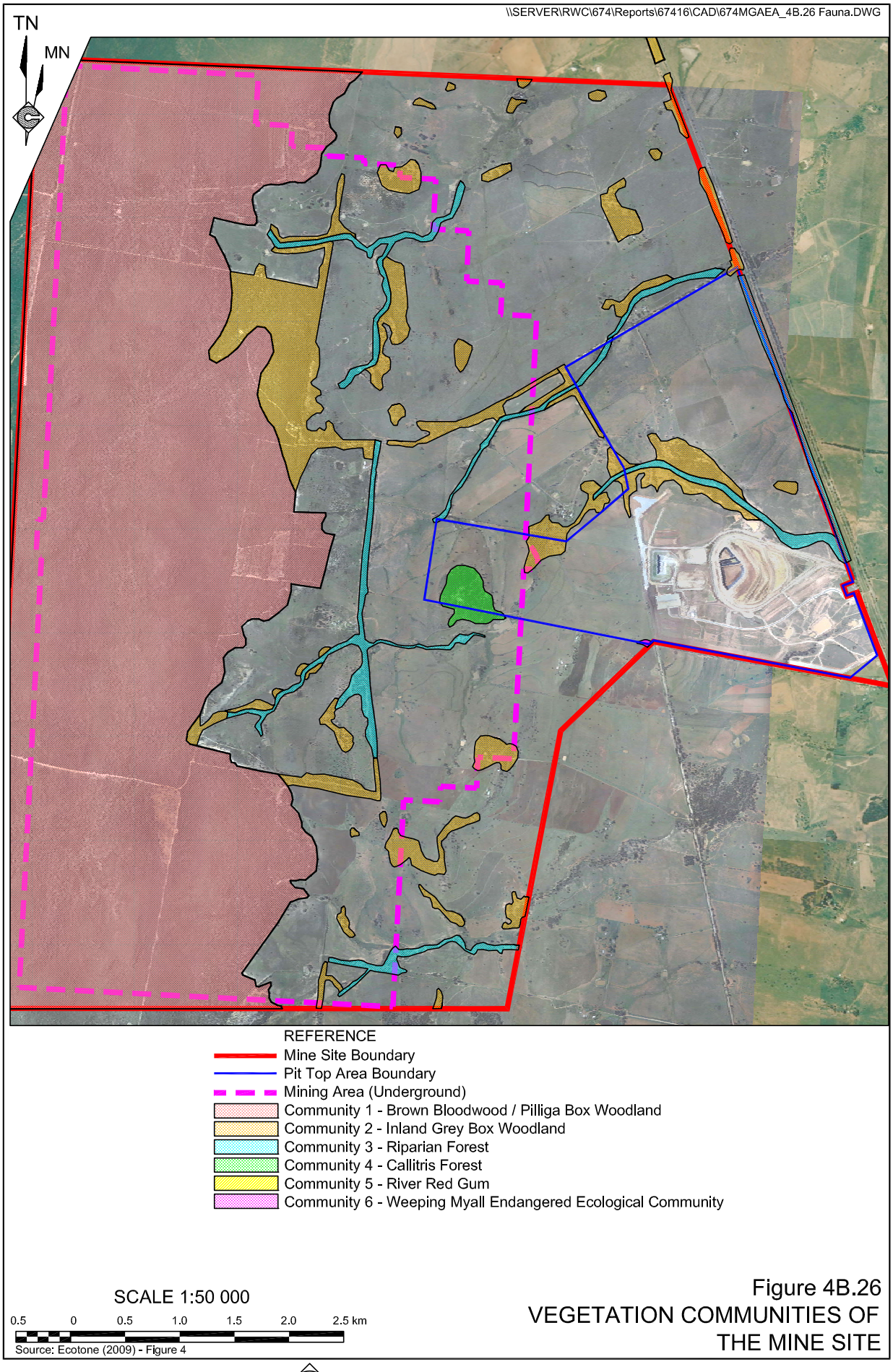


Figure 4B.26
VEGETATION COMMUNITIES OF THE MINE SITE

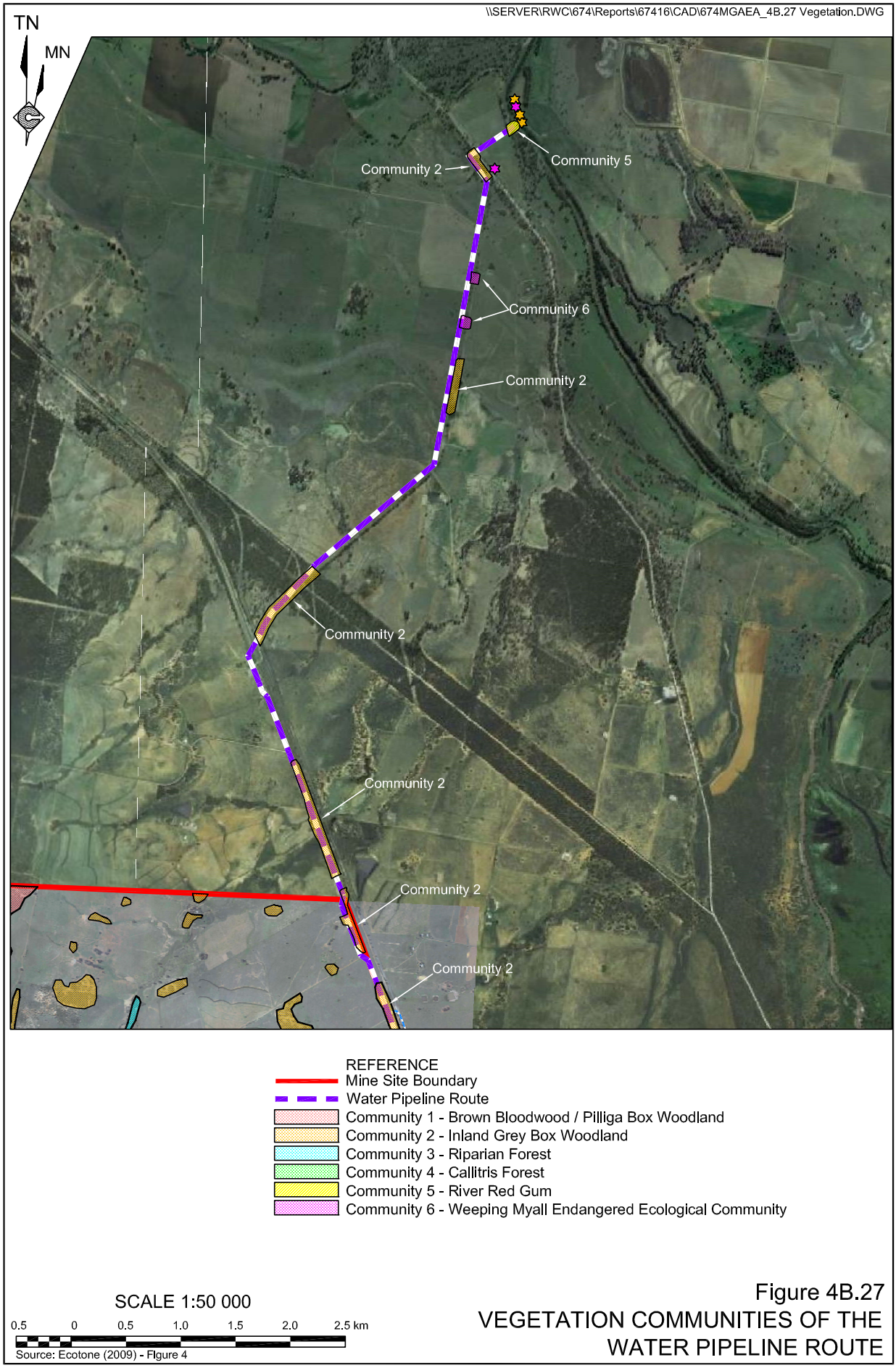


Figure 4B.27
VEGETATION COMMUNITIES OF THE WATER PIPELINE ROUTE

- Community 4 – White Cypress Forest.
  This simplified community consists almost entirely of White Cypress Pine, *Callitris glaucophylla*, with no shrub layer and a sparse, grazed ground layer.
- Community 5 – River Red Gum Riparian Open Forest / Woodland.
  This community was identified on the banks of the Namoi River and has been partially cleared. While modified it remains a relatively intact open forest to woodland dominated by river red gum and species adapted to wetter areas or permanently available water. Shrub and ground layers are variable in density.
- Community 6 – Weeping Myall Woodland.
  Identified as remnant patches of woodland on an existing farm track along the southern edge of the Pit Top Area and within the road reserve of Old Narrabri Road of the water pipeline route. Modified by clearing, the remnant patches of this community contain weeping myalls (*Acacia pendula*) but lack a native understorey.

A seventh artificial (cleared/semi-cleared or cultivated) community makes up the balance of the surface facilities, namely:

- Community 7 – Cleared Open Grassland / Cropland / Weedy areas / Cultivated Gardens.
  This community occupies the majority of the eastern two-thirds of the Mine Site. It is composed predominantly of cleared open pasture without trees, or isolated paddock trees with groundcover generally to a height of less than 50cm. Cropped fields and artificially planted gardens around homesteads are also included in this artificial community. The community is regularly grazed and/or ploughed and cultivated. The community has no flora conservation significance.

As illustrated on **Figure 4B.26**, Community 1 generally occupies the western third of the Mine Site, whilst Communities 2, 3 and 4 are spread over small areas of the eastern two thirds of the Mine Site. Community 5 occurs along the Namoi River at the proposed discharge point of the water pipeline. One small patch of Community 6 was identified along a farm track on the Mine Site (on the southern boundary of the Pit Top Area) with additional patches identified within the road reserve of the water pipeline route. Community 7 is the largest single community in area, and make up the balance of the eastern two thirds of the Mine Site.

The flora species diversity across the entire Mine Site was observed to be high with 209 flora species from 60 families identified. A total of 22 species of introduced flora were identified, representing approximately 11% of the total species identified.

No threatened flora species listed under either the TSC Act or EPBC Act or rare species on the ROTAP database were detected on the Mine Site during the flora survey.

The condition of the vegetation varied significantly across the Mine Site. The natural vegetation of Community 1 over the western portion of the Mine Site was reported by Ecotone (2009) to be often close to pristine, with few or no exotic species (although some evidence of past logging and/or clearing was evident). Overall, the condition of the vegetation was considered good by Ecotone (2009), even in the grazed pasture areas with patches of remnant tree cover where there was moderate to high native species diversity and a low diversity and cover of weeds.

4B.4.3.2.2 Water Pipeline Route

Figure 4B.27 displays the presence of patches of four of the vegetation communities identified on the mine site, namely:

- Community 2: Inland Grey Box / Bimble Box / Blakely's Red Gum Woodland.
- Community 5: River Red Gum Riparian Open Forest / Woodland.
- Community 6: Weeping Myall Woodland.
- Community 7: Cleared Open Grassland / Cropland / Weedy areas / Cultivated Gardens.

Each of these communities within the water pipeline route contain similar tree, shrub and grass species to those on the Mine Site.

4B.4.3.3 Noxious Weeds

Weeds were recorded almost exclusively in the cleared areas of Communities 2 to 5 over the eastern two thirds of the Mine Site. Six of these species are declared Noxious Weeds in the Narrabri Shire Council control area, pursuant to the *Noxious Weeds Act 1993*, namely:

- Bathurst burr (*Xanthium spinosum*) – Class 4[4];
- Creeping oxalis (*Oxalis corniculata*) – Class 5[5];
- Mother of millions (*Bryophyllum delagoense*) – Class 4;
- Noogoora burr (*Xanthium occidentale*) – Class 4;
- Prickly pear (*Opuntia stricta*) – Class 4; and
- Spiny burrgrass (*Cenchrus longispinus*) – Class 4

4B.4.3.4 Flora of Conservation Significance

Endangered Ecological Communities

Of the vegetation communities identified on the Mine Site, Community 2, qualifies as the TSC Act listed Endangered Ecological Community (EEC) *Inland Grey Box Woodland in the Riverina, NSW Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions.*

Ecotone (2009) reports that a second EEC listed by the TSC Act, *Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions,* occurs in marginal form only in scattered parts of Community 1 over the western slopes of the Mine Site. A third EEC listed by the TSC Act, *Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South western Slopes bioregions*

[4] Class 4: Locally Controlled Weeds: The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority.

[5] Class 5: Restricted Plants: The requirements in the *Noxious Weeds Act 1993* for a notifiable weed must be complied with.

was also identified by Ecotone (2009), both as a narrow patch of weeping myalls (*Acacia pendula*) along both sides of a dirt road on a more elevated part of the central plains area on the Mine Site and at isolated locations within the road reserve of the water pipeline route (see **Figure 4B.27**). On the basis of these occurrences, other remnant occurrence of the species could occur elsewhere on the Mine Site.

Threatened Species

As noted in Section 4B.4.3.2, no threatened or rare flora species were detected on the Mine Site during the flora survey. Based on the identified habitat of the vegetation communities of the Mine Site, Ecotone (2009) assessed the likelihood of those species previously identified within the locality, or predicted to occur within the locality by BIOCLIM or the Protected Matters Report of the EPBC Act.

Only one species, *Bertya opponens*, was assessed as having a high likelihood of occurring. One species, *Cadellia pentastylis*, is assessed as having a moderate likelihood of occurring and a further species, *Lepidium aschersonii*, a low to moderate likelihood of occurring. All remaining species are assessed as having a low or minimal likelihood of occurring.

General Significance of the Flora of the Mine Site

The flora of the Mine Site is significant in terms of threatened species legislation, as one threatened flora species (*Bertya opponens*) has been identified within the Mine Site, the presence of one EEC has been confirmed with two further EECs identified in marginal or very small remnant form.

More generally, the Sandstone Slopes Woodland (Community 1) is contiguous with the large area of natural vegetation in Jacks Creek State Forest beyond the western boundary of the Mine Site. This community is of a high quality and represents a large remnant of practically undisturbed, weed free natural vegetation. It has high species diversity, and is a sharply contrasting vegetation type to the community on the low-lying flats and floodplains. The natural vegetation on the low-lying flats and floodplains of Communities 2, 3 and 4 is much more disturbed by past and current clearing and grazing, however, retains a high native species diversity, particularly in the ground layer. These communities are disturbed remnants of the once extensive floodplain communities that would have occurred widely on the flat areas that are now largely cleared for grazing and agriculture.

All the remnant natural vegetation within the site has ecological value in that it facilitates movement of fauna and exchange of genetic material between native flora species locally, from one part of the Mine Site to another via remnant connections and riparian corridors (including scattered trees in some areas). Although loss or modification of this vegetation may not isolate any populations of flora or fauna, it could have local impacts on natural populations and compromise movements.

4B.4.4 Fauna

4B.4.4.1 Regional Threatened Fauna

A total of 27 threatened terrestrial fauna species have previously been recorded within the locality, comprising 19 bird, seven mammal and one reptile species (see **Table 4B.26**).

Table 4B.26
Threatened Fauna Previously Recorded Within the Study Locality

Scientific Name	Common Name	Status		Records (Locality)	Records (within 10km)
		TSC Act	EPBC Act		
Alectura lathami	Australian Brush-turkey	E2	~	8	2
Anseranas semipalmata	Magpie Goose	V	~	1	0
Ephippiorhynchus asiaticus	Black-necked stork	E1		2	2
Hamirostra melanosternon	Black-breasted Buzzard	V	~	2	1
Rostratula benghalensis australis	Painted Snipe (Australian subspecies)	E1	V, Mi	1	1
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	~	7	6
Neophema pulchella	Turquoise Parrot	V	~	10	1
Polytelis swainsonii	Superb Parrot	V	V	1	1
Tyto novaehollandiae	Masked Owl	V	~	1	1
Ninox connivens	Barking Owl	V	~	7	5
Climacteris picumnus	Brown Treecreeper	V	~	19	12
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	~	1	0
Pyrrholaemus saggitatus	Speckled Warbler	V	~	10	9
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V	~	1	0
Xanthomyza phrygia	Regent Honeyeater	E1	E, Mi	1	1
Melanodryas cucullata	Hooded Robin	V	~	3	2
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	~	5	5
Stagonopleura guttata	Diamond Firetail	V	~	4	0
Phascolarctos cinereus	Koala	V	~	17	6
Petaurus norfolcensis	Squirrel Glider	V	~	2	1
Macropus dorsalis	Black-striped Wallaby	E1	~	1	0
Petrogale penicillata	Brush-tailed Rock-wallaby	E1	V	8	0
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	~	5	3
Nyctophilus timoriensis	Eastern Long-eared Bat	V	V	3	2
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	2	1
Hoplocephalus bitorquatus	Pale-headed Snake	V	~	1	0

Status (TSC): refers to the NSW *Threatened Species Conservation Act* 1995 (TSC)
E1 Schedule 1, Part 1: Endangered species
CE Schedule 1A, Part 1: Critically endangered species
V Schedule 2: Vulnerable species

Status (EPBC): refers to the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC)
E Endangered Species
V Vulnerable Species
Mi Migratory Species

At the date of submission, the following preliminary determinations for listing under the TSC Act exist on the following species known to occur in the locality (recorded during surveys for this project or recorded on the Atlas of NSW Wildlife):

- Little lorikeet (*Glossopsitta pusilla*): proposed vulnerable species listing;
- Little eagle (*Hieraaetus morphnoides*): proposed vulnerable species listing; and
- Varied sittella (*Daphoenositta chrysoptera*): proposed vulnerable species listing.

An Australian Brush-turkey population in the Nandewar and Brigalow Belt South Bioregions is located within the locality.

4B.4.4.2 Mine Site Fauna

A habitat assessment of the various components of the Mine Site was undertaken by Ecotone (2009). The habitat assessment identified four primary fauna habitat types, all of which occurred on the Mine Site (see **Figure 4B.28**) and three of which occur along the water pipeline route.

- Woodland areas[6].
- Open areas comprised of pasture and/or cropping paddocks[6].
- Drainage lines[6].
- Farm dams.

A total of 156 fauna species were recorded within the study area during the field surveys, comprising 93 birds, 37 mammals, 16 reptiles and ten frogs. Nine introduced species (two birds and seven mammals) were recorded.

Notably, the drainage lines of the Mine Site (Kurrajong and Pine Creeks and their tributaries) were inspected by Ecotone (2009) who reported that these drainage features comprise little more than dry drainage lines lacking pools of semi-permanent or permanent water. No aquatic vegetation was recorded and no fish habitat was identified or considered likely to occur.

4B.4.4.3 Fauna of Conservation Significance

Fourteen Threatened fauna species listed on the TSC Act were recorded during field surveys across the Mine Site (see **Figure 4B.28**).

- Pale-headed snake.
- Glossy-black cockatoo.
- Turquoise parrot.
- Superb parrot.
- Speckled warbler.
- Grey-crowned babbler.
- Eastern pygmy possum.
- Diamond firetail.
- Koala.
- Delicate mouse.
- Black-striped wallaby.
- Eastern long-eared bat.
- Little pied bat.
- Yellow-bellied sheathtail-bat.

Of the fourteen threatened fauna species, the Delicate mouse and Black striped wallaby are the only endangered species (TSC Act) with the 12 remaining species listed as vulnerable on the TSC Act.

The Varied sittella, for which a preliminary determination under the TSC Act for vulnerable status has been completed, was also identified on the Mine Site. An additional two threatened species, the squirrel glider and spotted-tailed quoll, are likely to occur but were not recorded during field surveys.

[6] Occurs along the water pipeline route.

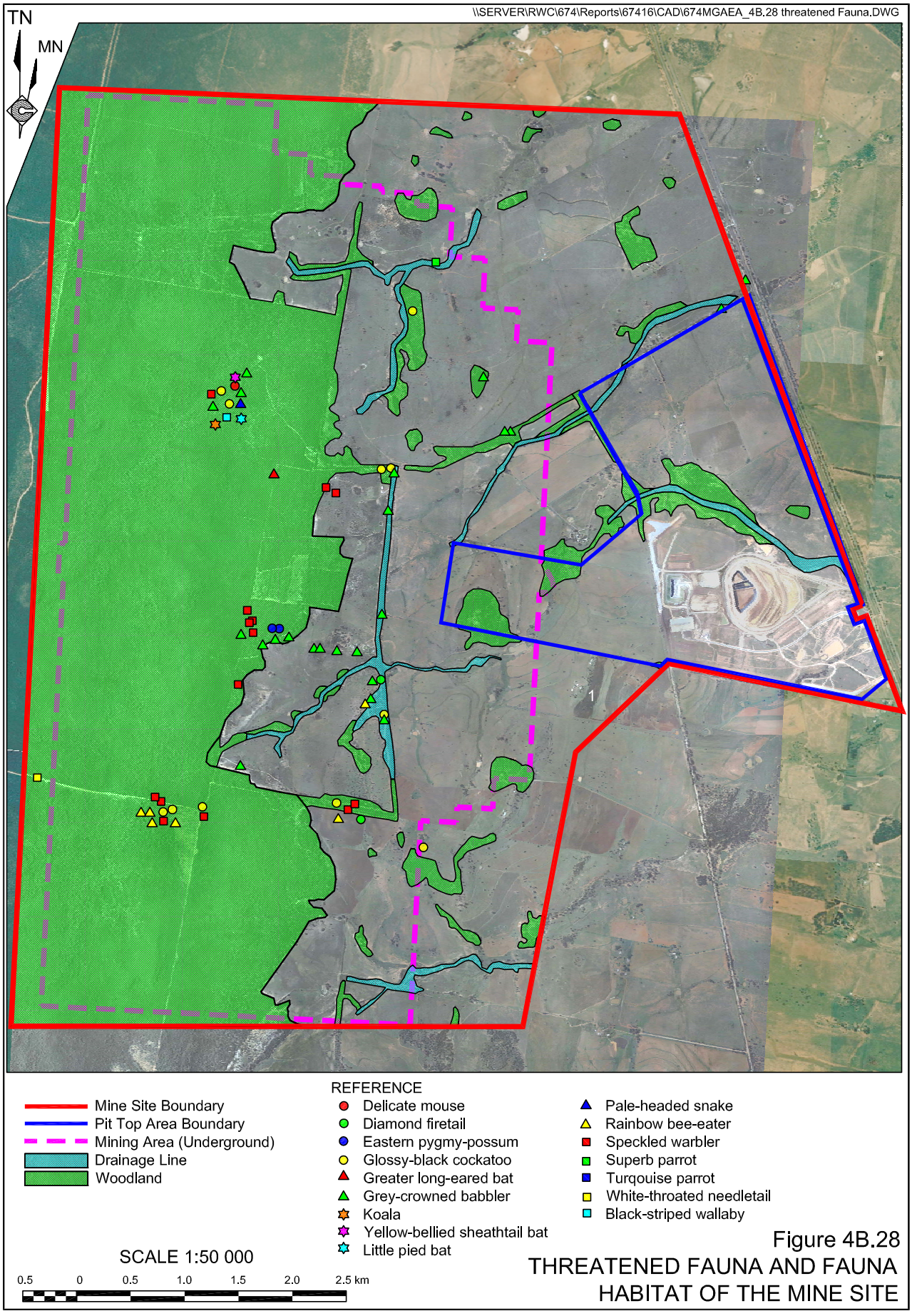


Figure 4B.28
THREATENED FAUNA AND FAUNA HABITAT OF THE MINE SITE

Six threatened or migratory species listed within the *Environment Protection and Biodiversity Conservation Act* (EPBC Act) were recorded during field surveys, namely:

- superb parrot[7];
- delicate mouse[7];
- white-throated needletail;
- eastern long-eared bat[7];
- rainbow bee-eater; and
- yellow-bellied sheathtail-bat[7].

Potentially suitable habitat exists across the Mine Site for a further 20 threatened or migratory species that were not identified during field surveys (Ecotone, 2009).

4B.4.5 Potential Impacts of the Longwall Project

4B.4.5.1 Vegetation Clearing and Habitat Loss

Section 2.4.9 provides a detailed summary of the surface disturbing activities associated with the proposed Longwall Project. It has been estimated that up to 705ha of the Mine Site would be disturbed by activities such as the construction of mine ventilation shafts, gas drainage, extension of the Pit Top Area, development of the Reject Emplacement Area, Brine Storage Area and construction of access tracks and power line corridor across the Mine Site.

Over the eastern two thirds of the Mine Site, where Community 7 is the dominant vegetation type, the majority of this disturbance would be able to be restricted to the cleared lands of Community 7. However, the Mining Area of LW7 to LW20 includes significant areas of remnant vegetation (predominantly Community 1) where it would not be possible to avoid the disturbance to native vegetation. While the exact location of surface disturbing activities such as ventilation shaft construction and gas drainage cannot be exactly plotted, as underground and mining conditions at the time would dictate the exact location of these activities, **Figure 4B.29** presents the estimated location of all surface disturbance over the life of the mine. **Table 4B.27** provides a summary of the areas of disturbance of each vegetation community based on this estimate.

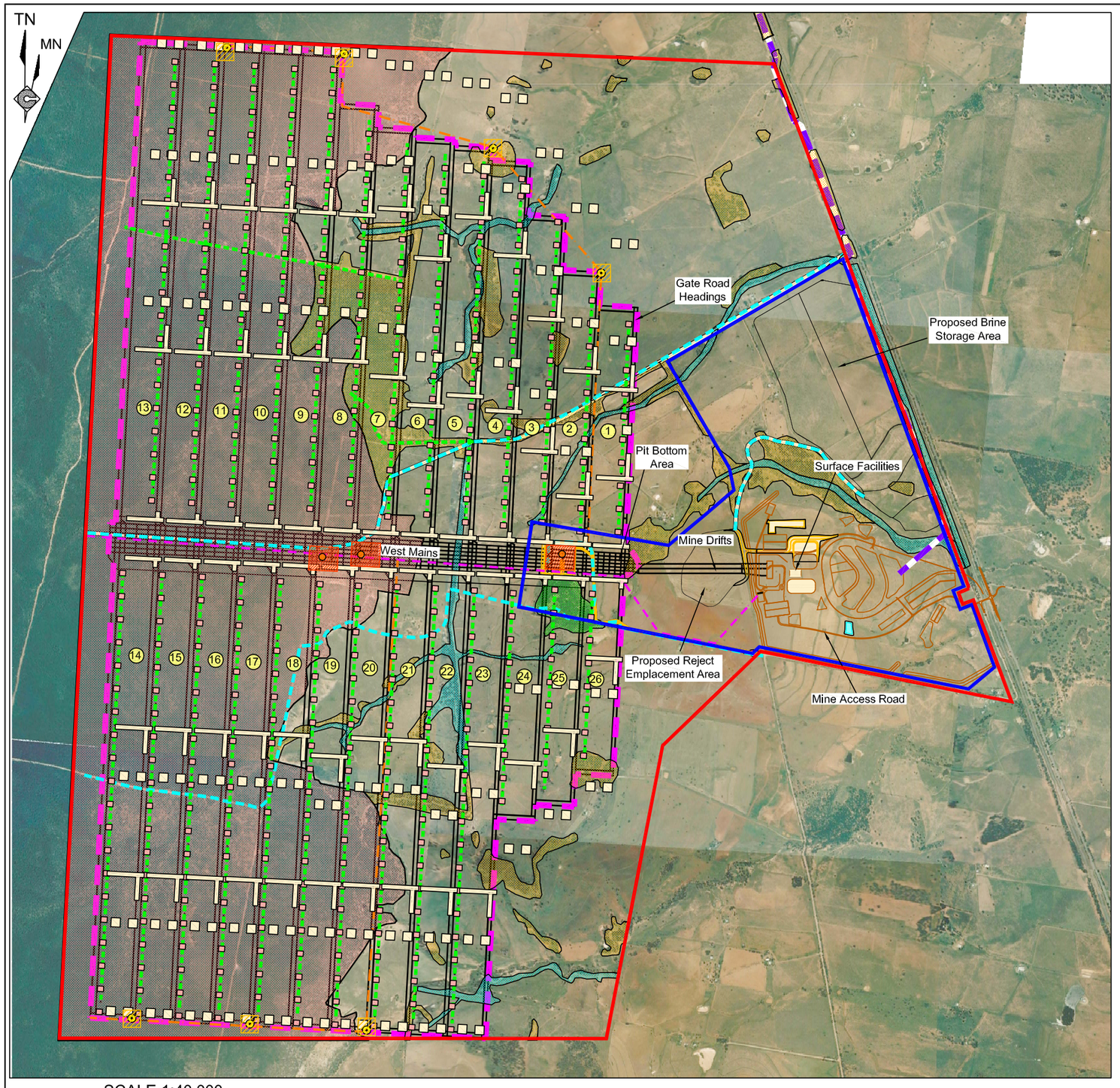
Based on the results of the desktop and field surveys of the Mine Site, there are only three Threatened flora species that are considered as potentially occurring on the Mine Site which could be disturbed as a result of the proposed surface disturbing activities. Habitat for up to 37 fauna species, 15 of which were identified on the Mine Site, would be disturbed. Section 4B.4.6 describes the management measures to minimise the impact of the proposed clearing and habitat loss and Section 4B.4.7 evaluates the residual impact on the 40 threatened species potentially affected (in accordance with Step 3 of Part 3A Guidelines).

Table 4B.27
Estimated Disturbance to Native Vegetation Associated with the Longwall Project

Surface Disturbing Activity	Area of Disturbance (ha) of Communities					
	1	2	3	4	6	Total
Ventilation Fan Sites	13.0	1.0	0	0	0	17.0
Pre-drainage Sites	88.6	11.2	0.6	1.0	0	101.4
Goaf Gas Drainage Sites	62.0	8.0	3.0	1.0	0	74.0
Internal Access Roads, Power Lines and Service Corridors	15.3	2.7	0.5	0.2	0	18.7
Pit Top Area	0	1.9	0	0.5	0	2.4
Total	**178.9**	**24.8**	**4.1**	**2.7**	**0**	**210.5**

[7] Also listed under the TSC Act.

\\SERVER\RWC\674\Reports\67416\CAD\674MGAEA_4B.29 Surface Dist.DWG



SCALE 1:40 000

0.5 0 0.5 1.0 1.5 2.0 km

Base Photo Source: Geo-spectrum (Australia) Pty Ltd - Date of Photo: 5 December 2005

REFERENCE
- Mine Site Boundary
- Pit Top Area Boundary
- Limit of Longwall Mining Area
- (1) Longwall Panel No.
- Underground Gate Road
- Water Pipeline Route
- Cadastral Boundary
- 260 Contour (m AHD)(Interval = 10m)
- Creek / Drainage Line
- Approved Disturbance within the Pit Top Area
- Area of Proposed Stage 2 Surface Disturbance
- Proposed All Weather Unsealed Access Road
- Proposed Stage 2 Access for Goaf Drainage
- Proposed Power Line
- Proposed Power Line Advancing with Mine
- Ventilation Shaft Area
- Proposed Ventilation Shaft Location* [1]
- Proposed Rear of Panel Ventilation Shaft
- Proposed Goaf Drainage Borehole Site
- Proposed Gas Production Site
- Proposed Pre-drainage Borehole Site
- Community 1 - Brown Bloodwood / Pilliga Box Woodland
- Community 2 - Inland Grey Box Woodland
- Community 3 - Riparian Forest
- Community 4 - Callitris Forest
- Community 5 - River Red Gum
- Community 6 - Weeping Myall Endangered Ecological Community

Note *[1]: The exact location of the additional ventilation shafts would be determined during mine operations and would be based on measured gas desorption rates, actual ventilation requirements and surface features

Figure 4B.29
INDICATIVE SURFACE DISTURBANCE
FOR THE LONGWALL PROJECT

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4B.4.5.2 Habitat Fragmentation

Disturbance associated with the construction of access roads between ventilation and gas drainage sites would result in some fragmentation of the native vegetation, in particular that of Community 1 over the western third of the Mine Site. The width of the corridors is likely to be no greater than 10m (see **Table 2.9**), and it is therefore unlikely that they would create significant barriers to the movement for many species. However, the creation of these corridors would increase the area of edge habitat within the Mine Site. Edge effects such as increased levels of light, solar radiation and wind penetration may alter the suitability of the environment for many species. Edges are also more likely to be colonized by weed species which may then spread further into woodland areas.

Section 4B.4.6 describes the management measures to minimise the impact of edge effects and Section 4B.4.7 evaluates the residual impact on the 37 threatened fauna species potentially affected (in accordance with Step 3 of Part 3A Guidelines).

4B.4.5.3 Habitat Isolation

The 30m wide power line corridor which would be aligned along the northern edge of the Mining Area may result in the isolation the northern portion of Community 1 from the southern portion and may prevent the movement of some species between these portions. As noted in Section 4B.4.5.2, the narrow width of access tracks running between the goaf boreholes (<10m) would not create a barrier for native species resulting in habitat isolation.

Section 4B.4.6 describes the management measures to minimise the impact of habitat isolation and Section 4B.4.7 evaluates the residual impact on the 37 threatened fauna species potentially affected (in accordance with Step 3 of Part 3A Guidelines).

4B.4.5.4 Corridor Function

Much of the vegetation within Communities 2 and 3 is located along fence lines (Community 2) and drainage features (Community 3) and provide a linkage between the western woodland area of Community 1 and the riparian habitat along the Namoi River, approximately 5km to the east of the Mine Site. The creation of access road and power line corridors may have some impact on the function of these corridors.

The large woodland remnant of Community 1 in the western third of the Mine Site also provides a corridor function, ie. it provides a north to south and east to west linkage for species within the remnant, and an east-west linkage for species moving from or to the remnant from the creek line and fence line corridors to the east. The northern power line corridor may reduce the corridor function for some species, eg. small terrestrial species and some arboreal species. The reduction in corridor function caused by the access tracks for ventilation and gas drainage activities is unlikely to significantly affect the corridor function of the remnant although they would increase the potential for edge effects on the habitat.

Where the proposed pipeline corridor requires the removal of trees along road easements, particularly along the dirt road running north-south along the eastern perimeter of the Mine Site, the likely removal of all woodland trees within such areas would result in a loss of corridor areas within the local landscape.

Section 4B.4.6 describes the management measures to minimise the impacts on corridor function and Section 4B.4.7 evaluates the residual impact on the 37 threatened fauna species potentially affected (in accordance with Step 3 of Part 3A Guidelines).

4B.4.5.5 Fish Passage

The development of access roads and power line corridors over the Mine Site would require the crossing of Kurrajong and Pine Creeks and their tributaries. While Ecotone (2009) did not identify aquatic or fish habitat, nor consider the occurrence of aquatic or fish habitat to be likely (see Section 4B.4.4.2), the disturbance associated with the development and operation of these corridors could result in fish passage being blocked. Subsidence related changes to drainage line structure could also result in blockage or restriction of fish passage.

While the presence of aquatic or fish habitat has not been identified on the Mine Site, precluding any impacts on fish passage, Section 4B.4.6 describes the management measures that would be implemented to identify and manage fish passage over the life of the mine.

4B.4.5.6 Groundwater Dependent Ecosystems

Changes to groundwater levels associated with in-flow to the underground workings could potentially impact on any vegetation which is reliant on the impacted groundwater. It is also possible that surface cracking may impact on shallow groundwater aquifers such as the perched systems that exist at the base of the weathered zone (see Section 4B 2.5.9).

4B.4.5.7 Subsidence

Section 4B.1.6 assessed the impacts of subsidence on the land surface. The impacts most likely to affect the flora and fauna of the Mine Site are as follows.

- Surface Cracking. Small terrestrial fauna may fall into cracks formed at surface and may perish as a consequence. Cracking may also affect surface drainage with the potential, although considered unlikely, for surface flows to be re-routed underground. This could in turn impact on the habitat value of the drainage features of the Mine Site, ie. Community 3.
- Sub-surface Cracking. Should cracks develop between the geological strata, especially near surface strata, vertical flow of groundwater may be accelerated. This may in turn reduce the availability of water within groundwater required by some vegetation communities to maintain floristic diversity and vegetation structure, ie. Groundwater Dependent Ecosystems (GDEs).
- Ponding. As a result of the differential height of subsidence along the drainage lines of the Mine Site, ponds may form at various points along these. This could affect vegetation structure and therefore habitat value at these points.
- Erosion. Accelerated erosion may impact on the habitat value of affected areas of the Mine Site.

Section 4B.4.6 describes the management measures to minimise the impacts of subsidence and Section 4B.4.7 evaluates the residual impact on the 40 threatened species potentially affected (in accordance with Step 3 of Part 3A Guidelines).

4B.4.5.8 Discharge of Raffinate to the Namoi River

The volume of water to be discharged to the Namoi River is predicted to commence after 7 years of operations, peaking in Year 20 at approximately 2.1ML/day before gradually reducing throughout the remaining life of the Longwall Project (see **Table 4B.19**). This discharge is likely to have some small but positive impacts on the water quality and flow rate within the Namoi River, which in turn may benefit aquatic or riparian habitat and the flora and fauna that depend on these. Further discussion regarding the discharge to the Namoi River is presented in Section 4B.7.7.

4B.4.6 Ecological Management

4B.4.6.1 General Management Measures

The following management measures relate to the proposed general management of flora and fauna on the Mine Site.

- The Mine Site layout has been designed to minimise the clearing of native vegetation, particularly with the additional disturbance within the Pit Top Area and Reject Emplacement Area located within Community 7 (see **Table 4B.25**). Importantly, the vegetation of Community 3 along Kurrajong Creek Tributary 1, would not be disturbed by the proposed surface disturbing activities within and surrounding the Pit Top Area.
- The boundaries of all areas to be disturbed would be clearly marked for the machinery operators to minimise the extent of clearing. No clearing would occur outside these boundaries.
- During operations, the sediment dams and evaporation / storage ponds would be regularly inspected for fauna during the course of regular maintenance and operational inspections.
- Any cleared native vegetation would be dispersed whole or mechanically reduced and spread outside the perimeter bund around the ventilation shaft to provide habitat, increase the seed bank and to provide a mulch material for nutrient cycling and water retention purposes.
- A weed management strategy would be implemented, to be developed in consultation with the Livestock Health and Pest Authority and the Narrabri Shire Council weeds officer, for the retained or rehabilitated natural vegetation within the Mine Site. All noxious weeds would be treated in accordance with their weed Class as per the *Noxious Weeds Act 1993*.
- A feral animal management program would be implemented as part of the Landscape Management Plan for the Proponent to lower the predator impact upon small terrestrial native species, and would be reviewed on an annual basis throughout the life of the mine.

- The facilities within the Pit Top Area and the Reject Emplacement Area would be decommissioned and the area rehabilitated on completion of the Longwall Project to re-instate a final land use of agriculture and native vegetation in accordance with that detailed in Section 2.13.2.

4B.4.6.2 Management of Progressive Surface Disturbance

As the Longwall Project is developed, disturbance associated with construction of gas drainage sites (both pre-drainage and goaf gas drainage), ventilation sites and access roads and power line corridors to these sites would be progressively undertaken. Whilst the general area of disturbance for these activities can be identified (see **Figure 4B.29**) a degree of flexibility in the exact location of these sites of disturbance is required as this would be dictated by underground and mining conditions at the time. In order to accommodate the fact that the exact location of disturbance cannot be nominated, the Proponent has committed to the following management measures.

- Once the location of the surface disturbance is nominated, a qualified ecologist would be commissioned to complete a pre-clearance survey to identify whether any threatened species, population or community or their habitat is present. In particular, the survey would target threatened species known or potentially occurring in the area and identify habitat within the clearing areas, particularly substantial habitat trees. The Proponent has committed to retain all substantial habitat trees, wherever possible.
- The pre-clearance survey would also include an assessment of whether aquatic or fish habitat is present within the drainage features to be traversed by the access road and/or power line corridors.
- In the event that an EEC or threatened species or population is identified, alternate locations or orientations of the disturbance area would be considered and confirmed, if practicable.
- If the relocation or re-orientation of the area to be disturbed is not practicable (for reasons of mine / operational safety), the consultant ecologist would relocate any fauna species residing within the area to be cleared.
- Any tree-felling required would be undertaken in accordance with a Tree Felling Protocol to be developed and implemented by the Proponent. The Tree Felling Protocol would be developed by a qualified ecologist with previous experience supervising the felling of trees and would include, but not necessarily be limited to a description of:
  - the best time of the year for felling (which depends on the likely species to be affected);
  - pre-felling mapping of habitat trees;
  - inspections of trees on the day of felling;
  - procedures for the safe removal of fauna species from trees prior and post felling;
  - a relocation/release protocol; and
  - a protocol for the assessment and salvaging of tree hollows.

- Where trees are to be felled, an assessment of distribution of tree hollows surrounding the area to be cleared would be undertaken by the commissioned ecologist. The ecologist would determine the need for local supplementing of tree hollows (using salvaged tree hollows or nest boxes) based on the number of hollows lost during felling and the surrounding distribution of remaining natural hollows.
- As far as practicable, the more significant areas of surface disturbance associated with ventilation and gas drainage would be located away from the riparian corridors of Community 3.
- The location of access tracks would be determined in conjunction with an ecologist after inspecting each proposed route and determining the path with least impact on environmental values.
- In the event that fish habitat is identified, the crossing of the drainage feature would be constructed in accordance with the Policy and Guideline document of DPI-NSW Fisheries "*Why do Fish need to Cross the Road? Fish Passage Requirements for Waterway Crossings*."
- All earthworks would be undertaken in accordance with an Erosion and Sediment Control Plan to be prepared for each activity, eg. gas pre-drainage sites, ventilation shaft sites, access roads, etc. particular emphasis would be placed on surface disturbing activities where runoff could flow directly into the drainage features of the Mine Site.
- To prevent the importation of root-rot fungus (*Phytophthora cinnamomi*) to the vegetation of the Mine Site, imported machinery would be required to be certified as being free of the disease prior to entry onto the Mine Site.
- As disturbed areas are no longer required for ongoing operational activities, these would be rehabilitated to re-establish either agricultural land or native vegetation as described in Section 2.13.3.

As noted in Section 4B.4.5.1 and **Table 4B.27**, the progressive disturbance associated with the Longwall Project would require the disturbance of approximately 210.5ha of native vegetation (predominantly that of Community 1). While this land would ultimately be rehabilitated to re-establish the vegetation of Community 3, a biodiversity offset strategy has been developed by the Proponent to compensate for this temporary disturbance to the biodiversity values of the Mine Site. Section 4B.4.6.4 provides a description of the proposed biodiversity offset strategy.

4B.4.6.3 Management of Subsidence-related Disturbance

As noted in Section 4B.4.5.7, subsidence could potentially impact on Mine Site ecology through surface cracking, ponding and erosion. The Proponent proposes to manage these potential impacts as follows.

Surface Cracking

As described in Section 4B.1.6.1, the potential cracking zones of each longwall panel would be regularly inspected and any cracking identified and filled in either by natural processes or through minor earthworks.

Ponding and Other Hydrological Changes

Changes to surface drainage would be monitored and any stream re-direction or modification works would be undertaken after consultation with an appropriately qualified hydrological professional and/or the Department of Environment, Climate Change and Water – Office of Water.

The Proponent would also regularly inspect the drainage lines of the Mine Site and should the variable subsidence result in the blockage of any identified fish or aquatic habitat (noting that Ecotone (2009) found no evidence of this habitat within the drainage features of the Mine Site), earthworks would be undertaken in accordance with "*Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings*."

Erosion

To minimise the potential impacts of erosion and steeply eroded creek banks toppling the Proponent would:

- monitor surface slope displacement along subsidence cross lines;
- in-fill cracks as they appear;
- regrade or revegetate areas significantly affected by erosion; and
- regularly review and appraise any significant changes to surface slopes after each longwall is extracted.

4B.4.6.4 Management of Groundwater Dependent Ecosystems

The former DWE was consulted to identify the location of any known Groundwater Dependent Ecosystems (GDEs) on, or in the vicinity of the Mine Site. Two groundwater dependent ecosystems, identified as Hardys Spring and Eather Spring, have been recorded approximately 6km and 7km south of the Mine Site respectively. Groundwater investigation undertaken by Aquaterra (2009) identified a third GDE approximately 1.2km from the southern boundary of the Mine Site on the "Mayfield" property (referred to hereafter as the Mayfield Spring). The locations of the three springs are displayed on **Figure 4B.10**. This spring, which discharges at a very low rate (<0.1 L/s), appears to coincide with a topographic sub-crop of the Purlawaugh Formation and emanates within a low lying topographical area within a valley which acts as a drainage pathway.

Should significant changes to the floristics or structure of the GDE become evident, remedial measures which could include the provision of supplementary water to the vegetation would be undertaken. Any remedial measures would be developed in consultation with a suitably qualified ecologist and the DECCW-NOW.

4B.4.6.5 Biodiversity Offset Strategy

The Proponent would implement an offset strategy to compensate for the loss of woodland communities across the Mine Site. While the exact component areas and activities of the offset strategy have yet to be finalised, the Proponent is committed to implementing these within 3 years of commencement of the Longwall Project, or prior to surface disturbing activities above LW4, whichever occurs first. This approach to establishing and implementing the offset strategy will allow the Proponent to more accurately determine the exact areas of vegetation that will be disturbed. The Proponent notes that it is likely that gas pre-drainage activities will revert to conventional in-seam underground methods once the initial longwall panels are established, as well as obtaining more detailed information on the impact of subsidence on the local landform. Consequently, the potential removal of up to 101.4ha of native vegetation for the surface to in-seam drilling may be reduced substantially. In the interim, the Proponent has identified two parcels of land, namely Lots 64 and 65, DP757114, in the northwestern section of the Mine Site (**Figure 4B.30**) that are to be protected under a covenant under Section 88B of the *Conveyancing Act 1919* or similar. **Table 4B.28** details the area of each vegetation community that would be removed for mining activities (across the entire Mine Site), the area of each community in the proposed Biodiversity Offset Area, and the resulting offset ratio.

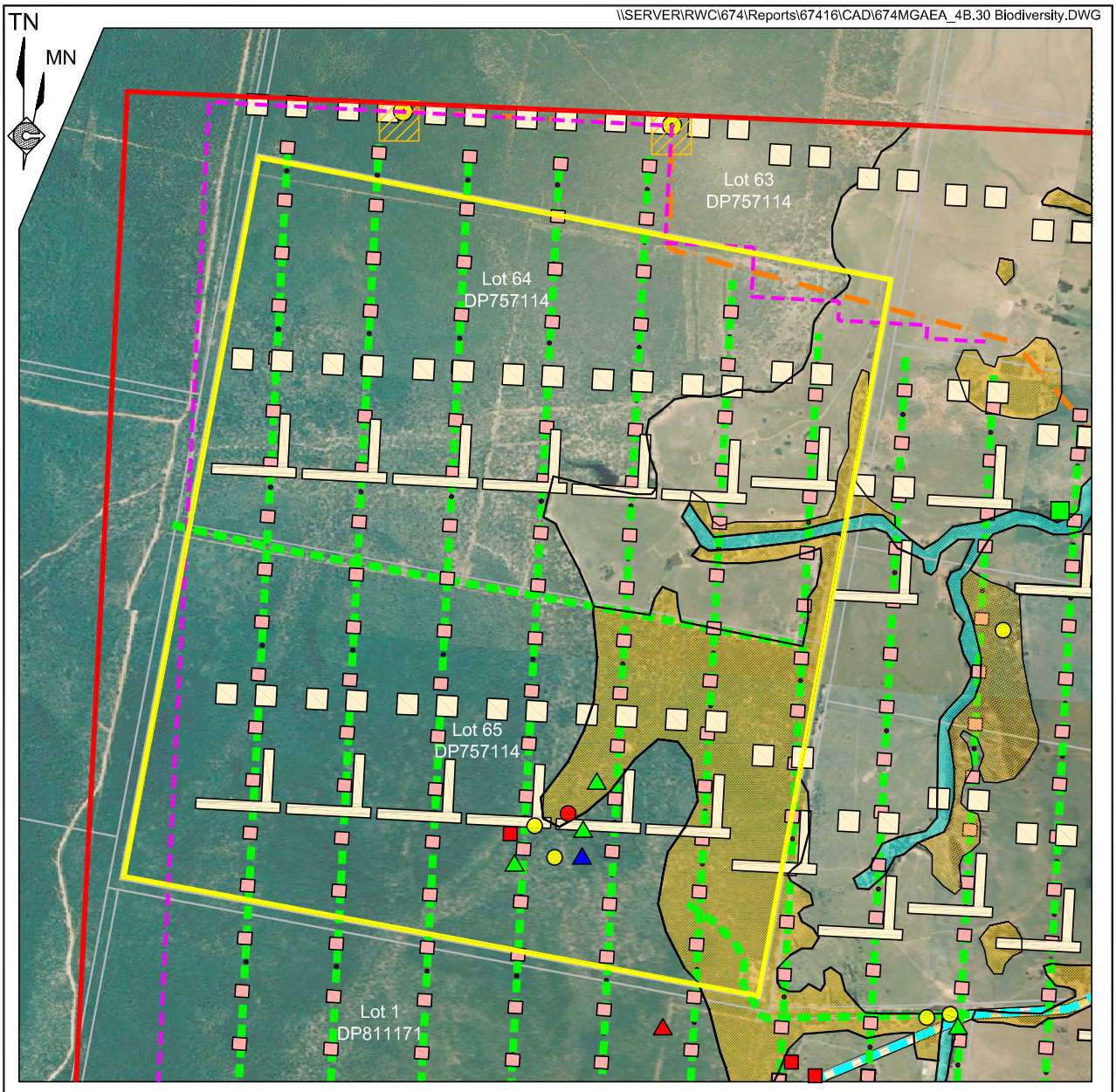
Table 4B.28
Calculated Biodiversity Offset Ratio for the Longwall Project

Vegetation Community	Area on the Mine Site	Area to be Disturbed*	Area to be Conserved	Offset Ratio (Area Conserved : Area Disturbed)
Community 1	2058	178.9	465.7	2.6 : 1
Community 2	318	24.8	78.7	3.2 : 1
Community 3	98	4.1	2.9	0.7 : 1
Community 4	20	2.7	0	--
Community 6	0.3	0.0	0	--
Total	**2494.3**	**210.5**	**547.3**	**2.6 : 1**
* This area nominated is a maximum as a substantial proportion of the native vegetation nominated to be cleared for the surface to in-seam drilling may not eventuate.				
Source: Modified after Ecotone (2009) - Table 13				

The Proponent would implement the following management measures during the life of the Longwall Project and while ever the Proponent continues to own the relevant land.

