

Wandoan Coal Project Environmental Impacts from Blasting

November, 2008

Wandoan Joint Venture

Contents

	Page Number
Glossary	iii
Executive summary	vi
1. Introduction	1
1.1 Project background	1
1.2 Description of study area	1
2. Methodology of assessment	4
2.1 Relevant legislation and guidelines	4
2.1.1 Framework	4
2.1.2 Noise criteria	4
2.1.3 Vibration criteria	4
2.1.4 Times of blasting	5
2.1.5 Criteria adopted for this study	5
2.2 How the study was conducted and information obtained	5
2.3 Limitations	6
3. Existing environment	8
3.1 Current level of disturbance	8
3.2 Ground conditions	8
3.2.1 Topography	8
3.2.2 Site geology	8
3.2.3 Groundwater	10
3.3 Sensitive receptors	11
3.3.1 Definition	11
4. Description of proposed development	14
4.1 Mining areas	14
4.1.1 Pits	14
4.1.2 Production schedule	14
4.2 Mining method	14
4.2.1 Resource characteristics	14
4.2.2 Equipment	17
4.2.3 Pit geometry	17
4.3 Blasting operations	18
4.3.1 Role of blasting	18
4.3.2 Blasting characteristics of Wandoan overburden and interburden	18
4.3.3 Blast designs	20
5. Potential impacts	22
5.1 Environmental impacts from blasting	22
5.1.1 Impacts	22
5.1.2 Fly-rock	22
5.1.3 Ground vibration	24
5.1.4 Airblast overpressure	28
5.1.5 Impacts from Wandoan blasting operations	32
6. Mitigation measures	36
6.1 Fly rock	36
6.2 Ground vibration	36
6.3 Airblast overpressure	36
6.3.1 Township of Wandoan	36
6.3.2 Wandoan Cemetery	37
6.3.3 Telstra communications tower	Error! Bookmark not defined.
6.3.4 Abattoir	37

Contents (continued)

	Page Number
6.3.5 Farm houses and farm structures	37
6.3.6 Mine Infrastructure, powerlines, pipelines, railway and bores	38
6.4 General operating procedures and monitoring	38
7. Residual impacts	40
8. Conclusions	42
9. Summary of mitigation strategies.....	44
10. References	45

List of tables

Table 3-1: A summary of the stratigraphic sequence in which the coal measures lie	8
Table 4-1: Nominal blast designs for Wandoan overburden and interburden	20
Table 5-1: Summary of PPV calculations for distance to 5 mm/s	27
Table 5-2: Summary of airblast overpressure calculations	31

List of figures

Figure 1-1: Project location	2
Figure 1-2: Project area	3
Figure 3-1: Sensitive vibration and airblast receptors	12
Figure 4-1: Wandoan Project — proposed mining areas	15
Figure 4-2: Schematic west-east section through the southern half of the Austinvale Pit	16
Figure 4-3: Schematic north-south section through the western side of the Mud Creek Pit	17
Figure 5-1: Scaled distance plot of vibration data from a Queensland open pit coal mine	26
Figure 5-2: Relationship for simple estimation of distance to 5 mm/s PPV	28
Figure 5-3: Scaled distance plot of airblast overpressure data from a Queensland open pit coal mine	31
Figure 5-4: Relationship for simple estimation of distance to 115 dBI airblast overpressure	32
Figure 5-5: Location of affected sensitive receptors and distance to 115dB(linear) airblast overpressure prior to mitigation	35
Figure 7-1: Location of sensitive receptors and distance to 115dB(linear) airblast overpressure after mitigation	41