- Stock would be excluded from the Biodiversity Offset Area.
- Wildlife-friendly boundary fences would be maintained to prevent stock from surrounding properties entering the Biodiversity Offset Area.
- Ongoing pest control programs would be implemented, including for rabbits, European Red Foxes and feral cats.
- Ongoing implementation of weed control programs, including for noxious weeds such as Bathurst burr, Creeping oxalis, Mother of millions, Noogoora burr, Prickly pear and Spiny burr grass.

Should the Proponent donate the land covered by the Biodiversity Offset Area to a public authority, an appropriate arrangement for the ongoing management of the land would be negotiated with the appropriate government agency prior to the land being transferred.



REFERENCE

- Mine Site Boundary
- Cadastral Boundary
- Creek / Drainage Line
- Boundary of Biodiversity Offset Area (offset for clarity)
- Indicative Limit of Underground Workings
- Proposed Stage 2 All Weather Unsealed Access Road
- Proposed Stage 2 Power Line
- Proposed Stage 2 Power Line Advancing with Mine
- Proposed Stage 2 Access for Goaf Drainage
- Proposed Stage 2 Rear of Panel Ventilation Shaft
- Proposed Goaf Drainage Borehole Site
- Proposed Gas Production Site
- Community 1 - Brown Bloodwood / Pilliga Box Woodland
- Community 2 - Inland Grey Box Woodland
- Community 3 - Riparian Forest
- Community 4 - Callitris Forest
- Community 5 - River Red Gum
- Community 6 - Weeping Myall Endangered Ecological Community

- Delicate mouse
- Glossy-black cockatoo
- Greater long-eared bat
- Grey-crowned babbler
- Pale-headed snake
- Speckled warbler

Vegetation Community	Biodiversity Offset Area	
	Total Area (ha)	Area to be Disturbed (ha)
1	520	54.3
2	88.1	9.4
3	3.2	0.3
4	0	0
5	0	0
Cleared	76.1	11.0
Total	**687.4**	**75.0**

SCALE 1:25 000

250 0 250 500 750 1000 1250 m

Base Photo Source: Geo-spectrum (Australia) Pty Ltd - Date of Photo: 5 December 2005

Figure 4B.30
BIODIVERSITY OFFSET AREA

It is noted that a number of access tracks, pre-drainage and goaf boreholes and gas production sites would be located within the Biodiversity Offset Area. The areas that would be disturbed by each of these have not been incorporated within the area calculation for the Biodiversity Offset Area and would be rehabilitated as soon as practicable once they are no longer required for gas drainage and production purposes.

4B.4.7 Assessment of Ecological Impacts

4B.4.7.1 Threatened Flora and Fauna of the TSC Act

This section draws on the evaluation of impact on the EECs and threatened species and populations either identified on, or considered as potentially occurring on the Mine Site completed by Ecotone (2009) in accordance with Step 3 of the Part 3A Guidelines. Discussion of the evaluation of impacts with respect to Steps 4 and 5 of the Part 3A Guidelines is also provided.

Evaluation of Impact on Threatened Flora Species and EECs (Step 3 of the Part 3A Guidelines)

(a) ***How is the proposal likely to affect the lifecycle of a threatened species and/or population?***

Of the three threatened flora species identified as potentially occurring on the Mine Site, Ecotone (2009) concludes the following.

- ***Bertya opponens***. If occurring on the Mine Site, any individuals are likely to represent the outer fringe of the substantial known population in Jacks Creek State Forest. Given the known presence of this nearby extensive source of propagules, the lifecycle of the locally occurring population of *Coolabah bertya* is unlikely to be significantly affected, even if individual plants happen to be removed or disturbed.
- ***Cadellia pentastylis*** and ***Lepidium aschersonii***. In both cases, the potential habitat for these species occur across the Mine Site (with it being most likely to be present over the flat plains area of the eastern part of the Mine Site). Therefore, given the generally wide distribution regionally of both species, it is unlikely that any removal of, or disturbance to individuals of the species within the Mine Site would affect the lifecycle of either species on a regional basis.

(b) ***How is the proposal likely to affect the habitat of a threatened species, population or ecological community?***

Threatened flora species

- ***Bertya opponens***. Potential habitat occurs within the pilliga vegetation of Community 1. Limited areas of potential habitat would be disturbed by the proposed surface disturbance, as well as any changes resultant from subsidence, eg. changes to local drainage. Notably, a significant occupied area of habitat occurs to the west in Jacks Creek State Forest, where a large population is known to occur.

- ***Cadellia pentastylis and Lepidium aschersonii***: While potential habitat may be disturbed by the proposed surface disturbance, as well as any changes resultant from subsidence, the majority of the potential habitat on the flat plains area of the eastern part of the Mine Site would remain unaffected by the Longwall Project.

Threatened Ecological Communities

- ***Inland Grey Box Woodland:*** Patches of known occupied habitat occur on the flat plains area in the eastern part of the Mine Site (Community 2). Parts of this habitat could be affected by subsidence and the associated changes in hydrology and drainage.
- ***Brigalow:*** Patches of marginal occupied habitat occur in the undulating pilliga community (Community 1) in the western part of the Mine Site. This area could be affected by subsidence and the associated changes in hydrology and drainage.
- ***Myall Woodland:*** At least one small disturbed remnant of the community occurs along a dirt road in the south-eastern part of the Mine Site (see **Figure 4B.27**). This area of the Mine Site would not be disturbed.

(c) ***Does the proposal affect any threatened species or populations that are at the limit of its known distribution?***

All three species would be at the limit of their currently known distribution.

- ***Bertya opponens*** would occur at the eastern limit of the Jacks Creek State Forest sub-population.
- ***Cadellia pentastylis*** would be at the western limit of its known distribution.
- ***Lepidium aschersonii*** would be at the eastern limit of its known distribution.

(d) ***How is the proposal likely to affect current disturbance regimes?***

Current disturbance regimes within the study area include stock grazing, fire, weed invasion and human presence. Of these disturbance regimes, stock grazing and fire are likely to remain unchanged or decrease over the life of the mine. The area and level of weed invasion may increase due to the increased human activity on the Mine Site.

(e) ***How is the proposal likely to affect habitat connectivity?***

The proposed northern power line corridor would split Community 1 roughly in half and may fragment habitat for potential threatened flora species and the marginal occurrence of the brigalow EEC. Minor fragmentation of the Inland Grey Box Woodland EEC (Community 2) and riparian habitat (Community 3) would also occur further to the east. Further minor fragmentation would occur as roads are developed to enable access to the gas drainage and ventilation infrastructure required by the Longwall Project, although these are not expected to result in significant fragmentation of habitat.

(f) ***How is the proposal likely to affect critical habitat?***

No areas of critical habitat proclaimed occur in the vicinity of the study area.

Conclusion

The proposed Longwall Project may directly or indirectly impact on one or more threatened flora species with potential to occur. However, any impact would be minimal given the known distributions and abundances of the species elsewhere.

The proposed Longwall Project may also have minor direct impact on the Inland Grey Box Woodland and Brigalow EECs as a result of proposed surface disturbance as well as a minor indirect impact associated with subsidence and consequent hydrological changes. Ecotone (2009) concludes that any impact would be adequately mitigated by the proposed measures described in Section 4B.4.6.

Evaluation of Impact on Threatened Fauna Species (Step 3 of the Part 3A Guidelines)

(a) ***How is the proposal likely to affect the lifecycle of a threatened species and/or population?***

Threatened Population

- **Australian brush-turkey (Endangered Population under the TSC Act)**. The Australian brush-turkey was not recorded on the Mine Site, however, 10 records for the species occur within a 10km radius. While no evidence of habitation by the species was identified, Community 1 of the Mine Site was considered to be potential habitat. Should the species occur on the Mine Site the lifecycle of the species may be affected by the proposed longwall mining. Cracking resulting from subsidence may damage the species nest mounds and reduce the reproductive output of some pairs and reduce the overall reproductive output of any local population.

Threatened Species

- **Magpie goose and Black-necked stork**

  Neither species was identified on the Mine Site although they may on rare occasions utilise farm dams and nearby grassland habitats within the Mine Site. While surface cracking following subsidence may drain farm dams and reduce the available habitat for the magpie goose and black-necked stork, the highly mobile nature of the two species and the likely infrequency of visits to the subject site suggest that the life cycles of the magpie goose and black-necked stork are unlikely to be significantly affected by the proposed longwall mine.

- **Black-breasted buzzard and Little eagle**

  Neither species were recorded on the Mine Site, however, they may utilise habitat areas across the Mine Site on an occasional or rare basis. There is no suitable breeding habitat for the black-breasted buzzard (timbered water courses) and both species are only likely to visit the Mine Site on an occasional or rare basis. Given all trees to be felled would be inspected for fauna prior to disturbance and no tree-fall is expected as a result of subsidence the proposed longwall mine is unlikely to significantly affect the life cycle of either species.

- **Hollow dependent woodland bird species**[8]

  The Glossy-black cockatoo and Superb parrot were recorded during field surveys. The Little lorikeet, Turquoise parrot, Swift parrot, Masked owl and Barking owl were not recorded during field surveys, however, suitable habitat is present for each species. These woodland bird species require tree hollows for breeding and either woodland areas or woodland/grassland areas for foraging. Areas of this habitat would be cleared as part of the progressive disturbance associated with gas drainage and mine ventilation activities. Notably, all clearing activities would be undertaken according to a tree clearing protocol to avoid direct disturbance to nesting birds. Additional tree losses due to subsidence are unlikely as tree fall is not predicted to occur.

  The loss of potential foraging and nesting trees during clearing activities is therefore unlikely to affect the lifecycle of the above hollow dependent bird species due to the small area of vegetation to be removed relative to the area to be conserved as part of the proposed biodiversity offset area.

- **Non-hollow dependent woodland bird species**[9]

  The Speckled warbler, Grey-crowned babbler, Varied sitella and Diamond firetail were recorded during field surveys. The Black-chinned honeyeater, Regent honeyeater and Hooded robin were not recorded during field surveys, however, suitable habitat is present for each species. Areas of this habitat would be cleared as part of the progressive disturbance associated with gas drainage and mine ventilation activities. Notably, all clearing activities would be undertaken according to a tree clearing protocol to avoid direct disturbance to nesting birds.

  The loss of potential foraging and nesting trees during clearing activities is therefore unlikely to affect the lifecycle of the above hollow dependent bird species due to the small area of vegetation to be removed relative to the area to be conserved as part of the proposed biodiversity offset area.

- **Spotted-tailed quoll**

  The spotted-tailed quoll was not recorded during field surveys, however suitable habitat is present. Areas of this habitat would be cleared as part of the progressive disturbance associated with gas drainage and mine ventilation activities. Notably, hollow bearing habitat trees would be avoided as far as practicable with additional tree fall as a consequence of subsidence not predicted. Surface cracks may result in the death or injury of some prey species of the Spotted-tailed quoll, although the species preys on a large range of species and so this is unlikely to have any significant impact.

  The loss of some woodland areas during clearing activities and impacts on some prey species is unlikely to affect the lifecycle of the spotted-tailed quoll due to the small area of vegetation to be removed relative to the area to be conserved as part of the proposed biodiversity offset area.

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[8] Glossy black-cockatoo, Little lorikeet, Turquoise parrot, Swift parrot, Superb parrot, Masked owl, Barking owl

[9] Speckled warbler, Black-chinned honeyeater, Regent honeyeater, Hooded robin, Grey-crowned babbler, Varied sittella, Diamond firetail.

- **Koala**

  A single scat sample was identified on the Mine Site. Areas of Koala habitat would be cleared as part of the progressive disturbance associated with gas drainage and mine ventilation activities. Notably, all clearing activities would be undertaken according to a tree clearing protocol to avoid direct disturbance to resident Koalas.

  The loss of some woodland areas during clearing activities is unlikely to affect the lifecycle of the Koala due to the small area of vegetation to be removed relative to the area to be conserved as part of the proposed biodiversity offset area.

- **Eastern pygmy-possum**

  The eastern pygmy-possum was recorded on the Mine Site. Areas of woodland habitat would be cleared and due to their small size individual pygmy possums may not be detected during felling and individuals may perish or become injured during the clearing process. Additionally, as the home range of this species is limited to 0.68ha for adult males and 0.35ha for adult females, the proposed disturbance has the potential to affect, through removal or fragmentation, significant portions of individual possums home ranges. The life-cycle of the Eastern pygmy possum may also be affected by surface cracking if individuals fall into cracks while moving between trees. This would be partially mitigated by the Proponent's commitment to identify and fill in cracks as they develop on the Mine Site.

  It is noted, however, that large areas of similar woodland exist to the west and south of the Mine Site and it is likely that the population of eastern pygmy possums extends into these areas. Therefore, it is considered unlikely that the possible loss of some individuals and potential fragmentation of part of the Mine Site population are unlikely to significantly impact on the life cycle of the species.

- **Squirrel glider**

  The squirrel glider was not recorded during field surveys, however suitable habitat was identified and the species may occur. Areas of potential habitat would be cleared as part of the progressive disturbance associated with gas drainage and mine ventilation activities. Notably, all clearing activities would be undertaken according to a tree clearing protocol to avoid direct disturbance to resident gliders.

  The loss of potential foraging and nesting trees during clearing activities is unlikely to affect the lifecycle of the squirrel glider due to the small area of vegetation to be removed relative to the area to be conserved as part of the proposed biodiversity offset area.

- **Black-striped wallaby**

  The Black-striped wallaby was recorded from a single hair tube sample. Areas of wallaby habitat would be cleared as part of the progressive disturbance associated with gas drainage and mine ventilation activities. Surface cracking has the potential to result in injury to individuals, although this risk is considered unlikely by Ecotone (2009). This risk would be further minimised by the commitment of the Proponent to fill in cracks as they develop.

The loss of some woodland areas during clearing activities and impacts on some prey species is unlikely to affect the lifecycle of the Black-striped wallaby due to the small area of vegetation to be removed relative to the area to be conserved as part of the proposed biodiversity offset area.

- **Hollow roosting bat species**[10]

  The Yellow-bellied sheathtail-bat, Little pied bat[11] and Eastern long-eared bat were recorded during field surveys. Potential roosting and breeding trees and foraging area would be cleared as part of the progressive disturbance associated with gas drainage and mine ventilation activities. Notably, all clearing activities would be undertaken according to a tree clearing protocol to avoid breeding periods and the felling of trees while bats may be roosting.

  The loss of habitat is unlikely to affect the lifecycle of the hollow roosting bats due to the small area of vegetation to be removed relative to the area to be conserved as part of the proposed biodiversity offset area.

- **Cave roosting bat species**[12]

  The Little pied bat[11] was recorded on the Mine Site. The large-eared pied bat was not recorded, however, suitable habitat is present. Notably no caves or mine shafts for roosting were identified by Ecotone (2009) and it is unlikely that any occur in areas not covered during the survey. Foraging habitat would, however, be cleared as part of the progressive disturbance associated with gas drainage and mine ventilation activities.

  The loss of foraging habitat is unlikely to affect the lifecycle of the hollow roosting bats due to the small area of vegetation to be removed relative to the area to be conserved as part of the proposed biodiversity offset area.

- **Delicate mouse**

  The Delicate mouse was recorded on the Mine Site. Areas of woodland habitat would be cleared and due to their small size individual Delicate mice may not be detected during felling and individuals may perish or become injured during the clearing process. Additionally, the proposed northern power line corridor may fragment parts of the existing population if individuals are unable or unwilling to cross the cleared power-line easement. The life-cycle of the Delicate mouse may also be affected by surface cracking if individuals fall into cracks while foraging. This would be partially mitigated by the Proponent's commitment to identify and fill in cracks as they develop on the Mine Site.

  It is noted, however, that large areas of similar woodland exist to the west and south of the Mine Site and it is likely that the population of Delicate mouse extends into these areas. Therefore, it is considered unlikely that the possible loss of some individuals and potential fragmentation of part of the Mine Site population are unlikely to significantly impact on the life cycle of the species.

[10] Yellow-bellied sheathtail-bat, Eastern long-eared bat, Little pied bat.
[11] Little Pied Bat uses both caves and tree hollows for roosting.
[12] Large-eared pied bat, Little pied bat.

- **Pale-headed snake**

  The Pale-headed snake was recorded on the Mine Site. Pale-headed snakes utilise hollows and the tree canopy for nesting and foraging which would be cleared as part of the progressive disturbance associated with gas drainage and mine ventilation activities. Notably, all clearing activities would be undertaken according to a tree clearing protocol to minimise the felling of trees while snakes may remain in hollows or the tree canopy. The life-cycle of the pale-headed snake may also be affected by surface cracking during subsidence as individual snakes, particularly smaller juveniles, may be injured or perish if falling into the cracks. This would be partially mitigated by the Proponent's commitment to identify and fill in cracks as they develop on the Mine Site.

  Due to the potential for harm to individuals during clearing, including possible home range reductions, and the occurrence of surface cracking across what may be limited home ranges of the snake, the life-cycle of the pale-headed snake may be negatively affected by the proposed longwall mine.

(b) ***How is the proposal likely to affect the habitat of a threatened species, endangered population or endangered ecological community?***

Habitat for the 37 threatened fauna species would be cleared as part of the progressive disturbance associated with gas drainage and mine ventilation activities. Notably, all clearing activities would be undertaken according to a tree clearing protocol to avoid breeding periods and the felling of trees while individual species may be resident. The risk of tree fall as a result of subsidence is considered minimal and therefore unlikely to impact on threatened species habitat.

The proposed clearing would be unlikely to impact on the habitat of 34 of the 37 threatened species, however, may affect species with small home range areas such as the Eastern pygmy-possum, Delicate mouse, and Pale-headed snake. It is noted, however, that large areas of similar habitat exist to the west and south of the Mine Site and it is likely that the populations of these three species extend into these areas. Therefore, due to the small area of habitat to be removed relative to the area to be conserved (as part of the proposed biodiversity offset area, as well as off the Mine Site) it is considered unlikely that the possible loss of habitat would significantly impact on any of the above species.

(c) ***Does the proposal affect any threatened species or endangered population that are at the limit of its known distribution?***

The Mine Site is at the limit of the southern distribution of the Delicate mouse. The identification of the delicate mouse extends its southern most record by approximately 210km to the southeast. As noted above, individual Delicate mice may be injured or perish by falling into surface cracks, however, it is unlikely that species would be significantly impacted by the proposed longwall mine.

(d) ***How is the proposal likely to affect current disturbance regimes?***

Current disturbance regimes within the study area include stock grazing, fire, weed invasion and human presence. Of these disturbance regimes, stock grazing and fire are likely to remain unchanged or decrease over the life of the mine. The area and level of weed invasion may increase due to the increased human activity on the Mine Site.

(e) ***How is the proposal likely to affect habitat connectivity?***

The northern power line corridor would split the habitat of Community 1 roughly in half and may create a barrier to movement for species wary of open areas, eg. Delicate mouse and Eastern pygmy possum. Further minor fragmentation would occur as roads are developed to enable access to the gas drainage and ventilation infrastructure required by the Longwall Project, although these are not expected to result in significant fragmentation of habitat.

(f) ***How is the proposal likely to affect critical habitat?***

No areas of critical habitat proclaimed occur in the vicinity of the study area.

Conclusion

The proposed Longwall Project may directly or indirectly impact on one or more threatened fauna species which either have been identified or have the potential to occur on the Mine Site. In most cases, the proposed mitigation measures described in Section 4B.4.6 would be sufficient to reduce the potential impact on the identified threatened species such that any significant impact on the life cycle or habitat is considered by Ecotone (2009) to be unlikely (given the known distributions and abundances of the species elsewhere).

As a consequence of the reduction in habitat and surface cracking, the proposed Longwall Project could possibly impact on the life cycle, home ranges or habitat connectivity of a limited number of threatened fauna including the Delicate mouse, Eastern pygmy possum and Pale-headed snake.

Avoid, Mitigate, Offset Impacts (Step 4 of the Part 3A Guidelines)

As noted in Section 4B.4.6, prior to disturbance related to the development of gas drainage and mine ventilation infrastructure, the Proponent would commission an assessment of the proposed area to be disturbed and advise of any recommended relocation of activities to avoid impacts on identified threatened species, populations or EECs. If the proposed relocation of activities would not compromise the safety of underground operations, eg. as a result of reduced efficiency of gas drainage or mine ventilation, the Proponent would revise the proposed location of disturbance as recommended.

It is also noteworthy that the Proponent has located all surface facilities, including the Reject Emplacement Area over the already cleared agricultural land of Community 7. All activities have been set back from the riparian areas of Community 3, with appropriate management measures in place to ensure no indirect impacts on this vegetation.

However, despite these commitments, the clearing of up to 210.5ha of native vegetation, including habitat for up to 40 threatened species and possibly one EEC would be unavoidable. Some impact on threatened species and their habitats has also been predicted as a consequence of surface cracking associated with mine subsidence. Sections 4B.4.6.1 to 4B.4.6.4 describe the measures proposed to mitigate these unavoidable impacts. In summary, these include the following measures.

- The filling in of surface cracks as they are identified. The filling would be allowed to occur naturally for small cracks but would be undertaken manually by the Proponent for larger or persisting cracks.
- Changes to surface drainage would be monitored and remedial works undertaken to maintain current drainage patterns and riparian corridors in consultation with an appropriately qualified hydrological professional and the DECCW-OW.
- To minimize the potential impacts of erosion and steeply eroded creek banks toppling the Proponent would:
  - monitor surface slope displacement along subsidence cross lines;
  - fill in cracks as they appear;
  - re-grade or revegetate areas significantly affected by erosion; and
  - regularly review and appraise any significant changes to surface slopes after each longwall is completed.
- Native vegetation to be cleared would be inspected by an ecologist for threatened flora species and roosting or nesting fauna prior to clearing. Any identified fauna would be relocated prior to disturbance.
- The location of access tracks would be influenced by an ecologist after inspecting each proposed route and determining the path with least impact on environmental values.
- A flora and fauna management plan and monitoring program would be developed to ensure regular reassessment of the ecological values of disturbed and natural areas.

The Proponent acknowledges that these measures cannot completely mitigate the impacts resultant from the activities of the proposed Longwall Project. Therefore to compensate for the residual impacts, the Proponent has proposed the establishment of a Biodiversity Offset Area on the Mine Site (see Section 4B.4.6.5). The biodiversity offset area would include approximately 466ha of Community 1, 79ha of Community 2 and 3ha of Community 3, the condition of which has been described as “almost pristine” in places by the consulting ecologist, and linked to Jacks Creek State Forest to the west which in turn is linked to Pilliga East State Forest to the south.

Assessment of Impacts Against Key Thresholds (Step 5 of the Part 3A Guidelines)

Ecotone (2009) completed an assessment of the residual impacts of the proposed Longwall Project on threatened species, with the results summarised as follows.

- Whether or not the proposal, including actions to avoid or mitigate impacts or compensate to prevent unavoidable impacts would maintain or improve biodiversity values.

  Given the loss of approximately 210.5ha of native vegetation would be offset by the conservation of 547.3ha of equivalent vegetation, with all disturbance to be rehabilitated to re-establish the original vegetation community, the Longwall Project would maintain overall biodiversity values.

- Whether or not the proposal is likely to reduce the long-term viability of a local population of the species, population or ecological community.

  The Longwall Project would be unlikely to reduce the long-term viability of any local population of flora or fauna species.

- Whether or not the proposal is likely to accelerate the extinction of the species, population or ecological community or place it at risk of extinction

  The Longwall Project would not accelerate the extinction of, or place any species, population or ecological community at risk of extinction.

- Whether or not the proposal would adversely affect critical habitat.

  The Longwall Project would not affect any areas of identified critical habitat.

4B.4.7.2 Koala Habitat Assessment (SEPP 44)

A single Koala scat was identified during the site survey on the Mine Site, however, no further evidence of a resident Koala population was identified. On this basis, and as the only food tree species identified on the Mine Site *Eucalyptus albens* was found at densities of <15% within the woodland areas, it could not be determined whether the Mine Site represents "Core Koala Habitat" as defined by SEPP 44.

The above notwithstanding, Ecotone (2009) concludes that even in the event of a resident population being identified, the loss of some woodland areas during clearing activities is unlikely to affect the lifecycle of the Koala due to the small area of vegetation to be removed relative to the area to be conserved as part of the proposed biodiversity offset area and that within the adjoining State Forest and private property. The possible impact would be further mitigated by the proposed pre-clearing surveys to be undertaken prior to each clearing campaign.

4B.4.7.3 Matters of National Environmental Significance of the EPBC Act

The EPBC Act focuses Commonwealth interests on matters of national environmental significance (NES) including integrated biodiversity conservation and the management of important protected areas. With regard to flora and fauna, the only matters of NES relevant to the proposed Longwall Project are:

- nationally listed threatened species;
- nationally listed threatened ecological communities; and
- nationally listed threatened migratory species.

Ecotone (2009) considered the impact of the proposed Longwall Project on each matter of NES and concluded the following.

Nationally Listed Threatened Species

- Due to the small area of vegetation to be removed, and the proposed mitigation of surface cracking, the proposed longwall mine is unlikely to lead to a long-term decrease in the size of any populations of the threatened flora or fauna.
- The clearing of vegetation associated with the proposed Longwall Project is unlikely to have a significant impact on occupancy of these species on the Mine Site.
- There is the potential for the disturbance associated with the northern power line to fragment populations of the Delicate mouse, Border thick-tailed gecko and Five-clawed worm skink corridor, however, given the large area of equivalent habitat on and surrounding the Mine Site, the impact of this fragmentation would be significantly reduced. No other populations of threatened species are likely to suffer significant fragmentation.
- The proposed Longwall Project would not adversely affect habitat critical to the survival of any threatened species.
- Due to the retention of significant areas of equivalent habitat to that to be disturbed, the proposed Longwall Project is considered unlikely to affect the breeding cycle of any threatened species.
- The proposed Longwall Project would not modify, destroy, remove or isolate or decrease the availability or quality of habitat for any threatened species to the extent that any would be likely to decline.
- The proposed Longwall Project is highly unlikely to result in an invasive species harmful to the identified threatened species from becoming established within the study area.
- With the adoption of appropriate equipment certification to confirm appropriate decontamination, the risk of introducing plant disease or pathogens such as *Phytophthora cinnamomi* would be significantly reduced. The proposed Longwall Project is highly unlikely to result in the introduction of a disease that would cause threatened fauna species to decline.
- While the proposed Longwall Project would result in the loss of some potential habitat for the identified threatened species, this would not interfere significantly with the recovery of these species.

Nationally Listed Threatened Ecological Communities

- The limited surface disturbance proposed is unlikely to significantly reduce the extent of the two endangered ecological communities, Brigalow and Weeping Myall, on the Mine Site.
- Some fragmentation of the Brigalow community may occur as a result of the northern power line corridor, however, other populations would remain intact. The Weeping Myall EEC is already highly fragmented and would not be affected by the proposed disturbance of the Longwall Project.

- No habitat critical to the survival of either EEC occurs within the Mine Site.
- Although some hydrological changes could occur within the Mine Site as a consequence of subsidence, neither EEC is critically dependent on strict maintenance of the current hydrological regime for survival.
- No substantial changes in the species composition of either EEC are expected as a direct or indirect result of the longwall Project.
- Assuming the implementation of a weed management strategy, the risk of invasive weeds and disease would be reduced so as unlikely to have a major impact.

Nationally Listed Threatened Migratory Species

Given the small area of vegetation to be removed relative to the area to be conserved as part of the proposed biodiversity offset area and on land to the south, west and north of the Mine Site, the proposed Longwall Project would not have any significant impact on the life cycle, habitat or survival of nationally listed migratory species.

4B.4.7.4 Impacts on Non-listed Species and Communities

The Mine Site contains a high diversity of flora species, but none of those recorded were listed on the Rare or Threatened Australian Plants (ROTAP) database (Briggs & Leigh, 1996) or were otherwise locally or regionally significant. In the event that one or more ROTAP species do occur, Ecotone (2009) concludes that the minor level of removal or temporary disturbance is unlikely to place their local populations at risk of extinction.

A total of 140 non-listed native fauna species were recorded during the field survey. The loss of habitat associated with the proposed Longwall Project would decrease the extent of fauna habitat available, however, given the small area of habitat to be removed relative to the area to be conserved as part of the proposed biodiversity offset area and on land to the south, west and north of the Mine Site, Ecotone (2009) concludes that this would be unlikely to greatly impact any of these fauna species.

4B.4.7.5 Impacts on Riparian Zones

The riparian vegetation (Community 3) on the Mine Site may suffer very minor direct impact as a result of clearing required to develop access roads to the sites of gas drainage and mine ventilation. The impacts would be avoided where possible, ie. by crossing the various drainage features of the Mine Site where there is no remnant riparian vegetation, and minimised by limiting disturbance to the minimum area in consultation with an ecologist commissioned to advise on the alignment of Mine Site access roads. If aquatic or fish habitat is identified, then the crossing would be designed and constructed so as not obstruct fish passage. As noted in Section 4B.4.6.5, unavoidable disturbance to the riparian vegetation would be offset by the inclusion of approximately 3ha of Community 3 within the proposed biodiversity offset strategy of the Proponent. Assuming the implementation of the avoidance, mitigation and offset measures, the direct impact of the proposed Longwall Project on the Mine Site would be relatively minor.

A potentially more significant impact on the riparian vegetation of the Mine Site would be that resultant from ponding within Kurrajong and Pine Creeks and their tributaries caused by subsidence. Subsidence predictions of DGS (2009) determine that the net fall across the Mine Site would provide for surface drainage to continue un-impeded, thereby maintaining the water supply to the riparian vegetation. However, ponding of 0.5m and 1.5m could occur, extending beyond the banks of the drainage features and potentially 'drown' areas of remnant riparian and surrounding vegetation.

The exact magnitude and impacts of ponding cannot be accurately predicted and it is proposed to monitor and manage ponding events on a case by case basis. Following the identification of ponding, the affected area would be inspected by a suitably qualified ecologist and hydrologist who would advise on the most appropriate management strategy. This could include earthworks to re-open the drainage line, however, in some cases this may be more harmful to the flora and fauna species of the riparian zone, in which case alternative management methods such as pumping or leaving the affected area alone would be implemented.

While adverse impacts on the riparian vegetation of Kurrajong and Pine Creeks and their tributaries cannot be ruled out, it is assessed that by following the recommendations of suitably qualified ecology / hydrology specialists, the impact of ponding on riparian vegetation could be minimised.

4B.4.7.6 Impacts on Groundwater Dependent Ecosystems

The groundwater modelling of Aquaterra (2009) predicts that the impacts of groundwater depressurisation of the underlying Permian coal measures would have minimal (Mayfield Spring) or nil (Hardys Spring and Eather Spring) impact on the groundwater level and therefore flows within these springs. All three GDEs are also located outside the zone of potential surface cracking (see **Figure 4B.5**). As such, it is unlikely that the proposed Longwall Project would significantly impact on these GDEs. This notwithstanding, groundwater levels, as well as the health and condition of the vegetation of Mayfield Spring would be monitored by the Proponent.

It is possible that deep rooted vegetation, reliant on groundwater, may be present on the Mine Site and could potentially be impacted by the drawdown in groundwater levels. However, the groundwater modelling of Aquaterra (2009) predicts almost no drawdown in the upper geological strata (Namoi Alluvium and Pilliga Sandstone) from which this vegetation would draw groundwater, with the Purlawaugh Formation insulating the shallow groundwater accessed by this vegetation from any impacts of groundwater depressurisation of the underlying Permian coal measures due to mining activities. Therefore it is anticipated that there would be no impact to deep rooted vegetation GDEs should they be present on the Mine Site or surrounds.

4B.4.7.7 Impacts Associated with Discharge to the Namoi River

It is predicted that the Longwall Project would result in a discharge of up to approximately 2.1ML/day into the Namoi River, which typically (>70% of the time) carries a flow of 100ML/day or greater (WRM, 2009). This increase in flow <3% is unlikely to have any significant impact on aquatic or riparian habitats. The discharged water quality would comply

with the water quality criteria nominated in **Table 4B.15** and would be of equivalent or lower salinity to historic concentrations measured for average to low flows (river salinity levels (total dissolved solids) may be less than the discharged 500mg/L during high flow periods) (see **Figure 4B.23**).

Whilst a detailed assessment of hydrologic impacts of this additional flow has not been undertaken, Ecotone (2009) suggests that this discharge into the Namoi River would contribute to improved health of aquatic and riparian habitats by increasing environmental flows. Some level of seasonal variation in discharge volume may be appropriate and could be accommodated if such seasonal flow variations occur naturally in the Namoi River system as seasonal flow variations are known to initiate breeding in some inland fish species and may be important for other aquatic and riparian biota.

4B.4.7.8 Impacts on State Forests

The Mine Site includes portions of the Jacks Creek and Pilliga East State Forests which may be affected by clearing and/or subsidence. The impact of this disturbance on the state forests is considered as follows.

Clearing of Vegetation

Of the native vegetation to be cleared on the Mine Site, none would be required within Jacks Creek State Forest with clearing within Pilliga East State Forest limited to approximately 20ha (associated with pre-drainage and goaf gas drainage sites and associated tracks). This represents approximately 0.0125% of Pilliga East State Forest (which covers approximately 160 000ha) and is therefore unlikely to have any impact on the ecological or forestry value of the forest. The impact of native vegetation clearing is therefore deemed to be negligible.

Subsidence

Portions of both Jacks Creek and Pilliga East State Forests occur within areas of the Mine Site that would be affected by subsidence in the manner described in Section 4B.1.5.2. Any impacts would, however, be mitigated by the management measures proposed by the Proponent (see Section 4B.1.6). In addition, the affected areas of both state forests represent less than 0.1% of the total area of each (Pilliga East State Forest = 160 000ha, Jacks Creek State Forest = 4 600ha). Based on the relatively small area of impact (compared to the total area of each state forest) and the implementation of the proposed mitigation measures, the impact of subsidence on the ecological or forestry value of the forests is deemed to be negligible.

4B.4.7.9 Assessment of the Biodiversity Offset Strategy

Ecotone (2009) provides an assessment of the proposed Biodiversity Offset Strategy against:

- the offset selection priority criteria used to identify potential offset areas across the available properties (owned by the Proponent) within the Mine Site; and
- the principals identified in Principles for the use of Biodiversity Offsets in NSW presented as Appendix II of the document Guidelines for Biodiversity Certification of Environmental Planning Instruments – Working Draft published by the Department of Environment and Climate Change in April 2007.

Offset Selection Priority Criteria

Priority 1. Areas should be selected on a like-for-like basis.

a) Areas should be selected that contain the same vegetation communities as those areas to be impacted;

b) Areas should be selected that contain, as much as possible, the same fauna species that are present in the areas are to be impacted.

The vegetation communities with the Biodiversity Offset Area and the areas proposed to be disturbed are the same, with Communities 1 and 2 dominating both areas. In addition, Ecotone (2009) states that as the vegetation communities are the same, the fauna species that utilise the Biodiversity Offset Area would be the same as the fauna species that utilise other woodland areas within the Mine Site.

Priority 2. Areas should be selected that contain known locations of threatened species, populations and/or ecological communities;

a) *Where possible an appropriate radius (generally 100m or more) around each known location of a threatened species should be included in the Biodiversity Offset Area.*

b) *Where possible the entire area of a threatened population or ecological community should be included in the offset area.*

Ecotone (2009) notes that 10 of the 16 locations where threatened fauna species were observed within the Mine Site were recorded within the Biodiversity Offset Area. In addition, all 16 threatened fauna species were recorded in either Community 1, 2 or 3, each of which would be preserved within the Biodiversity Offset Area.

Priority 3. Areas should be selected to protect threatened species, populations or ecological communities that may be impacted by the proposal.

Ecotone (2009) notes that the Biodiversity Offset Area has been selected to incorporate as many of the locations where threatened species have been observed as possible. In addition, the offset area has been selected to incorporate areas of vegetation that are equivalent to the areas that would be disturbed.

Priority 4. Areas should be selected that minimize the level of landscape fragmentation of the vegetation community.

a) Areas within large existing patches should be selected over isolated small patches.

b) Areas within existing patches or nearby existing patches should be selected in preference to patches distant from other patches.

The proposed Biodiversity Offset Area comprises one of the larger patches of relatively undisturbed vegetation within the Mine Site. In addition, the Biodiversity Offset Area is location adjacent to an area of the regional Pilliga forest area within the Jacks Creek and Pilliga East State Forest.

Priority 5. Areas should be selected that minimize the level of landscape isolation of the vegetation community.

Vegetation within the proposed Biodiversity Offset Area is well connected to surrounding woodland habitat.

Priority 6. Areas should be selected that minimize edge effects:

a) Areas within existing patches should be selected in preference to entire patches with edges;

b) Patches with high area to circumference ratios (circular or block shaped patches) should be selected over patches with low area to circumference ratios (thin linear patches).

Ecotone (2009) notes that with the exception of the east where it is bordered by agricultural grazing land, the Biodiversity Offset Area is contiguous with neighbouring habitat on all sides. The offset strategy also maximises the area to circumference ratio of the woodland areas.

Priority 7. Areas of high diversity (flora and/or fauna) should be selected over less diverse areas.

a) *Riparian vegetation should be selected in preference to mid slope or ridge line vegetation to conserve a likely higher diversity of fauna species.*

Vegetation Communities 1, 2 and 3 are the most species diverse communities recorded within the Mine Site. All three vegetation communities contain diverse canopy, mid-storey and ground cover flora species which support a diverse range of fauna species.

Priority 8. Areas should be selected that are the least disturbed of the available areas.

The Biodiversity Offset Area is dominated by a large area of woodland with little disturbance.

Principles for the Use of Biodiversity Offsets in NSW

Principle 1 Impacts must be avoided first by using prevention and mitigation measures.

Offsets are then used to address remaining impacts. This may include modifying the proposal to avoid an area of biodiversity value or putting in place measures to prevent offsite impacts.

The Proponent has, to the greatest extent possible, minimised the area of disturbance associated with the Longwall Project. This has been achieved through location of those components of the Longwall Project with the most concentrated level of disturbance, namely the Pit Top and Reject Emplacement Areas within areas of low conservation significance, namely within cleared areas previously used for agricultural activities (Community 7).

Principle 2 All regulatory requirements must be met.

Offsets cannot be used to satisfy approvals or assessments under other legislation, e.g. assessment requirements for Aboriginal heritage sites, pollution or other environmental impacts (unless specifically provided for by legislation or additional approvals).

The Proponent would meet all regulatory requirements related to the construction, operation and rehabilitation of the Longwall Project.

Principle 3 Offsets must never reward ongoing poor performance.

Offset schemes should not encourage landholders to deliberately degrade or mismanage offset areas in order to increase the value from the offset.

The Proponent has not deliberately degraded or mismanaged any land under its control. Ecotone (2009) report that the lands of the Mine Site are currently being managed for conservation (woodland areas to the west) or grazing at low stocking rates (scattered woodland and open pasture paddocks in the eastern two thirds of the Mine Site). Both management strategies represent appropriate environmental management of the proponents land within the Mine Site.

Principle 4 Offsets will complement other government programs.

A range of tools is required to achieve the NSW Government's conservation objectives, including the establishment and management of new national parks, nature reserves, state conservation areas and regional parks and incentives for private landholders.

The establishment of the Biodiversity Offset Area would increase the total area of conservation lands within the region and complement other nearby conservation areas such as Mount Kaputar National Park (to the northeast) and Pilliga Nature Reserve (to the southwest).

Principle 5 Offsets must be underpinned by sound ecological principles.

They must:

- include the consideration of structure, function and compositional elements of biodiversity, including threatened species;
- enhance biodiversity at a range of scales;
- consider the conservation status of ecological communities; and
- ensure the long-term viability and functionality of biodiversity.

Biodiversity management actions, such as enhancement of existing habitat and securing and managing land of conservation value for biodiversity, can be suitable offsets. Reconstruction of ecological communities involves high risks and uncertainties for biodiversity outcomes and is generally less preferable than other management strategies, such as enhancing existing habitat.

Ecotone (2009) identify that the proposed Biodiversity Offset Strategy comprises the conservation of existing habitat and the promotion of natural regeneration. It is a commonly understood ecological principle that the conservation of existing habitats is preferred to the reconstruction of habitat in disturbed areas. In addition, the proposed Biodiversity Offset Area was selected based on numerous sound ecological principals identified previously, including:

- incorporating areas of similar vegetation, including areas of known threatened species, population and ecological community habitat;
- conserving areas of high landscape value;
- conserving areas of high flora and fauna diversity;
- maximising the area to circumference ratio; and
- maximising the linkages between areas of vegetation within the Mine Site and areas surrounding the Mine Site.

Principle 6 Offsets should aim to result in a net improvement in biodiversity over time.

Enhancement of biodiversity in offset areas should be equal to or greater than the loss in biodiversity from the impact site.

Setting aside areas for biodiversity conservation without additional management or increased security is generally not sufficient to offset against the loss of biodiversity. Factors to consider include protection of existing biodiversity (removal of threats), time-lag effects, and the uncertainties and risks associated with actions such as revegetation.

Offsets may include enhancing habitat, reconstructing habitat in strategic areas to link areas of conservation value, or increasing buffer zones around areas of conservation value and removal of threats by conservation agreements or reservation.

The implementation and management of the proposed Biodiversity Offset Area would be likely to result in a net improvement in biodiversity over time through the removal of threats to the vegetation communities and the encouragement of natural regeneration. This would include protection from grazing, tree harvesting, firewood collection, track creation and other possible detrimental land management actions. The removal of such threats, combined with management to encourage natural regeneration, would be likely to result in an increase in the area of Communities 1 to 3 over time and, as a result, a net improvement in biodiversity within the Mine Site.

Principle 7 Offsets must be enduring – they must offset the impact of the development for the period that the impact occurs.

As impacts on biodiversity are likely to be permanent, the offset should also be permanent and secured by a conservation agreement or reservation and management for biodiversity. Where land is donated to a public authority or a private conservation organisation and managed as a biodiversity offset, it should be accompanied by resources for its management. Offsetting should only proceed if an appropriate legal mechanism or instrument is used to secure the required actions.

The Proponent would secure the Biodiversity Offset Area through an enduring covenant or restriction on the use of the land under Section 88B of the *Conveyancing Act 1919* or similar arrangement, to the satisfaction of the Department of Planning and the Department of Environment, Climate Change and Water – Environment Protection and Regulatory Group. The purpose of such an arrangement would be to restrict the use of the Biodiversity Offset Area for the purposes of native vegetation conservation in perpetuity. In addition, the Proponent would undertake to manage the Biodiversity Offset Area for the purpose of native vegetation and fauna conservation during the life of the Longwall Project and while ever the Proponent continues to own the relevant land. In the event that the land is donated to a public authority, the Proponent would negotiate an appropriate arrangement with the relevant government agency for the ongoing management of the land prior to the transfer of control of the land.

Principle 8 Offsets should be agreed prior to the impact occurring.

Offsets should minimise ecological risks from time-lags. The feasibility and in-principle agreements to the necessary offset actions should be demonstrated prior to the approval of the impact. Legal commitments to the offset actions should be entered into prior to the commencement of works under approval.

The Biodiversity Offset Area and a timeframe for putting the appropriate legal arrangements and management strategies in place would be agreed with the relevant government agencies prior to Longwall Project-related disturbance occurring.

Principle 9 Offsets must be quantifiable – the impacts and benefits must be reliably estimated.

Offsets should be based on quantitative assessment of the loss in biodiversity from the clearing or other development and the gain in biodiversity from the offset. The methodology must be based on the best available science, be reliable and used for calculating both the loss from the development and the gain from the offset. The methodology should include:

- the area of impact;
- the types of ecological communities and habitat/species affected;
- connectivity with other areas of habitat/corridors;
- the condition of habitat;
- the conservation status and/or scarcity/rarity of ecological communities;
- management actions; and
- level of security afforded to the offset site.

The best available information/data should be used when assessing impacts of biodiversity loss and gains from offsets. Offsets will be of greater value where:

- they protect land with high conservation significance;
- management actions have greater benefits for biodiversity;
- the offset areas are not isolated or fragmented; and
- the management for biodiversity is in perpetuity (eg. secured through a conservation agreement).

Management actions must be deliverable and enforceable.

The following factors are relevant when considering whether the proposed Biodiversity Offset Strategy complies with the requirements of this principle.

- The area of Communities 1 and 2 that would be preserved within the Biodiversity Offset Area are approximately 2.5 and 3.6 times the area that would be disturbed respectively.
- The area of Communities 3 and 4 would be marginally less than the areas that would be disturbed.

- The floristic characteristics and habitat values of those areas to be disturbed are similar to those areas to be preserved.
- The Biodiversity Offset Area would have a low area to circumference ratio and is located adjacent to very large areas of habitat within the Jacks Creek and Pilliga East State Forests.

Principle 10 Offsets must be targeted.

They must offset impacts on the basis of like-for-like or better conservation outcome. Offsets should be targeted according to biodiversity priorities in the area, based on the conservation status of the ecological community, the presence of threatened species or their habitat, connectivity and the potential to enhance condition by management actions and the removal of threats. Only ecological communities that are equal or greater in conservation status to the type of ecological community lost can be used for offsets. One type of environmental benefit cannot be traded for another: for example, biodiversity offsets may also result in improvements in water quality or salinity but these benefits do not reduce the biodiversity offset requirements.

The Biodiversity Offset Area would preserve areas of Communities 1 and 2 that are 2.5 and 3.6 times the area that would be disturbed respectively. In addition, as highlighted previously, the Biodiversity Offset Area was carefully selected to preserve the maximum number of locations where threatened fauna were observed, maximise the area to circumference ratio and the linkages with surrounding vegetation and habitat areas.

Principle 11 Offsets must be located appropriately.

Wherever possible, offsets should be located in areas that have the same or similar ecological characteristics as the area affected by the development.

The Biodiversity Offset Area is located adjacent to the areas of proposed disturbance. In addition, the offset area is also located adjacent to Jacks Creek and Pilliga State Forests and the large areas of native vegetation and habitat associated with those areas of forest.

Principle 12 Offsets must be supplementary.

They must be beyond existing requirements and not already funded under another scheme. Areas that have received incentive funds cannot be used for offsets. Existing protected areas on private land cannot be used for offsets unless additional security or management actions are implemented. Areas already managed by the government, such as national parks, flora reserves and public open space cannot be used as offsets.

The Biodiversity Offset Area is supplementary to rehabilitation activities and commitments that apply to the Stage 1 operation and the commitments made in this *Environmental Assessment*. In addition, the proposed area is not the subject of any other biodiversity management program or incentive scheme.

Principle 13 Offsets and their actions must be enforceable through development consent conditions, licence conditions, conservation agreements or a contract.

Offsets must be audited to ensure that the actions have been carried out, and monitored to determine that the actions are leading to positive biodiversity outcomes.

It is envisaged that the proposed Biodiversity Offset Area and related commitments made in this document would be incorporated into the conditions associated with project approval, should it be granted. In addition, it is anticipated that the conditions to any project approval would include a requirement for the Proponent to undertake an independent compliance audit of the Longwall Project against the conditions of the project approval. It would also be expected that an independent audit would be required of the offset area to ratify its condition and value over time.

4B.4.8 Flora and Fauna Monitoring

A Flora and Fauna Monitoring Program would be developed to assess impacts of the proposed Longwall Project. The monitoring program would be developed in conjunction with a qualified ecologist and would place particular emphasis on the following elements.

Monitoring the populations of the Delicate mouse, Eastern pygmy possum and Pale-headed snake to ensure that these species are not negatively affected by the progressive disturbance associated with the gas drainage and mine ventilation of the mine and surface cracks caused by subsidence. The monitoring program would commence prior to the initiation of longwall mining to establish baseline population levels. The monitoring program would involve, as a minimum, a large number of permanently established pitfall and funnel traps across unaffected and mined areas.

In accordance with the recommendations of the *Impacts of Underground Mining on Natural Features in the Southern Coalfield* (DoP, 2008), flora and fauna monitoring would (to the extent practicable) follow the Before, After, Control, Impact (BACI) method. This would enable more detailed statistical analyses of the impacts of subsidence on Mine Site flora and fauna to be included in the analysis of monitoring data.

4B.5 ABORIGINAL HERITAGE

The Aboriginal heritage assessment was undertaken by Archaeological Surveys & Reports Pty Ltd. The full assessment is presented in Volume 2, Part 5 of the Specialist Consultant Studies Compendium, with the relevant information from the assessment summarised in the following subsections. The full assessment is referred to as AS&R (2009a) throughout this document.

4B.5.1 Introduction

Based on the risk analysis undertaken for the proposed Longwall Project (see Section 3.3 and **Table 3.5**), the potential environmental impacts related to Aboriginal heritage requiring assessment and their unmitigated risk rating are as follows.

- Impact on identified sites and/or artefacts of Aboriginal cultural heritage as a result of the proposed construction and mining activities and without the permission of LALC or DECCW (high risk).

- Impact on unidentified sites and/or artefacts of Aboriginal cultural heritage as a result of subsidence and without the permission of LALC or DECCW (high risk).

In addition, the Director-General's Requirements issued by DoP require that the assessment of Aboriginal heritage refer to the draft *Guidelines of Aboriginal Cultural Heritage Assessment and Community Consultation* (Department of Environment and Conservation).

The following subsections present the method of assessment, review the results of an Aboriginal heritage survey undertaken, provide the proposed management of identified sites and assess the significance of any impact on these. The assessment was undertaken in consultation with the Narrabri Local Aboriginal Land Council (Narrabri LALC) and Narrabri Gomeroi Traditional Owner Group (Gomeroi), and with reference to the comments provided by DECCW on the requirements of an assessment of impacts on Aboriginal cultural heritage values.

4B.5.2 Method of Investigation

4B.5.2.1 Introduction

In order to identify the nature and extent of impacts on Aboriginal cultural heritage values across the Mine Site, Archaeological Surveys & Reports Pty Ltd (AS&R, 2009a) considered the existing archaeological record, consulted with the local Aboriginal community, undertook a field survey of the areas likely to be disturbed on the Mine Site (as well as a proposed water pipeline corridor between the Mine Site and the Namoi River), considered the significance of identified sites on the Mine Site and on this basis assessed the significance of any impact(s).

The potential impacts of the proposed Longwall Project were also considered within a regional context to enable the cumulative impact of proposed and approved developments to be assessed.

The following subsections provide a summary of the key elements of the Aboriginal heritage investigation undertaken by AS&R (2009a).

4B.5.2.2 Review of the Archaeological Record

Initially, a search of the Aboriginal Sites Register (Aboriginal Heritage Information Management System – AHIMS) was completed by AS&R (2009a) over a 256km^2 search area centred on the Mine Site to identify the type and frequency of sites recorded in the local and regional area.

One previous archaeological investigation has been completed on the Stage 1 Pit Top Area within the Mine Site (AASC, 2007), focussing on the Pit Top Area and initial Ventilation Shaft Area, and this was reviewed by AS&R (2009a) to provide an indication of the type of sites that may be encountered over the rest of the Mine Site. AS&R (2009a) also considered the archaeological potential of the Mine Site based on the presence or absence of resources such as vegetation, water and stone.

4B.5.2.3 Consultation

The following consultation has been undertaken as part of the preparation of AS&R (2009a).

- An advertisement was placed in the *Narrabri Courier* on 26 August 2008 (in accordance with the *Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* – DEC, 2005). Representatives of Narrabri LALC and Gomeroi responded to the advertisement registering their interest.
- Representatives of both Narrabri LALC and Gomeroi were subsequently contacted to arrange a date for the field investigation of the Mine Site.
- After agreement over the survey of the Mine Site could not be reached with Gomeroi, a copy of the proposed survey strategy of the Mine Site was provided to both Narrabri LALC and Gomeroi. A copy of this proposed survey strategy has been appended to AS&R (2009a).
- Following a protracted period of consultation between AS&R (on behalf of the Proponent), Narrabri LALC and Gomeroi, agreement over the survey strategy for the areas above LW1 to LW7 ("the Panels 1 to 7 Survey Area") was reached.
- At the completion of the field survey (see Section 4B.5.2.4), a listing of all sites recorded during the investigation was forwarded to both Narrabri LALC and Gomeroi, and a request made for each stakeholder to provide their comments and/or recommendations in relation to the results of the field survey to the Proponent. Correspondence from both stakeholders was received confirming their participation in the surveys, agreeing to the completion of further survey over the Mine Site (Panels 8 to 26) and, in the case of Narrabri LALC on 20 April 2009, providing recommendations as to the management of the identified sites.
- Following the completion of the Panels 1 to 7 Survey, a representative of the Proponent met with representatives of Gomeroi to discuss the completion of field survey over the remaining areas of the Mine Site that could be affected by the proposed Longwall Project ("the Panels 8 to 26 Survey Area"). Mutual agreement over a proposed approach to the field survey of the Panels 8 to 26 Survey Area was reached and the survey was completed between 6 and 14 July 2009. Similar to the process followed following the completion of the field survey of the Panels 1 to 7 Survey Area, a listing of all sites recorded during the investigation was forwarded to both Narrabri LALC and Gomeroi and a request made for each stakeholder to provide their comments and/or recommendations in relation to the identified sites.
- Prior to the receipt of any correspondence from the Aboriginal stakeholder groups, the Proponent identified that additional land on the Mine Site would need to be disturbed to enable the construction of the Brine Storage Area and a pipeline between the Mine Site and the Namoi River installed. The Aboriginal stakeholder groups were again contacted by the archaeologist and invited to take part in field surveys of the Brine Storage Area and Water Pipeline Route. Both Aboriginal stakeholder groups accepted the invitation and provided a representative to take part in the field surveys on the 29 and 30 July.

- Following the completion of these surveys, the Proponent finalised a Statement of Commitments in relation to the management of the identified Aboriginal sites and Aboriginal cultural heritage on the Mine Site in general. Meetings between representatives of the Proponent and both Narrabri LALC (6 August 2009) and Gomeroi (13 August 2009) were convened in which the Statement of Commitments was explained and a request for written comment on the proposed site management made. Both Aboriginal stakeholder groups agreed to provide formal correspondence to the Proponent commenting on the proposed management of the identified Aboriginal sites and Aboriginal cultural heritage on the Mine Site.

Importantly, all consultation meets the requirements of the DECC guideline document *Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* (DEC, 2005).

4B.5.2.4 Development of a Predictive Model and Field Survey

In order to design an investigative strategy, it is firstly necessary to develop a predictive model for site location. The objective of the predictive model is not to determine where the investigation should be conducted, rather to establish a theoretical model for the distribution of archaeological material against which the effectiveness and subsequent analysis of the survey results can be tested, compared and reasoned. The predictive model developed by AS&R (2009) considers the existing archaeological record, resource availability, knowledge of the habitation and land use patterns of the Aboriginal people of the region (and generally) and factors affecting identification.

Considering the above, AS&R (2009a) proposed the following model for site distribution for the Mine Site, in which there was no reliable water source, few exposures of sandstone bedrock, and no rock overhangs, and which in the absence of both water and shelter, there were unlikely to be any places of potential archaeological deposits (PADs).

- Isolated artefacts may be present and visible within erosion features.
- Low-density artefact scatters may be present and visible in erosion features, but it is unlikely that any debitage would be visible.
- There is potential for trees more than 150 years old to exhibit scarred surfaces.
- There is potential for any trees more than 150 years old to exhibit carved surfaces.
- There are unlikely to be any engravings, and/or grinding grooves.
- There are unlikely to be any PADs.
- In the absence of shelters or overhangs there is little potential for shelters to exist and therefore no potential for art sites, and therefore no potential for undisturbed occupation deposits.
- There would be no Aboriginal stone quarries.
- There would be no shell middens.

- There would be no visible evidence of burials.
- There would be no surviving Bora rings.
- There would be no stone arrangements.
- There are no known cultural associations with the area.

4B.5.2.5 Field Surveys

Four separate field surveys have been completed as part of the Aboriginal heritage assessment for the Longwall Project as follows.

1. A detailed survey of the proposed disturbance areas of the Mining Area above longwall panels LW1 to LW7, referred to hereafter as the "Panels 1 to 7 Survey". The primary objective of this survey was to identify all Aboriginal sites and artefacts that could be impacted by the proposed layout of the surface disturbing activities (over the first 7 years of the Longwall Project) and to develop measures to manage these. A secondary objective was to validate the predictive model for site location such that a more general field survey of the remaining Mining Area could be undertaken.
2. A reconnaissance field survey of those locations and environmental features of the Mining Area above LW8 to LW26 considered as having higher potential for Aboriginal site occurrence and identification. Referred to hereafter as the "Panels 8 to 26 Survey", the objective of this survey was to provide a basis for assessing the likely cumulative impact of the Longwall Project on the Aboriginal archaeological record.
3. A detailed field survey of the Pit Top Area where the proposed Brine Storage Area would be located. Referred to hereafter as the Brine Storage Area Survey, the objective of this survey was to identify all Aboriginal sites and artefacts that could be impacted by the proposed layout of the Brine Storage Area and develop measures to manage these.
4. A detailed field survey of the route of the proposed water pipeline between the Mine Site and the Namoi River. Referred to hereafter as the Water Pipeline Route Survey, the objective of this survey was to identify all Aboriginal sites such that the alignment of the proposed pipeline could avoid these (as far as practicable).

The following provides a summary of the survey methodology and effort for each of the four surveys.

Panels 1 to 7 Survey

In accordance with the agreed survey strategy (see Section 4B.5.2.3), a field survey of the Panels 1 to 7 Survey Area was undertaken by Mr John Appleton (of AS&R) between 30 March and 1 April, and 7 and 8 April. Ms Kristie Toomey (Sites Officer of Narrabri LALC) and Mr Mick Trindall (Sites Officer of Gomeroi) were present for all five days of the field survey with Mr Craig Trindall of Gomeroi taking part on the morning of 30 March 2009 (and assisting in the identification and recording of the first two sites).

The survey was undertaken on foot, in dry conditions, in light ideal for observing any artefactual material present and observable. The survey route followed the alignment of the likely location of gas drainage and ventilation infrastructure as well as local creeks and drainage lines (all ephemeral) along which sites would be most likely to be found. **Figure 4B.31** identifies the area included in the Panels 1 to 7 Survey. Both prior to and during the survey, the potential for particular site types to be present, and the particular environments in which they might occur was discussed. At the conclusion of the survey the results were discussed, as were the possible outcomes in view of the potential impacts from the proposed gas drainage and ventilation boreholes, and access roads.

Panels 8 to 26 Survey

In order that a more definitive statement could me made as to the likely site numbers and distribution within the Mining Area a field 'reconnaissance' survey was made targeting those locations in which it was predicted from the results of the survey of the Panels 1 to 7 Survey, sites were most likely to occur. As the Mining Area over LW8 to LW26 is unlikely to be disturbed for at least seven years, AS&R (2009a) considers it probable that many of the sites recorded during a survey in 2009 would become covered in 7 years time (or sooner) and similarly, other sites which are currently not exposed or visible would become exposed over this 7 year period. The survey was undertaken, therefore, not for the purpose of recording every site, but to provide a firmer basis on which to assess the cumulative impact of disturbing or salvaging sites within the Panels 1 to 7 Survey. At the conclusion of the survey, the results were discussed, as were the possible outcomes in view of the potential impacts from the proposed gas drainage and ventilation boreholes and access roads.

The investigation was undertaken over 7 days, from 6 to 14 July, by Mr John Appleton (of AS&R) with Matt Trindall and Tahnesha Trindall - on different days (of Narrabri LALC) and Mick Trindall and Patrick Sevil (of Gomeroi) present during all stages of the 7 day investigation. Both prior to and during the survey, discussions were held regarding the potential for particular site types to be present, and the particular environments in which they might occur. The survey strategy and results were considered and discussed throughout the survey and at the completion of each survey unit.

Brine Storage Area Survey

A pedestrian survey of the entire Brine Storage Area was completed on 29 July 2009 by Mr John Appleton (of AS&R), accompanied by Matt Trindall (of Narrabri LALC) and Mick Trindall and Patrick Sevil (of Gomeroi), targeting any ground surface exposures and in particular the elevated areas overlooking flooding zones of Kurrajong Creek Tributary 1.

Water Pipeline Survey

A pedestrian survey of the entire Water Pipeline Route was completed on 30 July 2009 by Mr John Appleton (of AS&R), accompanied by Matt Trindall (of Narrabri LALC) and Mick Trindall and Patrick Sevil (of Gomeroi). Mature trees and ground exposures within the road and rail easements were inspected.

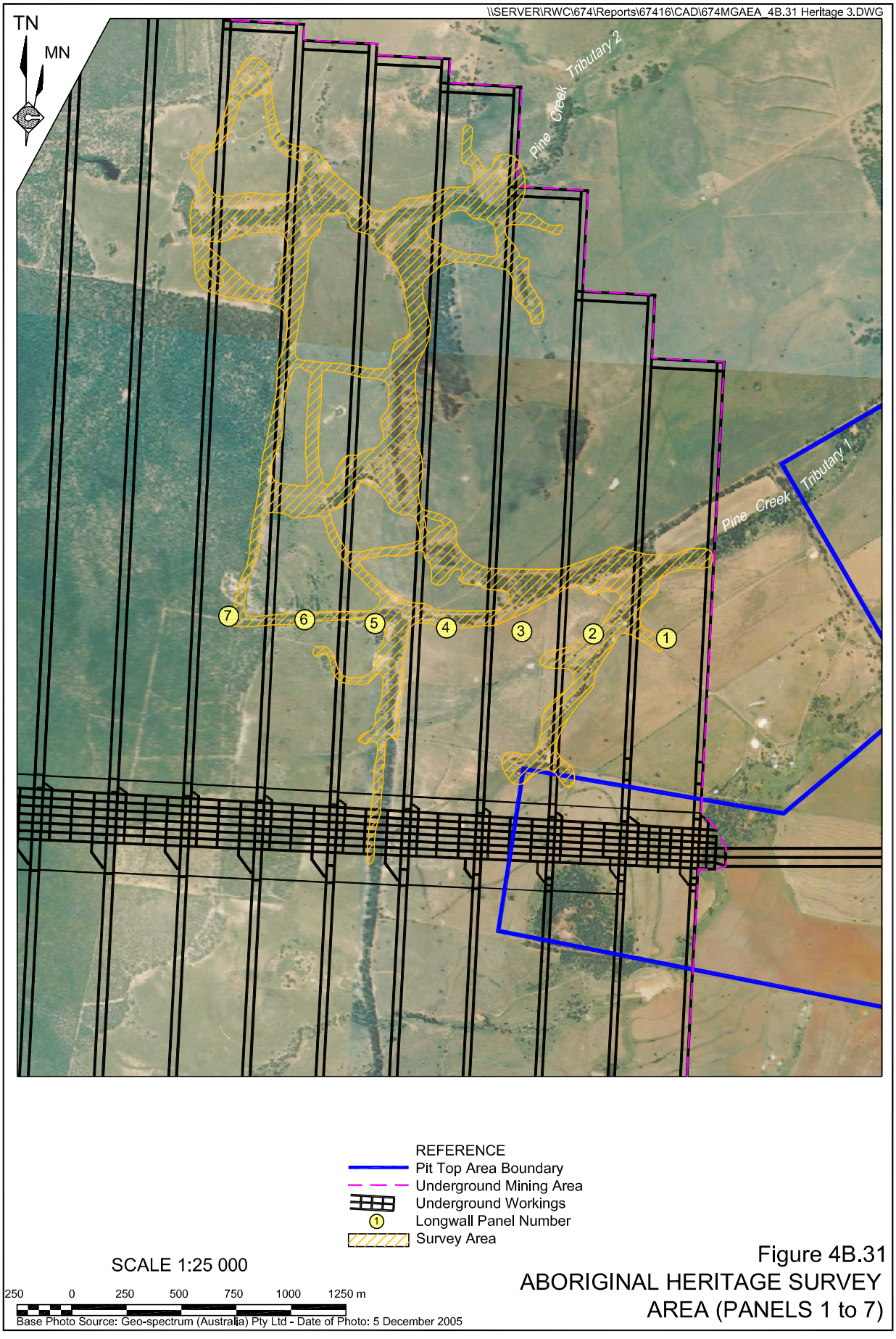


Figure 4B.31
ABORIGINAL HERITAGE SURVEY AREA (PANELS 1 to 7)

4B.5.2.6 Review of Predicted Subsidence

The impacts of subsidence on Aboriginal sites may occur as a result of the following.

- The differential lowering of the ground surface over large areas.
- Surface cracking which may occur along the margins of the subsidence (above the line of longwall panels), and where differential tilting of the surface may occur.

The Subsidence Assessment prepared for the proposed Longwall Project was subsequently reviewed to identify the area and magnitude of the likely subsidence and surface cracking.

4B.5.2.7 Consideration of Cultural and Research Potential and Assessment of Impact(s)

The Aboriginal or cultural significance of an Aboriginal artefact, relic or site can only be assessed by the Aboriginal community, and in particular, the Elders. As noted in Section 4B.5.2.3, the results of the field survey were provided to both Narrabri LALC and Gomeroi for comment on the cultural significance of the identified sites and to provide recommendations for management of these sites.

The research potential has been considered based on the type, condition and location of any identified sites.

On the basis of the cultural significance and research potential, and management measures developed in consultation with the Aboriginal community, AS&R (2009a) assessed the significance of any impact on identified Aboriginal sites. The assessment of impacts considers both the impact on any affected site, but also the cumulative impact on the regional archaeological record.

4B.5.3 Summary of Results

4B.5.3.1 The Archaeological Record

Only a single record was identified within the 256km^2 search area of the Aboriginal Sites Register. This site, Site #19-3-0010 is identified as a scarred tree at "Laluba: Bunda Wallah Waterhole" nearly 4km to the north of the Mine Site. This lack of registered sites should not be interpreted as representing the frequency or distribution of sites in the area, rather a reflection of the lack of survey for Aboriginal heritage sites in the region.

Supporting the conclusion that the lack of recorded sites does not reflect the actual archaeological record is the results of AASC (2007). This study identified seven archaeological sites recorded (including a Wild Orange Tree of no known direct cultural association), none of which are currently recorded on the Aboriginal Sites Register. Of the six archaeological sites, two were described as isolated artefacts, two were described as artefact scatters and two scarred trees were identified. All artefactual material is currently being managed in accordance with an Aboriginal Cultural Heritage Management Plan, prepared in consultation with Gomeroi and Narrabri LALC.

4B.5.3.2 Field Survey

Panels 1 to 7 Survey

43 sites were recorded during the Panels 1 to 7 Survey, with all but one recorded within 50m of a creek or drainage line. **Figure 4B.32** illustrates the location of these sites, including site groupings likely to represent locations visited regularly or periodically by Aboriginal inhabitants.

Of the 43 sites, 28 were identified as open artefact scatters of which 19 contained 5 artefacts or less. Seven open artefact scatter sites contained 10 or more artefacts, with only one believed to contain more than 100 artefacts. A single set of axe grinding grooves, a scarred tree and a fireplace were also identified. AS&R (2009a) identifies sites 10b (axe grinding grooves) and 39 (a large open scatter of in excess of 100 artefacts) as being of greatest significance.

On first viewing, the archaeological record appears to be represented predominantly by many very low density sites. However, by considering groupings of sites based on proximity and environmental setting, evidence of more regularly visited or occupation sites is provided. AS&R (2009a) suggests the following site groupings as representative of locations of multiple visits, occupation and use (see **Figure 4B.32**).

- Sites 16, 17, 18, 19, 22 and 23 containing at least 38 artefacts.
- Sites 38 and 39 containing in excess of 113 artefacts.

Sites 11, 12 and 13; Sites 32, 33 and 34; and Sites 1, 4, and 7, could also be grouped together demonstrating more frequent historic use of certain areas.

Panels 8 to 26 Survey

As a result of the Panels 8 to 26 Survey, an additional 69 sites were recorded. With the exception of three sites at the southern end of LW 23 (Sites 107, 111 and 112), all of the additional sites were either isolated artefacts (14 sites), or low density scatters (52 sites). **Figure 4B.32** provides the locations of all sites identified on the Mine Site, ie. as part of the Panels 1 to 7, Panels 8 to 26 and Brine Storage Pond Surveys.

Brine Storage Area Survey

A total of nine sites were identified as part of the Brine Storage Area Survey, comprising three isolated artefacts, two sites of 2 artefacts, two sites of 3 artefacts, and two sites of 5 artefacts.

Water Pipeline Route

No sites were identified during the survey of the Water Pipeline Route.

Summary

Considering the results of the four surveys, AS&R (2009) reports that of the 121 sites recorded, 97 (81.51%) contained 1 to 5 artefacts, 13 (10.92%) contained 6 to 10 artefacts, 5 (4.20%) contain 11 to 20 artefacts, and 4 sites (3.37%) contained in excess of 20 artefacts. In simple terms four in every five sites will contain 5 artefacts or less, and only 4 in 121 sites will contain more than 20 artefacts.

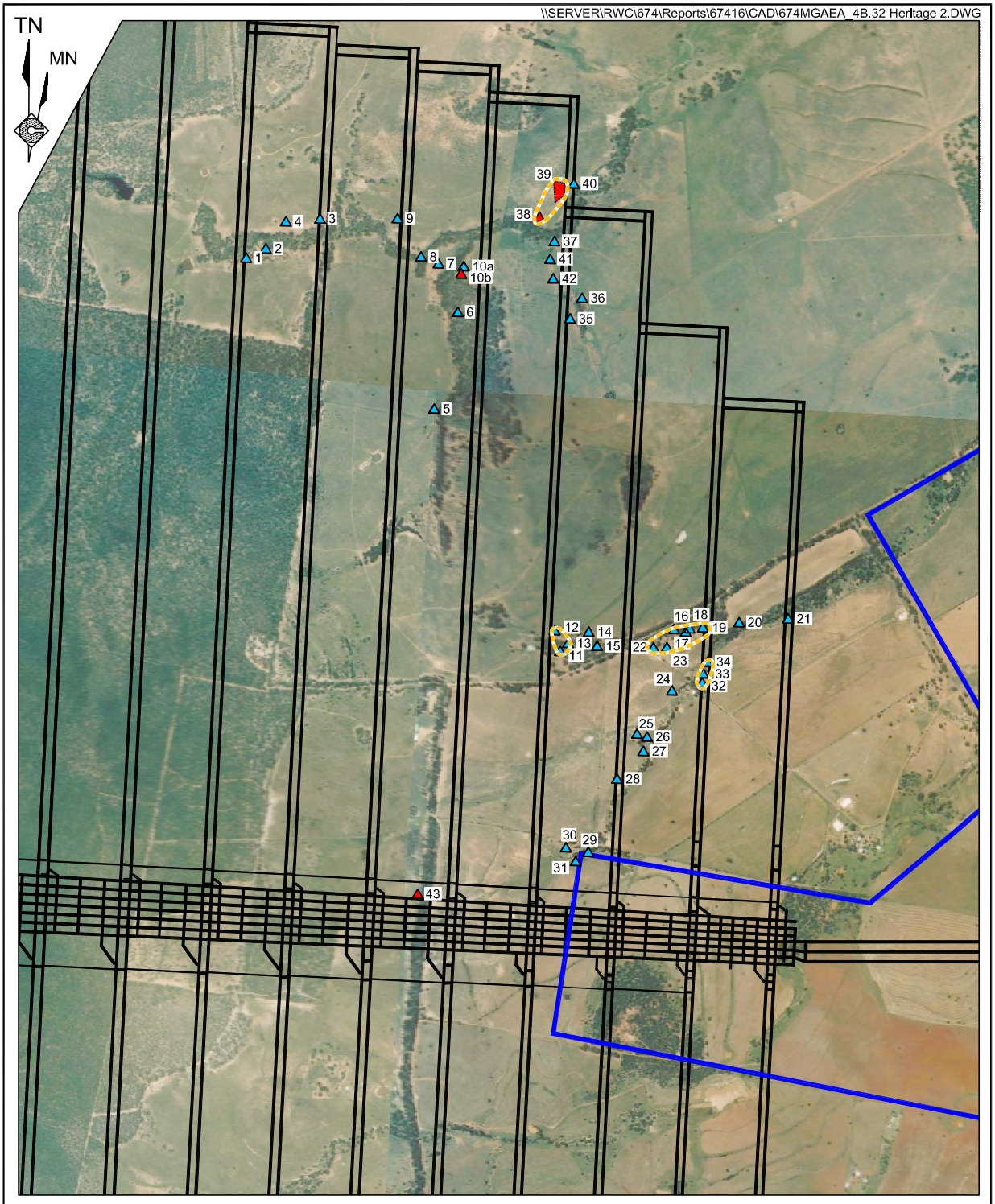


Figure 4B.32
ABORIGINAL HERITAGE SITES
AND GROUPINGS (PANELS 1 to 7)

4B.5.4 Significance Assessment

4B.5.4.1 Cultural Significance

The cultural significance of Aboriginal relics and sites can only be assessed by the Aboriginal community, and in particular, the Elders. On completion of the field survey, separate listings of all sites recorded (during the four surveys) were forwarded to both Narrabri LALC and Gomeroi, to provide them with the information on which they could provide information on the cultural significance of the identified sites and artefacts. Narrabri LALC responded stating that "*sites that have been recorded should not be impacted on*", and that, "*In relation to knapping areas that have been recorded these areas that require preserving and our recommendation is that the bore holes should be relocated"*. This second statement, relates specifically to Site 10b (see **Figure 4B.32**). Narrabri LALC further states that it is, *"keen to support and work with Narrabri Coal Mine with preserving these sites*". No correspondence providing assessment of cultural heritage or recommendation on preferred site management has been received from Gomeroi.

4B.5.4.2 Scientific Significance

AS&R (2009a) has assessed the scientific significance, ie. the potential of a site or place to generate knowledge through archaeological research or knowledge, of the sites and artefacts identified during the four field surveys as follows.

Panels 1 to 7 Survey

The majority of the artefact containing sites (36 of the 41) are considered to be of low scientific significance as they are of very low artefact density (<10 artefacts) and in disturbed contexts. Sites 38 and 39, however, are considered to be of higher scientific significance as they contain at least 113 artefacts (and maybe as many as 500 artefacts) which would provide a good sample for further analysis into choices of material, knapping strategies and tool types.

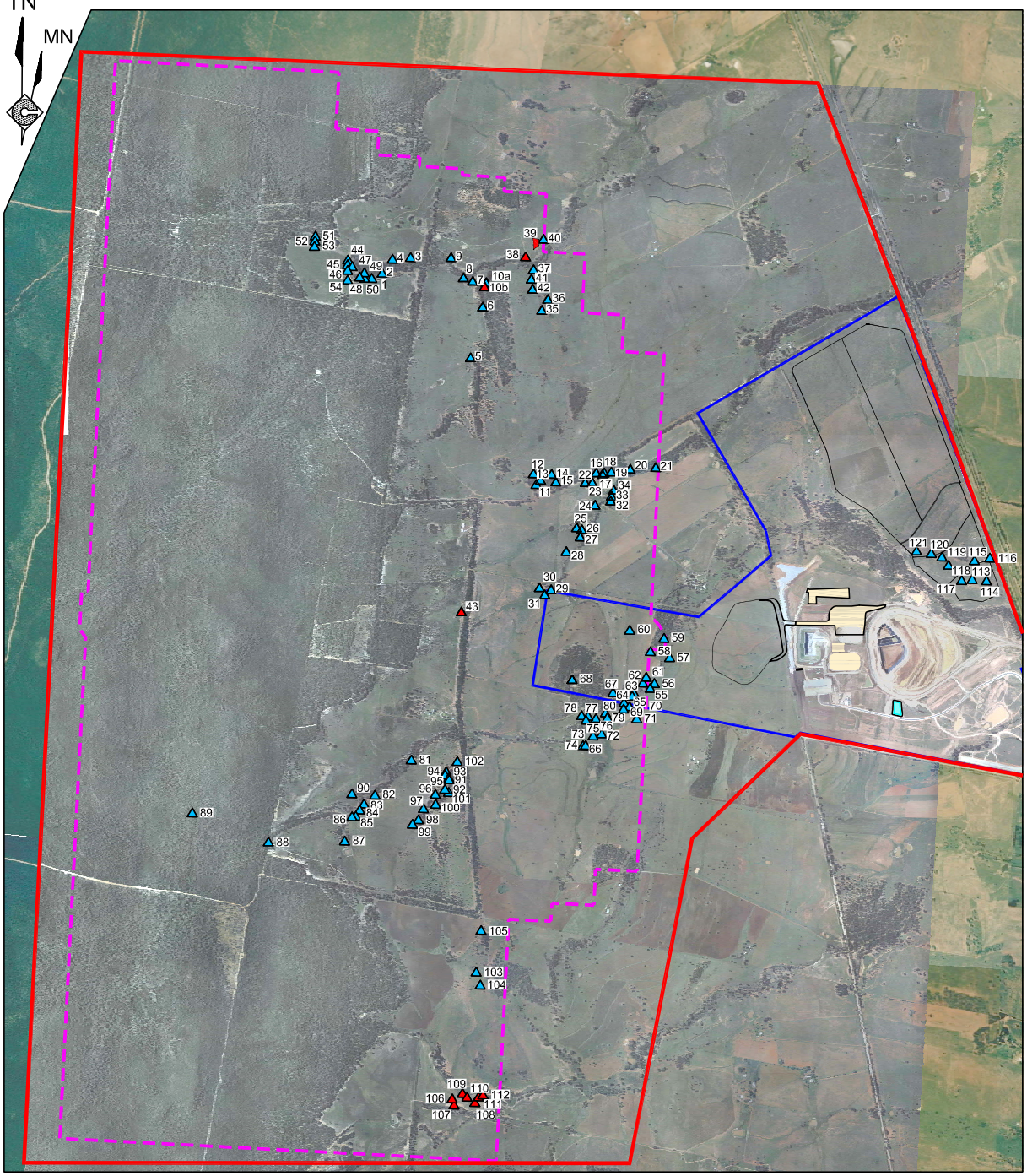
Site 43, a fireplace, is also of higher scientific significance as through collection of the charcoal or ash remaining within the site, the age of the site could be obtained through C_{14} (radio-carbon) date. This would allow for a better understanding as to the period of Aboriginal occupation of the region.

Panels 8 to 26 Survey

Similar to the sites of the Panels 1 to 7 Survey, the majority of the identified sites (62 of 69) are of low artefact density and low scientific significance. However, the complex of sites numbered 106 to 112 (see **Figure 4B.33**) occur in an environment in which there are likely to be many more artefacts, and may provide useful information on knapping strategies, material choice, material use, and intra-site activity areas.

Brine Storage Area and Water Pipeline Route

None of the nine sites recorded in the Brine Pond Storage Area are of scientific significance. No sites were recorded along the Water Pipeline Route.



Note: No Aboriginal Heritage Sites were identified during the Water Pipeline Route Survey

Figure 4B.33
ABORIGINAL HERITAGE SITES
AND GROUPINGS (ALL SURVEYS)

4B.5.5 Management Measures

In-situ Protection of Sites

Of the 43 sites identified within the Mining Area above LW1 to LW7 (Panels 1 to 7 Survey), the Proponent would avoid impact to those identified as being of scientific significance (Sites 38 and 39), specifically noted by the Aboriginal stakeholders (Site 10b) or of higher artefactual density (Site 19). These sites would be protected from inadvertent or accidental damage by vehicular traffic by the erection of fencing, para-webbing or equivalent method and signs erected identifying an "Environmental Protection Zone". By marking these sites in this manner, gas drainage and ventilation design can be more easily tailored to avoid these.

Following the completion of activities in the vicinity of the protected site, the fencing would be removed to allow the cattle to continue to graze the area, and thereby provide a measure of weed control and potential grass-fire hazard reduction that would otherwise not occur if the fencing was to remain.

The Proponent has also committed to avoiding the remaining Aboriginal sites, wherever practicable, through modification to the location or alignment of surface disturbing activities and access roads. It is considered likely that most if not all of these sites would be avoided as the majority of the identified sites occur adjacent to drainage lines, areas likely to be avoided anyway by the Proponent as unsuitable for the purposes of drilling.

No specific protection measures have been developed for the Aboriginal sites located over the remainder of the Mining Area. These areas would be the subject of further more detailed field surveys (including representatives of the registered Aboriginal stakeholders) undertaken over specific areas, eg. LW8 to LW13, LW14 to LW18 etc. The field survey and development of specific management measures to manage the sites identified would be undertaken in accordance with an updated Aboriginal Cultural Heritage Management Plan (ACHMP) for the Mine Site (which is currently being prepared by the Proponent in consultation with the registered Aboriginal stakeholders). This approach to managing Aboriginal sites is considered appropriate given that during the ensuing period between the commencement of the Longwall Project and disturbance over LW8 and beyond, it is probable that many of sites currently not visible would become exposed and similarly many sites currently exposed would no longer be identifiable. It is therefore appropriate that specific management measures be developed and implemented based on the Aboriginal record of the time.

Assuming the implementation of the measures described above, the proposed in-situ management strategy for Aboriginal sites is likely to be highly effective in preventing impact on the Aboriginal sites of higher scientific and cultural significance. The association between the artefact and the location would be maintained, with the local setting returned to pre-mining conditions once the mine has progressed beyond the affected longwall panel.

Site Salvage

The Proponent acknowledges that on some occasions, the location of disturbance associated with ventilation or gas drainage may have restricted scope for relocation due to the requirement to maintain a safe environment underground. Based on the location of the identified sites and proposed disturbance presented in **Figure 4B.32**, a list of the sites that are located within the immediate vicinity of proposed surface disturbing activities and which should be salvaged unless the Company can avoid them has been compiled.

Site	Site Name	Site Type	No of Artefacts
1	Pine Creek T2/OS 1	Artefact scatter	10 to 15
3	Pine Creek T2/OS 2	Artefact scatter	7
6	Pine Creek T2/OS 5	Artefact scatter	3
9	Pine Creek T2/ISO 3	Isolated artefact	1
11	Pine Creek T1/OS 8	Artefact scatter	11
12	Pine Creek T1/OS 9	Artefact scatter	3
15	Pine Creek T1/OS 11	Artefact scatter	2
28	Pine Creek T1/ISO 9	Isolated artefact	1
29	Pine Creek T1/IAO 10	Isolated artefact	1
30	Pine Creek T1/OS 19	Artefact scatter	2
32	Pine Creek T1/OS 21	Artefact scatter	2
33	Pine Creek T1/OS 22	Artefact scatter	2
34	Pine Creek T1/OS 23	Artefact scatter	4
35	Pine Creek T2/OS 24	Artefact scatter	2
40	Pine Creek T2/OS 27	Artefact scatter	4
43	Pine Creek T1/FP1	Fireplace	-

In the instance where a site cannot be avoided, the Proponent would follow the appropriate archaeological management strategy which would be to salvage the artefact(s) and remove them to a secure place agreed to by the registered Aboriginal stakeholders. Any salvage operation would be undertaken following consultation with both Narrabri LALC and Gomeroi and would form part of the updated ACHMP for the Mine Site. Subject to modification by the local Aboriginal stakeholders, salvage would be undertaken as follows.

- The archaeologist would return to the Panels 1 to 7 Survey Area, accompanied by Sites Officers from Narrabri LALC and Gomeroi, to salvage the artefacts from those sites.
- The artefacts would be taken by the archaeologist to allow him time to produce a full analysis of the material. In the case of Site 43, sufficient charcoal or ash would be removed to enable radio-carbon dating).
- The salvaged artefacts would be returned to the authorised Aboriginal organisation within 21 days of the salvage.
- The salvaged artefacts would be placed in the care and control of the Aboriginal organisation agreed to by Narrabri LALC and Gomeroi.
- The archaeologist would produce a report of the salvage, including full descriptions of the salvaged material, and an interpretation of the archaeological record within the Salvage Area.
- Copies of the reports would be given to Narrabri LALC, Gomeroi, DECCW and the Proponent.

- The archaeologist would lodge updated Site Recording Forms for those sites that have been salvaged with DECCW for amending the AHIMS Site Register.
- Should an appropriate long term storage facility or 'keeping place' not be available at the time of salvage, the Proponent has committed, following consultation with the local Aboriginal stakeholders and DECCW, to providing an interim facility until a long term facility is identified.

The proposed salvage of artefacts would be a reliable and effective method of avoiding impacts on the artefacts themselves. However, as these artefacts would be removed from their original location, a residual impact on the site itself would be incurred.

4B.5.6 Assessment of Impacts

4B.5.6.1 Impacts of Surface Disturbance Associated with Longwall Panels 1 to 7

In most cases, there would be no direct impact on the identified sites, as the Proponent would modify surface activities to avoid the identified site. Fencing off the most culturally and scientifically significant sites, would assist in the design of surface activities to avoid these sites.

In the event that mine gas drainage or ventilation requirements prevent the relocation of activities away from an identified site, the impact would be minimised by salvaging, cataloguing and securely storing all artefacts that would be disturbed if retained in-situ. While it is acknowledged that the residual impact on the site itself could not be mitigated, the artefacts themselves would be saved and add to the archaeological record of the region (which currently is very concise). All salvage activities would be undertaken in accordance with an ACHMP to be developed in consultation with Narrabri LALC and Gomeroi, with representatives of both organisations invited to take part in the salvage operations.

On the basis that site salvage would be a last resort of the Proponent, and that the salvage operations would be undertaken as described in Section 4B.5.5, the impact on Aboriginal cultural heritage would be minimised.

4B.5.6.2 Impacts of Subsidence

The impacts of subsidence on Aboriginal sites, ie. differential lowering of the ground surface and/or surface cracking on the identified site types has been assessed by AS&R (2009a). The following provides a summary of the assessed impact of subsidence.

Scarred Trees

The scarred tree (Site 20) is described by AS&R (2009a) as a healthy, living tree with a strong root system and is located on the northern bank of Pine Creek Tributary 2 over the retained chain pillar on the maingate side of LW1. The site is almost certainly within the zone likely to be affected by surface cracking and could possibly be affected by altered drainage patterns. However, AS&R (2009a) have assessed that it is probable that the tree's root system would resist any change to local drainage and/or surface cracking and would be unlikely to fall. AS&R (2009a) concludes that any impact to the tree resulting from subsidence would be minimal if at all.

Axe-grinding Grooves.

The three axe-grinding grooves occur on two sandstone floaters (Site 10b) and so the only impact to the site from subsidence would be the vertical displacement of the floaters, which would have no impact on the axe-grinding grooves.

Artefact Scatters

All of the artefact scatters and isolated artefacts occur on actively degrading surfaces, and some occur within active gullies, and AS&R (2009a) notes that most are likely to have been displaced by slope-wash, stock movement, land clearance, ploughing, harrowing and vehicular traffic, ie. there would be very few artefacts in their original depositional context.

Any subsidence and/or cracking is likely to displace artefacts vertically, however, this is unlikely to have any significant impact on the natural processes affecting horizontal displacement of the artefacts. On the basis of the above it is assessed that the likely impact to open artefact scatters from subsidence to be minimal.

4B.5.6.3 Assessment of Cumulative Impact

The archaeological record of the region is limited, largely due to the fact that most surveys for sites of Aboriginal heritage are associated with proposed development, of which there has been little locally. In the absence of a detailed regional record, AS&R (2009a) considered the cumulative impact of salvaging sites within the Panels 1 to 7 Survey Area in two ways.

1. The impact of salvaging sites relative to the total number of known sites in the Panels 1 to 7 Survey Area.
2. The impact of salvaging sites in the Panels 1 to 7 Survey Area relative to the anticipated total number of sites likely to be present in the Mine Site.

Known Sites in the Panels 1 to 7 Survey Area

As the Proponent has committed to avoiding those sites deemed to be of higher scientific and cultural significance, the only sites likely to be impacted are those of low artefact density or site types which are frequently identified. The cumulative impact of disturbance to a small number of these sites (disturbance is considered unlikely as the Proponent would preferentially avoid all sites) would therefore be minor as a large number of similar low density sites would be retained.

Further mitigating the cumulative impact of the Longwall Project, the Proponent has committed to salvaging those Aboriginal sites that cannot be avoided and undertaking the archaeological research in accordance with the management measure described in Section 4B.5.4. The cumulative impact would be further mitigated by retaining the salvaged artefacts in a 'keeping place', such that a direct connection to the Aboriginal community could be maintained.

Anticipated Archaeological Record of the Mine Site

The southern half of the Mine Site contains similar landforms to that of the Panels 1 to 7 Survey Area and it is therefore anticipated that there would be a similar number and type of sites over the remaining Mining Area as identified in the Panels 1 to 7 Survey Area. By extrapolating the number of sites recorded in the ~800ha area of the Panels 1 to 7 Survey Area over the remaining ~2 400ha of the Mine Site (and taking into account that there are likely to be fewer sites upstream in the densely vegetated woodland covering the western third of the Mine Site),

then it is reasonable to assume that at least another 120 sites would be recorded in the remaining area the vast majority (at least 90%) of which would be isolated artefacts or scatters of five or less artefacts. This prediction is supported by the results of the Panels 8 to 26 Survey Area within which 69 sites were identified of which 82% contained ≤5 artefacts.

Assuming any sites of higher scientific or cultural significance could be avoided, eg. the complex of Sites 106 to 112 (see **Figure 4B.33**) (through for example the design of the gas drainage infrastructure), only low density artefact sites or those types which are frequently identified are likely to be disturbed. The cumulative impact on the local and regional archaeological record is therefore likely to be minor for the same reasons as discussed for the panels 1 to 7 Survey Area.

Based on the relatively low proportion of sites likely to be disturbed and salvaged and the maintenance of those sites of higher significance (cultural and scientific), AS&R (2009a) concludes that the sites remaining after salvage would be representative of the type, number and content of sites throughout the wider region.

4B.6 NON-INDIGENOUS HERITAGE

The non-indigenous heritage assessment was undertaken by Archaeological Surveys and Reports Pty Ltd. The full assessment is presented in Volume 2, Part 6 of the Specialist Consultant Studies Compendium with the relevant information from the assessment summarised in the following subsection. The full assessment is referred to as AS&R (2009b) throughout this document.

4B.6.1 Desktop Search of Heritage Listed Items

A desktop search of the Mine Site on the following heritage databases was conducted on 24 August 2009.

- Narrabri Local Environmental Plan 1992 – Schedule 2.
- Australian Heritage Council Database (which includes places listed in the World Heritage List, National Heritage List, Commonwealth Heritage list and Register of the National Estate).
- National Trust of Australia.

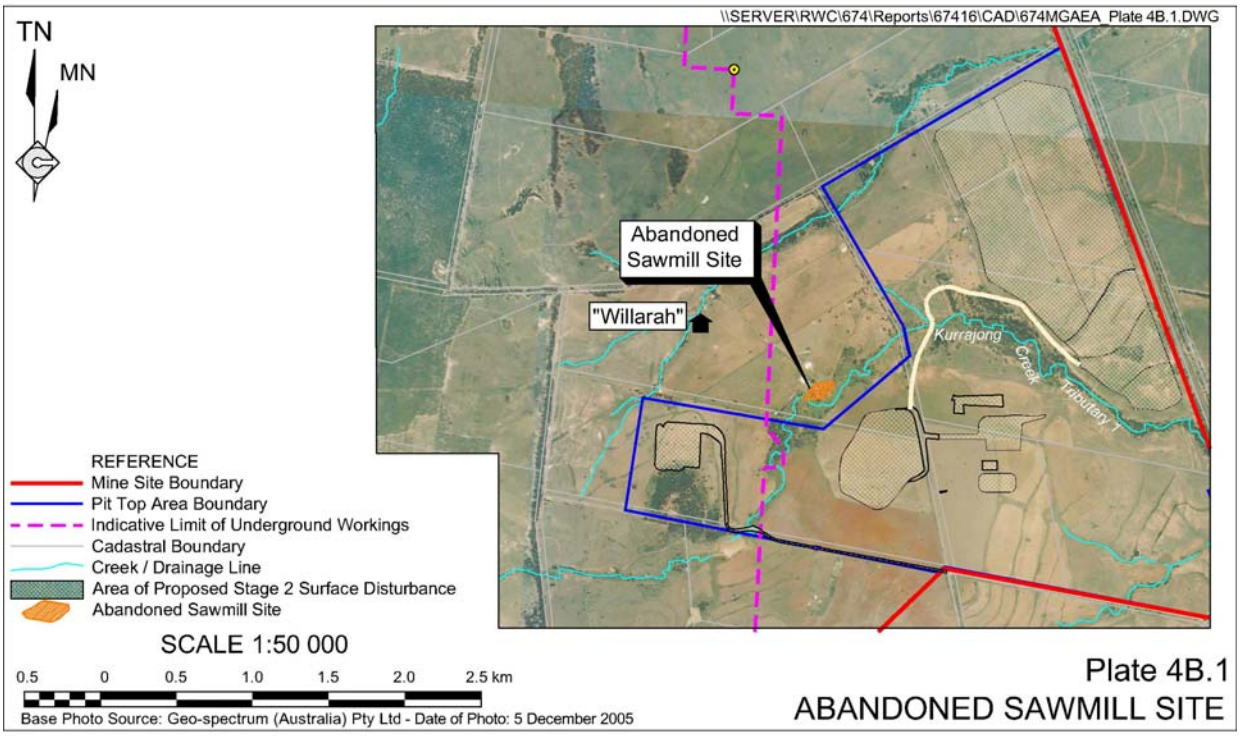
No listed heritage sites were identified within the Mine Site, nor within the vicinity of the Mine Site, with the nearest identified sites being in Narrabri. Additionally, no listed sites occur within Baan Baa nor Turrawan.

4B.6.2 Field Survey of the Mine Site

Archaeological Surveys and Reports Pty Ltd (AS&R) was commissioned to undertake a field survey to record structures, places or relics of heritage significance within the Mine Site. While AS&R identified several older residential structures which would classify as relics (as defined by Section 4 of the *Heritage Act 1977*), only one structure of interest, an abandoned sawmill, was identified.

The sawmill, which AS&R considers to provide an excellent example of the material, equipment and the sequence and relationship of the equipment to the milling process, occurs on the northern bank of Pine Creek Tributary 1, inside the western boundary fence line of the "Willarah" property (see **Plate 4B.1**). A comprehensive photographic record of the site along with a site plan have been recorded and held by (AS&R, 2009b).

Section 4B.6.3 provides an assessment of the heritage significance of the site.



4B.6.3 Assessment of Impacts

While the sawmill site is not listed on the registers of the National Trust, Australian Heritage Council or the Narrabri LEP 1992, it is considered an item of historic interest and accordingly warrants an assessment of its heritage significance.

The following evaluates the sawmill against the NSW Heritage Office (2001) criteria.

- Criterion (a) – *an item is important in the course, or pattern, of NSW's cultural or natural history (or the cultural or natural history of the local area).*
  Nothing is known of the history of this sawmill and its role would only have been significant to the immediate local community. AS&R (2009b) assesses that the site does not meet this criterion.
- Criterion (b) – *an item has a strong or special association with the life or works of a person, or group of persons, of importance in NSW's cultural or natural history (or the cultural or natural history of the local area).*
  AS&R (2009b) assesses that the sawmill does not meet this criterion.

- Criterion (c) – *an item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in NSW (or the local area)*.

  There is no evidence to suggest that the site was unique or in any way technically different to others that might exist elsewhere in the Pilliga or on the adjacent properties. AS&R (2009b) assesses that the site does not meet this criterion.

- Criterion (d) – *an item has strong or special association with a particular community or cultural group in NSW (or the local area) for social, cultural or spiritual reasons*.

  AS&R (2009b) assesses that the sawmill does not meet this criterion.

- Criterion (e) – *an item has potential to yield information that will contribute to an understanding of NSW's cultural or natural history (or the cultural or natural history of the local area)*.

  The information provided by the site is only of value to a specific application, eg. educational purposes and illustration of the milling process. It is probable that there are numerous other abandoned sawmill sites elsewhere and that the Mine Site sawmill is just one of many variations of the sawmilling process. AS&R (2009b) assesses that the site does not meet this criterion.

- Criterion (f) – *an item possesses uncommon, rare or endangered aspects of NSW's cultural or natural history (or the cultural or natural history of the local area)*.

  AS&R (2009b) assesses that the sawmill does not meet this criterion.

- Criterion (g) – *an item is important in demonstrating the principal characteristics of a class of NSW's:*
  - *cultural or natural places; or*
  - *cultural or natural environments (or a class of the local area's: cultural or natural places; or cultural or natural environments)*.

  AS&R (2009b) assesses that the sawmill does not meet this criterion.

AS&R (2009b) concludes that *"the Sawmill is assessed to be of no local historical interest, and of only low educational value, insufficient to warrant its classification as a structure of Heritage Significance"*.

4B.7 NOISE AND VIBRATION

The noise and vibration assessment was undertaken by Spectrum Acoustics Pty Ltd. The full assessment (hereafter as Spectrum Acoustics, 2009) is presented as Volume 2, Part 6 of the Specialist Consultant Studies Compendium, with the relevant information from the assessment summarised in the following subsections. In addition, information on the pre-mining noise environment presented in the previous noise assessment undertaken for Stage 1 of the Narrabri Coal Mine remains applicable in 2009 has been used during this assessment. That report is referred to hereafter as Spectrum Acoustics (2007).