Glossary

<i>Airblast</i>	Airblast is the pressure wave (sound) produced by a blast and transmitted through the atmosphere.
<i>ANFO</i>	Ammonium Nitrate and Fuel oil — a common bulk explosive used in mining.
<i>Aquifer</i>	Permeable strata in which water may be stored.
<i>Bedding plane</i>	The boundary between contiguous layers of different sedimentary strata.
<i>bcm</i>	Bank cubic metre
<i>Bench</i>	A level or slightly inclined working area within an open pit mine.
<i>Blast Management Plan</i>	Standard operating procedures prepared by mine management to govern the planning and implementation of blasting operations.
<i>Burden</i>	The shortest distance between an explosive charge in a blast hole and point of relief or minimum confinement.
<i>Cast blasting</i>	A style of blast designed to preferentially displace overburden or mid-burden into a previously mined area of the pit.
<i>Charge</i>	A quantity of explosive placed in a blast hole.
<i>dB(linear) Peak</i>	The peak sound pressure level represented on a standard logarithmic scale that is not weighted to favour audible frequencies.
<i>Detonating cord</i>	A thin string of high explosive used to initiate some explosive charges in mine blasting.
<i>Detonation</i>	The rapid oxidation reaction between the ingredients of an explosive to generate stresses and high pressure gases to fracture and displace in-situ rock to form a muckpile.
<i>Diluted ANFO</i>	ANFO diluted with low density organic material to reduce its density.
<i>Dip</i>	The angle that strata lies relative to the horizontal.
<i>Dozer</i>	A track or rubber tyred machine with a blade designed to push broken rock and soil.
<i>Dragline</i>	An machine with a bucket suspended beneath a long boom capable of excavating blasted material from above a coal seam and swinging around to place it in an area of the pit from which the coal has been removed.
<i>EPA</i>	Environmental Protection Agency
<i>Excavator</i>	A track mounted machine with a bucket on a hydraulic boom capable of excavating loose rock and soil and loading it into trucks.
<i>Exclusion zone</i>	A zone required to be evacuated of equipment of personnel prior to a near-by blast being fired.

<i>Fault</i>	A natural fracture in the ground at which some relative displacement has occurred.
<i>Face</i>	The vertical or sloping side of a bench.
<i>Fly rock</i>	Rock fragments thrown into the air by a blast.
<i>Free face</i>	A bench face that is free of broken material and available to act as a plane of relief for an explosive charge.
<i>Front End Loader</i>	A rubber tyred machine with a bucket mounted at the front capable of excavating loose rock and soil and loading it into trucks.
<i>Highwall</i>	The long bench face of intact overburden or mid-burden that defines the edge of the next strip.
<i>In-situ</i>	Undisturbed rock.
<i>Interburden</i>	Rock found between major coal horizons in an open pit coal mine.
<i>Intrusion</i>	The solidified remnants of an igneous flow of rock into sedimentary strata.
<i>Joint</i>	A natural fracture in rock across which no relative displacement has occurred.
<i>Kg</i>	kilogram
<i>m</i>	metre
<i>Massive</i>	In-situ rock which has little natural structure.
<i>MIC</i>	Maximum instantaneous charge which is usually taken to be that mass of explosive expected to detonate in any 8 ms time window.
<i>Mid-burden</i>	Non-coal strata between major coal horizons.
<i>MPa</i>	Mega Pascal —usually used to quantify the unconfined compressive strength of rock and equivalent to one million newtons of force per square metre.
<i>MLA</i>	Mining Lease Application
<i>mm/s</i>	Millimetres per second.
<i>Ms</i>	Millisecond — one thousandth of a second.
<i>Muck</i>	Rock and soil blasted prior to excavation.
<i>Noise Sensitive Place</i>	Places defined in EPA Guideline on noise and vibration from blasting including dwellings, places of business and leisure.
<i>Overburden</i>	Rock and soil overlying a coal seam.
<i>Parting</i>	A thin layer of non-coal material lying between two coal layers.
<i>Pit</i>	A surface excavation involving the removal of overburden and interburden to expose and mine coal.

<i>Powder Factor</i>	The ratio of the number of kilograms of explosive used to blast a given volume of rock expressed as kilograms per bank cubic metre.
<i>Pre-split</i>	A style of blast designed to create a plane of fracture on the alignment of a new bench face.
<i>PPV</i>	Peak Particle Velocity — the peak velocity of the ground movement as measured from the instantaneous vector sum of velocities measured by geophones in three orthogonal directions.
<i>Ripping</i>	The process of fracturing rock by dragging a metal tool through intact strata using a bulldozer.
<i>ROM</i>	Run of Mine — in the form as excavated and transported from the mine prior to any treatment of processing.
<i>Shot</i>	A blast designed to fragment and loosen rock in a mine.
<i>Stemming</i>	Inert granular material used to confine explosion gases immediately following the detonation of a blast hole.
<i>Strip</i>	A long mining zone within a pit allocated to a single production process.
<i>Structure</i>	Any fault, joint or discontinuity in a rock mass.
<i>Superposition</i>	The process of adding vibration waveforms from different sources to estimate the overall impact.
<i>t</i>	tonne
<i>tpa</i>	Tonne per annum.
<i>UCS</i>	The unconfined compressive strength of a rock measured in a laboratory according to standard testing procedures.
<i>Waveform</i>	The time history of ground vibration velocity as measured by a geophone.