4B.7.1 Introduction

Based on the risk analysis undertaken for the Project (see Section 3.3 and **Table 3.5**), the potential environmental noise impacts requiring assessment and their unmitigated risk rating are as follows.

- Increased noise levels associated with Mine Site activities causing annoyance, distractions, ie. amenity impacts (moderate risk).
- Increased noise and/or vibration levels associated with road and rail traffic causing annoyance, distractions, ie. amenity impacts (moderate risk).
- Maximum noise levels causing sleep disturbance (moderate risk).
- Increased noise levels associated with the project leading to reduced production, ie. impacts on livestock (low risk).
- Blasting-related ground vibration resulting in structural damage to buildings and structures (moderate risk).
- Nuisance/amenity impacts on surrounding landowners / residents resultant from blasting related ground vibration and air overpressure soundwave (low risk).

In addition, the Director-General's Requirements issued by DoP require that the assessment of noise and noise impacts refer to the *NSW Industrial Noise Policy*, *Environmental Criteria for Road Traffic Noise* (EPA, 1999) and *Environmental Noise Control Manual* (EPA, 1994)).

Relevant information on the pre-mining noise environment, environmental noise criteria, proposed operational safeguards and mitigation measures for the Longwall Project and an assessment of the residual impacts following the implementation of these safeguards and mitigation measures is presented in the following sub-sections.

4B.7.2 Pre-mining Noise Environment

As identified in Section 4A.3.2 and **Figure 4A.4**, approximately 14 non-project related residences are located within a 5km radius of the Pit Top Area at which noise may be audible under certain meteorological circumstances during the construction and operation of the Stage 2 components of the Narrabri Coal Mine.

Given the rural locality in which the Narrabri Coal Mine is located, none of the identified residences are currently subjected to significant noise-related impacts, for a high proportion of time, ie. noise levels from transportation or industrial sources. It is therefore assumed that background noise levels (L_{A90})are currently at or below 30dB(A) at all residences during day, evening and night periods.

Under the NSW *Industrial Noise Policy*, it is a standard requirement that noise levels below 30dB(A) can be taken as 30dB(A) for the purposes of assessing industrial noise, such as noise that would be produced by the Longwall Project. As such, a 30dB(A) L_{90} background level has been adopted for all residences during the day, evening and night.

4B.7.3 Environmental Noise and Vibration Criteria

4B.7.3.1 Introduction

The assessment of impacts of the project on the local noise climate has been undertaken by calculating likely noise levels during both the site establishment and operational stages of the Longwall Project and comparing those noise levels against the noise criteria established through reference to:

- the *Industrial Noise Policy* (INP) - for site operational noise (EPA, 2000);
- NSW Environmental Criteria for Road Traffic Noise (ECRTN) (EPA, 1999); and
- Assessing Vibration: A Technical Guideline" (AVTG) published by the DECC

Criteria relevant to assessing the likelihood of sleep disturbance are drawn from current DECCW (EP&RG) considerations which, as yet, are not fully documented.

For the purposes of defining relevant criteria, the DECCW nominate the following times relevant to daytime, evening, night-time periods, ie. for Monday to Saturday.

- Daytime – 7.00am to 6.00pm
- Evening – 6.00pm to 10.00pm
- Night-time – 10.00pm to 7.00am

For Sundays and public holidays, night-time extends from 10.00pm to 8.00am.

4B.7.3.2 Site Establishment Noise Criteria

The Longwall Project is a continuation and expansion of the approved and commenced Narrabri Coal Mine operation. Accordingly, both DECCW and DoP consider the activities to be part of the ongoing mine operation and the existing operational noise criteria, as discussed in Section 4B.7.3.3, are applicable.

4B.7.3.3 Operational Noise Criteria

The INP specifies two noise criteria:

- an *intrusiveness criterion* which limits L_{Aeq} noise levels from the industrial source to a value of 'background plus 5dB(A)';and
- an *amenity criterion* which aims to protect against excessive noise levels where an area is becoming increasingly developed.

Since there is no existing major industry dominating noise levels at any residences near the Mine Site, and road traffic noise is not continuous, only the intrusiveness criteria were considered in setting the existing project-specific operational noise limit.

In addition, as the Mine Site is situated in a rural environment with limited other noise sources, the INP default background noise level of 30dB(A) has been assumed for day, evening and night-time at all non-project related residences.

As a result, the relevant $L_{eq(15\text{-minute})}$ operational noise assessment criteria for the Project for all periods of the day is 35dB(A). It is noted that this is the lowest intrusiveness criterion that can be established under the INP.

4B.7.3.4 Sleep Disturbance Criteria

The DECCW recommends a $L_{1(1\text{-minute})}$ sleep disturbance criterion at building facade of background plus 15dB(A). As a result, the $L_{1(1\text{-minute})}$ sleep disturbance criterion that would apply to the Longwall Project would be 45dB(A).

4B.7.3.5 Road Traffic Noise Criteria

Vehicle noise associated with vehicles operating within the Mine Site is considered to be operational noise. However, vehicle noise associated with Stage 2 components (and the overall Mine Site) on public roads is considered to be road traffic noise. Road traffic noise emissions are managed under the *NSW Environmental Criteria for Road Traffic Noise* (ECRTN) applies.

It is noted that the Longwall Project would result in additional traffic travelling on the Kamilaroi Highway, an arterial road. These vehicle movements would be primarily the result of employees driving to and from work and delivery of consumables and other equipment.

Spectrum Acoustics (2009) notes that the ECRTN arterial road traffic noise criteria are intended to apply to a relatively high traffic flow road. However, as the traffic associated with the Project would tend to be concentrated into short periods of time around shift changes, Spectrum Acoustics (2009) states that the collector road noise traffic criteria are more appropriate for the Project.

As a result, the following $L_{Aeq(1hr)}$ road traffic noise criteria would apply to the Project.

- Day (7:00am to 10:00pm) – 60dB(A)
- Evening (10:00pm to 7:00am) – 55dB(A)

4B.7.3.6 Rail Traffic Noise and Vibration Criteria

Product coal would be transported from the Mine Site to the Port of Newcastle by train via the North Western Branch and Main Northern Railway Lines. **Table 4B.29** presents the noise limits recommended by Chapter 163 of the ENCM.

Table 4B.29
ECNM Recommended Train Noise Levels

Descriptor	Planning Levels	Maximum Levels
$L_{eq,\ 24\ hour}$	55dB(A)	60dB(A)
L_{max}	80dB(A)	85dB(A)
Source: Spectrum Acoustics (2009) – Table 5		

In addition, train traffic vibration criteria were determined based on Appendix B of *Assessing Vibration: A Technical Guideline"* (AVTG) published by the DECC. That document established a maximum allowable vibration velocity of 2.82mm/s for train-induced ground vibration.

4B.7.3.7 Blasting Criteria

The DECCW commonly adopts blasting assessment criteria based on the human comfort criteria identified in the document *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration – September 1990* published by the Australian and New Zealand Environment and Conservation Council (ANZECC). These criteria have been adopted for any blasting associated with the construction of the ventilation shafts and are as follows.

- The recommended maximum overpressure level for blasting is 115dB(L).
- The level of 115dB(L) may be exceeded for up to 5% of the total number of blasts over a 12-month period, but should not exceed 120dB(L) at any time.
- The recommended maximum vibration velocity for blasting is 5mm/s Peak Vector Sum (PVS).
- The PVS level of 5mm/s may be exceeded for up to 5% of the total number of blasts over a 12-month period, but should not exceed 10mm/s at any time.

4B.7.4 Noise and Vibration Controls

A preliminary acoustic assessment identified that under some meteorological conditions, activities undertaken as part of site establishment would likely generate noise levels above the Mine Site noise criteria. In order to minimise the potential for any such noise exceedance, the following controls would be adopted.

Operational Noise Controls

- Ensure that all equipment exhibits sound power levels consistent with the schedules in *Appendix A* of Spectrum Acoustics (2009).
- Restrict the operation of scrapers during construction operations under temperature inversion conditions, namely cool, calm conditions that would typically occur in the late evening to early morning or southwest winds, to only one of the following areas.
  - the longwall unit assembly area;
  - the ROM coal pad area; or
  - the Reject Emplacement Area.
- Apply specific noise reduction in the order of 8dB(A) to 10dB(A) to each drill site over the northern portions of LW1 to LW6 (an equivalent point-source sound power level of ≤109 dB(A) in the direction of the affected residence(s)).

- If specific noise reduction of 10dB(A) cannot be achieved, suspend drilling operations under inversion conditions.
- Fully enclose the rotary breaker with a building (or similar) clad with tilt-up aerated concrete panels, or similar. This form of enclosure would substantially mitigate the low frequency noise from the rotary breaker.
- Enclose the CPP with fully clad steel sheeting with an acoustic profile and line 50% of the internal surface with acoustic insulation.
- Refrain from using the bulldozer on the Reject Emplacement Area under temperature inversion conditions.
- Refrain from construction activities within the Brine Storage Area under temperature inversion conditions.
- Update the existing Noise Management Plan (NMP) prior to the commencement of longwall mining activities. The NMP would incorporate the specific details of all noise controls and the measures to address noise criteria exceedances and/or complaints.
- Undertake noise monitoring at the residences most likely to be affected by noise generated by the initial operations of the Longwall Project, including monthly monitoring at "Greylands", "Kurrajong" (if accessible), "Bow Hills" and "Naroo" during the first winter of construction operations.

Transport Noise Controls and Operational Procedures

- Ensure strict adherence to hours of operation, including road transport activities which would only occur between 7:00am to 10:00pm / 7 days. The despatch of rail wagons carrying product coal is not limited to these hours.
- All project employees and contractors would be instructed to enter and exit the Mine Site in a courteous manner and without causing undue traffic noise.

Blasting Controls

- Ensure that all blasts are designed by a suitably qualified and experienced blasting engineer or shotfirer and that each blast is designed to ensure compliance with the relevant assessment criteria or conditional requirements.

Other Noise and Vibration Controls

In addition to the design and operational features of the Longwall Project, the Proponent would apply the following noise controls.

- Ensure that equipment with lower sound power levels is used in preference to more noisy equipment.
- Maintain the on-site road network to limit body noise from empty trucks travelling on internal roads.
- Maintain an open dialogue with the surrounding community and neighbours to ensure any concerns over noise or vibration are addressed.

For the purposes of this assessment, and based on noise monitoring undertaken by Spectrum Acoustics (2009), inversion conditions are deemed to occur until 8:30am.

4B.7.5 Assessment Methodology

4B.7.5.1 Operational and Sleep Disturbance Noise Assessment

The noise impacts of the operating Longwall Project have been established by Spectrum Acoustics using the *Environmental Noise Model* to predict noise levels at the surrounding residences. The model was constructed by placing the various noise generating equipment in either the most exposed location that mobile equipment would be likely to operate in, or in the proposed location for fixed equipment such as the CPP or rotary breaker. This information was then used to determine estimated noise levels at each of the surrounding residences for three operational scenarios.

- ***Scenario 1:*** Establishment of additional surface facilities, roadworks, the main ventilation shaft and pre-drainage above LW1.
- ***Scenario 2a:*** All surface plant and train loading activities occurring. Goaf drainage pumps above LW1, pre-drainage construction and operation above LW3, goaf gas drainage construction above LW2 and ventilation operations (from the main ventilation shaft and rear of panel ventilation shaft).
- ***Scenario 2b:*** As for Scenario 2a with brine storage pond construction in the northern corner of the allocated area (representing worst-case operating conditions for residences to the north and northeast of the mining operations).
- ***Scenario 3a:*** All surface plant and train loading activities occurring. Goaf drainage pumps above LW23 and LW24, goaf gas drainage construction above LW24, pre-drainage construction above LW25 and LW26, and ventilation operations (from the main ventilation shaft and rear of panel ventilation shaft).
- ***Scenario 3b:*** As for Scenario 3a with brine storage pond construction in the southeastern corner of the allocated area (representing worst-case operating conditions for residences to the south and southeast of the mining operations).

The noise assessment initially assumed that all construction activities would take place simultaneously (as illustrated on **Figures 4B.34)** and that the sound power levels of all earthmoving equipment would correspond with the sound power levels presented in *Appendix A* of Spectrum Acoustics (2009). Additional noise modelling was then undertaken, incorporating additional noise control measures aimed at reducing the noise levels predicted at the various residences surrounding the Mine Site. The most effective of these controls would be implemented as described in Section 4B.7.4.

As mining operations would be undertaken 24 hours per day with the activities occurring during each period essentially the same, separate operational noise scenarios for each period were not calculated. However, based on the likelihood of intense temperature inversions and a prevailing wind from the southeast, the following meteorological conditions were modelled.

- Daytime lapse: 20°C, 70% relative humidity, no wind, 1°C/100m vertical temperature gradient.
- Temperature inversion (mild): 2-10ºC, 80-95% relative humidity, 2°C/100m vertical temperature gradient
- Temperature inversion (moderate): 2-10ºC, 80-95% relative humidity, 4°C/100m vertical temperature gradient
- Temperature inversion (severe): 2-10ºC, 80-95% relative humidity, 6°C/100m vertical temperature gradient
- Prevailing (southeast) wind: 20ºC, 70% relative humidity, 3m/s wind from the southeast.

A potential for sleep disturbance would occur during operations within the Pit Top Area due to general impact noise from the rotary breaker, CPP and coal (train) loading operations. Spectrum Acoustics (2009) modelled impact noise under the noise-enhancing atmospheric conditions discussed above using the sound power levels presented in *Appendix A* of Spectrum Acoustics (2009).

4B.7.5.2 Road and Rail Traffic Assessment

Additional rail traffic generated by the Longwall Project would be of an intermittent rather than constant nature. As a result, the methodology described in the document *Information on Levels of Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, March 1974* published by the US Environmental Protection Agency was used to determine the road and rail traffic noise. The equations used in that assessment are presented as Equations 1 and 2 of Spectrum Acoustics (2009).

4B.7.5.3 Rail Vibration Assessment

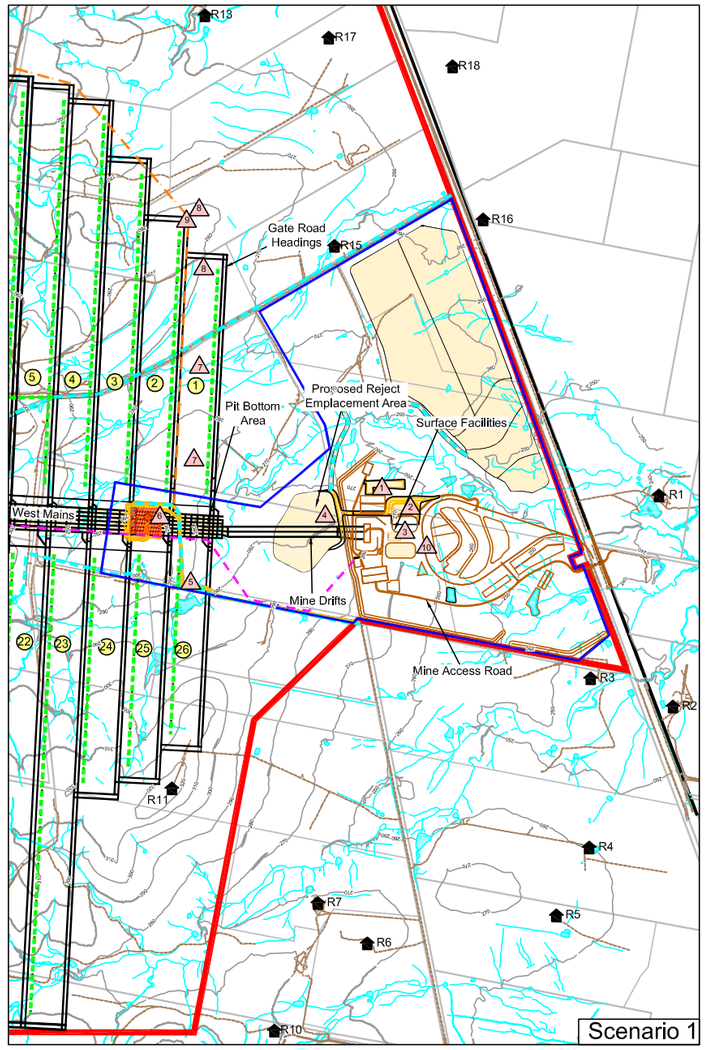
Spectrum Acoustics (2009) notes that vibration levels from laden and unladen coal trains have been widely studied. These studies concluded that vibrations at a distance of 20m from the track are typically less than 1mm/s. As no residences in the vicinity of the Mine Site occur within 20m the North Western Branch Railway Line and the Main Northern Line, Spectrum Acoustics (2009) did not consider rail vibration further.

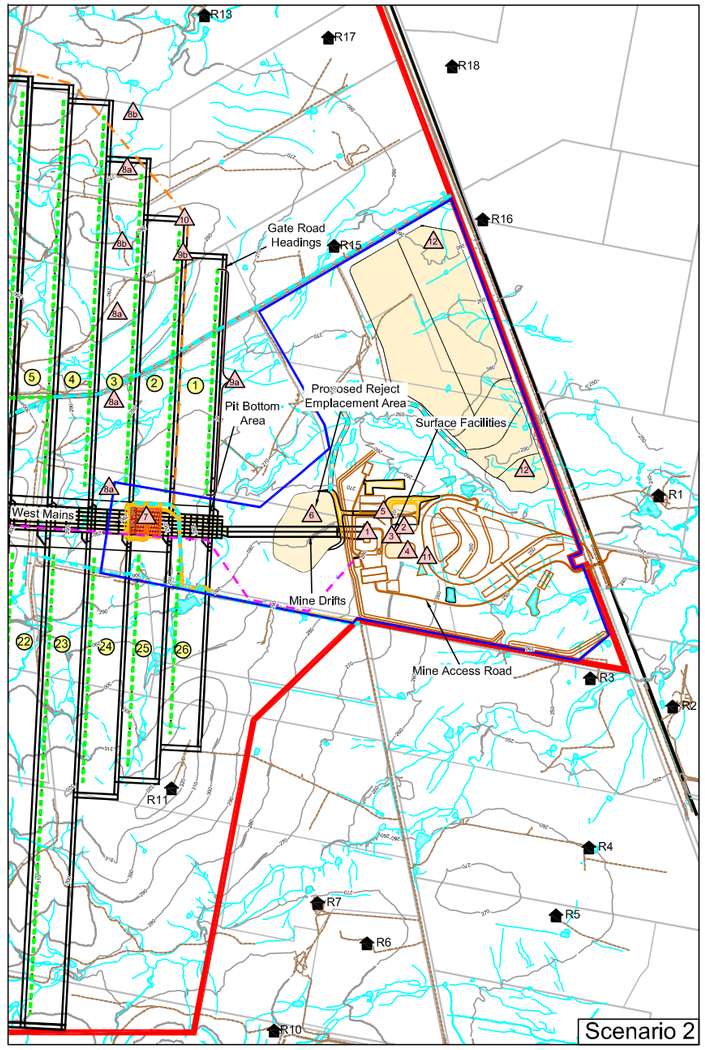
4B.7.5.4 Blasting Assessment

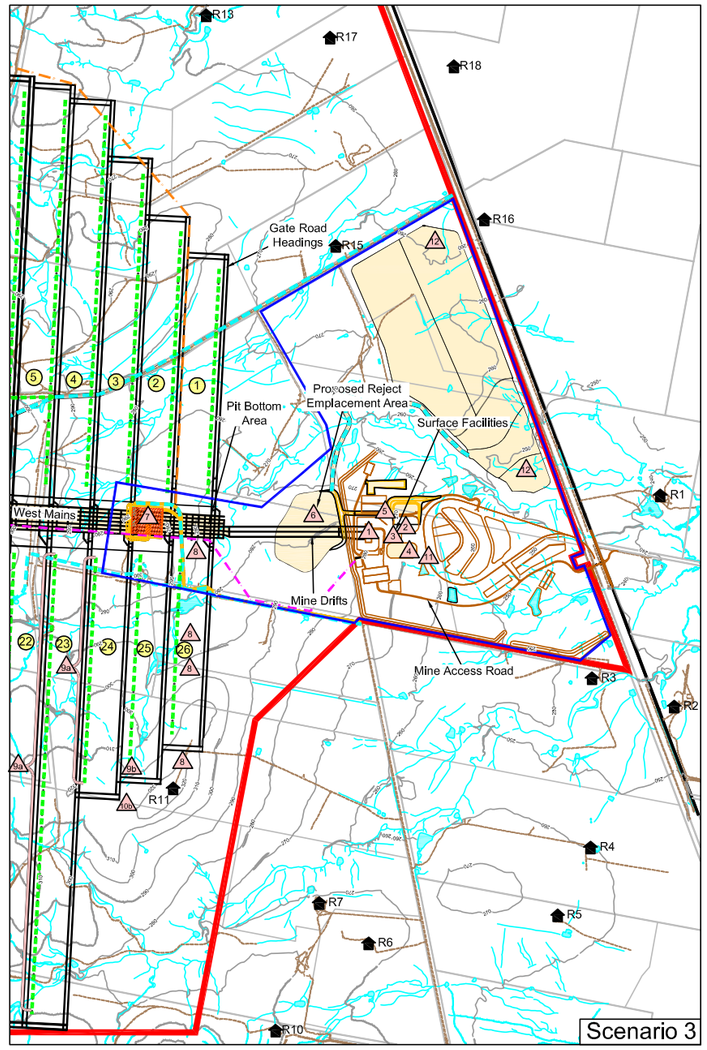
Blast overpressure and ground vibration levels have been predicted by Spectrum (2009) using the following standard equations sourced from the United States Bureau of Mines.

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TN
MN







Noise Activity Areas - Scenario 1

1. **Longwall Unit Assembly Area :** Crane (x3), Scraper (x2), Excavator (35t) & Water cart.
2. **ROM Coal Pad Extension :** Cranes (x2), Scraper (x2), Excavator (45t), Bulldozer (D8), Grader (14G Cat) & Water cart.
3. **Coal Preparation Plant:** Cranes (x3) & Excavator.
4. **Reject Emplacement Area Construction:** Scraper (x2), 50t articulated haul truck & Water cart.
5. **General Road Construction :** Grader (14G Cat), Gravel truck (x2) & Water cart
6. **Ventilation Shaft Construction :** Drill Rig, Bulldozer (D8), Gravel truck & Water cart
7. **Coal Seam Pre-Drainage Activities:** Various pumps and generators
8. **Pre-Drainage Site Preparation:** Drill rig, Bulldozer (D8), Gravel truck & Water Cart*.
9. **Rear of Panel Exhaust Ventilation (Construction) :** Drill Rig, Bulldozer (D8), Gravel truck & Water Cart*.
10. **Rail Load-out:** Rail loading from bin to Wagons, idling locomotives on Rail Loop & shunting wagons on Rail Loop.

*Note: Bulldozer and Drill Rig would not operate simultaneously

REFERENCE
- Mine Site Boundary
- Pit Top Area Boundary
- Cadastral Boundary
- 260 Contour (m AHD)(Interval = 10m)
- Creek / Drainage Line
- Approved Disturbance within the Pit Top Area
- Area of Proposed Stage 2 Surface Disturbance
- Proposed Stage 2 All Weather Unsealed Access Road
- Proposed Stage 2 Power Line
- Proposed Stage 2 Power Line Advancing with Mine
- Proposed Stage 2 Access for Goaf Drainage
- Proposed Stage 2 Rear of Panel Ventilation Intake or Exhaust Shaft
- Proposed Ventilation Shaft Location
- 1 Longwall Panel No.
- Ventilation Shaft Area
- Noise Generating Activity Reference
- R1 Residential Receiver

Noise Activity Areas - Scenario 2

1. **Box Cut and Mine Portals:** Drift Conveyor (x1), Underground Transports (x7).
2. **ROM Coal Pad:** ROM skyline conveyor and tipper (x1), Bulldozer (D10)(x2), Rotary breaker (x1), Dry screen (x1), Water cart (x1).
3. **Coal Preparation Plant:** Jig Washing Plant (24hours/7 days), Tertiary Screen, Cyclones & Thickener.
4. **Product Coal Pad:** Product skyline conveyor and tripper (24hours/7days), Bulldozer (D10)(x2), & Water cart (x1).
5. **Reject Stockpile Area:** Conveyor (x1) & Front-end loader (x1).
6. **Reject Emplacement Area :** Haul Truck (50t)(x1), Bulldozer (D8)(x1), & Water cart (x1).
7. **Ventilation Shaft Area:** Ventilation fan & Support vehicle.
8a. **Pre-Drainage Sites:** Dewatering pump, Vacuum pump & Generator.
8b. **Pre-Drainage Site Preparation:** Drill rig or Bulldozer (D8), Gravel truck & Water Cart*.
9a. **Goaf Gas Drainage:** Vacuum pump & Generator (x2) (multiple locations).
9b. **Goaf Gas Drainage Site Preparation:** Drill rig, Bulldozer (D8), Gravel truck & Water Cart*.
10. **Rear of Panel Exhaust Ventilation :** Ventilation fan & Support vehicle.
11. **Rail Load-out:** Rail loading from bin to Wagons, idling locomotives on Rail Loop & shunting wagons on Rail Loop.
12. **Brine Storage Area Construction:** Haul Truck (50t)(x1), Bulldozer (D8)(x1) & Water cart (x1) .

*Note: Bulldozer and Drill Rig would not operate simultaneously

Noise Activity Areas - Scenario 3

1. **Box Cut and Mine Portals:** Drift Conveyor (x1), Underground Transports (x7).
2. **ROM Coal Pad:** ROM skyline conveyor and tipper (x1), Bulldozer (D10)(x2), Rotary breaker (x1), Dry screen (x1), Water cart (x1).
3. **Coal Preparation Plant:** Jig Washing Plant (24hours/7 days), Tertiary Screen, Cyclones & Thickener.
4. **Product Coal Pad:** Product skyline conveyor and tripper (24hours/7days), Bulldozer (D10)(x2), & Water cart (x1).
5. **Reject Stockpile Area:** Conveyor (x1) & Front-end loader (x1).
6. **Reject Emplacement Area:** Haul Truck (50t)(x1), Bulldozer (D8)(x1), & Water cart (x1).
7. **Ventilation Shaft Area:** Ventilation fan & Support vehicle.
8. **Pre-Drainage Sites:** Dewatering pump, Vacuum pump & Generator.
9a. **Goaf Gas Drainage:** Vacuum pump & Generator (x2) (multiple locations).
9b. **Goaf Gas Drainage Site Preparation:** Drill rig or Bulldozer (D8), Gravel truck & Water Cart*.
10a. **Rear of Panel Exhaust Ventilation :** Ventilation fan & Support vehicle.
10b. **Rear of Panel Exhaust Ventilation :** Drill rig or Bulldozer (D8), Gravel truck & Water Cart.
11. **Rail Load-out:** Rail loading from bin to Wagons, idling locomotives on Rail Loop & shunting wagons on Rail Loop.
12. **Brine Storage Area Construction:** Haul Truck (50t)(x1), Bulldozer (D8)(x1) & Water cart (x1) .

*Note: Bulldozer and Drill Rig would not operate simultaneously

SCALE 1:50 000

0.5 0 0.5 1.0 1.5 2.0 2.5 km

Figure 4B.34
MINE SITE OPERATIONAL ACTIVITIES (SCENARIOS 1,2 & 3) AND SURROUNDING RESIDENCES

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Blast Overpressure

$$OP = 165 - 24(\log_{10}(D) - 0.3\log_{10}(Q)) \text{ [dB(L)]}$$

Where:

- D is distance from the blast to the assessment point (m); and
- Q is the weight of explosive per delay (kg).

Spectrum Acoustics (2009) reports that analysis of 12 months of blast data for a coal mine in the Hunter Valley has shown this equation to underestimate overpressure levels by up to 3dB(L) for small blasts (MIC 100-400kg) and over-estimate by 1dB(L) for larger blasts (MIC >400kg). Given the small MIC values likely to be necessary for ventilation shaft construction, a 3dB(L) correction has been applied for the Longwall Project.

Blast Vibration

$$PPV = 1140\left(\frac{D}{Q^{0.5}}\right)^{-1.6} \text{ [mm/s]}$$

Where:

- D is distance from the blast to the assessment point (m); and
- Q is the weight of explosive per delay (kg).

4B.7.6 Assessment Results

4B.7.6.1 Operational Noise Assessment

Scenario 1

Figure 4B.35 presents noise contours generated by the noise modelling of Spectrum Acoustics (2009) for Scenario 1 under severe inversion and southeast wind conditions[13]. **Table 4B.30** presents the predicted operational noise levels at the nominated residential receivers on and surrounding the Mine Site under calm and noise enhancing conditions. The results presented in **Table 4B.30** apply a 4dB(A) reduction to the modelling results presented in Spectrum Acoustics (2009) under inversion conditions. This is based on the supplementary modelling undertaken by Spectrum Acoustics (2009) that calculated a reduction in the total number of operating scrapers from six to two reduces the predicted noise level received by 4dB(A). The results presented in **Table 4B.30** also apply the supplementary modelling results of Spectrum Acoustics (2009) related to the application of specific noise reduction measures to the drilling operations. Both noise mitigation measures are identified in Section 4B.7.4.

When considering the scale of noise exceedance, receivers are considered to be within a noise 'affectation' (or 'acquisition') zone or noise 'management' zone. The noise affectation zone refers to where there are exceedances greater than 5dB(A) that cannot reasonably or feasibly be reduced to the criterion level, or at least to no more than 5dB(A) above this level. The noise management zone refers to where the predicted noise levels are 1 to 5dB(A) above the criterion.

[13] The contours supplied by Spectrum Acoustics (2009) and presented on **Figure 4B.35** are the unmitigated noise levels, ie. these do not incorporate the noise mitigation measures described in Section 4B.7.4 which are predicted to reduce received noise levels to the levels presented in **Table 4B.30**.

Table 4B.30
Predicted $L_{eq(15\text{-}minute)}$ Operational Noise Levels (Scenario 1)

Location		Scenario					Criterion dB(A)	Maximum Differential dB(A)*
		1	2	3	4	5		
		Lapse (calm)	Inversion (^{0}C/100m)			SE wind (3m/s)		
			2	4	6			
R1	"Bow Hills"	30	35	**36**	**38**	29	35	+3
R2	"Ardmona"	25	30	31	34	20	35	-1
R3	"Naroo"	31	**36**	**37**	**40**	26	35	+5
R4	"Oakleigh"	25	31	32	34	20	35	-2
R5	"Pineview"	<20	26	27	29	<20	35	-6
R6	"Matilda"	<20	27	28	30	<20	35	-5
R7	"Haylin View"	20	29	30	32	<20	35	-3
R10	"Merrilong"	<20	25	27	28	<20	35	-7
R11	"Kurrajong"	30	**≤35***	**≤35***	**≤35***	28	35	0
R13	"Newhaven"	32	35	≤35*	≤35*	≤35*	35	0
R15	"Greylands"	35	**≤35***	**≤35***	**≤35***	**39**	35	**+4**
R16	"Belah Park"	29	32	34	**≤35***	32	35	0
R17	"Bungaree"	28	31	32	35	30	35	0
R18	"Merulana"	20	27	29	31	26	35	-4

Note: **Bold** = Exceedance of criterion
Note *: Compliance achieved through noise mitigation of drilling operations

Source: Modified after Spectrum Acoustics (2009) – Table 6 (4dB(A) reduction applied based on noise mitigation related to restricted operation of scrapers under inversion conditions – see Section 4B.7.4)

Exceedances of noise criteria at the 'southern' receivers (R1 to R11), where operating scrapers are the dominant noise source, would be maintained within the noise management zone (assuming the implementation of the nominated noise control measures).

Exceedances of noise criterion at the 'northern' receivers (R13 to R18), where the dominant noise sources are drilling activities at the northern ends of LW1 to LW3, would be restricted to southeast wind conditions (in the event the specific noise reductions are not implemented at each drill site, rather drilling operations restricted under inversion conditions).

Through the implementation of the proposed noise controls documented in Section 4B.7.4, exceedance of the noise criterion could be achieved at most receivers under most conditions. When inversions occur, exceedances of up to 5dB(A) are predicted at "Naroo" and "Bow Hills". Exceedances of up to 4dB(A) are also predicted under southeast wind conditions at the "Newhaven" and Greylands" residences. It is noted that no further reasonable or feasible mitigation measures have been identified which could be implemented to reduce the predicted noise levels further.

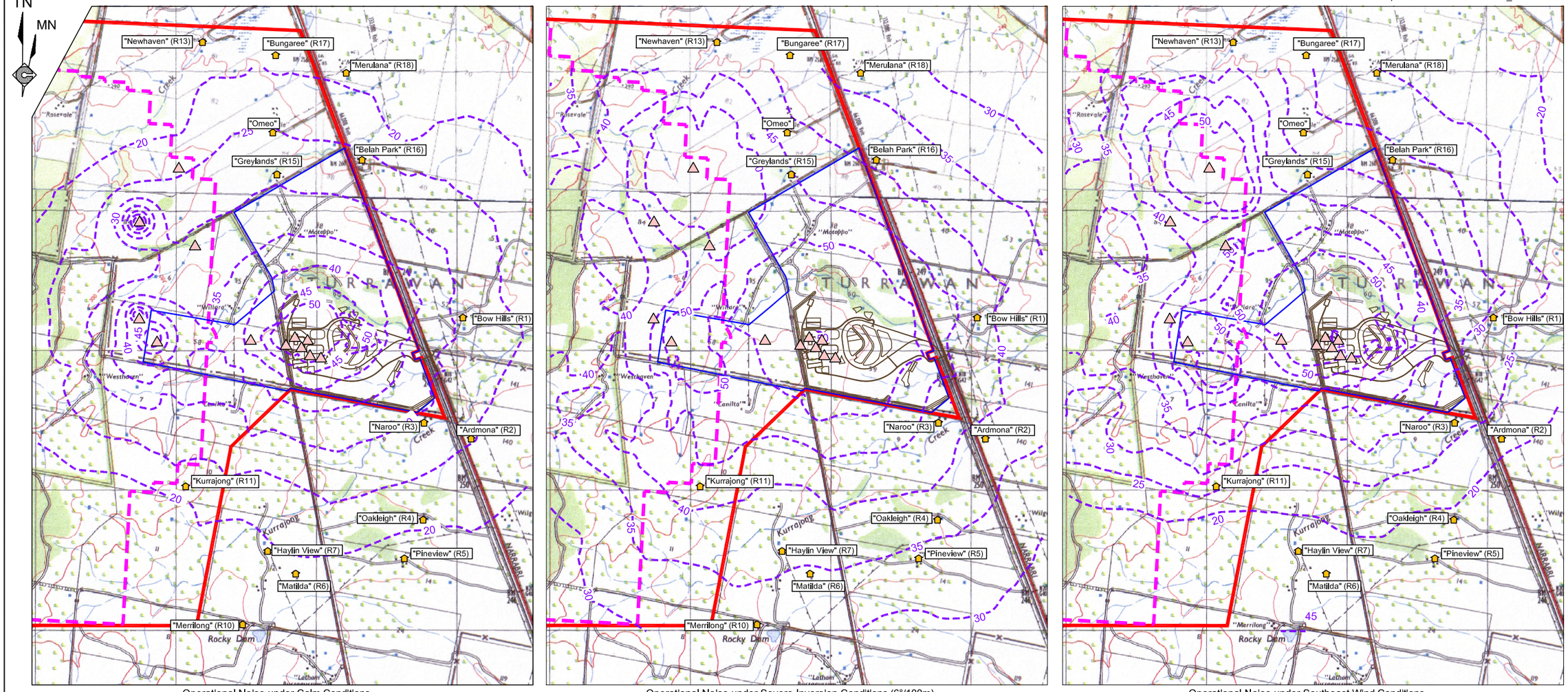
The moderate exceedances of criteria, which fall within the noise management zone, are considered acceptable given:

i) the reasonable or feasible mitigation measures have been identified and would be implemented;

ii) the predicted exceedances are only likely to occur under specific conditions, eg. severe inversion conditions only occur when the air temperature is $\leq 0^0$C, the relative humidity is near 100%, barometric pressure is high (stable atmosphere) and there is little or no cloud cover or air movement; and

iii) the predicted noise levels will ultimately decrease as surface earthworks requiring scrapers are completed and drilling activities move further to the west.

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Operational Noise under Calm Conditions

Operational Noise under Severe Inversion Conditions (6°/100m)

Operational Noise under Southeast Wind Conditions

REFERENCE
Mine Site Boundary
Indicative Limit of Underground Workings
Pit Top Area Boundary
Approved Disturbance within the Pit Top Area
Noise Generating Activity (see Figure 4B.34 for Detail)
25 Noise Contour (dB(A)), Leq(15 minute)
Residential Receiver

SCALE 1:60 000

1 0 1 2 3km

Source: Spectrum Acoustics Pty Ltd (2009) - Figures B4, B5 & B6

Figure 4B.35
PREDICTED OPERATIONAL NOISE
(SCENARIO 1)

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Noise monitoring would be conducted monthly, rather than quarterly, during the first winter of longwall operations, ie. 2011 to determine the level of impact at the four potentially affected residences. Criterion exceedances would be mitigated or otherwise addressed through the development and implementation of an updated Noise Management Plan.

Scenario 2a and 2b

Figure 4B.36 presents noise contours generated by the noise modelling of Spectrum Acoustics (2009) for Scenario 2(b) under severe inversion and southeast wind conditions[14]. **Table 4B.31** presents the predicted noise levels of Scenario 2a at the nominated residential receivers on and surrounding the Mine Site under calm and noise enhancing conditions. The results presented in **Table 4B.31** apply the supplementary modelling results of Spectrum Acoustics (2009) (which include the noise mitigation measures presented in Section 4B.7.4).

Assuming the implementation of the proposed noise mitigation measures (see Section 4B.7.4), exceedances of the noise criterion would be restricted to a 2dB(A) exceedance at the "Bow Hills" and "Naroo" residences under severe inversion conditions, and a 3dB(A) (increasing to 5dB(A) when construction activities are undertaken in the Brine Storage Area) exceedance at the "Greylands" residence.

It is noted that no further reasonable or feasible mitigation measures have been identified which could be implemented to reduce the predicted noise levels further.

The moderate exceedances of criteria, which fall within the noise management zone, are considered acceptable given:

i) the reasonable or feasible mitigation measures have been identified and would be implemented;

ii) the predicted exceedances are only likely to occur under specific conditions, eg. severe inversion conditions only occur when the air temperature is $\leq 0^0$C, the relative humidity is near 100%, barometric pressure is high (stable atmosphere) and there is little or no cloud cover or air movement; and

iii) the predicted noise levels will ultimately decrease as surface earthworks requiring scrapers are completed and drilling activities move further to the west.

As noted previously, noise monitoring would be conducted monthly during the first winter of longwall operations to determine the level of impact at the four potentially affected residences. Criterion exceedances would be mitigated or otherwise addressed through the development and implementation of an updated Noise Management Plan.

[14] The contours supplied by Spectrum Acoustics (2009) and presented on **Figure 4B.36** are the unmitigated noise levels, ie. these do not incorporate the noise mitigation measures described in Section 4B.7.4 which are predicted to reduce received noise levels to the levels presented in **Table 4B.31**.

Table 4B.31
Predicted $L_{eq(15\text{-}minute)}$ Operational Noise Levels (Scenario 2a)

Location		Scenario					Criterion dB(A)	Maximum Differential dB(A)*
		1	2	3	4	5		
		Lapse (calm)	Inversion (^{0}C/100m)			SE wind (3m/s)		
			2	4	6			
Scenario 2a								
R1	"Bow Hills"	29	35	≤35*	**37***	27	35	**+2***
R2	"Ardmona"	25	31	33	35	20	35	0
R3	"Naroo"	29	35	≤35*	**37***	25	35	**+2***
R4	"Oakleigh"	22	30	32	34	<20	35	-1
R5	"Pineview"	<20	27	29	31	<20	35	-4
R6	"Matilda"	<20	28	30	32	<20	35	-3
R7	"Haylin View"	20	30	32	34	<20	35	-1
R10	"Merrilong"	<20	26	27	30	<20	35	-5
R11	"Kurrajong"	23	32	35	≤35*	23	35	0*
R13	"Newhaven"	29	34	35	≤35*	35	35	0*
R15	"Greylands"	31	≤35*	<35*	≤35*	**37**	35	**+2***
R16	"Belah Park"	26	34	35	≤35*	31	35	0*
R17	"Bungaree"	24	30	32	33	29	35	-2
R18	"Merulana"	21	27	30	31	27	35	-4
Scenario 2b								
R1	"Bow Hills"	30	36	≤35*	**37***	27	35	**+2**
R2	"Ardmona"	25	31	34	35	20	35	0
R3	"Naroo"	30	35	≤35*	**37***	25	35	**+2**
R4	"Oakleigh"	23	30	33	35	20	35	0
R5	"Pineview"	<20	27	29	32	<20	35	-3
R6	"Matilda"	<20	28	30	33	<20	35	-2
R7	"Haylin View"	20	30	32	34	<20	35	-1
R10	"Merrilong"	<20	26	28	31	<20	35	-5
R11	"Kurrajong"	26	34	35	<35*	24	35	0
R13	"Newhaven"	30	34	35	<35*	35	35	0
R15	"Greylands"	35	≤35*	<35*	≤35*	**40**	35	**+5**
R16	"Belah Park"	34	≤35*	<35*	≤35*	35	35	0
R17	"Bungaree"	25	30	33	34	29	35	-1
R18	"Merulana"	22	28	31	33	28	35	-2

Note: **Bold** = Exceedance of criterion
Note *: Incorporates the proposed noise mitigation measures of Section 4B.7.4
Source: Modified after Spectrum Acoustics (2009) – Tables 8 and 9 (after incorporation of the noise mitigation measures of Section 4B.7.4)

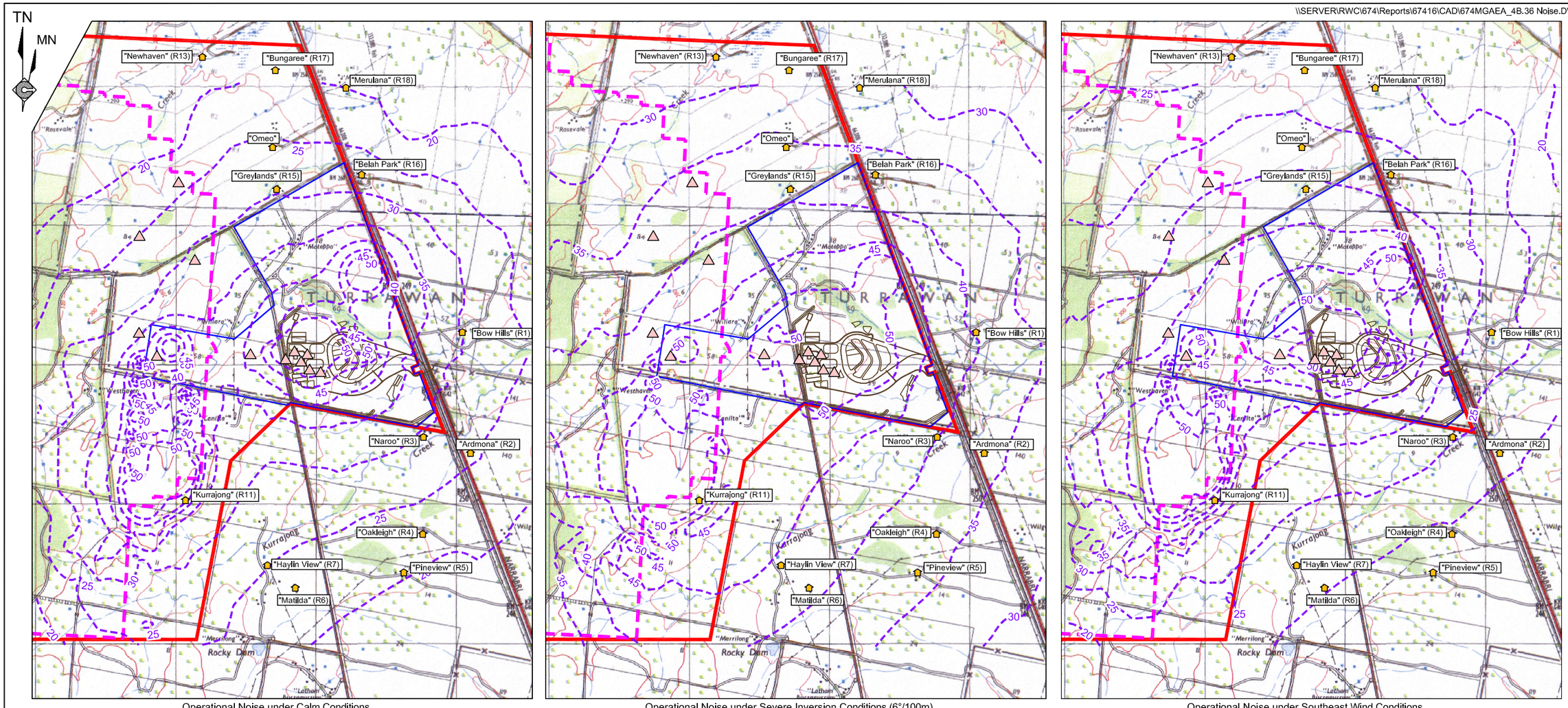
Scenario 3a and 3b

Figure 4B.37 presents noise contours generated by the noise modelling of Spectrum Acoustics for Scenario 3(b) under severe inversion and southeast wind conditions[15]. **Table 4B.32** presents the predicted operational noise levels at the nominated residential receivers on and surrounding the Mine Site under calm and noise enhancing conditions.

Notably, the proposed noise mitigation measures described in Section 4B.7.4 would reduce the noise levels received at most residences such that compliance with noise criteria could be achieved. Moderate exceedances of up to 3dB(A) (within the noise management zone) are still predicted under moderate inversion, severe inversion and/or southeast wind conditions at three residences, namely: "Bow Hills", "Naroo", and "Greylands".

[15] The contours supplied by Spectrum Acoustics (2009) and presented on **Figure 4B.37** are the unmitigated noise levels, ie. these do not incorporate the noise mitigation measures described in Section 4B.7.4 which are predicted to reduce received noise levels to the levels presented in **Table 4B.32**.

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Operational Noise under Calm Conditions

Operational Noise under Severe Inversion Conditions (6°/100m)

Operational Noise under Southeast Wind Conditions

REFERENCE
- Mine Site Boundary
- Indicative Limit of Underground Workings
- Pit Top Area Boundary
- Approved Disturbance within the Pit Top Area
- Noise Generating Activity (see Figure 4B.34 for Detail)
- 25 Noise Contour (dB(A)), Leq(15 minute)
- Residential Receiver

SCALE 1:60 000

1 0 1 2 3km

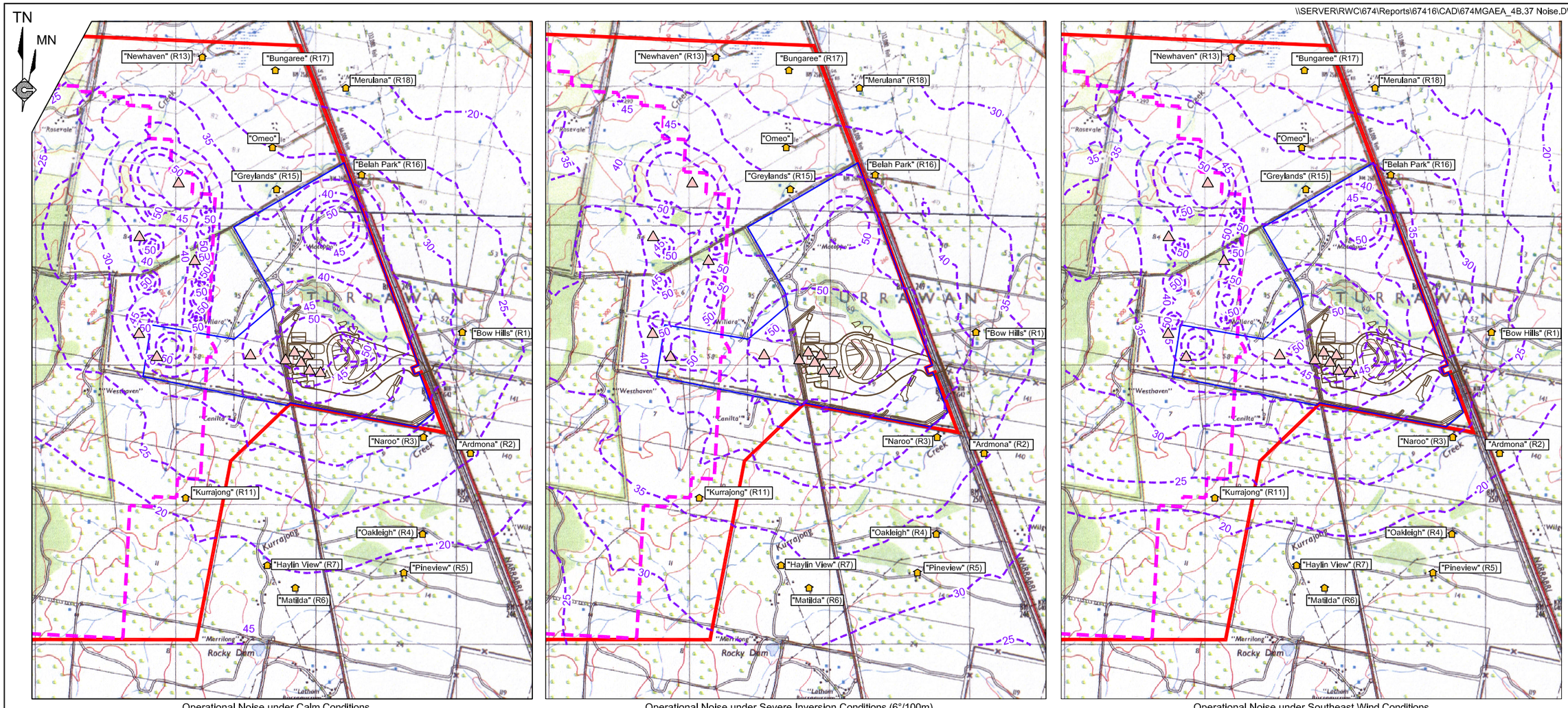
Source: Spectrum Acoustics Pty Ltd (2009) - Figures B4, B5 & B6

Figure 4B.36
PREDICTED OPERATIONAL NOISE
(SCENARIO 2B)

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Operational Noise under Calm Conditions

Operational Noise under Severe Inversion Conditions (6°/100m)

Operational Noise under Southeast Wind Conditions

REFERENCE
- Mine Site Boundary
- Indicative Limit of Underground Workings
- Pit Top Area Boundary
- Approved Disturbance within the Pit Top Area
- Noise Generating Activity (see Figure 4B.34 for Detail)
- 25 Noise Contour (dB(A)), Leq(15 minute)
- Residential Receiver

SCALE 1:60 000

1 0 1 2 3km

Source: Spectrum Acoustics Pty Ltd (2009) - Figures B4, B5 & B6

Figure 4B.37
PREDICTED OPERATIONAL NOISE
(SCENARIO 3B)

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Table 4B.32
Predicted $L_{eq(15\text{-}minute)}$ Operational Noise Levels (Scenario 3)

Location		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Criterion dB(A)	Maximum Differential dB(A)*
		Lapse (calm)	Inversion (^{0}C/100m) 2	Inversion (^{0}C/100m) 4	Inversion (^{0}C/100m) 6	SE wind (3m/s)		
Scenario 3a								
R1	"Bow Hills"	30	<35*	**36***	**37***	27	35	**+2**
R2	"Ardmona"	25	<33*	<34*	34	21	35	-1
R3	"Naroo"	29	34*	**36***	**38***	25	35	**+3**
R4	"Oakleigh"	23	<33*	<35*	35*	20	35	0
R5	"Pineview"	20	32	33	35	<20	35	0
R6	"Matilda"	22	34	<35*	<35*	20	35	0
R7	"Haylin View"	25	<35*	<35*	<35*	22	35	0
R10	"Merrilong"	24	<35*	<35*	<35*	20	35	0
R11	"Kurrajong"	**>40**	**>40**	**>40**	**>40**	**43**	35	**8**
R13	"Newhaven"	21	25	28	29	25	35	-6
R15	"Greylands"	30	34*	**37***	**38***	**37**	35	**+3**
R16	"Belah Park"	26	<34*	33*	35*	31	35	0
R17	"Bungaree"	20	28	30	31	28	35	-4
R18	"Merulana"	20	27	29	31	27	35	-4
Scenario 3b								
R1	"Bow Hills"	30	<35*	**36***	**37***	27	35	**+2**
R2	"Ardmona"	25	<33*	<34*	34	21	35	0
R3	"Naroo"	30	34*	**36***	**38***	25	35	**+3**
R4	"Oakleigh"	23	<34*	<35*	35*	20	35	0
R5	"Pineview"	20	32	33	35	<20	35	0
R6	"Matilda"	23	<35*	<35*	<35*	20	35	0
R7	"Haylin View"	25	<35*	<35*	<35*	22	35	0
R10	"Merrilong"	24	<35*	<35*	<35*	20	35	0
R11	"Kurrajong"	**>40**	**>40**	**>40**	**>40**	**46**	35	**11**
R13	"Newhaven"	20	27	28	30	26	35	-5
R15	"Greylands"	30	34*	**37***	**38***	**38**	35	**+3**
R16	"Belah Park"	26	<34*	33*	35*	34	35	0
R17	"Bungaree"	22	28	30	31	28	35	-4
R18	"Merulana"	21	28	30	31	27	35	-4

Note: **Bold** = Exceedance of criterion
Note *: Incorporates the proposed noise mitigation measures of Section 4B.7.4
Source: Modified after Spectrum Acoustics (2009) – Tables 10 and 11 (after incorporation of the noise mitigation measures of Section 4B.7.4)

Predicted noise levels received at the "Kurrajong" residence, however, are unable to be reduced to within the noise management zone through the proposed noise mitigation measures (due to the noise generated by drilling activities over LW24 to LW26). It is important to note, however, that Scenario 3 activities would not be undertaken for at least 20 years. Within this period, noise monitoring would be undertaken to validate the noise predictions presented in **Table 4B.32**, with further noise mitigation to be investigated and negotiations continuing in relation to possible acquisition of the "Kurrajong" residence by the Proponent.

As noted previously, noise monitoring would be conducted monthly during the first winter of longwall operations to determine the level of impact at the four potentially affected residences. Criterion exceedances would be mitigated or otherwise addressed through the development and implementation of an updated Noise Management Plan.

Consideration of Modifying Correction Factors

The INP requires that a +5dB correction factor be added to measured or predicted noise levels if the received noise contains certain annoyance characteristics such as distinct tones, low frequency noise or is intermittent in nature. Spectrum Acoustics (2009) notes that activities associated with the Longwall Project, as perceived from neighbouring residences, are not tonal or intermittent, however, may have a low frequency content that should be assessed. Spectrum Acoustics (2009) assessed the low frequency content by comparing the C-weighted and A-weighted levels at the receiver and adding 5dB to the received A-weighted level if the difference is greater than 15dB.

The difference between C-weighted and A-weighted levels (C-A range) generally increases with separation distance between source and receiver, with Spectrum Acoustics (2009) determining that the C-A range at the receivers surrounding the mining operations varied from 6dB to 15dB. Notably, the noise level at the only residence with a C-A range of 15dB ("Newhaven" under moderate inversion conditions for Scenario 3a) would only rise to 33dB when the correction factor 5dB is added.

The Proponent will measure and apply INP correction factors as required by conditions of the project approval or requirements of a Noise Monitoring Program.

Summary

Noise modelling completed by Spectrum Acoustics (2009) and illustrated on **Figures 4B.35** to **4B.37**, predicts that without the incorporation of the noise mitigation measures summarised in Section 4B.7.4, exceedances of the operational noise criteria are expected. These exceedances are primarily a consequence of the following activities.

- Operation of the CPP and rotary breaker within the Pit Top Area.
- Surface preparation activities (using scrapers or bulldozers) within the Pit Top Area (specifically within the Reject Emplacement Area, Brine Storage Area and Longwall Unit Assembly Area).
- Drilling activities at the northern and southern ends of the eastern-most longwall panels (LW1 to LW3 and LW24 to LW26).

However, with the implementation of the proposed noise mitigation measures nominated in Section 4B.7.4, Spectrum Acoustics (2009) predicts the compliance could be achieved at all but four of the residences surrounding the Longwall Project operations. The noise criteria exceedances that are unable to be mitigated are summarised as follows.

- Exceedances of 1 to 5 decibels (Noise Management Zone).
  - "Bow Hills" (up to 3dB(A) under moderate and severe inversion conditions).
  - "Naroo" (up to 5dB(A) under inversion conditions).
  - "Greylands" (up to 5dB(A) under moderate and severe inversion, and southeast wind conditions).
- Exceedances of >5 decibels (Noise Affectation Zone).
  - "Kurrajong" (>10dB(A) under all conditions when drilling activities are undertaken above LW24 to LW26).

In all cases, it is assessed that all reasonable and feasible noise mitigation measures have been considered and would be implemented to reduce the noise levels received at all residences surrounding the activities of the Longwall Project.

4B.7.6.2 Sleep Disturbance Assessment

Table 4B.33 presents the sleep disturbance assessment for the Project.

The predicted maximum noise levels are all well below the sleep disturbance criterion.

Table 4B.33
Predicted Maximum $L_{A1(1\text{-minute})}$ Operational Noise Levels

Location		Scenario					Criterion dB(A)	Maximum Differential dB(A)*
		1	2	3	4	5		
		Lapse (calm)	Inversion (^{0}C/100m)			SE wind (3m/s)		
			2	4	6			
R1	"Bow Hills"	32	38	40	43	29	45	-2
R2	"Ardmona"	26	31	34	36	23	45	-9
R3	"Naroo"	31	37	39	41	26	45	-4
R4	"Oakleigh"	25	29	31	35	24	45	-10
R5	"Pineview"	21	24	30	33	23	45	-12
R6	"Matilda"	21	29	32	35	21	45	-10
R7	"Haylin View"	22	31	32	37	23	45	-8
R10	"Merrilong"	22	26	29	33	23	45	-12
R11	"Kurrajong"	27	36	40	41	30	45	-4
R13	"Newhaven"	24	29	31	30	29	45	-15
R15	"Greylands"	31	38	40	42	39	45	-3
R16	"Belah Park"	27	34	36	39	34	45	-6
R17	"Bungaree"	22	30	31	31	29	45	-14
R18	"Merulana"	23	28	30	30	29	45	-15
Note 1: Bold = Exceedance of criterion								
Source: Spectrum Acoustics (2009) – Table 12								

4B.7.6.3 Rail Noise

Mine Site to Baan Baa

The closest residence to the North Western Branch Railway Line within several kilometres of the Mine Site is on the "Ardmona" property and is a distance of approximately 140m from the railway line. At this distance, and assuming an average of 5 train loads of coal per day, or 10 train movements, $L_{eq(24\ hour)}$ and L_{max} train noise levels of 46dB(A) and 54dB(A) are predicted by Spectrum Acoustics (2009). These are well below the relevant rail noise assessment criterion of 55dB(A) and 80dB(A) respectively.

Trains travelling south on the North Western Branch Railway Line would travel through the village of Baan Baa. The closest residence to the rail line in Baan Baa occurs at a distance of approximately 60m to the west and approximately 65m from a level crossing which has recently been equipped with lights and warning bells. $L_{eq(24\ hour)}$ and L_{max} train noise levels at this distance are predicted by Spectrum (2009) to be 52dB(A) and 60dB(A) respectively. These are less than the relevant rail traffic noise assessment criteria of 55dB(A) and 80dB(A) respectively.

Baan Baa to Port Newcastle

A review of the ARTC's *"Standard working Timetable – freight and Country Passenger Services from 5th August 2007 – Book 5 North and North West",* effective 8 January 2008, suggests that there are over 160 timetabled coal train slots (100+ during the day and 60+ during the night) on the Main Northern Line. This capacity is not filled by the current coal train numbers. Data presented in the *Environmental Assessment* for the Minimbah Third Track (GHD, 2008) suggest an actual maximum volume of 63 coal trains during the day and 35 coal trains at night through the most densely populated areas around Maitland.

The addition of up to ten additional trains per 24-hour period from the Longwall Project would increase existing L_{Aeq} train noise levels by an immeasurable and inaudible amount of approximately 0.4dB(A), with no increase in L_{Amax} levels. This insignificant increase in noise would not affect any current train noise set-back distances, and further assessment of train noise impacts from the proposal is not considered necessary.

4B.7.6.4 Road Traffic Noise

The estimated numbers of vehicle movements generated by the Longwall Project, is presented in **Table 2.11**. It is noted that the adopted traffic noise criteria (see Section 4B.6.3.5) apply to 1-hour noise levels rather than daily average levels. Maximum hourly traffic levels occur during shift changes and it is common for 25% of the total daily light vehicle traffic (workforce) to occur during a 1-hour period. It is therefore possible for up to 95 light vehicle movements to occur in 1-hour at shift change.

Residences on the "Belah Park" and "Ardmona" properties are the closest residences to the Kamilaroi Highway and are approximately 230m and 140m east of the highway respectively. Assuming that all peak hour light vehicle movements pass these residences at 100km/hour, the predicted road traffic $L_{eq(1\ hour)}$ noise levels would not exceed 42dB(A) (Spectrum, 2009). Spectrum Acoustics (2009) also notes that taking a worst case scenario, where all heavy vehicles arrive at the Mine Site at shift change during the night, the predicted $L_{eq(1\ hour)}$ noise levels at "Belah Park" and "Ardmona" would not exceed 47dB(A). These predicted road traffic noise levels are less than the relevant night-time road traffic noise assessment criteria of 55dB(A).

4B.7.6.5 Blasting Assessment

Based on the formulae presented in Section 4B.6.5.5 and a minimum distance from a non-project related residence to a ventilation shaft (approximately 1900m to "Kurrajong"), blasts with a maximum instantaneous charge of ≤225kg would result in emissions that meet the overpressure and ground vibration criteria (Spectrum, 2009). As blast monitoring information is collected, a "site law" for the Narrabri Coal Mine would be developed allowing for more precise predictions of blasting impacts (which may allow for blasts with maximum instantaneous charges of >225kg).

4B.7.7 Monitoring

The Proponent would implement the following noise and vibration monitoring program to ensure that noise and vibration impacts associated with the Project are managed appropriately.

- Undertake attended noise monitoring quarterly at the following residences, subject to landholder agreement.
  - "Bow Hills".
  - "Naroo".
  - "Oakleigh".
  - "Newhaven".
  - "Greylands".
  - "Belah Park".
  - "Kurrajong".
  - "Matilda"[16].
  - "Haylin View"[16].
  - "Merrilong"[16].
- Increase the frequency of attended noise monitoring from quarterly to monthly during the first winter (May to September) of construction or mining operations. Following completion of this monitoring program, the frequency of monitoring during the subsequent winter period would be determined in consultation with DoP, DECCW and affected landholders.

4B.8 AIR QUALITY

The air quality assessment was undertaken by Heggies Pty Ltd. The full assessment is presented in Volume 2, Part 7 of the Specialist Consultant Studies Compendium, with the relevant information from the assessment summarised in the following subsections. The full air quality assessment is referred to as Heggies (2009a) throughout this report. Heggies Pty Ltd also undertook an assessment of the likely quantity and management of greenhouse gases relating to the Project, a copy of which is presented in full as Volume 2, Part 8 of the Specialist Consultant Studies Compendium. The full assessment of greenhouse gases for the project is referred to as Heggies (2009b) throughout this report.

4B.8.1 Introduction

Based on the risk analysis undertaken for the project (see Section 3.3 and **Table 3.5**), the potential air quality impacts requiring assessment and their **unmitigated** risk ratings are as follows.

- Deposited dust levels attributable to the project are unlikely to exceed the DECC guideline level, (low risk).
- PM_{10} levels may occasionally (once every 1 to 2 years) rise above the project goal (only on those days when background levels attributable to other sources are high) (moderate risk).
- Greenhouse gas emissions (high risk).

[16] Monitoring to commence as surface activities approach the eastern end of the southern longwall panels.

- Detection of odour at surrounding non-project related residences (moderate risk).
- Restricted impacts to predominantly non-native vegetation within immediate vicinity of ventilation shafts (moderate risk).
- Impacts on native vegetation or extending beyond immediate vicinity of ventilation shafts (high risk).
- Impacts extend beyond the Mine Site or impact on extensive areas of native vegetation (high risk).

The Director-General's Requirements issued by the DoP require that the assessment of air quality is undertaken with reference to the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005).

The air quality issues addressed in this section relate to the following.

- Generation of dust by both construction and operational activities throughout the Pit Top Area and in isolated areas of the mine surface associated with access and drilling activities.
- Emission of odourous products of diesel combustion from both surface activities and underground activities (via the ventilation shaft exhausts).
- Generation of dust from coal wagons during the transportation of the coal from the Mine Site to Port Newcastle.
- Emission of greenhouse gases – principally carbon dioxide (CO_2) and methane (CH_4) during and following the mining of the coal.

Depending upon the size and concentration of dust particles in the air and their composition, airborne dust has the potential to affect human health as well as contribute to the general degradation of the environment. The term *"particulate matter"* refers to a category of airborne particles typically less than 50µm in aerodynamic diameter and ranging down to 0.1µm in size. Particles less than 10µm and 2.5µm are referred to in this document as PM_{10} and $PM_{2.5}$ particles respectively. The human respiratory system has a built-in defensive system that prevents particles larger than PM_{10} from reaching sensitive areas of the respiratory system. As particles larger than 10µm can also contribute to environmental degradation, the air quality assessment also considers the total mass of particles suspended in the air, ie. Total Suspended Particulate matter (TSP). Particles that have an aerodynamic sufficiently large so as not to be suspended in air (typically >35µm) are referred to as deposited dust.

The amount of fuel used each year for project-related activities would be optimised due to the use of rail for transporting coal products. The fuel use associated with transporting coal by rail would be significantly less than for the road transport of a comparable quantity of coal. As a result, the emission of greenhouse gases attributable to the Longwall Project would be noticeably less. On-site use of diesel would be comparatively low given the emphasis upon use of electricity, wherever possible.

Whilst both nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) are emitted as a result of diesel combustion, Heggies (2009a) concludes that based on the results of the Stage 1 air quality

assessment (Heggies, 2007), the quantity of these gases produced would be negligible and does not warrant further assessment.

Greenhouse gases, ie. CO_2 and CH_4 would be emitted principally from the coal seam during underground mining and following the transfer to and handling of coal at surface. These gases, as well as emissions from on-site consumption of diesel fuel are considered Scope 1 emissions. Scope 2 emissions relate to those released during the generation of purchased electricity whilst Scope 3 emissions relate to transportation and combustion of the coal beyond the Mine Site.

The following subsections describe and assess the existing air quality environment, identify the air quality management issues and the proposed air quality controls, safeguards and mitigation measures. Additionally, the assessment also presents the residual impacts upon air quality following the implementation of these safeguards and mitigation measures.

4B.8.2 Existing Air Quality

4B.8.2.1 Introduction

Air quality guidelines and goals refer to levels of "pollutants" in air which include both existing and proposed operational sources. In order to fully assess impacts against all the relevant air quality guidelines and goals, it is therefore necessary to compile information or estimates on existing dust deposition levels and concentrations of airborne particulates and odourous gases such as SO_2 and NO_2.

The description of existing air quality is provided based upon site-specific air quality data (a summary of which is provided in Section 1.4.3.3) and/or the best available regional data.

4B.8.2.2 Dust Deposition

As noted in Section 1.4.3.3.3, a total of eight dust deposition gauges (Sites ND1 to ND8) have been positioned within the vicinity of the Pit Top Area to obtain site-specific dust deposition data (see **Figure 1.4**). Five gauges were installed in December 2005 and three additional gauges were installed in April 2006. **Table 4B.34** provides a summary of all data collected from these dust deposition gauges since their installation.

The weighted background dust deposition rate attributable to predominantly rural activities and the initial surface earthworks within and surrounding the Mine Site is 1.9g/m^2/month, a level recognised to be typical of rural areas.

Table 4B.34
Mine Site Dust Deposition Monitoring Data

Site Location	Monitoring Period	Number of Samples	Total Insoluble Solids (g/m^2/month)
ND1	Dec 05 - Nov 08	36	2.8
ND2	Dec 05 - Nov 08	36	1.7
ND3	Dec 05 - Nov 08	36	1.2
ND4	Dec 05 - Nov 08	36	3.3
ND5	Dec 05 - Nov 08	36	2.6
ND6	June 06 - Nov 08	30	1.2
ND7	June 06 - Nov 08	30	1.0
ND8	June 06 - Nov 08	30	0.7
Weighted Average			**1.9**
Source: Heggies (2009a) – Table 6			* See **Figure 1.4**

4B.8.2.3 Particulate Matter

As also noted in Section 1.4.3.3.3, background levels of particulates <10µm (PM_{10}) specific to the Mine Site and surrounds have been established through two high volume air samplers measuring PM_{10} levels in accordance with the nominated DECC 6 day cycle. The first sampler (ND9) was established at the "Claremont" residence in December 2007 and the second (ND10) established at the "Turrabaa" residence in April 2008 (see **Figure 1.4**). The results of 24-hour PM_{10} monitoring conducted at these two locations are summarised in **Table 4B.35**.

Table 4B.35
Mine Site 24-hour Average PM_{10} Concentrations – From December 2007

Site Location	Number of Samples	Dataset Average ($\mu g/m^3$)	Dataset 24-hour Maximum ($\mu g/m^3$)
ND9	61	10.5	48
ND10	39	15.8	70
Weighted Average		12.6	
Source: Heggies (2009a) – Table 7			

A total of 100 samples collected at these locations established a weighted average 24hr PM_{10} level of 12.6µg/m^3.

Heggies (2009a) compares the site specific data drawn from the 6 day sampling regime with continuous data recorded during the sampling period recorded at the DECC Tamworth air quality monitoring station, approximately 115km southeast of the Mine Site. **Figure 4B.38** presents the comparison between the two data sets – which highlight a similar daily variation pattern across each data set. The annual average PM_{10} concentration for the Tamworth dataset was 15.8µg/m^3, a level consistent with that measured at Site ND10. Given the similarity in data between the data sets, Heggies (2009a) considers it appropriate to use the Tamworth 2008 24-hour average varying PM_{10} data set for the assessment of the Longwall Project. It is noteworthy that this data incorporates three exceedances of the DECC 50µg/m^3 24 hour guideline level which were attributable to anomaly regional natural events, such as bushfire or dust storm.

4B.8.2.4 Nitrogen Dioxide and Sulphur Dioxide

Existing background NO_2 and SO_2 concentrations are assumed to be negligible given the rural nature of the site although small concentrations would be emitted by vehicles travelling along the Kamilaroi Highway and diesel-powered trains travelling along the North Western Branch Railway Line.

4B.8.2.5 Carbon Dioxide and Methane

Existing background concentrations of carbon dioxide and methane are recognised to be negligible and typical of a rural area.

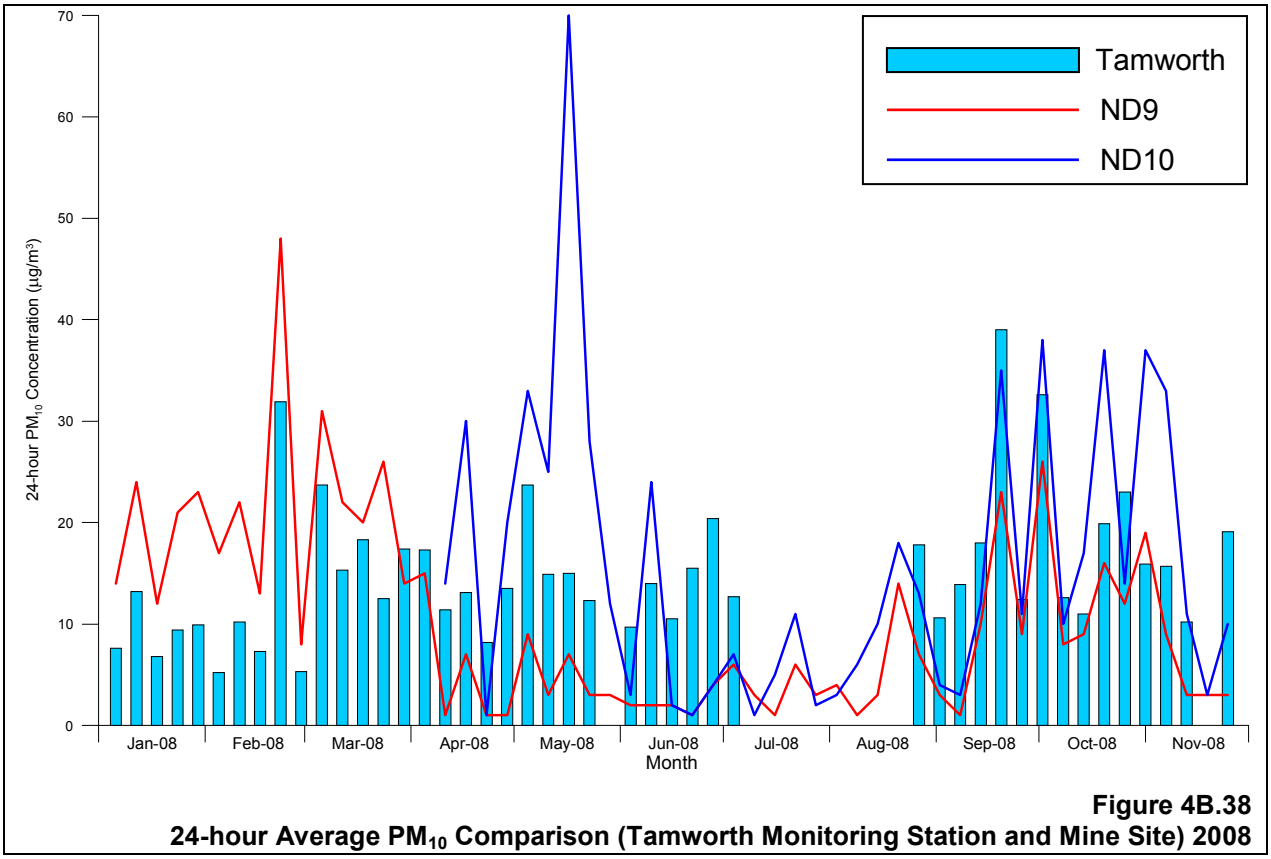


Figure 4B.38
24-hour Average PM_{10} Comparison (Tamworth Monitoring Station and Mine Site) 2008

4B.8.2.6 Summary of Existing Air Quality

For the purposes of assessing the potential air quality impacts of the project, **Table 4B.36** records the background levels adopted.

Table 4B.36
Background Air Quality Environment for Assessment Purposes

Air Quality Parameter	Averaging Period	Assumed Background Level	Source
PM_{10}	24-Hour	Daily Varying	DECC
	Annual	15.8µg/m^3	
Deposited Dust	Annual	1.9g/m^2/month	NCOPL
Odour	All Periods	Negligible	Assumed
Source: Heggies (2009a) – Table 8			

4B.8.3 Potential Sources of Air Contaminants

4B.8.3.1 Particulate Emissions

Specific project activities would contribute to the particulate emissions inventory during the Longwall Project. The following activities are related to specific site establishment or construction activities, operational and on-site transportation components attributable to the Longwall Project.

- Site construction activities involving earthmoving equipment to extend the ROM coal pad, construct the longwall unit assembly area, road construction and limited delivery of road construction materials.
- Drilling of pre-drainage and goaf drainage boreholes across the Mine Site.
- Conveying of additional quantities of coal:
  - from the conveyor drift portal to the ROM coal pad;
  - from the ROM coal pad to the coal breaker;
  - from the coal breaker to the Coal Processing Plant or coal product storage pad; and
  - from the product coal storage pad to the rail load-out bin.
- Coal processing activities within the Coal Processing Plant.
- Additional rail load-out activities.
- Movement of heavy vehicles on unsealed roads between the reject stockpile and the Reject Emplacement Area (predominantly truck wheel dust).
- Movement of light vehicles, drill rigs, etc. on the internal unsealed roads across the Mine Site.
- Wind erosion of the additional coal stored on the ROM coal and product coal on their respective pads and open areas around the Pit Top Area and disturbed areas throughout the Mine Site.

Particulate emissions would also be generated from open wagons transporting the coal between the Mine Site and Port Newcastle.

4B.8.3.2 Odour

The principal continuous source of odour generated on site would be the discharge of mine exhaust gases containing diesel fumes. These fumes would be vented to the atmosphere at one of the exhaust fans located along the central corridor above the West Mains.

It is possible, although unlikely, that small quantities of sulphurous gases may be produced as a result of localised spontaneous combustion of the coal stored on the ROM coal pad and / or the product coal storage pad. The likelihood of such an event is envisaged to be very small.

4B.8.3.3 Greenhouse Gas and Other Gas Emissions

The Longwall Project has the potential to generate additional greenhouse and other polluting gas emissions from a number of sources during both the establishment of additional site components and operations.

Establishment of Additional Stage 2 Components

- The combustion of fuel by diesel-powered equipment and vehicles, including front-end loaders, excavators, bulldozers, scrapers, graders, drill rigs and haul trucks.
- Combustion of diesel fuel for on-site power generation in remote areas on the Mine Site.

Operations

- The combustion of fuel by diesel-powered equipment, particularly the bulldozer on the ROM coal pad and product coal storage pad, site vehicles, trains and vehicles delivering consumables.
- The release of gas emissions during both underground mining and its handling on the surface.
- The product coal sold to predominantly export markets would ultimately be burnt to create energy. This process would generate greenhouse gases which are therefore attributable to the Project.
- Although carbon dioxide (CO_2) would be the principal gas produced, greenhouse gases emitted as a result of the Project would also include carbon monoxide (CO), methane (CH_4), oxides of nitrogen (NO_X), SO_2 and non-methane volatile organic compounds (NMVOCs).

4B.8.4 Air Quality Goals

4B.8.4.1 Particulate Matter and Dust Deposition

Goals Applicable to PM_{10}

Emissions of PM_{10} and $PM_{2.5}$ particles are considered important pollutants in terms of impact due to their ability to penetrate into the respiratory system.

The NSW DECC PM_{10} assessment goals as expressed in the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW, (DEC 2005) are:

- a 24-hour maximum of 50µg/m^3; and
- an annual average of 30µg/m^3.

The 24-hour PM_{10} reporting standard of 50µg/m^3 is numerically identical to the equivalent National Environment Protection Measure (NEPM) reporting standard except that the NEPM reporting standard allows for five exceedances per year.

Goal Applicable to Total Suspended Particulates

The annual goal for Total Suspended Particulates (or TSP) is 90µg/m^3, as recommended by the National Health and Medical Research Council (NHMRC). This goal was developed before the more recent results of epidemiological studies suggested a relationship between health impacts and exposure to PM_{10} concentrations.

In rural areas, the PM_{10} particle size fraction is typically of the order of 50% of the TSP mass, and as such, this goal is consistent with an annual PM_{10} goal of approximately 45µg/m^3. Thus, the historical NHMRC goal may be regarded as less stringent than the newer DECC PM_{10} goal of 30µg/m^3 expressed as an annual average. Therefore, as the annual TSP goal is seen to be achieved if the annual PM_{10} goal is satisfied, TSP has not been considered further in this assessment.

Goals Applicable to $PM_{2.5}$

The ambient Air Quality NEPM was amended in 2003 to extend its coverage to $PM_{2.5}$. This document references the following goals for $PM_{2.5}$.

- A 24-hour maximum of 25µg/m^3.
- An annual average of 8µg/m^3.

Historical quantitative assessments of air quality impacts of coal mining projects undertaken by Heggies (2009a) have indicated that providing maximum predicted PM_{10} concentrations satisfy project air quality goals, goals applicable to $PM_{2.5}$ are similarly met. In view of the foregoing, it is assumed that providing adequate mitigation of PM_{10} is achieved, goals applicable to $PM_{2.5}$ would be satisfied. Potential impacts of $PM_{2.5}$ have thus not been considered further in this assessment.

Deposited Dust

In NSW, accepted practice regarding the nuisance impact of dust is that dust-related nuisance can be expected to impact on residential areas when annual average dust deposition levels exceed 4g/m^2/month.

In order to avoid dust nuisance the DECC adopts the following goals to assess dust fallout. **Table 4B.37** presents the allowable increase in dust deposition relative to the ambient levels.

Table 4B.37
DECC Goals for Dust Deposition

Averaging Period	Maximum Increase in Deposited Dust Level	Maximum Total Deposited Dust Level
Annual	2g/m^2/month	4g/m^2/month
Source: Approved Methods for the Modelling and Assessment of Air Pollutants in NSW, (DEC 2005)		

Based upon the maximum levels in **Table 4B.38** and the initial site-based and longer term regional dust deposition data, a site-specific goal for all dust sources attributable to site activities would be in the order of 3.9g/m^2/month.

4B.8.4.2 Gas Emissions

While no specific guidelines are provided for maximum emissions of greenhouse gases, the *National Greenhouse Gas Inventory* (Australian Greenhouse Office, 2008) estimates of the carbon dioxide emissions allow for an assessment as to the relative level of impact the proposal would have on Australian greenhouse gas emissions. The estimates for greenhouse emissions throughout Australia are given as 553.7MtCO_2 equivalent.

4B.8.4.3 Goals Applicable to Odour Emissions

Impacts from odorous air contaminants are often nuisance-related rather than health-related and as such, odour performance criteria are not specifically intended to achieve "no odour". The methane released during mining of coal is not odourous. The detectability of an odour is a sensory property that refers to the theoretical minimum concentration that produces an olfactory response or sensation. This point is called the odour threshold and defines one odour unit per cubic metre (OU/m^3).

In practice, the character of a particular odour can only be judged by the receiver's reaction to it, however, based on the literature available, the level at which an odour is perceived to be a nuisance can range from 2OU/m^3 to 10OU/m^3.

Odour performance criteria need to be designed to take into account the range in sensitivities to odours within the community, and provide additional protection for individuals with a heightened response to odours, using a statistical approach which depends on the size of the affected population. A summary of odour performance criteria for various population densities is shown in **Table 4B.38**.

Table 4B.38
DECC Odour Performance Criteria vs. Population Density

Population of Affected Community	Odour Performance Criteria OU
Urban area (≥ 2 000)	2.0
500 – 2 000	3.0
125 - 500	4.0
30 - 125	5.0
10 - 30	6.0
Single residence (≤ 2)	7.0
Note: These should be regarded as interim criteria to be refined over time through experience and case studies.	
Source: "Technical Notes: Draft Policy, Assessment and Management of Odours from Stationary Sources in New South Wales", DECC 2006	

The area surrounding the Mine Site is primarily rural, hence it is assumed that the population that may potentially be affected by odour emissions associated with coal seam gases is of the order of 10 and 30 people. Consequently, the project odour performance goal adopted for this assessment is a maximum of 6.0 odour units (OU) expressed as a nose response average (1-second) value.

4B.8.4.4 Project Air Quality Goals

In summary, the DECC project specific air quality goals are as follows.

PM_{10}: A 24-hour maximum of 50µg/m^3
An annual average of 30µg/m^3

Dust: Nuisance expected to impact on surrounding residences when incremental annual average dust deposition levels exceed 2g/m^2/month

Odour: A maximum of 6.0OU expressed as a nose response average (1-second) value.

4B.8.5 Operational Air Quality Controls

4B.8.5.1 Introduction

The Proponent would apply a wide range of air pollution control measures to ensure air quality standards are not compromised by its activities. These operational controls have been categorised as either dust control measures or controls for other air contaminants.

4B.8.5.2 Dust Control Measures

The individual sources of dust and the proposed controls for Mine Site activities are listed in **Table 4B.39**.

4B.8.5.3 Control Measures for Other Potential Air Contaminants

Earthmoving equipment and on-site vehicles would be fitted with exhaust controls which satisfy the NSW DECCW emission requirements. The Proponent would ensure that all equipment is properly maintained to ensure no unacceptable exhaust emissions occur and commit to the removal of any vehicle or item of mobile equipment from on-site activities which is observed not to comply with NSW DECCW guidelines. The exhausts of all equipment would be directed upwards or to the side so as not to impinge on the ground and cause dust lift-off.

The Proponent would proactively minimise the use of diesel by:

- optimising and scheduling vehicle operations;
- maintaining engines according to manufacturers' guidelines and keeping tyres at optimum pressure;
- minimising vehicle idling time; and
- considering the use of alternative fuels with a reduced carbon content.

Table 4B.39
Dust Control Measures for Mine Site Activities

Page 1 of 2

Dust Emission Source	Operational Controls
Vegetation Clearing	• Cleared trees and branches would be retained on the margins of cleared areas for use in stabilising disturbed areas once they are no longer required.
Soil Stripping	• Where practicable, soil stripping would be undertaken at a time when there is sufficient soil moisture to prevent significant lift-off of dust. • The Proponent would avoid stripping soil in periods of high winds • Dust suppression by water application would be used to increase soil moisture, if required.
Continuous Miners and Longwall Unit	• Strategically located water sprays would be operational on all continuous miners, the longwall unit and the breaker feeder to minimise dust creation underground.
Coal Transfer, Crushing and Screening	• Notwithstanding the moist nature of the ROM coal, water would be applied to the coal at the feed hopper, crusher and at all conveyor transfer and discharge points. • All conveyors would be fitted with appropriate cleaning and collection devices to minimise the amount of material falling from the return conveyor belts. • The coal breaker would be enclosed. • All surface conveyors would be partly enclosed to minimise dust lift off. • Some flexibility would exist to temporarily cease operation in the event of protracted dry periods, high winds, and significant dust generation and dispersal towards the surrounding residences.
Construction of the Brine Storage Ponds	• When the prevailing winds are from the northwest quadrant, construction activities within the Brine Storage Area would cease.

Table 4B.39 (Cont'd)
Dust Control Measures for Mine Site Activities

Dust Emission Source	Operational Controls
Wind Erosion from Exposed Surfaces and Stockpiles	• Minimising the extent of clearing/site preparation during site establishment and preparation of operational sites across the Mine Site including the campaigns to construct the area for reject emplacement. • Clear definition of all site roads and the restriction of vehicles and equipment to those roads. • Progressive rehabilitation of areas of disturbance including topsoil and subsoil stockpiles. • Routine application of water sprayed onto stockpiles and hardstand areas. • Maintenance of the perimeter amenity bund and windbreaks.
Coal Loading to Rail Wagons	• The coal loaded onto the conveyor to the rail load-out facility would be watered as required to maintain a sufficient moisture content to prevent dust lift-off during loading – noting the wagons would be loaded within the rail cutting where wind protection would be achieved.

The above control measures relating to diesel fumes are also relevant to controlling odour arising from the underground mine. The generation of odour on either the ROM coal pad or product coal storage pad (arising from localised spontaneous combustion) would be avoided / minimised through constant monitoring of each pad. In the unlikely event localised spontaneous combustion is detected on either pad, the Proponent would isolate the affected coal, drench the coal with water and either process or despatch the subject coal as quickly as possible.

4B.8.5.4 Coal Transportation

The field studies documented by Heggies (2009a) indicate that no specific controls are required for the rail wagons to be used to transport coal between the Mine Site and Port Newcastle. (see Section 4B.8.6)

4B.8.5.5 Greenhouse Gas Reduction

The major greenhouse gas reduction initiative of the Longwall Project involves the use of rail over road transportation of coal products. The fuel use associated with transporting up to 8Mtpa of coal by rail would be significantly less than for the road transport of a comparable quantity of coal. The control measures outlined in Section 4B.8.5.3 would also assist to reduce greenhouse gases attributable to the Longwall Project.

The Proponent is committed to the implementation of the measures outlined in the approved Energy Savings Action Plan (ESAP) for Narrabri Coal Mine Stage 1. The ESAP would be updated following approval of the Longwall Project to reflect the modified mining operations.

4B.8.6 Assessment of Impacts

4B.8.6.1 Introduction

The assessment of impacts of the proposed additional activities involved with the Longwall Project was primarily undertaken through computer modelling to establish likely concentrations of PM_{10}, deposited dust, odour and greenhouse gases around the Mine Site. The modelling undertaken by Heggies (2009a) at the surrounding non-project related residences ("assessment locations") assumes the adoption of operational controls as set out in Section 4B.8.5.

In order to assess the level of impact of the Longwall Project, the predicted concentrations are compared against the air quality goals established in Section 4B.8.4.

4B.8.6.2 Air Quality Modelling

Computer predictions of fugitive emissions from the Mine Site were undertaken using CALPUFF (Version 6.2), a dispersion model developed for use in complex atmospheric dispersion situations. The model combines the particulate emission factors for the various Stage 2 activities, meteorological data and local topography to predict the dispersion of dust and other particulate matter.

Particulate Emission Factors

The inputs to the CALPUFF model have been taken primarily from the default emission factors identified in the *Emission Estimation Technique Manual for Mining* (DEH, 2001). Where the moisture content of materials on the Mine Site was not adequately reflected within the defaults emission factors, the equations presented within DEH (2001) were used.

Meteorological Data

The Air Pollution Model (TAPM) software, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), was used to simulate the meteorology of the area.

The simulation of the three-dimensional meteorological data was achieved using the 2008 data set compiled from the on-site meteorological station. The principal meteorological inputs to the modelling included wind speed and direction (and calm conditions), temperature, atmospheric stability, mixing depth, relative humidity and precipitation.

Local Topography

There are no significant topographic features within or surrounding the Mine Site which would impede atmospheric dispersion between the Mine Site and surrounding residences. Considering such uncomplicated near field topography, topography has not been considered in the dispersion model. Heggies (2009a) notes that whilst the amenity bund walls on the Pit Top Area locally influence wind patterns, their exclusion from the CALPUFF model suggests the predicted air quality impacts would be conservative.

Modelled Scenarios

Two scenarios were modelled to reflect different stages of the Longwall Project. The scenarios chosen take into consideration the movement of mobile equipment on the Pit Top Area and elsewhere on the Mine Site along with all fixed plant emissions. The scenarios aim to be representative of worst case conditions during the site establishment and operational phases of the Longwall Project.

The two scenarios modelled by Heggies (2009a) are as follows.

- Site Construction - incorporates the construction of Stage 2 Longwall Project components within the Pit Top Area including expansion of ROM coal pad, longwall unit assembly area, Coal Processing Plant, Reject Emplacement Area, ventilation and pre-drainage shaft areas and road and power line path construction.
- Longwall Mining Operations – incorporates the construction within the Brine Storage Area, increased coal production attributed to the Longwall Project, including conveying of coal, coal processing, stockpiling of ROM and processed coal, stockpile management, reject emplacement and loading of train wagons.

To determine the impact of coal dust emissions along the rail route from the Mine Site to Port Newcastle, Heggies (2009a) ran the transportation dispersion model CAL3QHCR, developed by the United States Environmental Protection Agency (USEPA).

4B.8.6.3 Dust Deposition

CALPUFF predictions for dust deposition at the assessment locations, including the assumed background level of dust deposition of 1.9g/m^2/month, are displayed in **Table 4B.40**. Total mean monthly dust deposition (background plus increment) rates associated with the proposal are predicted to be less than or equal to 2.0g/m^2/month at all assessment locations for the two scenarios modelled and readily satisfy the dust deposition criterion of 3.9g/m^2/month.

Table 4B.40
Dust Deposition at Nearest Assessment Locations

Residence	Average Monthly Dust Deposition Rate (g/m^2/month)			
	Scenario 1		Scenario 2	
	Increment	Background$^+$ and Increment	Increment	Background$^+$ and Increment
R1 - "Bow Hills"	0.1	2.0	0.1	2.0
R2 - "Ardmona"	0.2	2.1	0.1	2.0
R3 - "Naroo"	0.4	2.3	0.2	2.1
R4 - "Oakleigh"	0.1	2.0	<0.1	1.9
R5 - "Pineview"	<0.1	1.9	<0.1	1.9
R6 - "Matilda"	<0.1	1.9	<0.1	1.9
R7 - "Haylin View"	<0.1	1.9	<0.1	1.9
R10 - "Merrilong"	<0.1	1.9	<0.1	1.9
R11 - "Kurrajong"	<0.1	1.9	<0.1	1.9
R13 - "Newhaven"	0.1	2.0	0.1	2.0
R15 - "Greylands"	0.3	2.2	0.2	2.1
R16 - "Belah Park"	0.5	2.4	<0.1	1.9
R17 – “Bungaree”	0.1	2.0	<0.1	1.9
R18 – “Merulana”	0.1	2.0	<0.1	1.9
+ Background Monthly Dust Deposition Rate = 1.9g/m^2/month				
Source: Heggies (2009a) – Tables 14 and 15				

Figures 4B.39 and **4B.40** presents the predicted dust deposition on and surrounding the Mine Site in 1g/m^2/month increments for Scenarios 1 and 2. This reiterates that the residential receivers on and surrounding the Mine Site are located well away from those areas likely to be subject to significant dust deposition.

4B.8.6.4 PM_{10}

The maximum 24-hour average PM_{10} concentration at the nearest assessment locations was predicted for both Scenarios 1 and 2 using CALPUFF over a one-year time frame based on 2008 data (see **Table 4B.41**). It has been assumed that background levels of PM_{10} vary on a daily basis with these background levels incorporated into the model. *Appendix 2* of Heggies (2009a) provides an explanation regarding the use of varying background PM_{10} levels. A contour plot of the maximum incremental 24-hour PM_{10} concentrations attributable to each scenario at the Mine Site is presented in **Figures 4B.39** and **4B.40.**

Table 4B.41
Predicted Maximum 24-hour PM_{10} Concentrations

Residence	Maximum 24 hour PM_{10} Concentration (µg/m^3)			
	Scenario 1		Scenario 2	
	Increment	Background$^+$ and Increment	Increment	Background$^+$ and Increment
R1 - "Bow Hills"	<0.1	46.4	7.8	48.4
R2 - "Ardmona"	0.6	47.0	32.8	51.2
R3 - "Naroo"	1.2	47.6	30.8	58.2
R4 - "Oakleigh"	0.5	46.9	0.8	47.2
R5 - "Pineview"	<0.1	46.7	0.4	46.8
R6 - "Matilda"	<0.1	46.4	0.0	46.4
R7 - "Haylin View"	<0.1	46.4	0.0	46.4
R10 - "Merrilong"	<0.1	46.4	0.0	46.4
R11 - "Kurrajong"	<0.1	46.4	0.0	46.4
R13 - "Newhaven"	<0.1	46.4	0.0	46.4
R15 - "Greylands"	<0.1	46.4	0.0	46.4
R16 - "Belah Park"	<0.1	46.4	6.2	47.6
R17 – "Bungaree"	<0.1	46.4	0.0	46.4
R18 – "Merulana"	<0.1	46.4	0.0	46.4
+ Variable background – see Heggies 2009a				
Source: Heggies (2009a) – Tables 16 and 17				

Given the predicted exceedance of 24-hour maximum PM_{10} at two of the residences, Heggies (2009a) considers both the incidences of the 10 highest background levels (and their corresponding predicted increment) and the 10 highest predicted incremental increases (and their corresponding background) at these two non-project related residences (R2 – "Ardmona" and R3 – "Naroo"). The results of this assessment are presented in **Table 4B.42** and provide some perspective in relation to the potential for the 24-hour maximum PM_{10} to be exceeded. **Table 4B.42** identifies that the maximum (increment plus background) 24-hour PM_{10} concentration is predicted to exceed the assessment criterion twice at "Ardmona" and four times at "Naroo", beyond the exceedance initially reported in **Table 4B.42**.