Executive summary

The Wandoan Coal Project will develop a major open cut coal mine to the west of the township of Wandoan in the Dalby Regional Council local government area. Approximately 30 Mt per year of run of mine coal will be mined and processed in an operation with a scheduled life of 30 years. A number of coal seams will be mined after the removal of the overlying overburden and interburden materials. Blasting will be required to fragment and loosen the overburdens and interburdens. This study evaluates the environmental impact of the necessary blasting operations on the township of Wandoan and neighbouring areas. The measures necessary for the blasting operations to meet the Queensland Environmental Protection Agency Noise Guideline are also identified. Air quality and noise issues (other than from blasting activities) are outside the scope of this report and are addressed by separate technical reports.

The study has been based on information provided by the Wandoan Joint Venture (WJV) describing the proposed project and the conditions under which the blasting operations will be conducted. Appropriate blast designs have been prepared for the range of bench heights and mining conditions expected at the site. Prediction formulae recommended in the Australian Standard for blasting activities have been used to predict the ground vibration and airblast overpressure expected for the operations. Consideration has also been given to the approach required to manage fly-rock. In the absence of any actual field data from Wandoan, data from a similar type of mining operation in Queensland has been used to estimate values for site parameters required by the prediction formulae. This approach enables more reliable estimates of these parameters than relying on standard default values that may have originally been based on mines having quite different characteristics from Wandoan.

The unmitigated blasting operations were found to generate levels of ground vibration and airblast in the western side of the Wandoan township that exceed the EPA recommended limits. The closest pit to the town could also present a fly-rock hazard to the Leichhardt Highway. The Wandoan cemetery may be exposed to marginal airblast overpressures. A similar problem was identified for eight houses outside the Mining Lease Application area. In each case the excessive levels would only apply while blasting operations were being undertaken in the immediate vicinity.

The mining boundary nearest the town will be moved to the west to eliminate the fly rock hazard near the Leichhardt Highway. The operation in this same pit can be changed from utilising a dragline for overburden removal to using truck and shovel methods on shallower working benches. The changes in blast design to suit the shallow benches will reduce the ground vibration and airblast levels near the town to acceptable levels. Similarly, actual monitored data will be used to guide operations when mining near the Wandoan Cemetery to reduce airblast levels below the recommended levels in this area.

The WJV is planning to purchase a number of properties in the vicinity of the operation. Consultation will be undertaken with the owners of the eight properties outside the Mining Lease Application, but relatively close to the mining areas with a view to reaching agreement on appropriate mitigation arrangements prior to blasting outcomes affecting their properties.

Some of the WJV's operations will be delayed or interrupted as a result of their own blasting activities but these impacts should be readily managed by the required Blast Management Plan. No services such as power lines, pipe lines, groundwater bores, roads or railways outside the MLAs have been identified as being in any danger of damage from the Project's blasting operations.

A high standard of design and implementation will be needed for the blasting operations to meet both the production efficiencies required for the mining operations and to manage the impact on the surrounding

environment. Routine monitoring of environmental performance will enable the Wandoan Joint Venture to confirm the effectiveness of these management processes.

1. Introduction

1.1 Project background

The Wandoan Coal Project (the Project) comprises the development of thermal coal resources situated immediately west of the Wandoan township, located in the Dalby Regional Council local government area. The Project is located approximately 350 km northwest of Brisbane and 60 km south of Taroom as shown in Figure 1-1. The Project will be developed as an open cut mine with related infrastructure. The coal resources for this Project lie within three mining lease applications (MLAs), MLA 50229, 50230 and 50231 as shown in Figure 1-2. The coal resources will be mined using a combination of truck and shovel, dozer and dragline mining equipment. Coal will be mined at a rate of around 30 million tonnes per annum (Mtpa) run of mine (ROM) coal. The coal will be crushed, sized and washed before being transported by rail to the Port of Gladstone.