Table 4B.42
Predicted Background and Incremental 24-Hour PM_{10} Maxima at Receptors R2 and R3 – Scenario 2

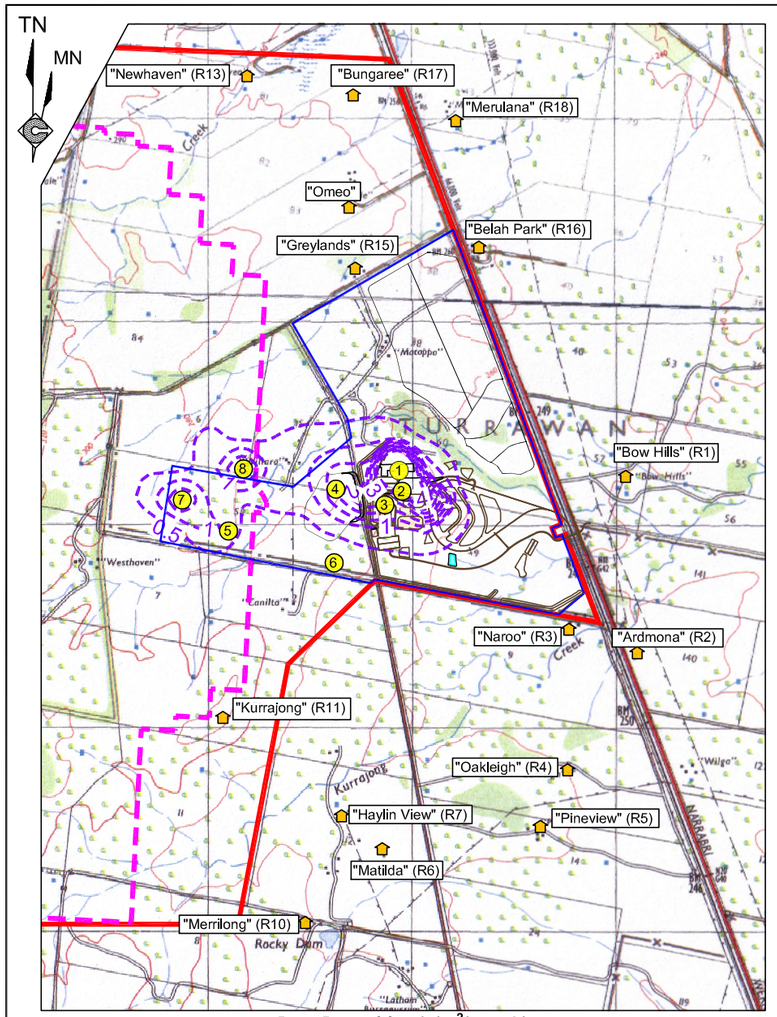
Date	PM_{10} - 24-Hour Average (µg/m^3)			Date	PM_{10} - 24-Hour Average (µg/m^3)		
	Highest Background	Predicted increment	Highest Predicted Total		Background	Highest Predicted Increment	Total
R2 – "Ardmona"							
15/09/2008	46.4	3.6	50.0	27/04/2008	18.4	32.8	51.2
23/11/2008	41.4	0.6	42.0	17/05/2008	15.0	13.1	28.1
19/09/2008	40.9	1.7	42.6	07/08/2008	15.8	11.8	27.6
01/07/2008	40.6	0.8	41.4	27/10/2008	26.0	9.6	35.6
20/09/2008	39.0	4.7	43.7	10/08/2008	15.8	9.2	25.0
17/12/2008	38.9	2.3	41.2	28/09/2008	20.0	8.4	28.4
18/09/2008	38.8	1.3	40.1	21/03/2008	19.9	8.3	28.2
31/10/2008	35.4	6.4	41.8	20/01/2008	9.2	8.2	17.4
31/12/2008	34.3	1.5	35.8	02/04/2008	22.8	7.5	30.3
03/10/2008	33.0	5.8	38.8	31/07/2008	15.8	7.5	23.3
R3 – "Naroo"							
15/09/2008	46.4	3.6	50.0	18/12/2008	27.4	30.8	58.2
23/11/2008	41.4	0.3	41.7	27/04/2008	18.4	23.9	42.3
19/09/2008	40.9	3.6	44.5	27/10/2008	26.0	23.4	49.4
01/07/2008	40.6	0.7	41.3	07/08/2008	15.8	20.9	36.7
20/09/2008	39.0	3.9	42.9	17/05/2008	15.0	19.0	34.0
17/12/2008	38.9	3.9	42.8	21/08/2008	15.8	18.6	34.4
18/09/2008	38.8	2.0	40.8	02/04/2008	22.8	16.0	38.8
31/10/2008	35.4	4.0	39.4	10/08/2008	15.8	15.9	31.8
31/12/2008	34.3	2.3	36.6	31/10/2008	35.4	14.9	50.3
03/10/2008	33.0	4.9	37.9	21/03/2008	19.9	14.5	34.4

Source: Heggies (2009a) – Table 18

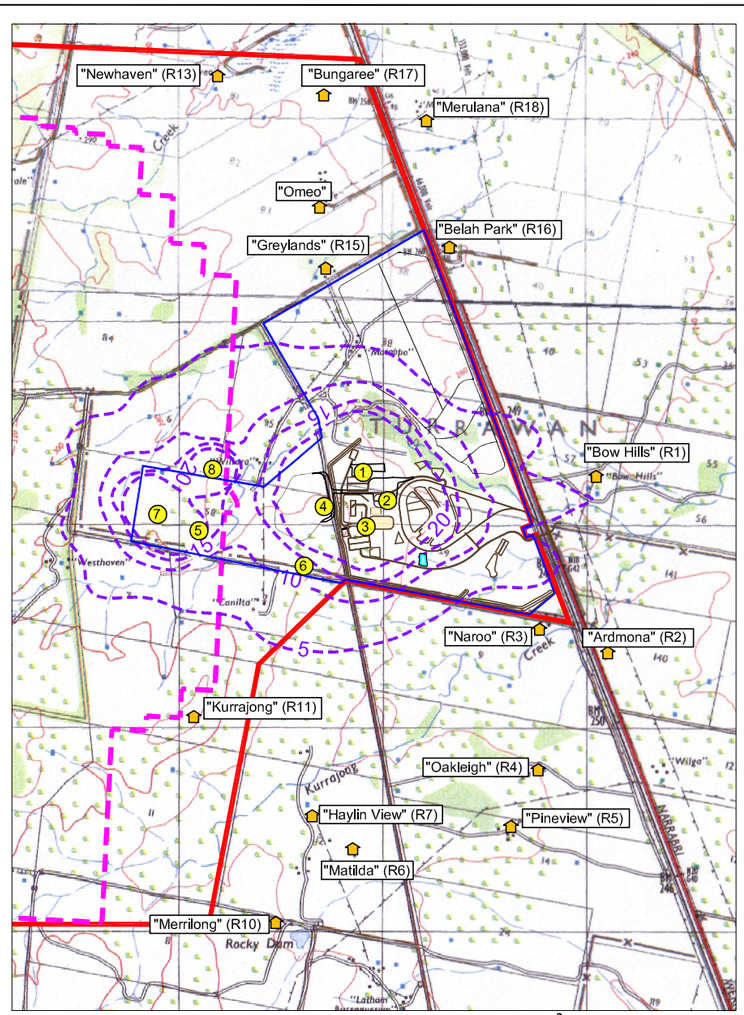
Heggies (2009a) reviewed both the background meteorological dataset and contributions of the various activities on the Mine Site and determined that the 24-hour maximum PM_{10} exceedances occur when moderate to fresh winds from the northwest quadrant were dominant, with construction within the Brine Storage Area the largest contributor to incremental contribution of the Longwall Project. Heggies (2009a) concludes that given the periodic and temporary nature of the construction activities within the Brine Storage Area and the relatively low frequency of moderate to fresh winds from the northwest quadrant (<10% in 2008), the predicted incremental PM_{10} concentrations for Scenario 2 are a conservative representation of the impacts likely to be experienced in the surrounding area. Furthermore, by ceasing construction activities within the Brine Storage Area when the prevailing winds are from the northwest quadrant, the potential for exceedance of the 24-hour PM_{10} criterion would be further reduced.

Table 4B.43 presents the predicted annual average PM_{10} concentrations assuming a background annual PM_{10} concentration of 15.8µg/m^3 at the assessment locations. **Table 4B.43** shows that for the scenarios modelled, annual average PM_{10} concentrations as a consequence of the project would be less than 18.5µg/m^3 and satisfy the project goal of 30µg/m^3.

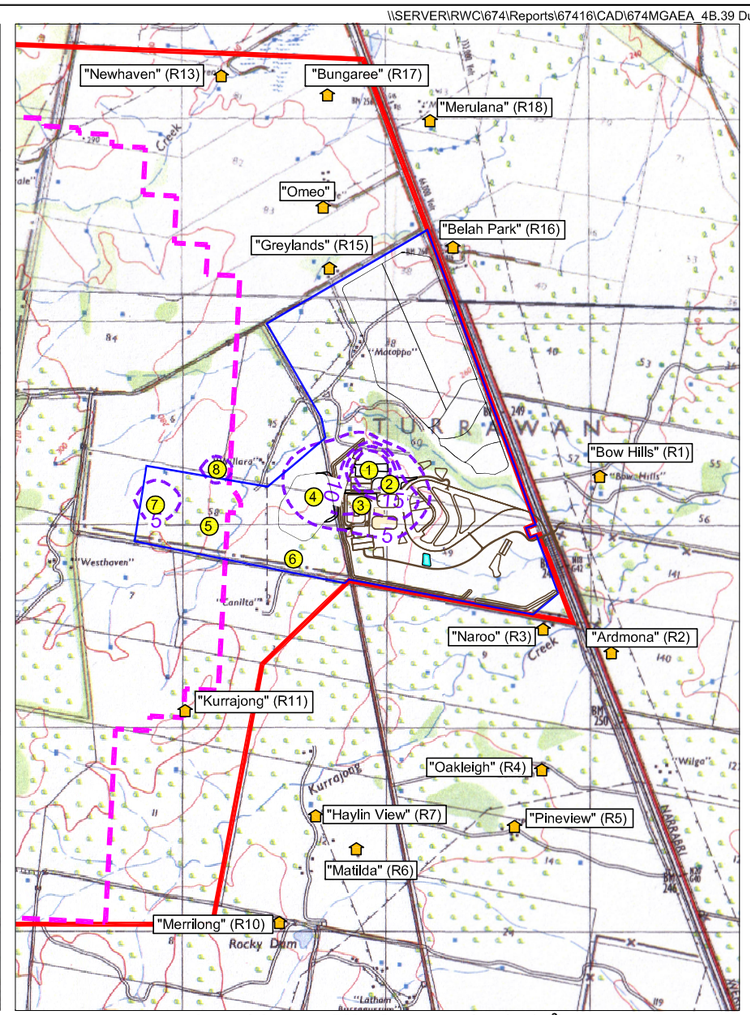
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Dust Deposition (g/m^2/month)



Maximum 24 Hour PM_{10} Concentration (µg/m^3)



Annual Average PM_{10} Concentration (µg/m^3)

Construction - Dust Generating Activities

1. **Longwall Unit Assembly Area**: Crane (x3), Scraper (x2), Excavator (35t) & Water cart.
2. **ROM Coal Pad Extension**: Cranes (x2), Scraper (x2), Excavator (45t), Bulldozer (D8), Grader (14G Cat) & Water cart.
3. **Coal Preparation Plant**: Cranes (x3) & Excavator.
4. **Reject Emplacement Area Construction**: Scraper (x2), 50t articulated haul truck & Water cart.
5. **General Road Construction**: Grader (14G Cat), Gravel truck (x2) & Water cart
6. **Powerline Construction:** Bulldozer (D8).
7. **Ventilation Shaft Construction**: Drill Rig, Bulldozer (D8), Gravel truck & Water cart
8. **Pre-Drainage Site Preparation:** Dril rig, Bulldozer (D8), Gravel truck & Water Cart.

REFERENCE
- Mine Site Boundary
- Indicative Limit of Underground Workings
- Pit Top Area Boundary
- Approved Disturbance within the Pit Top Area
- Area of Proposed Longwall Project Surface Disturbance
- (1) Dust / Particulate Matter Generating Activity
- 25 Air Quality Contour
- Residential Receiver

SCALE 1:60 000

1 0 1 2 3km

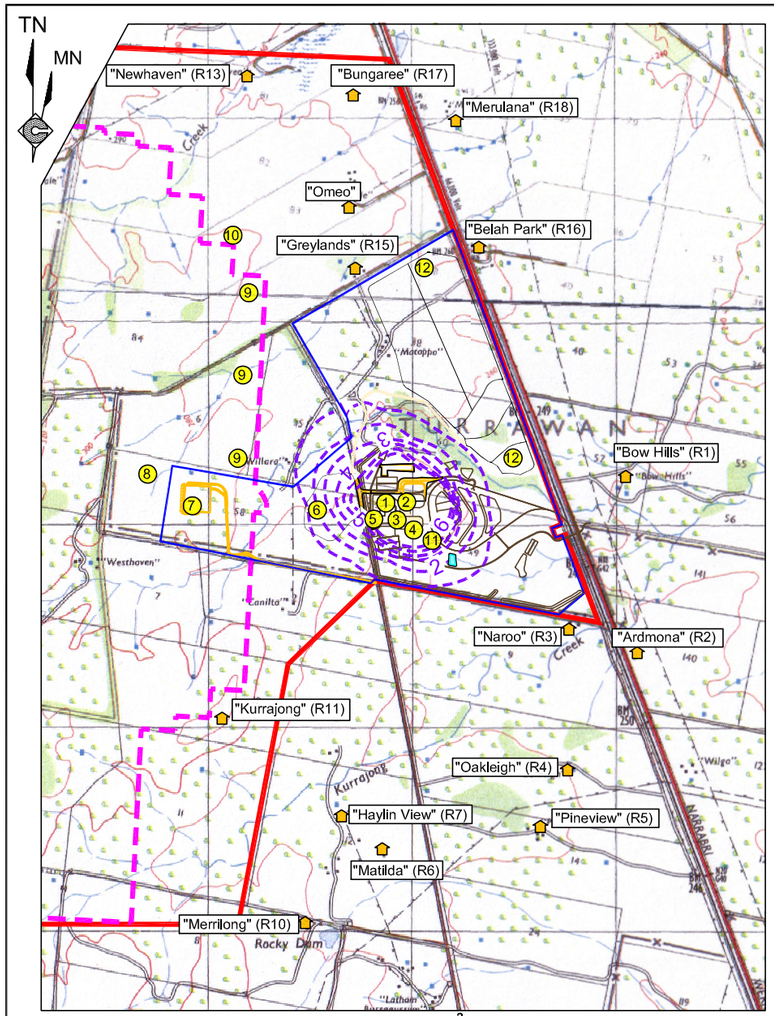
Source: Heggies Pty Ltd (2009) - Figures A4.1, A5.1 & A6.1

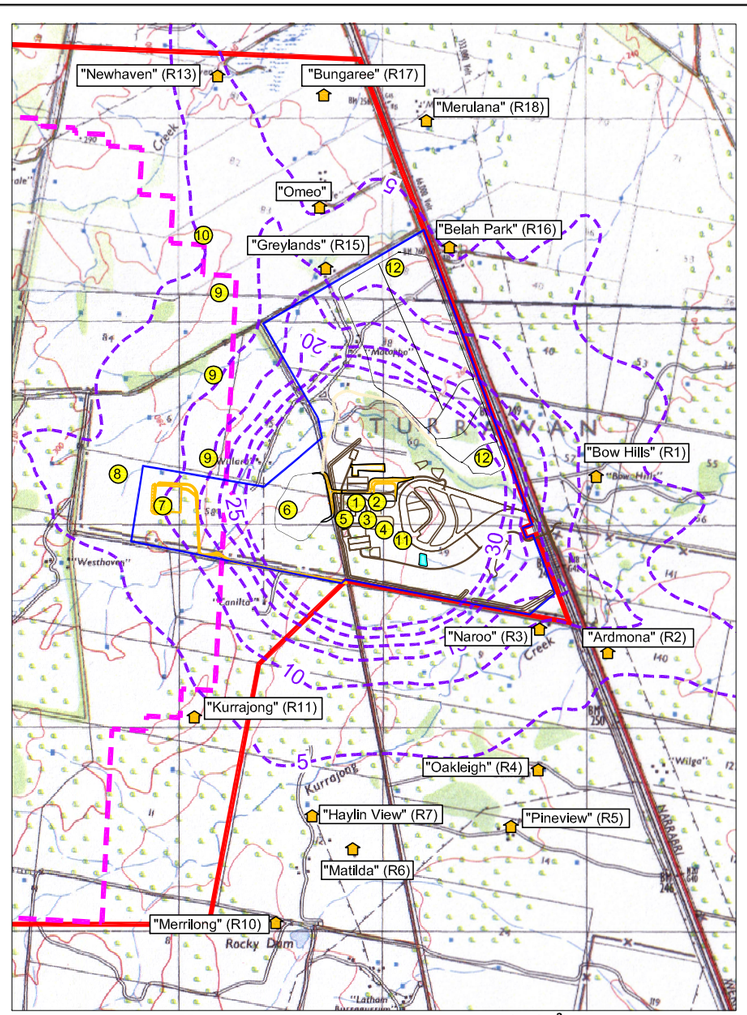
Figure 4B.39
PREDICTED AIR QUALITY CONTOURS
SCENARIO 1 - SITE CONSTRUCTION

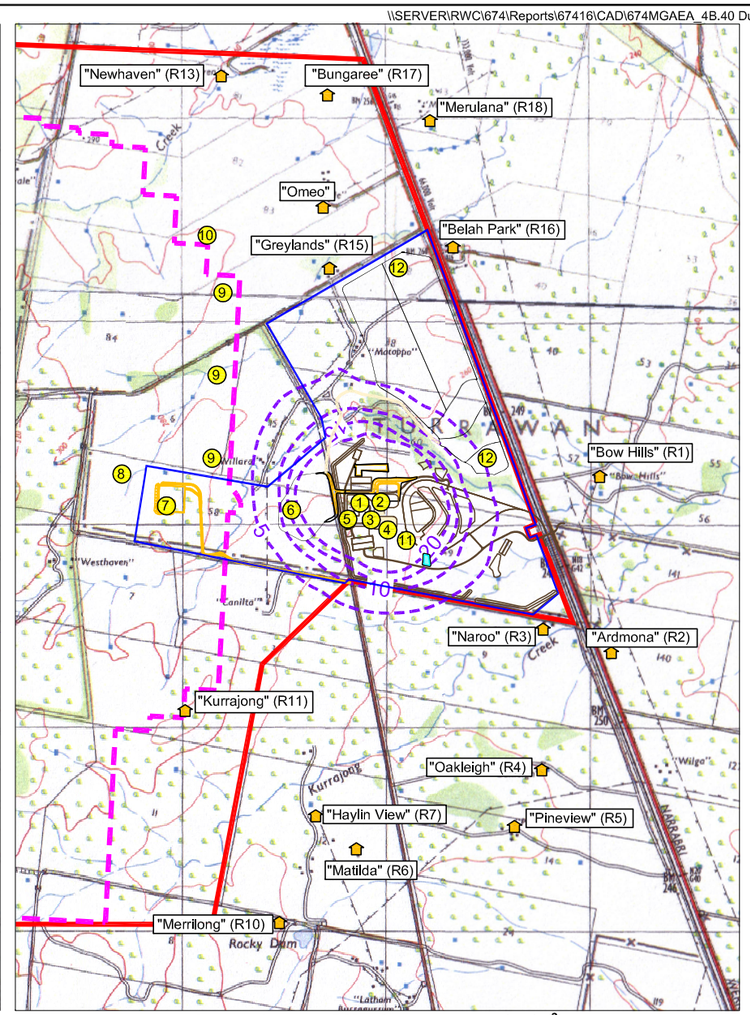
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Operational - Dust Generating Activities

1. **Box Cut and Mine Portals**: Drift Conveyor (x1), Underground Transports (x7).
2. **ROM Coal Pad**: ROM skyline conveyor and tipper (x1), Bulldozer (D10)(x2), Rotary breaker (x1), Dry screen (x1), Water cart (x1).
3. **Coal Preparation Plant**: Jig Washing Plant , Tertiary Screen, Cyclones & Thickener.
4. **Product Coal Pad**: Product skyline conveyor, Bulldozer (D10)(x2), & Water cart (x1).
5. **Reject Stockpile Area**: Conveyor (x1) & Front-end loader (x1).
6. **Reject Emplacement Area**: Haul Truck (50t)(x1), Bulldozer (D8)(x1), & Water cart (x1).
7. **Ventilation Shaft Area**: Ventilation fan & Support vehicle.
8. **Pre-Drainage Sites**: Dewatering pump, Vacuum pump & Generator.
9. **Goaf Gas Drainage**: Vacuum pump & Generator (x2).
10. **Rear of Panel Exhaust Ventilation**: Ventilation fan & Support vehicle.
11. **Rail Load-out**: Rail loading from bin to Wagons,
12. **Brine Storage Area Construction**: Scraper (x2), 50t Haul Truck & Water Cart.

REFERENCE
- Mine Site Boundary
- Indicative Limit of Underground Workings
- Pit Top Area Boundary
- Approved Disturbance within the Pit Top Area
- Area of Proposed Longwall Project Surface Disturbance
- (1) Dust / Particulate Matter Generating Activity
- 25 Air Quality Contour
- Residential Receiver

SCALE 1:60 000

1 0 1 2 3km

Source: Heggies Pty Ltd (2009) - Figures A4.2, A5.2 & A6.2

Figure 4B.40
PREDICTED AIR QUALITY CONTOURS
SCENARIO 2 - LONGWALL MINING OPERATIONS

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Table 4B.43
Predicted Annual Average PM_{10} Concentrations

Residence	Annual Average PM_{10} Concentration			
	Scenario 1		Scenario 2	
	Increment	Background[+] and Increment	Increment	Background[+] and Increment
R1 - "Bow Hills"	0.3	16.1	1.3	17.2
R2 - "Ardmona"	0.3	16.1	1.5	17.3
R3 - "Naroo"	0.4	16.2	2.6	18.4
R4 - "Oakleigh"	0.2	16.0	0.6	16.4
R5 - "Pineview"	0.1	16.0	0.4	16.3
R6 - "Matilda"	0.1	15.9	0.3	16.1
R7 - "Haylin View"	0.1	15.9	0.4	16.2
R10 - "Merrilong"	0.1	15.9	0.2	16.0
R11 - "Kurrajong"	0.2	16.0	0.5	16.3
R13 - "Newhaven"	0.2	16.0	1.1	17.0
R15 - "Greylands"	0.4	16.3	2.3	18.1
R16 - "Belah Park"	0.2	16.1	2.7	18.5
R17 – "Bungaree"	0.1	15.9	0.9	16.7
R18 – "Merulana"	0.1	15.9	0.7	16.5
+ Background Annual Average PM_{10} = 15.8µg/m^3				
Source: Heggies (2009a) – Tables 21 and 22				

A contour plot of the annual average PM_{10} concentrations (background plus increment) attributable to the Mine Site for each modelling scenario is presented in **Figures 4B.39** and **4B.40.**

4B.8.6.5 Odour

The results of odour modelling predictions for the 99th percentile concentration at the surrounding residences are presented in **Table 4B.44**. The results predict concentrations well below the nominated project goal at all residences. The highest concentration would be 0.5 Odour Units compared with the project goal of 6 Odour Units.

Table 4B.44
Predicted Maximum Odour Concentration

Residence	**99th percentile Odour Concentration (OU)**	**Residence**	**99th percentile Odour Concentration (OU)**
R1 - "Bow Hills"	0.1	R10 - "Merrilong"	0.0
R2 - "Ardmona"	0.1	R11 - "Kurrajong"	0.1
R3 - "Naroo"	0.2	R12 - "Westhaven"	0.2
R4 - "Oakleigh"	0.1	R13 - "Newhaven"	0.5
R5 - "Pineview"	0.1	R14 - "Omeo"	0.5
R6 - "Matilda"	0.1	R15 - "Greylands"	0.5
R7 - "Haylin View"	0.1	R16 - "Belah Park"	0.3
R8 - "Mayfield"	0.1	R17 – "Bungaree"	0.3
R9 - "Mayfield Cottage"	0.1	R18 – "Merulana"	0.2
Source: Heggies (2009a) – Table 23			

4B.8.6.6 Emissions from Coal Wagons

A study by Ferreira et al (2003) conducted measurement of TSP emissions from coal wagons over a 350km journey, and found that for such a distance, a 60t semi-covered wagon would lose approximately 0.001% of its load. Further testing by Ferreria et al. showed that if the wagon was uncovered, emissions could be increased by up to five times that of a semi-covered wagon.

The findings of Ferreria et al were used to derive emission factors for the dispersion modelling assessment conducted by Katestone Scientific (2009) for Queensland Rail Limited (QR). The resulting predicted concentrations paired well with the track-side air quality monitoring conducted during the QR study, suggesting that the conclusions of the Ferreria et al study were acceptable for estimating the fugitive coal dust emissions from rail wagons. Consequently, in the absence of site specific emissions estimation methods, the findings of Ferreria et al have been adopted to estimate coal dust emissions from trains leaving the Mine Site.

Modelling undertaken by Heggies (2009a) predictes that peak 24-hour average TSP concentrations along the modelled route would be in the order of 5.2µg/m^3, occurring close to the release point. Beyond this point, concentrations quickly decrease to approximately 0.5µg/m^3 at 100m from the track. All residences between the Mine Site and Baan Baa are located at distances further than 100m from the track and are therefore predicted to have concentrations less than 0.5µg/m^3.

It is considered that based on the predicted concentrations of TSP, there is unlikely to be a significant impact associated with PM_{10} generated by the movement of coal trains from the Mine Site in uncovered wagons

4B.8.6.7 Greenhouse Gases

Project mining and related activities would generate greenhouse gas emissions from the following sources.

i) The combustion of fuel by diesel-powered equipment and vehicles.

ii) The release of coal bed methane and carbon dioxide (CO_2) during mining and post-mining activities.

iii) Distribution of coal products.

iv) The use of purchased electricity on the Mine Site.

v) End use of coal products.

Greenhouse gas emitting sources are classified according to accepted greenhouse gas protocol as either Scope 1, 2 or 3 emissions, as follows.

Scope 1 Emissions

Those emissions resultant from activities under the Proponent's control or from sources which they own. Emission sources (i), (ii) and (iii) are considered Scope 1 emissions.

Scope 2 Emissions

Those emissions result which relate to the generation of purchased electricity consumed in its owned or controlled equipment or operations. Emission source (iv) is considered a Scope 2 emission.

Scope 3 Emissions

These emissions are defined as those which do not result from the activities of the Proponent although arise from sources not owned or controlled by the Proponent. In the case of the Project, this includes the transportation of coal to Port Newcastle and the use of this coal, either domestically or overseas, ie. emission source (v).

A full life cycle assessment of both the projects annual and total (50 years) greenhouse gas emissions from the above sources was conducted by Heggies (2009b). The results of this assessment indicate that the total annual emissions of CO_2-equivalent as a result of the operations at the project are predicted to be of the order of approximately 19.5Mt of CO_2-equivalent per annum. This quantity is based upon the following contributions.

Seam Methane	257 954t
Seam Carbon Dioxide	94 477t
On-site Diesel Usage (Scope 1)	5 459t
Off-site Diesel Usage (Scope 3)	12 774t
Electricity	52 239t
Coal Combustion	19 051 200t
Total	**19 474 103t**

This figure is inclusive of both transportation emissions and emissions associated with the burning of the coal at its end use. Heggies (2009b) calculated the coal seam emissions using the National Greenhouse and Energy Reporting (NGER) Guidelines method for estimating emissions (NGER Method 4) using gas data provided by Mr Roy Moreby (see Appendix A of Heggies, 2009b). It is noted that an alternate method of estimating emissions, which relies on the use of emission factors provided in *Table 6* of the NGA Factors Workbook (2008) (NGER Method 1), was also considered by Heggies (2009b). Using this methodology, which is considered to be less accurate as it relies on an emission factor as opposed to measured gas concentrations, coal seam emissions are calculated as 2 440 000t CO_2-e, 2 087 569t more than the estimated emissions of NGER Method 4. Due the reliance on gas data collected from the Hoskissons Coal Seam, NGER Method 4 is considered to be a more realistic estimation of coal seam emissions.

A comparison of the predicted maximum Scope 1 emissions from the Project with the 1990 estimate recorded by the Australian Greenhouse Office in 2008 demonstrates that these emissions would represent an increase of approximately 0.06% on the total baseline Australian emissions. Heggies (2009b) recorded that at full production, the predicted emissions would represent an increase of 0.3% over 2006 emissions in NSW.

4B.8.6.8 Impacts on Livestock

Livestock are exposed to dust from many natural sources, including airborne dust as a result of dust storms, yarding or general stock movements. This dust tends to accumulate on the coat or fleece of the animals and generally falls out or is washed out in heavy rain (Hunt, 1999). Increases to dust deposition associated with the Longwall Project would be considerably less than the DECC goal for allowable dust deposition of $2g/m^2$/month for all potential grazing land outside the Mine Site. It is therefore unlikely there would be any noticeable dust-related impact on livestock.

4B.8.6.9 Impacts on Pasture

Dust accumulation on pasture at the projected rate of deposition would have no effect on pasture palatability or stock production. In grazing trials with dairy cattle, coal dust added to pasture at a rate equivalent to $8g/m^2$/day, or 1 200 times the maximum incremental increase to dust deposition predicted at the assessment locations surrounding the Mine Site, has been shown to have no effect on palatability or production by the cattle (Hunt, 1999).

4B.8.7 Monitoring

The above assessment indicates that both deposited dust levels and PM_{10} concentrations are likely to be acceptable for both the Stage 2 construction activities and operational phases of the project and as such air quality is not anticipated to be adversely affected at the surrounding residences.

However, in order to demonstrate compliance with the project air quality goals (refer Section 4B.8.4) the Proponent would continue its current air quality monitoring program to demonstrate compliance with project air quality goals. The program would involve ongoing monitoring of:

- 24 hour PM_{10} concentrations at both "Claremont" and "Turabaa";
- deposited dust at eight locations (ie. ND1 to ND8); and
- continuous wind speed and direction.

It is proposed that the monitoring program would be conducted in accordance with the following guidelines and standards.

- Monitoring would be undertaken according to the DEC document *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales* 2001. Specifically, monitoring would be conducted in accordance with the following Australian Standards.
- AS 2922-1987 Ambient Air - Guide for the Siting of Sampling Units (NSW DEC Method AM-1).
- AS 3580.9.6-2003 Particulate Matter - PM_{10} - high volume sampler with size-selective inlet.

- AS 3580.10.1-2003 Methods for Sampling and Analysis of Ambient Air - Determination of Particulates - Deposited Matter - Gravimetric Method (NSW DEC Method AM-19).

The Proponent is also committed to a program of targeted periodic emissions monitoring of all gas pumped from the mine. This program would be one component of the Proponent's Greenhouse Gas Minimisation Plan. The frequency of emissions monitoring would be reviewed biennially and adjusted to achieve the most effective and practical outcomes for the Proponent.

4B.9 SOILS, LAND CAPABILITY AND AGRICULTURAL SUITABILITY

The soils and land capability assessment was undertaken by Geoff Cunningham Natural Resource Consultants Pty Ltd (GCNRC). GCNRC undertook two separate assessments, the first (GCNRC, 2009a) undertaken above the Mining Area within the Mine Site, the second (GCNRC, 2009b) undertaken over the Reject Emplacement Area, Brine Storage Area and Water Pipeline Route. The assessments are presented in full in Volume 2 of the Specialist Consultant Studies Compendium, as Parts 9a and 9b, with the relevant information from the assessment summarised in the following subsections.

4B.9.1 Introduction

Based on the risk analysis undertaken for the project (see Section 3.3 and **Table 3.5**), the potential soil impacts and changes to land capability and agricultural land suitability requiring assessment and their **unmitigated** risk ratings are as follows.

- Insufficient soil quantities for rehabilitation (high risk).
- Temporary disturbance to soil quality (moderate risk).
- Degradation of soil quality (moderate risk).
- Elevated erosion or erosion potential (high risk).
- Decreased land and agricultural capability of the final landform (high risk).

The Director-General's Requirements issued by the Department of Planning require that the assessment of soils and land capability / agricultural land capability should refer to *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004).

The following subsections describe the soils within the areas proposed to be disturbed as part of the Longwall Project, identify the soil and land management issues and the proposed soil-related controls, safeguards and mitigation measures. Additionally, an assessment of the residual impacts upon the soil resources following the implementation of these safeguards and mitigation measures is also presented.

4B.9.2 Soils

4B.9.2.1 Regional Setting

The Narrabri Soil Conservation Service Technical Manual (Anon, 1978) depicts the Mine Site located on the boundary of Red Brown Earth soils and the Pilliga Scrub soils.

Red Brown Earth soils are generally associated with gently undulating slopes. The soils are typically hardsetting with a sandy loam to sandy clay loam A horizon overlying a sandy clay loam to light clay B horizon. The soils are predominantly red brown in colour and have a weak to moderate degree of structure.

The Pilliga Scrub soils are mainly sandy solodised soils and sandy solodic soils. The soils possess a surface horizon of light texture that is sharply differentiated from the subsoil, which has a well developed columnar structure with a sandy texture. There is usually a strongly bleached zone above the subsoil. Other soils within this complex include sandy solodised and solodic soils, deep siliceous sands, earthy sands, lithosols and red and yellow earths.

4B.9.2.2 Mine Site Soils

4B.9.2.2.1 Soil Sampling and Analysis

Mining Area

The site investigations undertaken by GCNRC (2009a) focussed upon describing and assessing the soils within ten different landform units identified by stereoscopic aerial photograph assessment of the Mine Site. The soil investigation involved the complete description of soil profiles from 36 representative test pits, each dug to a depth of 2.5m or the depth of backhoe refusal. Following the completion of soil sampling from the 36 representative test pits, the Longwall Project was modified to include a Reject Emplacement Area to the west of the box cut and other Pit Top Area infrastructure (see **Figure 2.1**). The locations of the 2009 soil sampling sites within the Mine Site are shown in **Figure 4B.41**.

A range of soil characteristics were recorded for each test pit during the field work. Additionally, 55 samples from all profiles within 14 representative profiles were analysed in the Department of Lands' NATA - registered soil testing laboratory for more detailed analysis to determine the range of particle size, dispersion percentage, coherence (Emerson aggregate test) and electrical conductivity.

Reject Emplacement Area, Brine Storage Area and Water Pipeline Route

The site investigations undertaken by GCNRC (2009b) involved the excavation, complete description and analysis of the soil horizons from 40 representative profiles, each dug to a depth of 2.5m or the depth of backhoe refusal. Five of these profiles were at the proposed Reject Emplacement Area site, twenty two within the proposed Brine Storage Area and thirteen along the proposed Pipeline Route. The locations of the 2009 soil sampling sites within the Mine Site are also shown in **Figure 4B.41**.

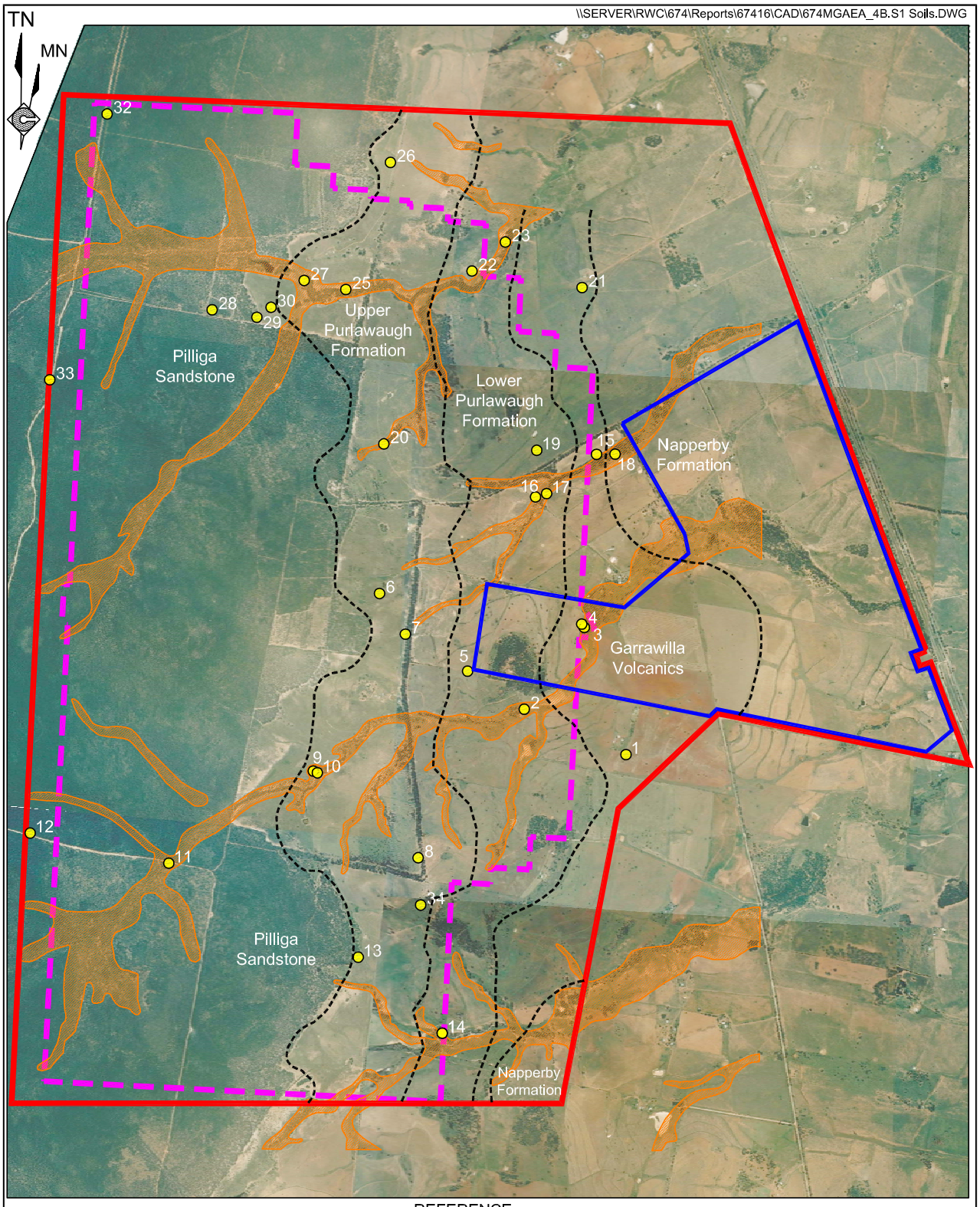


Figure 4B.41
SOIL SAMPLING SITES

4B.9.2.2.2 Soil Physical Attributes

Soils samples were analysed to characterise the physical properties of the horizons to provide a good indication of the soils likely behaviour in relation to erosive forces that may be experienced throughout the mine life. Three tests, namely particle size analysis (PSA), dispersion percentage (D%) and Emerson Aggregate Test (EAT) were undertaken and results are presented in GCNRC (2009a).

A summary of the soil analyses undertaken as part of GCRNC (2009a) and GCNRC (2009b) are as follows.

- Fifty five soil samples, representing horizons from 14 representative test pits, were taken as part of the investigations over the Mining Area (GCNRC, 2009a).
- Twenty samples, representing horizons from five soil profiles, were taken from the Reject Emplacement Area (GCNRC, 2009b).
- One hundred and eight samples, representing horizons from 22 soil profiles, were taken from the Brine Storage Area (GCNRC, 2009b).
- Twelve samples, representing horizons from three soil profiles, were taken from the Water Pipeline Route (GCNRC, 2009b).

Particle Size Analysis

The Particle Size Analysis (PSA) test shows the amounts of gravel, clay, silt, fine sand and coarse sand contained within each sample. The results recorded by GCNRC (2009a) and GCNRC (2009b) indicate the following.

- The soils of the Mining Area show that most contain very low levels of gravel. Horizons with higher levels of gravel were generally located at depth in the profile.
- The topsoils of the Reject Emplacement Area contain relatively low levels of gravel and consequently the material is suitable for use in rehabilitation works. Most subsoils also contained low amounts of gravel.
- Most of the topsoils and subsoils of the Brine Storage Area contain relatively low levels of gravel and consequently the material is suitable for use in rehabilitation works.
- The soils of the Water Pipeline Route contained low amounts of gravel.

Dispersion Percentage

The Dispersion Percentage (D%) test indicates the proportion of the soil material less than 0.005 mm in size that would disperse on wetting. The results recorded by GCNRC (2009a) and GCNRC (2009b) indicate the following.

- Based upon the results of the soil analysis of the selected soil profiles, GCNRC (2009a) identified that soil horizons with high clay contents and high D% values would be more dispersive than those with a high D% and a low clay content in the soil.

- The D% values of the topsoils within the Reject Emplacement Area indicate low levels of dispersibility. Most subsoils also displayed low dispersibility, although some samples indicated moderate to very high dispersibility. Despite the generally low dispersibility values of the topsoils, appropriate measures should be taken to protect stockpiled or respread stripped soil from erosion (GCNRC, 2009b).
- The D% values of the Brine Storage Area topsoils varied, although most displayed slight to moderate dispersibility. Subsoils were generally more dispersive (moderate to very high D%). Despite the generally low dispersibility values of the topsoils, appropriate measures should be taken to protect stockpiled or respread stripped soil from erosion (GCNRC, 2009b).
- The topsoils sampled along the Water Pipeline Route all showed slight to moderate levels of dispersibility. The D% of some subsoils was very high, however, as the pipeline trench would be refilled as soon as the pipes are laid, there should be no problems associated with stockpiling dispersible soils (GCNRC, 2009b).

Emerson Aggregate Test (EAT)

This test provides a measure of the coherence of soil aggregates when they are immersed in water. The degree of soil aggregate stability increases from Class 1 through to Class 8, with aggregates in Emerson Classes 1 and 2 being generally regarded as being unstable while those in Classes 4 to 8 are considered to be stable.

Results of the soil analyses completed by GCNRC (2009a) and GCNRC (2009b) indicate the following.

- Over the Mining Area, the topsoil layer of all geological formation / landform units are only slightly dispersive. The subsoils of all landform units generally tend to display higher dispersion than the topsoil, however, this is especially evident in the soils derived from the Purlawaugh Formation. The subsoil layers of the Pilliga Sandstone and Garrawilla Volcanics derived soils are generally much less dispersive than soils of comparable landform units derived from the Purlawaugh Formation (GCNRC, 2009a).
- The topsoils sampled from the Reject Emplacement Area show low levels of dispersibility. The subsoil EAT values were also usually low although some layers showed moderate to very high values. These values closely mirrored the results from the D% analysis (GCNRC, 2009b).
- The topsoils sampled from the Brine Storage Area generally display slight levels of dispersibility although some showed moderate to very high values. The subsoil EAT values were usually moderate to very high with an occasional slight or negligible reading (GCNRC, 2009b).
- The topsoils sampled from the Water Pipeline Route generally display slight levels of dispersibility although some showed moderate to high values. The subsoil EAT values varied from slight to very high (GCNRC, 2009b).

4B.9.2.2.3 Soil Chemical Attributes

The representative samples used for physical characterisation were also subject to laboratory chemical analyses to evaluate the likely salinity hazard. pH levels were measured in the field. The results of all chemical analyses are presented in GCNRC (2009a & 2009b).

Soil pH

The soil pH results indicate that for most soils, the pH is within the acceptable range for agronomic purposes (pH 4.0 to pH 8.5). The pH values of topsoils were typically in the range of 5.0 to 7.0 (GCNRC, 2009a & 2009b).

Electrical Conductivity

Soil salinity is a measure of the presence of water-soluble salts, mainly of sodium, calcium and magnesium in the soil solution. These salts may be chlorides, sulphates or carbonates and can have a major impact on plant growth if they occur in sufficiently large quantities. The level of salinity in a soil sample is determined by measuring the electrical conductivity [EC] of a 1:5 soil / water suspension.

The electrical conductivity data obtained from the soil analyses of GCNRC (2009a) indicates that:

- the topsoil of all landform units is non-saline;
- the subsoils derived from the Pilliga Sandstone and Garrawilla Volcanics are non-saline; and
- some subsoils derived from the Purlawaugh Formation are slightly to moderately saline.

The electrical conductivity data obtained from the soil analyses reported within GCNRC (2009b) indicate the following.

- The topsoil of all profiles from the Reject Emplacement Area is non-saline. The lower layers of two subsoil profiles are slightly saline.
- All but one of the topsoil profiles of the Brine Storage Area were non-saline. Many of the lower layers of the subsoils were slightly to moderately saline although others were non-saline. There appeared to be a trend for the profiles closer to Kurrajong Creek to be lower in salinity than those in more elevated areas.
- The topsoil of all profiles, and all but one subsoil profile, from the Water Pipeline Route are non-saline. A single subsoil profile displayed moderate salinity.

4B.9.2.2.4 Erosion Potential

Mining Area Soils

The soils within the study area are variably affected by soil erosion. Removal of vegetation cover and the development of subsidence cracks at the surface and in the subsoil would increase the likelihood of erosion particularly in heavy rain events.

Most of the topsoils are relatively sandy and so would erode quickly if unprotected. The presence of many sets of soil conservation banks and waterway systems suggests that soil erosion has been a problem in the past.

Reject Emplacement Area, Brine Storage Area and Water Pipeline Route

With the exception of some minor areas of sheet and gully erosion on sloping land, the soils within the three areas are currently generally stable. Groundcover varies over the site, but most areas support a low level of ground cover at the time of inspection.

Adequate groundcover should be maintained at all times to prevent further erosion.

4B.9.2.3 Soil Related Constraints on Development

4B.9.2.3.1 Mining Area Soils

Based upon the field observations and a review of the physical and chemical data, GCNRC (2009a) assembled a summary of the soil related constraints for the Longwall Project – see **Table 4B.45**. Reference to potential impacts associated with subsidence has been included.

4B.9.2.3.2 Soils of the Reject Emplacement Area, Brine Storage Area and Water Pipeline Route

Given the immediate replacement of soils disturbed in laying the water pipeline, GCNRC (2009b) reports no major soil-related constraints on the proposed activities.

Despite the low to moderate erodibility and erosion potential of the soils of the Reject Emplacement Area and Brine Storage Area, the soils should be managed carefully during the stripping and rehabilitation stages to ensure that damage to the soil structure is minimal and that they are suitably protected by vegetation or some other medium after rehabilitation.

There are no salinity-related constraints associated with the topsoils within the Reject Emplacement Area and Brine Storage Area, however, the levels of subsoil salinity identified in some profiles of the Brine Storage Area could constrain the establishment of an adequate vegetative cover during the stockpiling phase. The subsoil stockpiles would be seeded [hydroseeded] with a mix of pasture species that are salt tolerant and then covered with an additional hay / bitumen mulch as has been recommended to overcome the potential related dispersibility problems that may be encountered with these soils.

Table 4B.45
Topsoil and Subsoil Limitations

Soil Attribute	Surface Geology		
	Garrawilla Volcanics	**Pilliga Sandstone**	**Purlawaugh Formation**
Soil Depth	not limiting; generally quite deep profiles on slopes, floodplains and in drainage lines; more likely to be shallower on upper sloes and crests	not limiting; generally less than 250cm and much shallower on crests and slopes	not limiting; usually very deep profiles except on the crests where shallower profiles are encountered
Soil Texture	not limiting; usually finer textured [more clayey]	not limiting; generally the most sandy soils in the Mine Site;	not limiting; a mix of often coarse texture topsoils and more clayey subsoils
Soil Surface Characteristics	not limiting; surface stone usually absent but noted on upper slopes; surface sometimes self-mulching; not hydrophobic	not limiting; surface stone usually absent but noted on upper slopes; surface sometimes self-mulching; often hydrophobic	not limiting; surface stone often absent but noted on slopes; surface sometimes self-mulching; not hydrophobic
pH	not limiting; generally favourable for plant growth; usually increasing with depth	not limiting; generally lower than in the other Geological Formations and not increasing much with depth	not limiting; generally favourable for plant growth; usually increasing with depth but some lower horizons quite acid
Erodibility [as determined by the SOILOSS model]	low to moderate; some limitations where subsidence results in slope increases	low; may be some limitations where subsidence results in slope increases and in drainage lines	usually moderate; may be some limitations where subsidence results in slope increases and in drainage lines
Topsoil Dispersibility	topsoils usually not or only slightly dispersible; not limiting	topsoils usually slightly or moderately dispersible; may be limiting near subsidence cracks or where slope gradient increases following subsidence	topsoils usually slightly dispersible; usually not limiting
Subsoil Dispersibility	variable but often moderated to high; limitation in vicinity of subsidence cracks	slightly to very highly dispersible, particularly in drainage lines; may be limiting near subsidence cracks or where slope gradient increases following subsidence but may be an advantage in filling cracks	often moderately to highly dispersible; may be limiting near subsidence cracks or where slope gradient increases following subsidence but may be an advantage in filling cracks
Salinity	salinity not recorded; not limiting	salinity not recorded; not limiting	the most saline land units with slight to moderate salinity detected in drainage line, floodplain and some slopes areas; limitation in areas associated with subsidence cracks where down slope saline areas may develop after erosion

4B.9.2.4 Soil Management

Soil Handling (Mining Site)

The Longwall Project would require the disturbance of soils over a wide area of the Mine Site, associated with the construction of the Reject Emplacement Area cells, Brine Storage Area ponds and the creation of pads for drilling bore holes for gas drainage and ventilation. The following soil management procedures for both topsoils and subsoils have been developed from an interpretation of the results of the soil survey over the Mine Site and the associated field and laboratory analysis data.

- All soils would be handled as little as possible by ensuring the area to be stripped and the area of stockpiling is clearly identified.
- Soils would preferentially not be stripped or replaced when under wet conditions.
- Driving of machinery on the topsoil and subsoil stockpiles would be prohibited once the stockpiles are created, to minimise compaction and further degradation of soil structure.
- Topsoil stockpiles would not exceed 2m in height, while the subsoil stockpiles would not exceed 3m in height.
- Upslope water diversion banks and the perimeter amenity bund would direct overland surface water flow away from the soil stockpiles.
- Downslope sedimentation controls would be implemented as required, until such time as the surface of the soil stockpiles is appropriately stabilised using groundcover species.
- The formed soil stockpile surfaces would have a generally uneven surface that is as 'rough' as possible, in a micro-sense, to assist in runoff control and seed retention and germination.
- Soil stockpiles would be sown with stabilising groundcover species as soon as possible after placement and watered if necessary to speed up establishment. The vegetation would help stabilise the surface and minimise erosion and sedimentation. Salt tolerant species would be planted on the stockpiles of subsoil that has been identified as being moderately saline.
- Stabilisation measures would be taken to minimise loss of soil materials from the stockpiles prior to the establishment of stabilising ground cover. Stabilisation measures would include the use geotextile “silt fences” or lines of straw bales.

Additionally, a significant proportion of the Mine Site is, or has been actively cultivated involving the construction of a significant amount of soil conservation structures. Where the proposed surface disturbance does not impact these structures, they would be retained. In areas where surface disturbance would impact these structures, wherever possible, the alignment of these structures would be retained and they would be integrated into the areas surface water and soil management strategies.