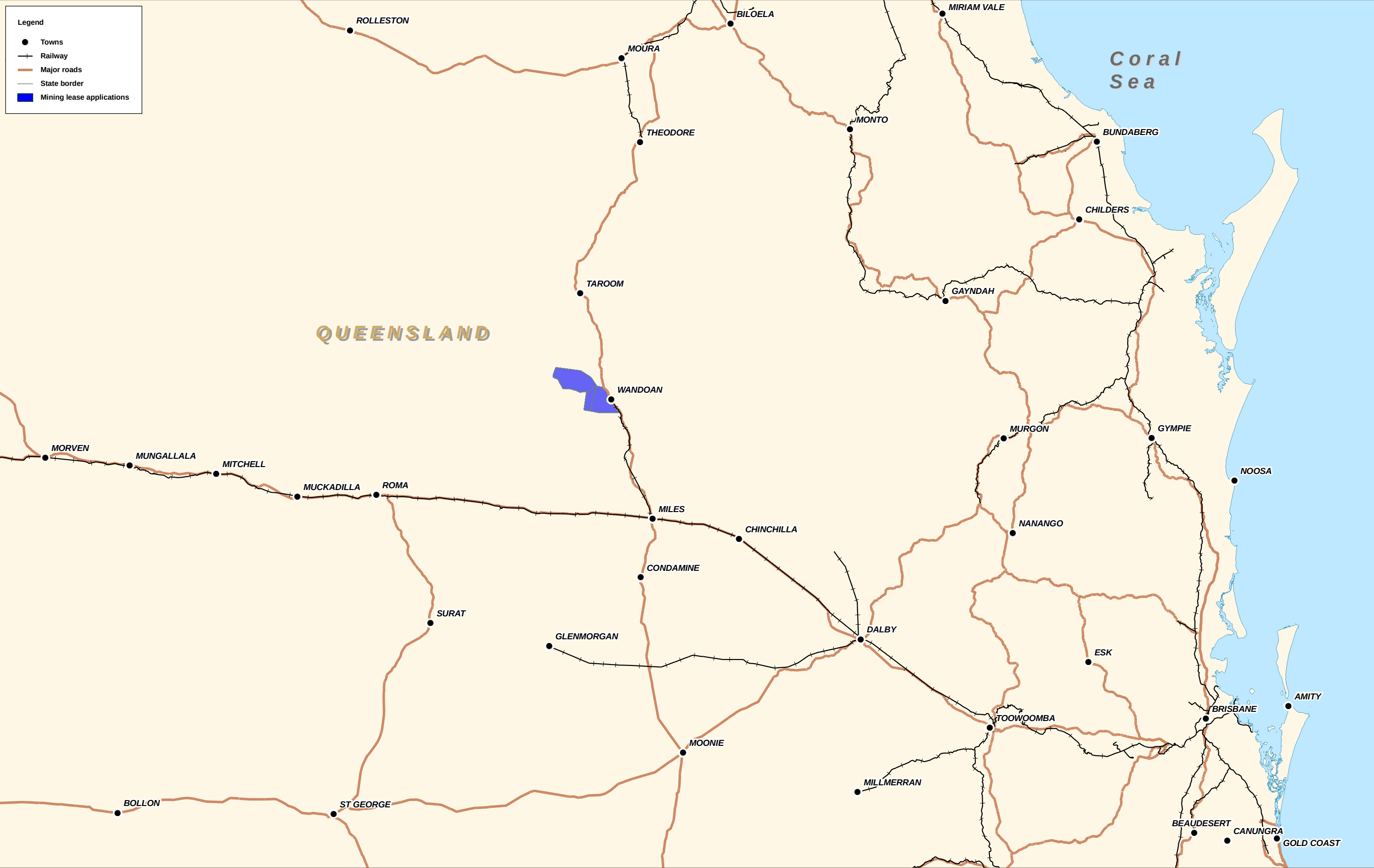
The Project will be developed by the Wandoan Joint Venture (WJV). The joint venture partners are Xstrata Coal Queensland Pty Ltd (XCQ), ICRA RPW Pty Ltd and Sumisho Coal Australia Pty Ltd.

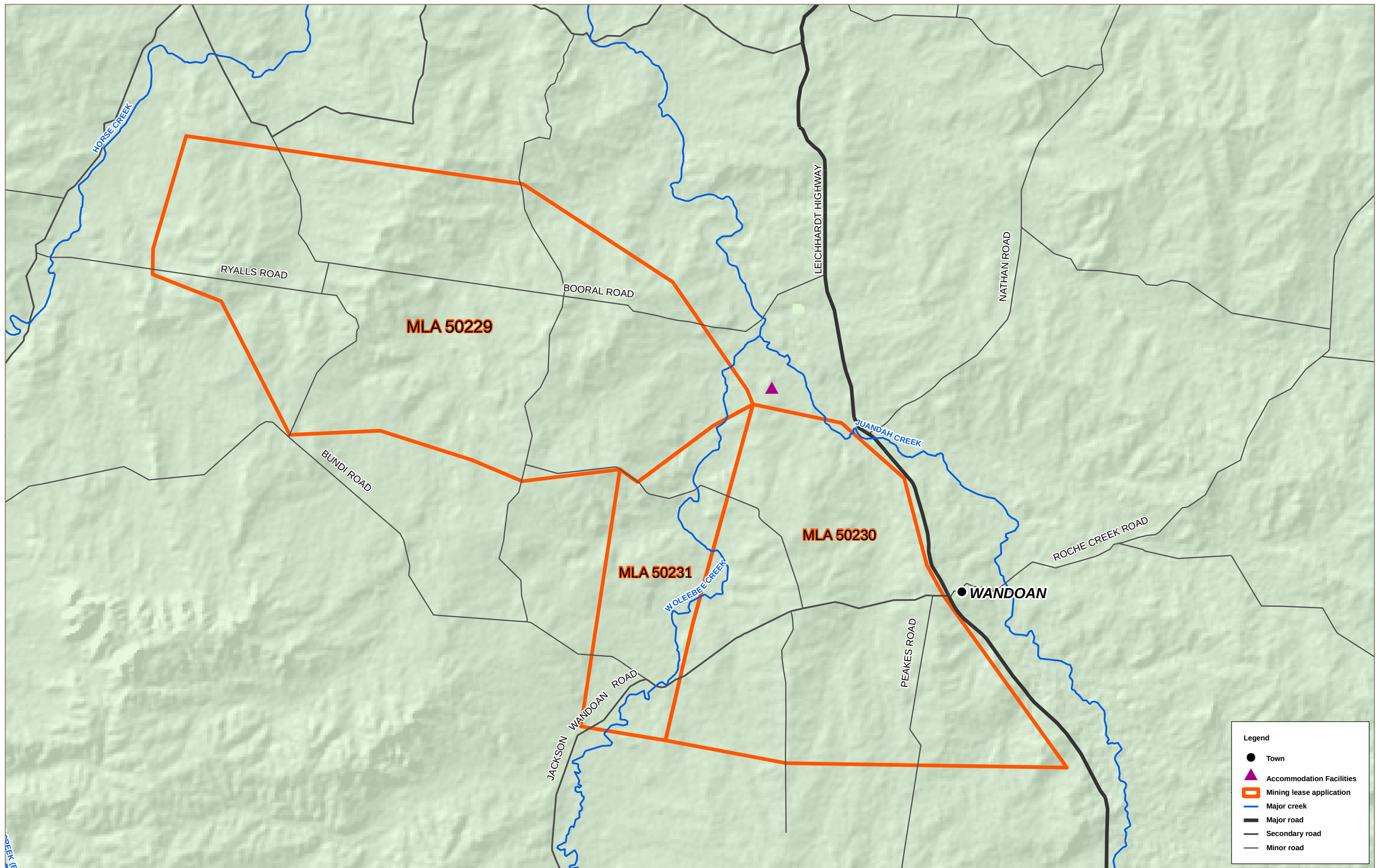
The Project was declared a Project of State Significance by the Coordinator-General in December 2007.

1.2 Description of study area

The Wandoan Coal Project will be developed over an area of approximately 32,000 ha within the three MLAs shown on Figure 1-2. A number of individual mining areas (pits) will be developed within these MLAs. These pits have been defined based on the value of the coal and its relative cost of production and so the individual pits vary in shape according to the quality, thickness and depth of the coal across the MLAs.

Blasting will be needed to prepare the overburden and interburden materials for excavation. This blasting will inevitably generate some ground vibration and noise. These effects will diminish in intensity away from the site of the blast and may extend some distance beyond the MLA boundaries. The study area adopted for the assessment of the environmental effects of blasting therefore includes a zone approximately 3,000 m beyond the mining lease boundaries. The township of Wandoan and a number of residences that lie within this distance of the MLAs are included in the study area.