Soil Handling (Water Pipeline Route)

The establishment of the water pipeline would require the temporary disturbance of a linear strip between the Mine Site and Namoi River. The following soil management procedures for both topsoils and subsoils have been developed based on the recommendations of GCNRC (2009b).

- Topsoil would be stripped to a depth of 15cm and stockpiled separately from the remaining profile to be excavated. The subsoil would only be removed from the trench after completion of excavation of the topsoil. This will ensure that more fertile topsoil material with its accumulated seed bank will be readily available for replacement over the trench to ensure rapid rehabilitation.
- Topsoil would only be removed from the immediate vicinity of the trench where subsoil excavation is to occur.
- The topsoil and subsoil will always be placed on the same (and opposite) side of the trench to avoid operator error during trench filling and rehabilitation.
- The soil profiles would be replaced in the same order as excavated, ie. the lowest subsoil profile first, with the topsoil replaced last.
- Given the relative fragility of some of the sandy topsoils, vehicular movements in the immediate vicinity of the trench would be minimized.

Subsidence Related Impacts

As subsidence modifies the surface topography of the Mine Site, the soils may be indirectly affected by changes to local drainage, surface cracking and other modifications to erosive and depositional forces. The exact impact of subsidence in the fashion cannot be accurately predicted and therefore the Proponent has committed to regularly inspecting those areas of the Mine Site where subsidence related impacts are likely to be most prevalent, ie. within the surface cracking zone above each chain pillar and along drainage lines.

The Proponent would also regularly inspect soil and water management structures on the Mine Site, ie. contour banks and dams, and undertake remedial works as necessary to repair any damage and halt further erosion (if occurring).

4B.9.2.5 Assessment of Impacts

4B.9.2.5.1 Direct Impact on Soils of the Mine Site

Analyses of the physical and chemical attributes of the soil to be stripped, stockpiled and ultimately respread indicate these soils have low to moderate erosion potential, pH levels suitable for plant growth and, with the exception of an area within the Brine Storage Area with moderately saline subsoil, are highly unlikely to result in increased salinity levels. As a result, the adoption of the soil management controls summarised in Section 4B.9.3 would ensure that there would be minimal impacts as a consequence of physical or chemical alteration and/or loss of biological activity. Erosion from soil stockpiles or revegetated surfaces would also be unlikely given the erosion potential of the soils and proposed protection measures.

Once the soils are replaced as part of the progressive rehabilitation of disturbance associated with gas drainage and ventilation on the Mine Site, they would provide a suitable substrate for revegetation. As such, the impact to the soils within the disturbance area is considered temporary and manageable.

4B.9.2.5.2 Possible Subsidence-related Impacts on the Soils of the Mine Site

This section identifies the possible subsidence-related impacts on Mine Site soils that may occur and which the Proponent would follow up to either repair or monitor further.

Erosion within Drainage Lines

The most likely impact of subsidence on Mine Site soils would be that of accelerated erosion along drainage lines associated with increased bed gradient. Where the soils are more clayey, it is likely that gully head cutting would develop, with this affect less noticeable where the soils of the stream beds are sandy (and less structured).

Erosion Generated by Surface Cracking

Soil erosion is expected to be associated with the subsidence induced surface crack lines within soils with moderate to high erodibility. Erosion that is triggered by a subsidence crack that is aligned down a slope may quickly develop into a rill and then a gully line if soil conservation works are not employed. Notably, the erodibility 'K' values of all soils tested were low to moderate (see **Table 4B.47**) suggesting the risk of gully erosion forming from surface cracks would not be significant.

GCNRC (2009) also identifies a risk associated with subsidence cracks aligned down the slope that they would cause the initiation of tunnel erosion on soils with dispersible subsoils (such as in some of the landform units of Purlawaugh Formation and Garrawilla Volcanics). Through the proposed Mine Site soils inspection program discussed in Section 4B.9.3.2, such impacts would be quickly identified and stabilised to reduce the impact of such processes.

Impacts on Soil Conservation Structures

Subsidence may alter the surveyed grades of the banks and lead to channel erosion and eventual ineffectiveness. Similarly, subsidence cracks can occur through banks and their associated channels making the whole system ineffective and leading to bank failure and concentration of runoff water such that it causes significant sheet, rill, gully and tunnel erosion elsewhere. By regularly inspecting soil conservation structures, the required remedial works would be identified and undertaken to minimise the potential for the changed conditions to accelerate erosional forces.

Soil Salinity

Soils within the landform units of the Purlawaugh Formation are saline at depth. Therefore, downslope aligned subsidence cracks that occur on sloping sections of these units would potentially be a source of induced soil salinity if the subsoils are dispersible and tunnelling action occurs. The sediment and soil solution that is spilled out onto downslope land after rains could potentially lead to the development of saline patches. The Proponent, through regular inspections of the Mine Site would quickly identify areas of tunnel erosion and in the event that saline soils are spread over areas of the Mine Site, these would be remediated by surface flushing or revegetation of the affected areas with salt tolerant species.

4B.9.3 Land Capability and Agricultural Land Suitability

4B.9.3.1 Existing Land Capability

"Land capability" was defined by Houghton and Charman (1986) as "*the ability of land to accept a type and intensity of use permanently, or for specified periods under specific management, without permanent damage*". Land that is used beyond its capability ultimately loses its production value through exhaustion of soil nutrient levels or land degradation of some description.

The 1: 100 000 scale Land Capability map of the Baan Baa map sheet area prepared by the former Soil Conservation Service of NSW indicates that the land within the Mine Site is mapped mainly as Class III land with a small area of Class IV land and larger areas of Class VI and Class VII land near Jacks Creek State Forest.

The field component of the soil investigation indicated that much of the area that has been cleared and farmed in the past is Class III land, land along the major drainage lines is Class IV and the remaining land of rocky ridges and sandy soils is Class VII.

Figure 4B.42 displays the land capability of the Mine Site interpreted by GCNRC (2009a) whilst **Table 4B.46** presents relevant land capability class descriptions drawn from Houghton and Charman (1986).

Table 4B.46
Land Capability Class Descriptions

Land Capability Class	Description
Class III	Sloping land suitable for cropping on a rotational basis. Structural soil conservation works such as graded banks, waterways and diversion banks, together with soil conservation practices such as conservation tillage and adequate crop rotations are required.
Class IV	Land not capable of being regularly cultivated but suitable for grazing with occasional cultivation and requiring soil conservation practices such as pasture improvement, application of fertilizer and minimal cultivation for the establishment or re-establishment of permanent pasture.
Class VII	Land best protected by green timber. It generally comprises areas of steep slopes, shallow soils and/or rock outcrop. Adequate ground protection must be maintained by limiting grazing and minimising damage by fire.
Source: Modified after GCNRC (2009a) - Section 6	

4B.9.3.2 Existing Agricultural Land Suitability

"Agricultural land suitability" is based on land capability, but with the incorporation of other factors, such as closeness to markets and availability of water or processing facilities, in order to provide an indication of its suitability with respect to agriculture (Cunningham *et al.,* undated).

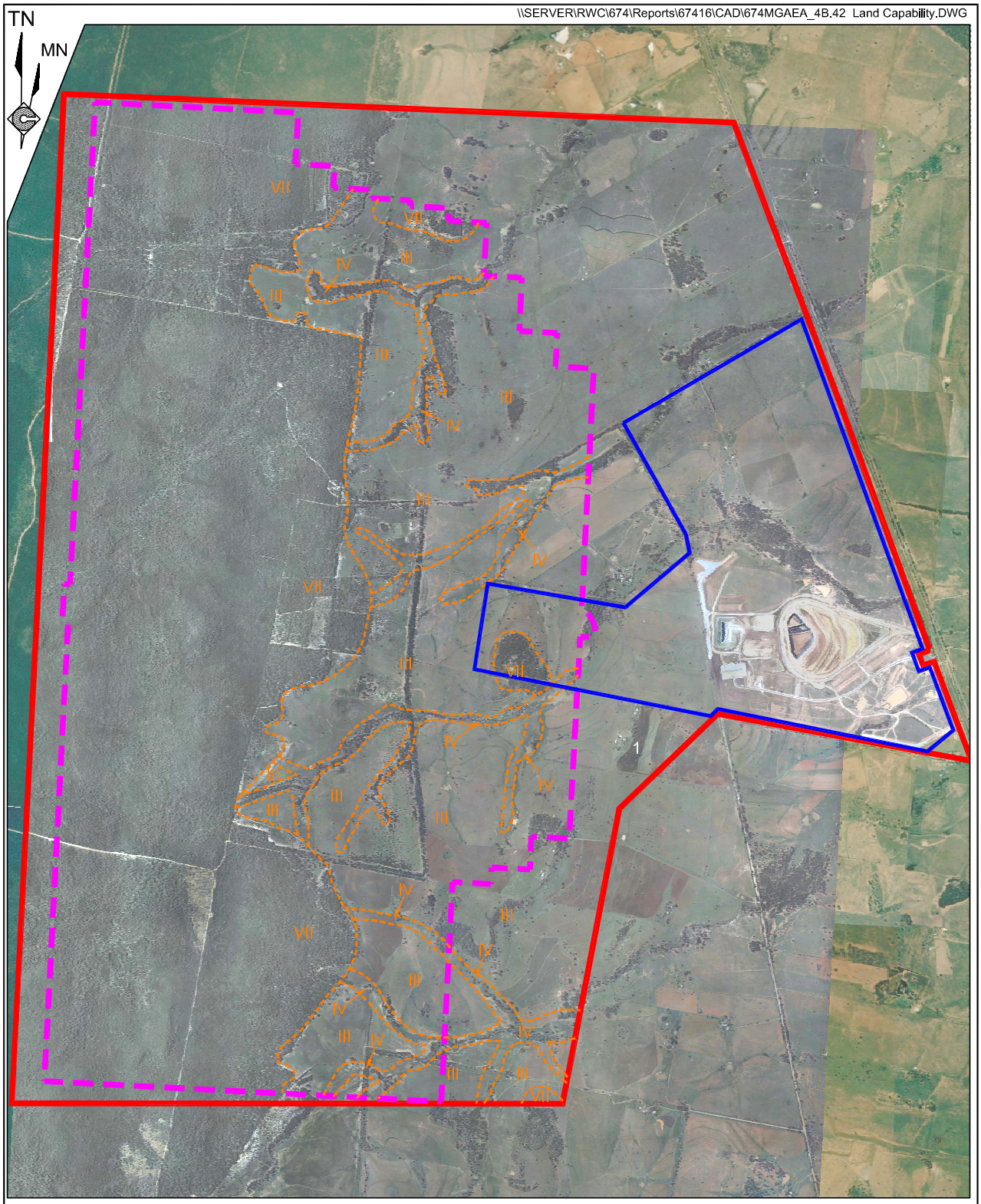


Figure 4B.42
MINE SITE LAND CAPABILITY

Through reference to the classification prepared by the former Department of Primary Industries - Agriculture (DPI-Agriculture), the lands of the Mine Site can be classified as predominantly Class 3 land with minor areas of Classes 2 and 4. Following the field survey of the Mine Site, GCNRC (2009a) generally confirmed the DPI-Agriculture assessment of the agricultural land suitability is generally correct, although the Class 4 lands would more appropriately be generally classified as Class 5. The descriptions of the agricultural land suitability classes are presented in **Table 4B.47**.

Table 4B.47
Agricultural Land Suitability Class Descriptions

Agricultural Land Suitability Class	Description
Class 2	"Arable land suitable for regular cultivation for crops but not suitable for continuous cultivation. It has a moderate to high suitability for agriculture though soil or other environmental factors reduce the overall level of production and may limit the cropping phase to a rotation within sown pastures".
Class 3	"Grazing land or land well suited to pasture improvement that may be cultivated and cropped in rotation with pasture. Erosion hazard or soil structural breakdown limit the frequency of ground disturbance, and conservation works may be required".
Class 4	"Land suitable for grazing but not for cultivation. Agriculture is based on native pastures on improved pastures established using minimal tillage techniques".
Class 5	"Land unsuitable for agriculture or at best suited only to light grazing. Agricultural production is very low or zero due to severe constraints which preclude improvement".
Source: Modified after GCNRC (2009a) - Section 6	

4B.9.3.3 Land Management Practices

The Proponent would adopt the following land management practices throughout the life of the Longwall Project and at the end of the operational life of the project that would maximise the return of land to its former capability and agricultural suitability.

- All topsoil and subsoil resources would be properly managed (see Section 4B.9.2.4).
- All surface water management controls nominated in Section 4B.3.4 would limit erosion of both natural and disturbed areas.
- Soil conservation structures on the Mine Site would be regularly inspected and damage caused by subsidence or other mining-related activity repaired.
- A substantial vegetative cover would be maintained on all areas within the Mine Site to minimise localised scouring during above-average rainfall events.
- All topsoil and subsoil would be replaced appropriately to maximise the return of vegetation following landform reconstruction.

4B.9.3.4 Assessment of Impacts

Disturbance associated with the progressive development of gas drainage and ventilation over the Mine Site would be progressively rehabilitated by replacing the soil stripped from these areas of disturbance and stockpiled as nominated in Section 4B.9.2.4. Given the relatively small areas covered by each area of disturbance within a much larger undisturbed area, it is probable that the final landform would have an equivalent land capability and agricultural suitability to that disturbed.

The Reject Emplacement Area and Brine Storage Area represent the largest surface area of disturbance of the Longwall Project. However, by replacing the originally stripped subsoil and topsoil and revegetating with agricultural pasture species, a land capability similar to that of the undisturbed landform could be established.

Subsidence may result in some small areas of the Mine Site where the land capability and/or agricultural suitability is downgraded due to waterlogging, altered drainage or erosion. However, these areas would be limited to a very small proportion of the Mine Site. The land capability and agricultural suitability of the remainder of the Mine Site would be unaffected by the changes to topography resultant from subsidence (GCNRC, 2009a).

4B.10 TRANSPORTATION ASPECTS

4B.10.1 Introduction

Based on the risk analysis undertaken for the Longwall Project (see Section 3.3 and **Table 3.5**), the potential environmental impacts related to traffic and transport requiring assessment and their unmitigated risk rating are as follows.

- Increased traffic congestion (low risk).
- Road pavement deterioration (low risk).
- Elevated risk of accident/incident on local roads (low to high risk).
- Elevated risk of rail related accident/incident (low to high risk).

In addition, the Director-General's Requirements issued by the DoP identify "Transport" as a key issue for consideration within the *Environmental Assessment* and require that the assessment refer to the Guide to Traffic Generating Development and Road Design Guide (Roads & Traffic Authority).

The following subsections assess the existing road, rail and traffic environments, the proposed changes generated by the Longwall Project, relevant design features, operational safeguards and ongoing management to mitigate the risks posed and an assessment of residual impacts.

4B.10.2 Existing Transport Network and Traffic Levels

4B.10.2.1 Introduction

The Mine Site is serviced by a private Mine Access Road, a network of local roads, a State highway and railway line. **Figure 4B.43** displays these roads and railway line all of which are described in the following subsections.

4B.10.2.2 Road Network

Mine Access Road

The Mine Access Road has been constructed as a two lane, sealed road of 8m pavement width with 1m wide unsealed shoulders and intersects with Kurrajong Creek Road, where it makes a right hand bend to the south on the western side of the railway line crossing. In order to provide for the continued drainage of surface water towards Tributary 2 of Kurrajong Creek, culverts have been constructed at natural drainage points of the existing topography.

The Mine Access Road creates a "T" intersection with Kurrajong Creek Road, ensuring priority is provided to traffic travelling east-west between the Mine Access Road and Kurrajong Creek Road, rather than traffic remaining on Kurrajong Creek Road, which continues in a north-south direction from the intersection. A Stop sign has been erected for northbound traffic on Kurrajong Creek Road to emphasise this traffic priority.

Kurrajong Creek Road

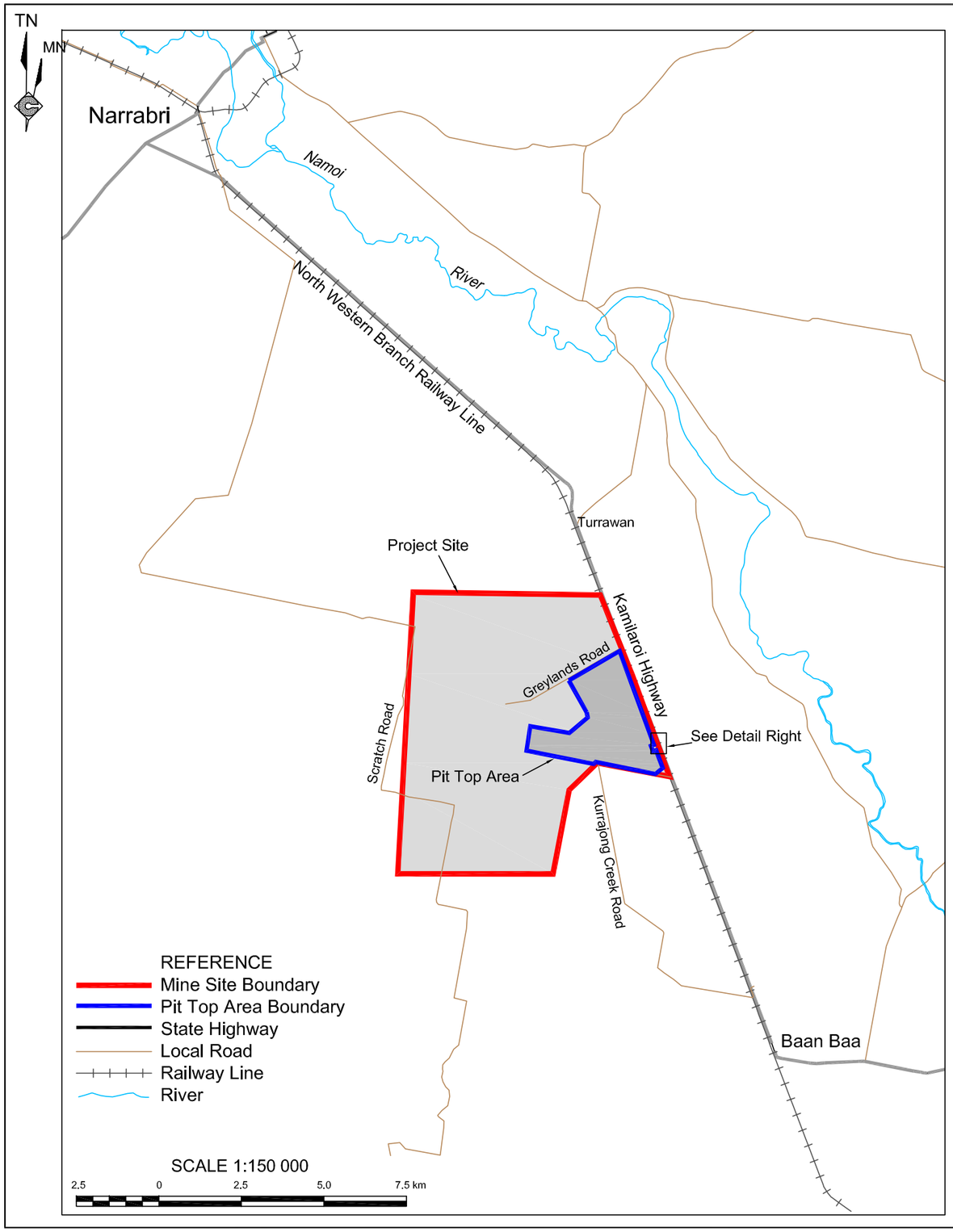
Kurrajong Creek which is sealed road for almost half its length provides access between the Kamilaroi Highway and up to 20 rural properties on the western side of the railway line. Approximately 80m of Kurrajong Creek Road is used by Narrabri Coal Mine traffic to gain access between the Kamilaroi Highway and the Mine Access Road. This 80m long section and the 7km section of the north-south section of Kurrajong Creek Road has been sealed by the Proponent.

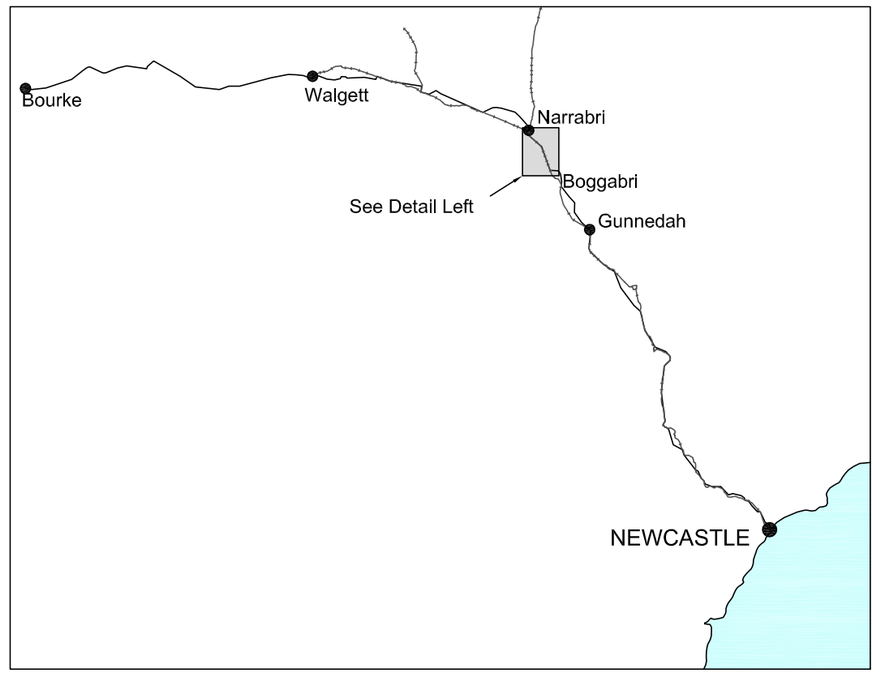
Design features of the railway level crossing on Kurrajong Creek Road are as follows.

- Flashing lights and warning bells have been installed.
- The road pavement has been strengthened with concrete for a distance of 5m on both sides of the railway line.
- A control box to activate the ground frame of the railway line (to allow movement of trains onto the Narrabri Coal Mine rail loop) is to be installed.

Prior to the commencement of operations on the Narrabri Coal Mine Site, annual average daily traffic levels on Kurrajong Creek Road are understood to have been in the order of approximately 50, the bulk of which were light vehicles. With the commencement of construction activities on the Narrabri Coal Mine Site, the number of vehicles using the 80m section of Kurrajong Creek Road has increased, on average, with an additional 80 light vehicle and 10 heavy vehicle movements per day.

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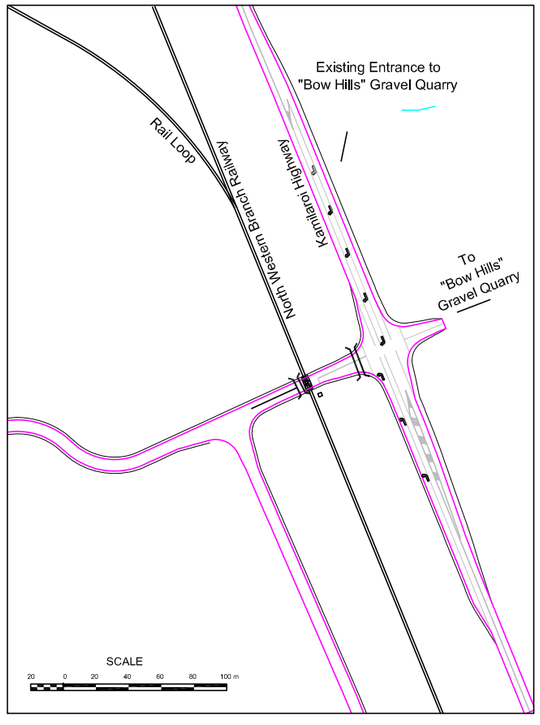


Figure 4B.43
EXISTING TRANSPORTATION NETWORK

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A school bus traverses Kurrajong Creek Road and the following summarises the operation of this service.

- School children are currently picked up and dropped off at relevant properties along the road.
- The morning pickup normally occurs between 7:45am and 7:50am and afternoon drop-off between 4:15pm and 4:20pm.
- The normal bus routine involves entering Kurrajong Creek Road at Baan Baa (from the Kamilaroi Highway), travelling northwards along Kurrajong Creek Road and picking up all children, continuing northwards and re-entering the Kamilaroi Highway at the Kurrajong Creek Road rail crossing. The bus then continues northward to Narrabri.
- The afternoon drop-off route is the reverse to the above.

The Proponent has provided the bus driver with a 2-way radio to enable regular contact with the mine control room. This contact between the bus driver and mine control room is understood to be working well.

Kamilaroi Highway

The Kurrajong Creek Road and the Mine Access Road is accessed via the Kamilaroi Highway (SH 29), a RTA highway starting at Willow Creek and passing through Gunnedah, Boggabri, Baan Baa and Narrabri before terminating at Bourke. The Kamilaroi Highway is sealed along its entire length and is part of the network of State highways that provide the basis for heavy vehicle haulage across NSW.

Table 4B.48 provides the Annual Average Daily Traffic (AADT) and traffic types on the Kamilaroi Highway (2005 data), 8km south of the Newell Highway junction in Narrabri (Station No. 92.289), ie. approximately 17km north of the Mine Site.

Table 4B.48
AADT and Traffic Types – Kamilaroi Highway

7 day /24 hr average daily traffic	Total Vehicle Breakdown				Heavy Vehicle Breakdown					
	Avg. daily cars		Avg. daily heavy vehicles		Avg. daily rigids[1]		Avg daily semis[2]		Avg. daily mutli-artics[3]	
	No.	%	No.	%	No.	%	No.	%	No.	%
1355	1122	82.8%	233	17.2%	54	4%	130	9.6%	49	3.6%

1: Austroads classification 3,4,5: two to five axle trucks
2. Austroads classification 6 to 9: three to six axle articulated trucks
3: Austroads classification 10, 11, 12: B-doubles, double and triple road trains

Source: Traffic Volume Data 2005 – Western Region (RTA, 2005).

Table 4B.48 indicates that the Kamilaroi Highway is already subject to a moderate proportion of heavy vehicles (17.2%) although the overall level of daily traffic is comparatively low and well within the capacity of the highway.

Based on traffic data collected at Station No. 92.289 at approximately four yearly intervals, and using an RTA traffic projection spreadsheet, a projection of the yearly traffic levels for the life of the project was predicted. **Figure 4B.44** presents a chart illustrating the predicted increase in traffic volumes at five yearly intervals. It is noted that **Figure 4B.44** uses the same proportions of light and heavy vehicles was assumed as provided by the RTA (2005) data (see **Table 4B.48**).

Since the RTA traffic data was collected (2005), the Narrabri Coal Mine has commenced operations increasing traffic by, on average, an additional 80 light vehicle and 10 heavy vehicle movements per day. This is still well within the capacity of this state highway.

In order to accommodate the increased traffic at the Kamilaroi Highway – Kurrajong Creek Road intersection, and to cater for the closure of the Kurrajong Creek Road railway crossing for up to 6 minutes, an intersection has been constructed to provide channelised right and left turn lanes (and deceleration tapers) on the Kamilaroi Highway, of the following distances.

	Storage	**Taper**
Right Turn Lane	98m	100m
Left Turn Lane	65m	100m

In accordance with the RTA Road Design Guide, these storage and taper zones have been developed to cater for the maximum anticipated traffic volume arriving at the intersection over a 6 minute period (equivalent to the maximum closure time of the railway crossing). Notably, the 98m storage zone of the right turn lane would cater for up to 13 light vehicles and 1 heavy vehicle and includes a 38m distance between the Kamilaroi Highway and the hold line of the railway crossing (to cater for heavy vehicle storage on this side of the intersection). It is also notable that the remaining 160m distance of the right hand turn lane is the maximum distance available before the Kamilaroi Highway narrows for a culvert ridge over Kurrajong Creek Tributary 2.

Pavement conditions of the Kamilaroi Highway are considered excellent at the intersection with Kurrajong Creek Road and both north and south of the intersection.

4B.10.2.3 Rail Traffic

The North Western Branch Railway Line provides rail access (with a single standard gauge track) between Werris Creek and Moree. Daily rail traffic on this line between Boggabri and Narrabri is currently as follows.

- Passenger train – 1 return journey (2 movements).
- Wheat train – 2 return journeys (4 movements).
- Container train - 2 return journeys (4 movements).

During a busy grain season, the number of wheat trains per day typically increase to 6 or 7 return journeys (12 to 14 movements), however, a representative of Pacific National (pers. comm. T. Kaminski) indicated that this has not occurred for several years and was unlikely in the future as local agriculture has moved away from cropping cereals to grazing or other land uses, eg. mining.

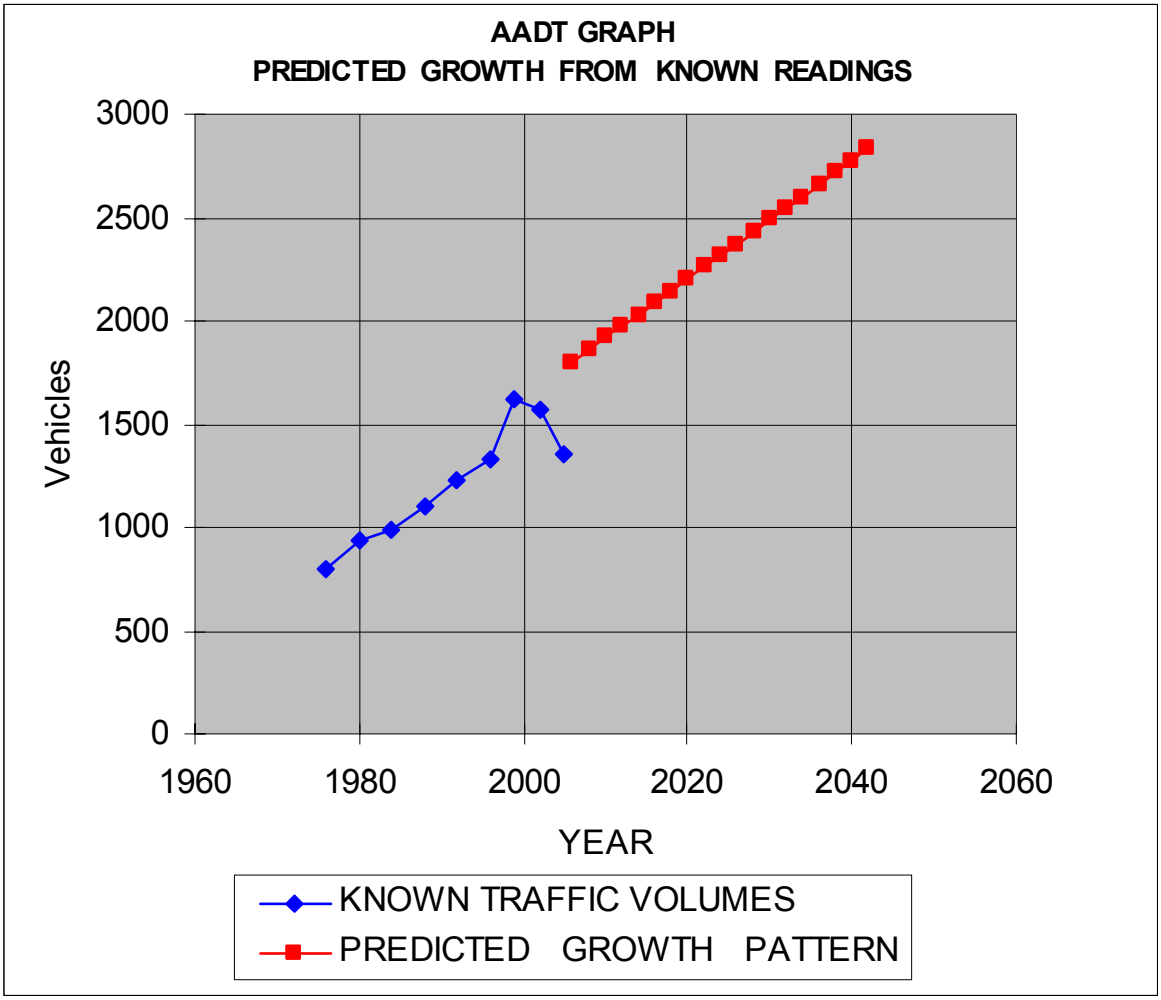


Figure 4B.44
RTA STATION 92.289 TRAFFIC PROJECTION

The average pass-by time for these trains across the Kurrajong Creek Road level crossing varies from less than 30 seconds for the shorter passenger train to an estimated 90 seconds for the longer wheat and container trains (pers. comm. T. Kaminski – Pacific National).

Further to the south on the North Western Branch Railway Line, rail transportation of coal is already occurring with coal being despatched from:

- the Whitehaven rail siding near Gunnedah (Whitehaven Coal Mining Pty Ltd) – currently drawing coal from the three operational coal mines around Gunnedah;
- the Idemitsu rail siding 4km north of Boggabri (Idemitsu Boggabri Coal Pty Ltd) – drawing coal from the Boggabri Coal Mine; and
- the Werris Creek rail siding 3km southwest of Werris Creek (Werris Creek Coal Pty Ltd) – drawing coal from Werris Creek Coal Mine.

Collectively, the operators of these rail loading facilities currently share a total of eight movements per day to Port Newcastle. Approval has also been obtained for the loading and entry of coal trains onto the North Western Branch Railway Line from the rail loop within the Narrabri Coal Mine Site.

4B.10.3 Proposed Traffic Increase

4B.10.3.1 Roads

Once the longwall component is fully operational, the Narrabri Coal Mine would increase pre-mine traffic movements by an average of 254 light and 8 heavy vehicles, and a maximum of 380 light and 20 heavy vehicles. This represents an additional 108 daily light vehicle movements (average) from that anticipated for the Stage 1 Narrabri Coal Mine operations. The light vehicle movements are expected to be concentrated around shift changeover times and based on a production crew of approximately 60, it is expected that up to 40 light vehicles may enter the Kamilaroi Highway intersection over a 30min period prior to each shift and exit via this intersection following the completion of each shift. Heavy vehicle movements would generally be restricted to daylight hours but without any specific scheduling.

The Kamilaroi Highway – Kurrajong Creek Road intersection has been designed to accommodate the over dimensional or restricted vehicles required to transport the longwall unit and other larger pieces of equipment or infrastructure onto the Mine Site.

4B.10.3.2 Rail

For the projected 8Mtpa production for the Longwall Project, an average of five loaded trains would be despatched daily to transport product coal from the Mine Site to Port Newcastle. In reality, the Proponent anticipates the number of loaded trains to be despatched daily would vary from three to seven, and occasionally eight per day. The number of trains and timetable for their arrival and departure is not controlled by the Proponent.

Given each coal train would be required to come to a complete stop prior to entering the rail loop to allow for the manual movement of the rail ground frame, it is anticipated it would take up to 6 minutes to completely exit the North Western Branch Railway and Kurrajong Creek Road rail crossing. The rail crossing would be closed for the entire period and any entering traffic required to wait at the rail crossing and possibly within the Kamilaroi Highway intersection.

4B.10.4 Design Features, Operational Safeguards and Ongoing Maintenance

4B.10.4.1 Design Features

The current and approved design of the road and rail infrastructure for the Narrabri Coal Mine is considered sufficient for the proposed Longwall Project operations at the intersection of the Kamilaroi Highway and Kurrajong Creek Road.

4B.10.4.2 Operational Safeguards

Rail Traffic

The Proponent would rely on upon the Hunter Valley Coal Chain Logistics Team for the scheduling of coal train movements between the Mine Site and Port Newcastle. Consequently, the Proponent would have little control over the operation and timetabling of rail traffic on the North Western Branch Railway Line.

Road Traffic

The following safeguards would be implemented to ensure impacts on local road users are minimised.

- All transport activities would be undertaken strictly in accordance with the project approval and environment protection licence. Deliveries of any "oversize" loads, eg. crushing / sizing plant or large earthmoving/mining equipment, would be undertaken in accordance with RTA and Council restrictions on transport hours and safety/warning requirements, and scheduled to avoid closure periods of the Kurrajong Creek Road railway crossing.
- Ensuring any project-related trucks are well maintained and that the drivers act in a courteous manner at all times.
- All employees would be instructed regarding the possible scenario where the rail crossing is closed at shift change over and requirement for patience whilst the crossing is closed.
- Routine liaison with local residents to ensure their satisfaction with all aspects of changed traffic conditions.

4B.10.4.3 Ongoing Management and Further Studies

The Proponent would manage the maintenance of the Mine Access Road, Kurrajong Creek Road, North Western Branch Railway Crossing and the identified project-related intersections for the life of the mine. It is anticipated emphasis would be placed upon maintaining:

- the sealed surface and drainage control along the Mine Access Road and sealed section of Kurrajong Creek Road;
- the intersections constructed between the Mine Access Road and the Kamilaroi Highway and Kurrajong Creek Road; and
- the Kurrajong Creek Road level crossing.

The Proponent has undertaken discussions with Gunnedah Shire Council regarding the proposed additional rail movements on the North Western Branch Railway and the impact this may have on local traffic and amenity within Gunnedah. It is recognised that similar impacts may be felt within other towns, and by other stakeholders between the Mine Site and Port Newcastle. Notwithstanding the fact that all rail traffic originating from the Narrabri Coal Mine would ultimately be allocated by Australian Rail Track Corporation (ARTC) in accordance with

rail track capacity, the Proponent has committed to continued liaison with Gunnedah Shire Council, to provide an equitable contribution to future studies on the cumulative impacts of rail traffic on all stakeholders. The Proponent is committed to working cooperatively with other rail users, the ARTC and relevant NSW government authorities once such a study is initiated. Notably, such an approach to assessing cumulative impacts of rail traffic was presented to Gunnedah Shire Council in correspondence sent on 30 September 2009, with return correspondence received from Gunnedah Shire Council supporting the approach sent on 9 October 2009 (see **Appendix 4**).

4B.10.5 Assessment of Impacts

4B.10.5.1 Traffic Congestion

Based on the traffic projection figures for the Kamilaroi Highway presented in **Figure 4B.44** (which does not include traffic generated by the Stage 1 Narrabri Coal Mine), average traffic levels generated by the Longwall Project would increase traffic on the Kamilaroi Highway by 14%. Maximum traffic levels generated by the Longwall Project would increase Kamilaroi Highway traffic by 21%. As road traffic levels would not increase throughout the Longwall Project, this percentage increase would reduce to 9% and 14% for average and maximum traffic generating days respectively.

This level of increase in traffic numbers is still well within the capacity of the Kamilaroi Highway and given the Kamilaroi Highway – Kurrajong Creek Road intersection has been designed to store up to 13 light and 1 heavy vehicle during rail crossing closure, there would be no noticeable impact on traffic flows and congestion on the Kamilaroi Highway.

4B.10.5.2 Road Pavement Condition

The Longwall Project would not noticeably increase heavy vehicle traffic volumes on the Kamilaroi Highway, and as such would not be expected to cause significant additional deterioration to road pavement condition.

In addition, the Proponent has committed to monitoring and maintaining all other Longwall Project-related roads and intersections to ensure a suitable standard of pavement is maintained.

4B.10.5.3 Road Safety

The primary road safety hazards associated with the Longwall Project would be managed to all but eliminate the possibility of an accident involving a project-related vehicle as follows.

- Flashing lights and warning bells would restrict entry to the crossing immediately prior to and while a train is using the crossing.
- The lane length between the crossing holding line and edge of the left turn lane pavement formation (38m) is sufficient to store the longest vehicle likely to require access to the Mine Site or local properties (25m B-double).

- The Kurrajong Creek Road – Kamilaroi Highway intersection has been designed to store the maximum number of vehicles considered likely to arrive at the intersection for the maximum closure time of the rail crossing, thereby removing the possible conflict with through traffic.
- Proponent employees and contractors would be instructed to obey all road rules and act in a safe, courteous and patient manner when entering or exiting the Mine Site.

Whilst human error resulting in accident cannot be completely ruled out, the likelihood of an accident caused by a project-related traffic condition alone is assessed as minimal.

4B.10.5.4 Rail Safety

Those hazard management features described in relation to road safety would also minimise the likelihood of a rail incident caused by Longwall Project-related conditions.

4B.10.5.5 Cumulative Rail Impacts

The Proponent has committed to ongoing support and contribution to any future study on cumulative impacts on the stakeholders located along the North Western Branch and Main Northern Railway Lines. An assessment of cumulative impact, and the contribution of the Proponent, would be assessed at this time. It is noted that Gunnedah Shire Council, who initially raised the issue is satisfied with this approach (see **Appendix 4**).

4B.11 VISIBILITY

4B.11.1 Introduction

Based on the risk analysis undertaken for the project (see Section 3.3 and **Table 3.5**), the potential environmental impacts on visual amenity requiring assessment and there unmitigated risk rating are as follows.

- Reduced amenity of the altered Mine Site landform as a result of:
  - temporary disturbance to the landform (high risk);
  - marginally identifiable changes to landscape in the final landform (high risk); and
  - highly identifiable changes to the landscape in the final landform (moderate risk).
- Reduced effectiveness of the Siding Springs Observatory as a result of night time lighting (low risk).

In addition, the Director-General's Requirements issued by DoP identify "Visual" as a key issue for consideration within the *Environmental Assessment*.

The following subsections assess the existing visual amenity of the local setting, identify operational safeguards and mitigation measures and provide an assessment of the residual impacts following the implementation of these safeguards and mitigation measures.

4B.11.2 Existing Visual Amenity

Existing visual amenity is considered in relation to views of the Mine Site component areas, namely, the Pit Top Area, Reject Emplacement Area, Ventilation Shaft Areas, and gas drainage sites to be developed progressively on the Mine Site. Various views of the Pit Top Area (and Reject Emplacement Area once constructed) are currently possible from the following non-project related residences or parts of these properties.

- "Naroo"
- "Kurrajong"
- "Pineview"
- "Oakleigh"
- "Ardmona"
- "Bow Hills"
- "Greylands"

Views of the Ventilation Shaft Areas and gas drainage activities would also be possible from the following additional non-project related residences or properties.

- "Newhaven"
- "Matilda"
- "Haylin View"
- "Bungaree"

Views of the component areas are described as either local (within 1km) or distant (>1km), direct (without significant obstruction from topography or vegetation) or obscured (with significant obstruction from topography or vegetation). **Table 4B.49** provides an assessment of the view afforded to each non-project related residence on or surrounding the Mine Site.

Table 4B.49
Local Views Afforded to Non-Project Related Residences

Page 1 of 2

Residence	Pit Top Area / Reject Emplacement Area / Brine Storage Area		Initial Ventilation Shaft Area		Gas Drainage Activities (see Figure 2.10)	
	Distance (m)	Description	Distance (m)	Description	Distance (m)	Description
"Naroo"	1 000	Local view obscured by vegetation	3 760	Distant view obscured by topography and vegetation	3160	Distant view
"Oakleigh"	2 160	Distant view obscured by vegetation	4 300	Distant view obscured by topography	3 320	No view - obscured by topography
"Haylin View"	2 580	Distant view obscured by topography and vegetation	3 260	No view - obscured by topography	1 580	Distant view
"Pineview"	2 630	Distant view obscured by vegetation	4 470	No view - obscured by topography	3 160	No view - obscured by vegetation
"Matilda"	2 840	Distant view	3 7400	No view - obscured by topography	2 420	Distant view
"Kurrajong"	2 100	Distant view obscured by topography and vegetation	2 100	No view - obscured by vegetation	200	Local and direct view
"Newhaven"	2 370*	Distant view - obscured by vegetation	3 950	Distant view - obscured by topography	840	Local and direct view

Table 4B.49 (Cont'd)
Local Views Afforded to Non-Project Related Residences

Residence	Pit Top Area / Reject Emplacement Area / Brine Storage Area		Initial Ventilation Shaft Area		Gas Drainage Activities (see Figure 2.10)	
	Distance (m)	Description	Distance (m)	Description	Distance (m)	Description
"Bungaree"	1 680*	Distant view - obscured by vegetation	3 950	Distant view - obscured by topography	1 530	Distant view
"Greylands"	200*	Distant view obscured by vegetation	3 000	Distant view obscured by vegetation	990	Local and direct view
"Merulana"	1 320*	Distant view obscured by road and roadside vegetation	4 210	No view - obscured by road and roadside vegetation	2 100	No view - obscured by road and roadside vegetation
"Belah Park"	260*	Local view obscured by road and roadside vegetation	3 420	No view - obscured by road and roadside vegetation	2 100	No view - obscured by road and roadside vegetation
"Bow Hills"	890	Local view obscured by roadside vegetation	3 950	No view - obscured by Pit Top Area	3 680	No view - obscured by Pit Top Area
"Ardmona"	1 580	Distant view obscured by road and roadside vegetation	3 950	No view - obscured by topography and vegetation	3 840	No view - obscured by road and roadside vegetation
Note *: Distance has been calculated to closest point of Brine Storage Area, which may not be constructed for many years (if at all) dependent on mine in-flow rates and dewatering requirements.						

Local views of the Pit Top Area are also possible from sections of Kurrajong Creek Road and the Kamilaroi Highway.

4B.11.3 Visual Control Measures

The principal visual control measures adopted within the Pit Top Area include the following.

- The 3m high perimeter amenity bund (see **Figure 2.2**) provides a barrier for views to the facilities within the Pit Top Area, particularly from Kurrajong Creek Road and the closest residences ("Naroo", "Ardmona" and Bow Hills"). A cover of grass is being established over the bund itself to limit its visual contrast, and it would be planted with a range of trees and shrubs to create a long term screen and fauna movement corridor.
- All areas not required for site operations, particularly following site establishment, would be revegetated to ensure the maximum area of grassed paddock is present.
- The load-out bin above the rail load-out area and site buildings would be painted in a grey/green hue to limit their overall visibility.
- A high standard of housekeeping would be adopted to maintain a tidy site.

The initial Ventilation Shaft Area has been selected in an area already shielded from residences to the south and southeast by topography and existing vegetation. The construction of the perimeter bund around the shaft itself would further reduce visual access to this area. Each additional ventilation shaft would also be surrounded by a bund wall, which would be grassed to reduce visual contrast.

Gas drainage activities would be temporary in nature, and similar visually to the exploration drilling activities which has been ongoing over the Mine Site for a number of years. Beyond a distance of a few hundred metres, the activities would be virtually imperceptible with dust suppression activities undertaken to reduce dust generation, likely to be the most noticeable aspect of these operations. Once completed, the gas drainage sites would be rehabilitated to re-establish the pre-existing vegetation.

4B.11.4 Assessment of Impacts

The development and operation of the Longwall Project would be noticeable in the local area, particularly the conveyor and processing infrastructure, and the load-out bin of the Pit Top Area, which would rise up to 25m above natural ground level.

The construction and operation of mine ventilation shafts is also likely to be noticeable from some residences and properties, although the visual impact would be largely mitigated by the construction and vegetation of an acoustic bund wall around each fan site. Drilling and gas pumping operations associated with the gas drainage of the Longwall Project may be noticeable from some properties, however, the disturbance associated with this activity would only be temporary and of very minor impact.

Finally, increased rail traffic may also be noticeable from those properties fronting the railway line.

On the basis of the relatively minor impacts of the activities proposed, and the controls proposed, it is assessed that the visual intrusiveness of the modified operations associated with the Longwall Project would be minor and acceptable.

4B.12 LAND USE

4B.12.1 Introduction

The three primary land uses on and surrounding the Mine Site, as identified in Section 4A.3.3 are agriculture (including rural residential occupation of local properties), forestry and native vegetation conservation. Based on the environmental risk analysis undertaken for the Longwall Project (see Section 3.3.1 and **Table 3.5**), the potential impacts related directly to local land use and the relative unmitigated risk rating, are as follows.

- Reduced access to agricultural lands (moderate risk) which would be influenced by:
  - decreased land and agricultural capability of the final landform (high risk);
  - Damage of destruction of structures or infrastructure on local properties (moderate/high risk);
  - reduction in the yield / saturated thickness of groundwater bores (moderate/high risk);
  - Altered surface flows affecting contour banks and drainage on agricultural land (low risk);

  - reduced productivity of downstream grazing lands as a result of reduced natural surface water flows (low risk); and
  - increased noise levels associated with the project leading to reduced production, ie. impacts on livestock (low risk).

- Loss of, or alteration to, existing habitats, impacts on threatened species or reduced local biodiversity as a result of direct disturbance or subsidence related impacts (moderate/high risk).
- Impacts on forestry activities (not allocated a risk ranking due to very minor scale of disturbance with the state forest).

The residual impacts of the Longwall Project on these identified land uses have been largely addressed throughout the preceding sections. This section consolidates the results of these previous assessments and provides a general conclusion regarding the compatibility of the Longwall Project with these land uses and impacts on current and future operations.

4B.12.2 Impact on Agricultural Land Use

4B.12.2.1 Pit Top Area and Progressive Mining Area Disturbance

Agricultural activities over the Mining Area and Pit Top Area of the Mine Site would be directly affected by the proposed surface disturbing activities associated with the construction of the Reject Emplacement Area, Brine Storage Area (if required) and infrastructure associated with the installation and operation of mine ventilation and gas drainage. The disruption caused to current agricultural activities would be limited to the areas of disturbance, the majority of which is proposed to occur on Proponent-owned properties.

4B.12.2.2 Subsidence-related Impacts on the Mine Site

As discussed in Section 4B.1, subsidence caused by the Longwall Project would result in damage to buildings and other farm-related infrastructure on the properties across the Mining Area or within the subsidence angle of draw. As a consequence, ongoing occupation of residences within this subsidence affected land would be incompatible with the longwall mining operations and the Proponent has arranged for these to be vacated well in advance of them being undermined.

As noted in Section 4B.1.6, subsidence is likely to affect local drainage, increase the erosion potential of some lands, damage farm infrastructure such as fences, roads, dams and other water management structures and result in surface cracks which could increase the risk of injury to livestock. These impacts alone may not preclude the ongoing use of the affected properties (with appropriate management controls), and as such agricultural activities may remain compatible with the Longwall Project. However, the risk of injury or other impact to farm personnel, livestock or equipment has been assessed and the Proponent would require the cessation of agricultural activities on Proponent-owned properties for a period of 1 or 2 years. On properties not owned by the Proponent, Individual Property Subsidence Management Plans (including dilapidation surveys of any farm structures) would be undertaken to provide fair and reasonable outcomes between the affected property owner and the Proponent. Ultimately,

ongoing agricultural activities on properties over the subsidence affected area may not be compatible with the Longwall Project for a period of time, ie. whilst longwall mining is undertaken below or adjacent to the property.

To ensure that the subsidence-affected land is available for future agricultural activities, the Proponent would provide for periodic maintenance of these properties, eg. slashing, fence, road and water management structure maintenance, although it is not planned to repair or rebuild any residential structures damaged beyond reasonable repair by subsidence-related impacts.

4B.12.2.3 Subsidence Related Impacts beyond the Mine Site

As discussed in Section 4B.1.6, direct subsidence-related impacts are predicted to be limited to immediately above the Mining Area and angle of draw. As such no direct impact of the Longwall Project on agricultural activities beyond the Mine Site is predicted as a direct consequence of mine subsidence (impacts on water resources which may be influenced by mine subsidence are considered separately).

4B.12.2.4 Impacts on Local Water Resources

As discussed in Sections 4B.2.5.6 and 4B.2.5.7, the Longwall Project would have minimal or no impact on the water resources of the Upper Namoi Alluvium or intake beds of the Great Artesian Basin GWMA's, which contain the aquifers from which most local agricultural producers derive their water. The majority of groundwater bores potentially affected by the predicted drawdown in the aquifers of the Gunnedah Basin GWMA are located on Proponent-owned properties, limiting the potential impact of the Longwall Project on water supply to local agriculture. The above notwithstanding, the Proponent has committed to mitigating or compensating any groundwater user affected by the longwall mining operations.

As discussed in Section 4B.3.4.3, there would be minimal impact on local surface water supplies as the harvesting of clean water from the Kurrajong Creek catchment would be well below the maximum harvestable right for the Proponent-owned lands. In fact, the discharge of surplus raffinate to the Namoi River may actually provide a net benefit to agriculture, by increasing the flow rate of the Namoi River (especially under low flow conditions) and thereby providing for increased security of supply for downstream users of Namoi River water.

4B.12.2.5 Noise and Air Quality related Impacts

Previous studies of mining and quarry projects have found that the noise levels such as those likely to be generated by the Longwall Project have no impact on livestock health or agricultural production (Hunt, 1999).

As discussed in Sections 4B.8.6.8 and 4B.8.6.9, the particulate matter generated by the Longwall project is unlikely to have any impact on livestock or crop production.

4B.12.2.6 Impacts on Soils and Land Capability

As discussed in Section 4B.9.2.5.1, the adoption of the soil management controls summarised in Section 4B.9.3 would ensure that there would be minimal impacts as a consequence of physical or chemical alteration and/or loss of biological activity. Erosion from soil stockpiles or revegetated surfaces would also be unlikely given the erosion potential of the soils and proposed protection measures.

As discussed in Section 4B.9.2.5.2, the most likely impact of subsidence on Mine Site soils would be that of accelerated erosion along drainage lines associated with increased bed gradient. Where the soils are more clayey, it is likely that gully head cutting would develop, with this affect less noticeable where the soils of the stream beds are sandy (and less structured). Erosion is also expected to be associated with the subsidence induced surface crack lines within soils with moderate to high erodibility. Through the proposed Mine Site soils inspection program discussed in Section 4B.9.3.2, such impacts would be quickly identified and stabilised to reduce the impact of such processes.

As discussed in Section 4B.9.3.4, subsidence may result in some small areas of the Mine Site where the land capability and/or agricultural suitability is downgraded due to waterlogging, altered drainage or erosion. However, these areas would be limited to a very small proportion of the Mine Site. The land capability and agricultural suitability of the remainder of the Mine Site would be unaffected by the changes to topography resultant from subsidence.

4B.12.2.7 Conclusion

The Longwall Project may be incompatible with ongoing agricultural activities over the subsidence affected land of the Mine Site, for a small proportion of the mine life. However, based on the commitments of the Proponent to ongoing management of affected lands, and the minimal impact predicted on aspects such as water resources, soils and land capability, a return to an agricultural land use at the cessation following stabilisation of subsidence impacts would be possible.

Importantly, the Longwall Project would not be incompatible with ongoing agricultural land uses beyond the subsidence affected land (both on and adjacent to the Mine Site). In fact, there may be some advantages to those who draw water from the Namoi River, which will be provided with additional flows.

4B.12.3 Impact on Forestry

Direct disturbance to Jacks Creek and Pilliga East State Forests, as a result of clearing for gas drainage sites and associated tracks, would represent less than 0.02% of total forest area of the two state forests (which cover approximately 164 600ha). If the entire subsidence affected land on the Mine Site is considered, the area of forestry land affected would increase to no more than 1% of the total forest area of the two state forests. It is considered preferable that forestry activities be restricted within the affected areas of the Mine Site for the life of the Longwall Project. There would be no reason however, to alter current forestry operations within the remaining 99.9% of the two state forests.

On completion of the Longwall Project, there would be no reason why forestry could not recommence within the section of the two state forests which are located within the Mine Site.

4B.12.4 Impact on Native Vegetation Conservation

The impact of the Longwall Project was discussed in detail in Section 4B.4. On the assumption that the proposed mitigation and offset measures are implemented, the Longwall Project would remain compatible with ongoing native vegetation conservation and through the implementation of the biodiversity offset area, may ultimately provide for greater security of conservation for a number of threatened species.

4B.13 SOCIO-ECONOMIC SETTING

The social assessment component within this subsection incorporates an update of the social assessment conducted in 2007 by Key Insights Pty Ltd for the Stage 1 Narrabri Coal Project whilst the updated economic assessment is based upon information supplied by the Proponent. It is noted that no substantial changes have occurred since 2007 to change the content or approach to the socio-economic assessment.

4B.13.1 Introduction

Given the location of the Narrabri Coal Mine between the major regional centres of Narrabri and Gunnedah, both of these towns and their respective Local Government Areas (LGAs) provide the focus of much of the socio-economic setting of the mine. The area around the mine enjoys a regional and rural setting recognised for its agricultural productivity and related industries centred on the productive Namoi Valley.

Based on the risk analysis undertaken for the Longwall Project (see Section 3.3 and **Table 3.5**), the potential socio-economic impacts requiring assessment and their unmitigated risk rating are as follows.

- Alteration of social activities or employment due to employment generation and capital expenditure (no risk rating).
- Perceived or real impacts on local amenity of neighbouring properties (moderate risk rating).
- Reduction in property values due to the presence of the mining operation (moderate risk rating).
- Implications of the increased workforce on the need for services and infrastructure (moderate risk rating).

The Director-General's Requirements particularly request that the assessment of socio-economic impacts makes particular reference to any increased demand for infrastructure and services in the Narrabri-Gunnedah region. Similarly, correspondence from the Namoi Catchment Management Authority requested consideration of:

- the negative socio-economic impacts on biodiversity, surface and groundwater sources, riparian areas and land use, and local, regional and catchment communities; and
- the social and economic impacts of the Reject Emplacement Area, particularly with respect to visual and amenity impacts and changes to landscapes.

The socio-economic assessment presented in this subsection incorporates both published background information and an analysis of previous social and economic assessments in the region in order to obtain a general understanding of the local setting, social issues of greatest concern and community views/opinions on the recent introduction of coal mining to the Narrabri District. This analysis reflects the experiences observed since the commencement of activities at the Narrabri Coal Mine.

The statistical data referenced in this section is drawn from the census data compiled by the Australian Bureau of Statistics for both 2001 and 2006.

An analysis was initially undertaken by Key Insights (2007) for Stage 1 of the Narrabri Coal Project and involved a detailed qualitative research of those social issues identified to be of greatest interest to local stakeholders, namely:

- housing;
- education;
- industry diversification;
- employment opportunities; and
- community services and facilities.

The results obtained by Key Insights in 2007 have been updated wherever possible.

Based on the identification of the various social issues, the qualitative research component of the assessment focuses on the:

- consideration of the existing services, facilities and opportunities within the Narrabri and Gunnedah Local Government Areas; and
- consultation with various professionals working in the key areas.

The socio-economic assessment of the proposed Longwall Project also reflects a number of the socio-economic outcomes of the Stage 1 mine development since site activities commenced in April 2008.

This section concludes with a review of potential socio-economic impacts and the management measures the Proponent intends to adopt to minimise adverse impacts on the local and regional communities and their economies. In this sense, reference is made to both potential negative and positive impacts of the mine and the proposed Longwall Project in particular.

4B.13.2 The Existing Social and Economic Setting

4B.13.2.1 Background

Five previous social assessments were reviewed, namely:

- the Boggabri Coal Project (AMAX/BHP, 1982);
- the Whitehaven Coal Mine proposal (RWC, 2000);
- the East Boggabri Coal Mine (Key Insights and Castlecrest Consulting, 2005);
- the Narrabri Coal Mine Stage 1 Assessment (Key Insights, 2007); and
- Assessment of Opportunities for Narrabri Shire from Coal Mining and Gas Extraction in the Gunnedah Basin (Narrabri Shire Council, 19 June 2007 – prepared by Jenny Rand and Associates).

These assessments identified the following common issues.

- The Narrabri/Gunnedah region has been experiencing declining populations over recent decades.
- There has been net migration from rural areas, especially as a result of young people moving to regional centres in search of further work and educational opportunities.
- There is generally wide community support for mining in the Gunnedah Basin, although concerns have been expressed for those potential coal resource areas underlying high productivity agricultural land in the Quirindi district. Residents of Narrabri and Gunnedah generally welcome the economic and employment benefits that flow through to their towns as a result of the continued expansion of coal mining activity.
- The communities recognise mining as a positive way to bring population growth and much needed diversity back to the local economy.
- Housing supply concerns have previously been raised with separate houses being the overwhelmingly dominant form of housing in the Narrabri/Gunnedah area. It has been recognised that the form of accommodation is changing to reflect the demand by mining and related industries. The influx of new workers for the construction and operation of the Longwall Project may provide particular short-term stress on the market although the global economic downturn in late 2008 / early 2009 has meant that this stress has been reduced to some extent and the influx of mine workers has ensured that the property markets in the Narrabri/Gunnedah area have remained relatively stable. It is understood from local real estate representatives that the prices for homes in Gunnedah have increased at a rate grater than that experienced in Narrabri during the same period.

- The Narrabri and Gunnedah economies are primarily driven by agriculture and subsequently, the labour market and skills pool are not particularly deep. The labour market is quite tight in the areas of professionals and skilled trades. These structural conditions of the labour market may mean that it is necessary to import a considerable proportion of the workforce, notably those with highly developed, mining-related skills.
- There may be some transfer of workers from the agricultural sector to the better paid mining sector, however, high levels of youth unemployment suggest a considerable pool of young workers, who would be available to engage in low-skill jobs or participate in structured training.

4B.13.2.2 Population and Age Profile

Statistics from the Australian Bureau of Statistics collected in 2001 and 2006, and summarised as follows, display the following data relating to the regional and local setting.

- The population of the main local towns and villages around the Mine Site are as follows.
  - Narrabri – 7 419 persons (6 102 within the town itself)
  - Baan Baa – 211 persons
  - Boggabri – 1 072 persons (901 within the town itself)
  - Gunnedah – 8 044 persons (7 542 within the town itself)
- A comparison between population data recorded in the 2001 and 2006 census revealed the following.
  - The population of the Narrabri township decreased by 132 (2.1%)
  - The population of the Boggabri township increased by 98 (12.2%)
  - The population of the Gunnedah township decreased by 313 (4.0%)
  - No comparison of the populations of Baan Baa was possible as this locality was not identified by the 2001 Census.
  - The population of the Narrabri and Gunnedah Local Government Areas decreased by 681 (4.9%) and 451 (3.8%) respectively.
- When compared to the NSW average statistics, there are:
  - fewer persons in the 15 to 24 (1.9%) and 25 to 54 (2.3%) age groups; and
  - more persons in the 0 to 4 (0.9%), 5 to 14 (2.2%), 55 to 64 (0.8%) and 65 and over (0.4%) age groups.

4B.13.2.3 Households and Dwellings

Average households in the communities of Narrabri, Baan Baa, Boggabri and Gunnedah range from 2.4 (Gunnedah) to 2.7 (Baan Baa) persons compared with 2.6 throughout NSW.

Consultation with Narrabri Shire Council and various Narrabri real estate agents established that there is a good supply of homes and vacant blocks for sale but the rental market is tight. (refer to **Table 4B.50**). It was reported that the number of houses on the market for sale was generally lower than previous years because a number of people are waiting for prices to rise before placing their homes on the market.

Table 4B.50
Availability of Residential Properties for Sale or Rental in Narrabri Shire (August 2009)

Town	Dwelling type		
	House for sale	Vacant blocks for sale	Residential rental
Narrabri	79	25	14 (5 houses, 9 units)
Boggabri	34	6	3
Wee Waa	19	0	11
Narrabri Shire (total)	132	31	28

It was also reported that the availability of short term accommodation such as motels is very limited and an additional motel in Narrabri would enjoy viable occupancy rates.

In 2008/2009 and 2007/2008, Narrabri Shire Council approved 27 and 78 development applications for dwellings and town houses respectively. Most of the 2007/2008 applications have been constructed. It is understood that there is a good supply of privately owned land in and around Narrabri which is suitable for residential development.

Consultation with Gunnedah Shire Council and a Gunnedah real estate agent established that there is a good supply of homes and vacant blocks for sale in the town and an adequate availability of houses and units for rental. At August 2009, there were approximately 150 dwellings for sale in Gunnedah, approximately 10% of which were units or townhouses. During 2009, the town has experienced an increase in the number of enquiries from people interested in relocating to Gunnedah. Reportedly these are predominantly families seeking a "tree-change", wanting to raise their children in a township which is large enough to provide quality education and other services, yet small enough to provide a safe and comfortable lifestyle, particularly for child rearing.

The Gunnedah LEP indicates that there are 1100 potential housing blocks within Residential zoning remaining. Since 2006, Gunnedah LGA has granted approval for the subdivision and development of approximately half of these. Approximately 20% of these approvals, primarily in three large residential estates, have been developed with road works and services. Of these, approximately 30% have had houses constructed. In Gunnedah, sixty residential units have been recently approved and developed, and rezoning undertaken in 2007 resulted in the approval of 90 industrial blocks, ranging from 2 500 to 60 000 m^2 in size and totalling 136 ha.

It is recognised that, based on the positive impacts of the first stage of the mine's development, a number of entrepreneurs have already commenced building housing in anticipation of new mining ventures. It is already noticeable that development of suitable accommodation types, eg. serviced apartments, is occurring in both Narrabri and Gunnedah with pleasing results for the developers. Also it has been observed that some developments in Narrabri are offering up-market quality houses, some with sought-after river views and views of the Kaputar Range. It remains the general view that new settlement would be limited in Baan Baa because of the lack of a town water supply and the absence of a primary school. Gunnedah Shire Council reports that the town of Gunnedah can increase to a population of approximately 14 000 without difficulty.

Local real estate agents describe the local housing market as reasonably stable and expressed that the housing market could cope with a further population increase caused by the creation of new employment opportunities associated with the Longwall Project. The limited availability of rental properties could be expected to continue or slightly improve during the proposed construction period for the Longwall Project. The ability of the various towns to accommodate the workforce during the Stage 1 construction period provides an excellent basis upon which to acknowledge that the Stage 2 construction period would similarly be managed in these towns.

4B.13.2.4 Existing Educational Facilities and Medical Services

Education Facilities and Services

Narrabri is serviced by a range of daycare centres and preschools, three primary schools and one secondary school. Narrabri High School draws students from a number of primary schools operating in the smaller towns and villages within the Narrabri LGA. Narrabri TAFE College offers a range of courses suitable for the mine workforce (eg. engineering, manufacturing, reception skills, payroll, bookkeeping, IT) as well as general interest courses (eg. childcare, business skills, digital photography etc.).

In August 2009, approximately 896 primary school students and 595 secondary school students were enrolled in the three primary schools and one secondary school in Narrabri. A total of 165 students were enrolled at Wee Waa High School. In Boggabri, 100 students attend Boggabri Public School and 38 attend the local Catholic primary school. It has been established that the existing primary and secondary schools in Narrabri have the capacity to enrol 1068 and 720 students respectively in their schools. Wee Waa has the capacity to easily expand to 200 students. The two schools in Boggabri have the capacity to increase combined enrolments to 205, without any capital works. In the Narrabri-Boggabri-Wee Waa area an increase of 274 primary school students and 160 secondary school students could be easily managed within the schools' existing structures and constraints.

Gunnedah is serviced by four primary schools, namely two State schools, one Catholic and one Christian Community School. Two high schools are present in Gunnedah, namely a State school and a Catholic High School, St Mary's College. Gunnedah is also serviced by a range of childcare centres and preschools. Gunnedah TAFE provides a range of State-approved courses with local content. It is most likely that Gunnedah TAFE would benefit from mining growth in the region and is likely to provide flexible delivery options to new and young workers.

In August 2009, there were reportedly 1039 primary school children and 917 secondary school students attending schools in Gunnedah. It has been established that the existing primary and secondary schools in Gunnedah have the capacity to enrol 1212 and 1520 students respectively in their schools. An increase of 173 primary school students and 603 secondary school students could be easily managed within the schools' existing structures and constraints.

The nearest university campus is the University of New England, which has a campus in Armidale. With respect to further education opportunities, it was noted that Narrabri TAFE, part of the New England Institute, is at the forefront of innovation in manufacturing and engineering-related trade courses. However, at present, the majority of the current mining-related TAFE courses are conducted at Tamworth TAFE. It is understood there is scope for Tamworth TAFE to coordinate relevant courses at Gunnedah and Narrabri if there is sufficient need and the availability of suitably qualified teaching staff.

Healthcare Facilities and Services

Narrabri is serviced by a District Group Level 2 (community acute) Health Service which provides the following services.

- Acute care
- Medical
- Surgical
- Maternal
- Paediatric Services
- 24hr emergency department.

The current Narrabri hospital is a forty bed facility with district level services in obstetrics and surgery featuring a newly refurbished emergency unit. The already extensive services would be improved in Narrabri with a $42 million project to build a brand new forty bed hospital and combined health service by 2011. Narrabri and district residents are serviced by only one dentist with waiting times recognised to cause difficulties for the locals.

Additional healthcare facilities and services in the Narrabri LGA include:

- Hospitals at Boggabri and Wee Waa
- community health centres in Narrabri, Boggabri and Wee Waa;
- aged care residential facilities in Narrabri, Boggabri and Wee Waa; and
- a home and community care program which includes community transport.

The Barwon Division of General Practice (BDGP) reports that at August 2009, the Narrabri LGA has 7.6 full-time equivalent (FTE) general practitioners (GPs) and 2 GP Registrars. This includes 4.6 FTE GPs and 1 GP Registrar in Narrabri, 1.0 FTE GP and 1 GP Registrar in Wee Waa and 2.0 FTE GPs in Boggabri. These practitioners service a population of approximately 14 000, giving a FTE GP ratio of 1:1458.

Gunnedah has a 50 bed capacity hospital which provides a high standard of general medical and surgical services including a Slow Stream Rehabilitation Unit, a day surgery care facility, a Public Health Dental Clinic and a Physiotherapy Unit. A range of additional healthcare and aged care services and facilities are available in Gunnedah.

4B.13.2.5 Existing Community Facilities, Services and Infrastructure

Narrabri and Gunnedah Shires are both well serviced by a range of sporting and recreational clubs, service organisations, sporting grounds and facilities, restaurants, retail facilities and several franchises and government services. Overall, both Shires and their central towns in particular have high levels of social capital. The smaller centres of Boggabri and particularly Baan Baa are well serviced by the nearby towns of Narrabri and Gunnedah. Their small population size makes a full range of services unsustainable and commercially unviable (the closing of the Baan Baa School in recent years is a pertinent example). A potential increase in population associated with the further development of the Narrabri Coal Mine could help communities establish critical mass and attract more services and facilities. This has already been evident in Boggabri where as a result of the increase in mining, a developer has built a new chemist shop which has attracted a full-time pharmacist. This renewed presence of a chemist, together with the fact that there are two doctors resident in Boggabri, as well as a hospital and modern multi-purpose medical centre, has ensured adequate medical services are available for the residents of the Boggabri area.

Gunnedah and Narrabri, being larger centres have the capacity to absorb growth more effectively than smaller towns such as Baan Baa and Boggabri.

Narrabri LGA has many services and facilities to meet the needs of the mine workforce, predominantly centred in the Narrabri township, although a range of services and facilities are also available in towns such as Boggabri and Wee Waa. As "Australia's sportiest shire", sporting clubs and facilities form an important part of recreational pursuits in the Narrabri LGA. In recent years, large shopping centres with large chain supermarkets have been developed. The recent development of the Crossing Theatre provides a showcase for cultural, performing arts and art gallery activities as well as conference rooms, function centres and two cinemas.

The most recent ABS data indicated there were an estimated 1 857 businesses registered in Narrabri LGA in June 2007 and the estimated total turnover of all industry within the shire in 2006/07 was $868 million (Narrabri Shire Economic Profile (Narrabri Shire Council)). At June 2007 mining accounted for 12 of the registered business and $153 100 or 0.2% of annual average turnover. The unemployment rate in Narrabri LGA in the September Quarter 2007 was 5.4%, slightly higher than the NSW average for the same period (4.9%).

Narrabri LGA has the following business and industry groups.

- Narrabri Chamber of Commerce.
- Wee Waa and District Chamber of Commerce.
- Boggabri Business Progress Association.
- Affiliation with several groups and association branches, including Cotton Growers Association and pork, sheep, wheat and grain growing and marketing groups.

Narrabri is a transport hub, located on the crossroads of the Newell and Kamilaroi Highways. There are extensive rail links for passengers and freight. An airport is located at Narrabri with Aeropelican providing morning and evening flights to and from Sydney, Sunday to Friday, and a single flight each way on Saturdays. Aeropelican report that this service, which they commenced in March 2009, has been well accepted in the local region and is proving to be very successful. Aeropelican are monitoring the demand for air services and would increase services as required. They have recently engaged a Route Development Manager to examine air service demand and develop effective routes and charter operations.

Gunnedah sees itself as attractive to business because of its rail and road transport links. An airport is located at Gunnedah although no commercial services currently operate from the airport. Air travellers from Sydney and Brisbane must fly to Tamworth and use alternative transportation such as hire-car to travel to and from Gunnedah. A focal point for activity of a cultural nature within Gunnedah and surrounding areas is the Gunnedah Cultural Centre. It includes the Civic theatre, which houses new cinema/theatre facilities. Also included are the original town hall and the creative arts centre. The creative arts centre displays the Shire's art collection. Gunnedah also boasts a swimming centre which includes a 50m Olympic pool, 25m indoor heated pool, children's wading pool, kiosk and BBQ facilities.

Gunnedah has the following business and industry groups.

- Gunnedah and District Chamber of Commerce and Industry.
- Gunnedah Stock and Station Agents Association.
- New South Wales Farmers Association.
- Tourism Gunnedah (Gunnedah Visitors Information Centre).
- Gunnedah District Unlimited.

The Narrabri Shire Council has an abundant supply of exceptionally high quality water from the Upper Namoi Aquifer, for Narrabri, Wee Waa and Boggabri and from the Great Artesian Basin, for Bellata, Pilliga and Gwabegar. Narrabri's current water use is 4 500ML/day in winter peaking at 14 500 ML/day in summer. The existing supply and water treatment facilities have a capacity of 16ML/day but an additional bore is able to supply an additional 13ML/day as required. With upgrades to the water treatment facilities Narrabri could cater for an increased growth of approximately 4000 people.

In Narrabri LGA, the townships of Narrabri, Wee Waa and Boggabri are sewered. About ten years ago, the Narrabri waste water treatment works was upgraded, approximately doubling its capacity. Consequently Narrabri's sewerage system could easily support a population increase of approximately 4 000–5 000 people. Wee Waa's waste water treatment facility is operating at capacity and Boggabri's waste water treatment facility could cope with a small increase in population. Both of these facilities could be easily upgraded to support population increases in the respective townships.

Similarly, Gunnedah has an abundant supply of exceptionally high quality underground water. Gunnedah Shire Council reports that with upgrades, the LGA's water and sewerage systems could support a significant increase in population although capacity still remains given the current population in Gunnedah is below that which was present in the 1990s.

4B.13.3 Predicted Changes to Local Demographics

The development of the Longwall Project involving the proposed earthworks, construction of plant and assembly of the longwall unit would initially involve the employment of approximately 75 persons over a 60 week period. The Stage 1 operations is expected to employ a total of 113 persons, whilst the Stage 2 operations is expected to employ 211 persons, comprising of 32 engineering / administration professionals, 37 operational staff and 142 wages employees. Therefore Stage 2 operations would involve the employment of an additional 98 persons after Stage 1 is fully operational.

The Stage 1 workforce of up to 140 persons involved construction activities that required persons on site for periods varying from less than one week up to 60 weeks. Overall, the average duration each construction person was/remains on site is approximately 12 weeks. It is noted that during the Stage 1 construction activities, the Proponent itself employed 24 full-time staff, 7 of which were drawn from the local community with the remaining drawn from other NSW and Queensland coal mining operations. It is expected that the Stage 1 construction workforce would gradually reduce by December 2009 as the longer term workforce involved in Stage 1 coal mining commences operations. The change from construction activities to the commencement of mining would result in a change in the type of accommodation required, ie. from short-term to medium and long-term accommodation.

Stage 2 construction is expected to commence in January 2010 and is due for completion during the last quarter of 2010. It is expected that the Stage 2 construction workforce would take up the accommodation vacated by the Stage 1 construction workforce and reside in similar short-term accommodation and support the increased level of this type of accommodation provided by local persons and companies. A similar distribution of locals/non-locals and their residence locations are expected for the Stage 1 and Stage 2 construction activities.

Table 4B.51 presents a breakdown of the likely source of workers for Stage 1 and Stage 2 operational activities. Underground mining requires a skilled workforce experienced in underground mining and it is expected that, since Narrabri Coal Mine is the first underground mine in recent times in the Gunnedah Basin, this would mean a substantial increase in new people coming to the area from other regions, probably the Hunter Valley and Queensland. Given that many mining jobs require skills that are not readily available in the local workforce, the Proponent estimates that approximately 62% of the operational workforce would be sourced from outside the local area.

Based upon current expectations, the Proponent estimates that approximately 90% of the incoming workforce would settle in approximately equal proportions in Gunnedah and Narrabri with approximately 10% settling in rural areas or small towns like Boggabri or Wee Waa.

Table 4B.51
Estimated Workforce for the Narrabri Coal Mine

	Estimated Workforce	
	Stage 1 Operations	**Longwall Operations**
Total workforce	113	211
Local workforce	43	80
Non-local workforce	70	131
Number residing in Narrabri	32	59
Number residing in Gunnedah	32	59
Number residing in smaller townships and rural settings	6	13

Based upon the estimated workforce at the Narrabri Coal Mine as displayed in **Table 4B.52**, it is predicted that the Stage 1 permanent workforce would result in approximately 70 persons and their families moving to the Narrabri/Gunnedah area in late 2009 and early 2010. For the Stage 2 permanent workforce, a further 61 persons and their families are likely to move to the area during late 2010 and early 2011.

Based upon the average NSW household size of 2.6 persons (the 2006 average) and representative splits of child ages, the estimated increases in population in Narrabri, Gunnedah and rural areas/small towns attributable to the Narrabri Coal Mine is as presented in **Table 4B.52**.

Table 4B.52
Estimated Population Increases attributable to the Narrabri Coal Mine and Residence Locations

	Stage 1 Operations	**Stage 2 Operations**
Total workforce	113	211
Increase in workforce	**113**	**98**
Workers sourced from outside the local area	70	61
Mean incoming population	**182**	**158**
Estimated Adults	140	122
Estimated children	42	36
Estimated children under 5 (NSW average = 7%)	13	11
Estimated primary school children (NSW average = 9%)	16	14
Estimated secondary school children (NSW average = 7%)	13	11
Estimated residence location		
Narrabri – adults (45% of incoming adults)	63	55
Narrabri –children under 5 (45% of incoming)	6	5
Narrabri – primary school children (45% of incoming)	7	6
Narrabri – secondary school children (45% of incoming)	6	5
Narrabri – total children (45% of incoming children)	19	16
Gunnedah – adults (45% of incoming adults)	63	55
Gunnedah – children under 5 (45% of incoming)	6	5
Gunnedah – primary school children (45% of incoming)	7	6
Gunnedah – secondary school children (45% of incoming)	6	5
Gunnedah – total children (45% of incoming children)	19	16
Rural areas/small towns – adults (10% of incoming adults)	14	12
Rural areas/small towns – children (10% of incoming children)	4	4

The estimated proportion and number of the incoming population likely to reside in Narrabri, Gunnedah and rural areas/small towns is also presented in **Table 4B.52**.

It is acknowledged that the above assessment focuses solely on Mine Site-based employment. The Proponent is well aware, based upon its experience with the mines developed throughout the Gunnedah area over the past 10 years, that the increased presence of mining in the area has attracted other personnel for companies providing technical and other support to the mining industry. A consequential population increase is also likely to occur, principally in Narrabri as the Narrabri Coal Mine progresses to full time employment in November 2010.

4B.13.4 Management Measures

The Proponent acknowledges the Longwall Project would have consequential socio-economic impacts and has identified management measures which would increase the positive impacts and mitigate against the negative impacts.

4B.13.4.1 Employment and Training

A key issue identified through consultation with local professionals and stakeholders in the development of the Longwall Project and ongoing operation of the Narrabri Coal Mine was the local education and training capacity to prepare local community members for employment at the mine and provide opportunities for the families of those employed at the mine (children, teenagers and partners).

- The Proponent remains committed to the implementation of a policy which encourages employment of local district personnel with arrangements for training and certification put in place to ensure suitable applicants can acquire the necessary skills.
- Arrangements for training and certification of suitable local persons have already been made and the Proponent intends to use its association with other operational mines in the region to provide the training required for the bulk of its workforce. The Proponent expects the Tamworth TAFE College would continue to conduct the required mining-related TAFE courses, however, it is possible that either or both Gunnedah and Narrabri TAFE colleges would be able to assist with the presentation of some components of the requisite courses.
- Acknowledging that a proportion of the initial mine workforce would be sourced from more established mining areas such as the Hunter Valley, and to assist in the community integration process, the Proponent would provide assistance, where possible, in identifying job opportunities for the partners of potential employees.
- The Proponent would also provide a local induction kit to new workers including contact details for community groups and services throughout the local area.
- The Proponent would continue to encourage the involvement of the local indigenous community in the workforce.

4B.13.4.2 Housing

A further issue identified through the consultation phase of the social assessment was ensuring sufficient housing was available to support population growth as a consequence of the increased employment opportunities provided by the project during both the Stage 2 construction phase and operations.

- The Proponent has established that the existing housing purchase market is buoyant, healthy and expectant and that normal market forces, without intervention or assistance by the Proponent would supply suitable accommodation for the increased population associated with the Longwall Project.
- To assist the workforce with any short term deficiencies in accommodation the Proponent would, consider provision of short term assistance for temporary accommodation.

4B.13.4.3 Economic Development

In order to gain an appreciation of the contributions the Narrabri Coal Mine has already had on the local economies, the Proponent has compiled an analysis of payments attributable to the development of the Narrabri Coal Mine Stage 1, a copy of which is provided in **Table 4B.53**. This was achieved through the examination of postcodes for invoices paid. This analysis does not consider wages of Narrabri Coal Mine personnel. Since commencement, the project has been responsible for an injection of $46 722 655 to the local area (Gunnedah, Narrabri, Boggabri and Wee Waa) and an injection of $65 565 370 to regional NSW. Of the money spent in the local area, $37 084 150 related to equipment and services from enterprises based in Narrabri. No payments were made directly to overseas-based enterprises although it is recognised a proportion of the equipment and consumables supplied by various companies were sourced from overseas. It is anticipated that as the Longwall Project develops the total amount and proportion of investment in the local region would increase as the mine contributes to the development and consolidation of local mining-related services and industries.

Table 4B.53
Geographic Distribution of Narrabri Coal Mine Payments

	Invoices from Narrabri Coal Mine - Commencement of project to 30 June 2009	
	$	% of total expenditure
Total Invoices	148 633 020	100.00
Local Region – Narrabri (Narrabri, Boggabri and Wee Waa)	37 084 150	24.95
Local Region – Gunnedah	9 638 505	6.48
Regional NSW – Hunter / Newcastle	34 923 590	23.50
Regional NSW – Other	30 641 780	20.62
Sydney/Suburban	11 639 677	7.83
Interstate	24 705 318	16.62

- The Proponent would continue to significantly contribute to the local economy through wages and payment for a wide range of goods and services.
- Apart from direct and indirect employment of local persons, the Proponent intends to identify opportunities to contribute to the local community to minimise any potential social impacts that may arise as a result of the project.
- The Proponent would continue to partner with Narrabri Shire Council to promote business in the area, particularly business that may supply or service the project. The Proponent has already committed to provide the Council with the names and contact details of organisations which were awarded tenders for the project. This would then allow the Council to contact the organisations to determine any services and support that the Council could provide.
- The Proponent intends to be an active member of the local Narrabri community as they have been in Gunnedah and Boggabri.

4B.13.4.4 Infrastructure and Services

With an increase in employment levels and subsequent population growth, a key issue for consideration is the available capacity of local infrastructure, services and facilities to accommodate the population increases.

- The Proponent has established that both Narrabri and Gunnedah have sufficient capacity in the areas of education, health and other more general services such as water, electricity and sewerage to manage the population growth associated with the project. The Proponent would continue to maintain close relationships with LGAs and other relevant agencies to ensure that infrastructure and services meet the needs of the increased population.

4B.13.4.5 Agricultural Lands

Construction of the mine infrastructure within the Pit Top Area and other surface disturbing activities and the predicted land subsidence would have a range of impacts upon agricultural production throughout the life of the mine.

- The Proponent has minimised the potential impacts upon agricultural lands through confining the Pit Top Area facilities to the smallest possible area to minimise the area of agricultural land that would be removed from agricultural production throughout the life of the project. The siting of the various storage ponds within the rail loop during Stage 1 construction has made greatest use of the land disturbed by the project in that area. The Proponent would, wherever practicable, continue to minimise the area of agricultural land disturbed throughout the mine life.

- The Proponent is committed to rehabilitate the mine following its closure, to a standard which would allow agricultural production to be resumed at an equivalent level to that prior to mining.
- The Proponent would continue to work closely with the former owners of much of the land within the Mine Site (and still residing on the land) to ensure the land is responsibly managed to ensure it remains agriculturally productive. The Proponent recognises it is important to control weeds, feral animals and the threat of bushfire.

4B.13.5 Impact Assessment

4B.13.5.1 Education and Health Services

With particular focus on the increased demand for 'soft' infrastructure such as health care and schooling, the following assessment for the Longwall Project has been made based upon the estimated population increases listed in **Table 4B.52**.

- The estimated additional 6 primary and 5 high school age children attending schools in the Narrabri area represent an increase of approximately 0.5% to potential school enrolments.
- The estimated additional 6 primary and 5 high school age children attending Gunnedah schools represent an increase of approximately 0.4% to potential school enrolments.
- The addition of another 79 people (55 adults and 16 children from Narrabri and 4 adults and 4 children from rural areas) would only marginally alter the Narrabri FTE GP ratio of 1:1458 to 1:1466. While both of these ratios are higher than BDGP preferences, increased economic activity and vibrancy in the area as a result of mining activity may help Narrabri attract more general practitioners, or explore alternative models such as nurse practitioners.

It is assessed that any increase in demand on 'soft' infrastructure such as schools and medical services would be manageable.

4B.13.5.2 Housing

Due to its size and proximity to the Mine Site, Narrabri is the town that most of the construction and potentially the mine workforce would be inclined to live in, although given the existence of a mine-related workforce already present in Gunnedah, a significant proportion is anticipated to commute from there.

The enquiries undertaken for this *Environmental Assessment* have established that Narrabri, Gunnedah and several smaller townships have the capacity to increase housing levels to accommodate the expected increased population attributable to the Longwall Project. It is recognised that the rental property market and provision of short to medium term accommodation would be limited in the short term, however, providers of such accommodation are likely to respond positively to the very high anticipated occupancy rates.

The predicted increase in population attributable to the Narrabri Coal Mine and planned to occur late in 2009/early 2010 has been known for some time. Accordingly, new home starts in Narrabri and Gunnedah have already increased. Given the employment for the Stage 2 mining operations is due to ramp up in late 2010, there would likewise be opportunities for new residences to be constructed for the incoming workforce.

4B.13.5.3 Infrastructure

Key stakeholders consulted by Key Insights as part of the qualitative research in 2007 and more recent discussions with Narrabri and Gunnedah Shire Councils have determined that both Narrabri and Gunnedah have the capability to easily expand infrastructure as required to provide quality services for an increased population. However, smaller centres of Baan Baa and Boggabri have less established infrastructure and services, eg. Baan Baa lacks a town water supply.

The level of established infrastructure and services in Gunnedah is understood to have capacity for further growth as in the late 1990s. Gunnedah provided services for a greater number of persons than at present. The closure of Gunnedah Abattoir and several long-operating coal mines resulted in an exodus of persons at that time seeking employment. The capacity of services at that time is gradually being filled as the population again rises in Gunnedah. The *Assessment of Opportunities for Narrabri Shire from Coal Mining and Gas Extraction in the Gunnedah Basin* reported that Gunnedah is anticipating and preparing for an additional 5000 people over the next few decades.

The infrastructure already constructed for the mine, namely the Kurrajong Creek Road rail crossing and the upgraded/sealed Kurrajong Creek Road have provided benefits already acknowledged by the local community.

The power, water and communication services required for Narrabri Coal Mine have all been installed or planned to be installed without any adverse impacts on the services provided for the surrounding community.

Whilst the introduction of additional persons into Narrabri, Gunnedah and the surrounding areas would increase the demand for local infrastructure and services, discussions with Narrabri and Gunnedah Shire Councils have confirmed that the existing capacity for the local services in particular would be sufficient for the expected increase in population due to the Longwall Project.

4B.13.5.4 Social

Given the reliance of modern farming on heavy machinery and the experience of Whitehaven Coal Limited to date in the Gunnedah area, the transition of local residents previously employed in agriculture to a number of the mining-related tasks would be relatively simple. Furthermore, there are a number of former employees from the previous coal mines that still live in the Gunnedah and Narrabri area who may consider re-joining the industry.

In addition to the direct and indirect employment opportunities that would arise from the introduction of the Longwall Project, employee-related population growth would also increase the numbers of local people available to work for service and sporting organisations and generally enhance the viability of local volunteer groups. The range of clubs, service organisations, facilities and government services available in Narrabri and Gunnedah LGAs indicate a well serviced community with high levels of social capital that would be strengthened further by new workers coming to the area and hopefully by a higher retention rate of its young people.

The conclusions of the social assessment conducted by Key Insights (2007) remain applicable for the Longwall Project, ie. the project would result in the following positive social impacts.

- Reduction of social stress through provision of local jobs and enhanced economic well being.
- Training opportunities for local people, including young people and indigenous people, in a growth industry (mining).
- Contribution to the diversity of the economic base in Narrabri and Gunnedah LGAs therefore enhancing the sustainability of rural communities within the LGAs.
- Stimulus to local businesses, particularly in Narrabri, including motel and hotel trade, cafes and restaurants, mining-related engineering and surplus spending activity such as gyms, cinema, recreational goods and services, beauty salons, and hair dressers.
- Increased population to participate in locals clubs, sporting groups, cultural activities, and organisations, therefore contributing to stronger social networks and social capital.
- More volunteers for community service organisations.

On a local level, the Baan Baa Hotel has recently re-opened reflecting a level of optimism in increased patronage and spending by the mine workforce and contractors, etc.

The positive social benefits arising from the Narrabri Coal Mine were regularly referred to by many of the participants at the Community Information Day held on 16 May 2009 at Baan Baa. These benefits were anticipated in view of increased spending in the local community, and increased opportunities for many local landholders to increase their off-farm income, particularly when on-farm income is curtailed due to drought and other factors.

With respect to potentially adverse social impacts resulting from the project, the following assessments are made.

- The noise assessment identified that the proposed increase in trains to an average of five return trips daily through Baan Baa would not raise noise above the applicable noise criteria (refer to Section 4B.9.5.2.4). Notwithstanding the compliance with noise criteria, the residents of Baan Baa would become aware of the increased number of train movements.

- 8 of the 19 properties within and immediately surrounding the Narrabri Coal Mine site are owned by the Proponent. Notwithstanding this, the potential impacts on air quality, traffic, mine-related noise and visibility would all be managed to reduce impacts on surrounding landholders to an acceptable level as addressed in Sections 4B.7, 4B.8, 4B.9 and 4B.6 respectively. The economic value of these impacts is assessed as marginal due to the establishment of property values based on agricultural productivity and not local amenity. It is not anticipated that property values would decline due to the development of the Longwall Project.
- Discussions with the NSW Farmers' Association during the social assessment for the Stage 1 project identified that the issue of the loss of a relatively small parcel of agricultural land for the Pit Top Area was not seen as a significant impact given the compensating benefits.

4B.13.5.5 Agricultural and Ecological Issues

The Longwall Project would have a range of both positive and negative impacts on the agricultural and ecological values of the Mine Site and the wider areas many of which in turn also have some degree of economic impact.

Agricultural Impacts

The Narrabri Coal Mine Stage 1 has already removed approximately 160ha of Class 3 and Class 4 agricultural land from production. This has involved the development of the Pit Top Area, rail and associated infrastructure and surface buildings and structures. As part of the Longwall Project, the establishment of the reject replacement area (up to 25ha), ventilation shaft areas (16ha) and brine storage ponds (up to 160ha) would lead to the additional removal of up to 189ha of Class 3 and 4 agricultural lands for the life of the mine. Based on an average annual income (after expenditure) of $80-$100 per hectare for activities on this land, the temporary annual loss in agricultural production would be in the order of $15 000 – 19 000 for 30 years. The construction of roads and tracks to service the development of the Longwall Project would also remove some areas of the Mine Site from agricultural production for varying periods of time.

Most loss and / or degradation of agricultural land would be only temporary. At the conclusion of the mine life, a substantial proportion of the previous agricultural land would be returned for agricultural production. By replacing the originally stripped subsoil and topsoil and revegetating with agricultural pasture species, a land capability similar to that of the undisturbed landform could be finally established. The land beneath the brine storage ponds would be re-instated, topsoiled and revegetated similarly. Some permanent loss of agricultural land would persist. This is due to the retention of valuable items of infrastructure such as the rail loop, site perimeter bund and the Mine Access Road. The rail loop would be maintained because it may offer value to future land uses such as cotton and grain growing and beef production.

In addition to the areas directly impacted by surface facilities associated with the mine, the subsidence impacts upon fencing, farm dams, and other farm infrastructure and reduced stocking rates would result in lost production for varying periods of time and repair and maintenance costs. The land would decline in productivity for periods up to two years as

subsidence progresses, because stock may need to be removed from paddocks due to the risk of injury and the condition of fences and dams. Given approximately 2 570ha or 48% of the area to be mined underlies cleared land used for agricultural purposes, and reduced or no agricultural production may occur for up to two years, it is calculated that throughout the mine life, the loss of agricultural income from the subject area would be in the order of $400 000 – $500 000.

The loss of agricultural production throughout the life of the Narrabri Coal Mine and following the cessation of coal mining would be offset to a degree by the following.

1. The North Western Railway line is being upgraded to cater for increased train movements for the coal mining industry which, in turn, would benefit the transportation of grain for export.
2. The land which would remain after mining would be supported by a greater number of water storages than currently exist. The pipeline from the Namoi River would also provide economic benefit for water to be pumped to an agricultural enterprise established on the site (subject to ongoing licencing).
3. The Proponent's purchase of the properties within the Mine Site would enable the former owners to purchase other agricultural properties. Invariably, the funds from the sale of the properties have also allowed the purchase of new farm equipment to improve the productivity of the land they have purchased.

Overall, the economic losses relating to the loss in agricultural production within the Mine Site would be more than offset by the substantial income, spread widely throughout the local, regional, NSW and Australian communities.

Ecological Impacts

Section 4B.4 describes the various impacts on flora and fauna that would be attributable to the Longwall Project, a number of which have some degree of economic impact. Importantly, the biodiversity offset package for the project would ensure that, on balance, there would be long term ecological gains, particularly since:

- an area of 547.3ha of naturally vegetated land in the northwestern corner of the Mine Site would be set aside in perpetuity; and
- many of the areas of native vegetation to be disturbed would be rehabilitated back to native vegetation comparable to the pre-mining status.

An ecological benefit is also likely to arise from the discharge of low salinity water (up to 2.1ML/day) into the Namoi River system. This quantity of water would contribute to re-establishing environmental flows to the Namoi/Darling River system.

Sections 4B.2 and 4B.3 describe the potential groundwater and surface water impacts of the Longwall Project. The socio-economic aspect of these impacts relates to drawdown of groundwater and reduced availability of water in aquifer stores and surface storage systems.

The relevant groundwater sharing plans include the *NSW Great Artesian Basin Groundwater Sources Water Sharing Plan* and the *Upper and Lower Namoi Groundwater Water Sharing Plan*. The groundwater assessment predicts that the likely impact on groundwater levels, bore yields and groundwater availability would not be significant. It is also noted that the Proponent has already purchased water access licences for the quantities of both groundwater and surface water predicted to be required or impacted upon the Longwall Project. Hence, in an overall sense, no adverse ecological impacts would occur.

The main populations throughout Narrabri and Gunnedah LGAs, with the exception of Baan Baa, rely upon groundwater supplies. None of these water supplies would be impacted upon by the Longwall Project.

It is predicted that the Longwall Project would not have significant adverse impact on the entitlements of other water users, the cost of water or the water sharing plans in place.

4B.13.5.6 Economic

An analysis of the spending associated with the mine over the past two years shows that in excess of $148 million has been invested by the Proponent with almost $47 million or 31.43% spent in the local region. To date, the economic impact from the Narrabri Coal Mine has contributed to the following.

- Growth in housing, retail, commercial and industrial development of land.
- Increased retail and commercial services in the towns of Narrabri, Gunnedah, Boggabri and Narrabri.
- Improved rail and air services to the region.
- Improved social and cultural services.
- Increased employment.
- Increased employment diversity.
- Increased training and further education opportunities.

Approximately 26% of the $295 million capital cost to establish the Longwall Project would be related to construction labour, on-site facilities construction and materials. A significant proportion of this capital would be spent locally, with labour and materials sourced from within the region, wherever possible. The remaining 74% of the capital costs would be directed overseas and throughout Australia for the purchase of the longwall equipment and coal processing equipment.

The Proponent anticipates that annual labour costs would be in the order of $36 million once mine production reaches the 8Mtpa level. A significant proportion of this money would be retained locally through payment of employees and local contractors.

Additionally, consumables and the purchase of sundry materials would inject a significant amount of money into the local services and suppliers, as well as those based in the Hunter Valley and beyond.

Royalties of up to $35 million per year would be payable to the NSW government when full production is reached which would contribute to the State economy, as would port and rail access fees. Considerable economic benefits would accrue for the Australian Government through the export volume of the coal (approximately $450million) based on current coal prices and the personal and company taxes paid.

Overall, the economic benefits of the conversion of the Narrabri Coal Mine to an 8Mtpa longwall mining operation are predicted to be very positive for the local, regional, NSW and Australian economies.

4B.13.5.7 Conclusion

In light of the range of available services in Narrabri and Gunnedah LGAs, combined with the positive attitude of the local Councils, the region currently has, or would quickly develop, capacity in the four key areas of education/training, housing capacity, infrastructure and economic development to meet the demands of a growing population of mine workers and related trades, even with the cumulative demand of other mines in the region.

The positive socio-economic impacts such as increased employment, development and services, improved employment diversity, training and community vibrancy and implementation of the Proponent's proactive management measures would offset any negative impacts related to temporary loss of agricultural productivity and social amenity. This positive assessment is confirmed by key stakeholders in the area who favourably anticipate development of the Longwall Project.