Source: Roads, QLD State Digital Road Network (2004); Towns, creeks 1:250K Topo, Geoscience Australia (2006)

2. Methodology of assessment

2.1 Relevant legislation and guidelines

2.1.1 Framework

The *Environmental Protection Act 1994* (EP Act), Regulations, policies and local government laws combine to protect the quality of Queensland's environment. Specifically, Section 6I of the *Environmental Protection Regulation 1998* states that:

Noise from blasting is not unlawful environmental nuisance for an affected building if:

- a) the airblast overpressure is no more than 115 dB (linear) Peak for 4 out of any five consecutive blasts; and
- b) the ground vibration is:
 - i. For vibrations of more than 35 Hz — no more than 25 mm a second ground vibration, peak particle velocity; or
 - ii. For vibrations of no more than 35 Hz — no more than 10 mm a second ground vibration, peak particle velocity.

It should be noted that the environmental effects of blasting is generally discussed under the topic of 'noise' even though it refers to both vibrations generated in the ground (ground vibration) and in the air (airblast over-pressure).

The Queensland Environmental Protection Agency (EPA) has prepared a Guideline to set criteria in conditions of environmental authorities for activities such as blasting in mines and quarries. The Guideline specifies recommended human comfort criteria for:

- airblast overpressure level
- ground vibration peak particle velocity and
- times of blasting.

The EPA criteria specified in the Noise and Vibrations from Blasting Guideline are listed below in Sections 2.1.2 to 2.1.5. It should be noted that these criteria are more restrictive than those defined in the *Environmental Protection Regulation 1998*.

2.1.2 Noise criteria

Blasting activities must be carried out in such a manner that if blasting noise should propagate to a noise-sensitive place, then:

- the airblast overpressure must not be more than 115 dB(linear) peak for 9 out of any 10 consecutive blasts initiated, regardless of the interval between blasts and
- the airblast overpressure must not exceed 120 dB(linear) peak for any blast.

2.1.3 Vibration criteria

Blasting operations must be carried out in such a manner that if ground vibration should propagate to a noise-sensitive place:

- the ground-borne vibration must not exceed a peak particle velocity of 5 mm/s for nine out of any 10 consecutive blasts initiated, regardless of the interval between blasts and
- the ground-borne vibration must not exceed a peak particle velocity of 10 mm/s for any blast.

2.1.4 Times of blasting

Generally, blasting is only permitted during the hours of 9 am to 3 pm Monday to Friday, and from 9 am to 1 pm on Saturdays. Ordinarily, blasting should not take place on Sundays or public holidays.

Blasting outside these recommended times may be approved where:

- blasting during the preferred times is clearly impractical or
- there is no likelihood of persons in a noise sensitive place being affected because of the remote location of the blast site.

2.1.5 Criteria adopted for this study

The criteria provided by the EPA Guideline on noise and vibration from blasting (as described above) have been adopted for this assessment of the suitability of the blasting operations proposed for the Project. In doing so it has been assumed that the times at which blasting operations will be conducted will be governed by sub-paragraph (b) above and generally be permissible in daylight hours on any day.

2.2 How the study was conducted and information obtained

This study has been based on information provided by The WJV describing the Project and the conditions prevailing at the site. Frequent discussions have been held with WJV staff and with the staff of consultants and contractors assisting them to plan for the Project and prepare the Environmental Impact Statement.

The information provided by the WJV included:

- general descriptive background to the Project
- geological cross sections through each proposed mining area showing the thickness of overburden and interburden to be blasted
- a draft report by Golder Associates on 'Geotechnical Evaluation for Open Pit Mining — Wandoan Coal Project, Wandoan, Queensland dated April 2008'
- mine plans and production schedules
- maps of the study area showing:
 - the township of Wandoan, its buildings and facilities
 - roads, railways and services
 - the boundaries of the MLAs
 - potential sensitive sites.

A site visit to Wandoan was undertaken on the 28th of October, 2007 to inspect drill core during the initial geotechnical drilling program.

Blast designs consistent with industry best practice have been developed for the range of operating conditions and the operational requirements of the Project. Australian Standard 2187.2 'Explosives — Storage and Use, Part 2: Use of explosives' (2006), Appendix J provides information on the prediction and management of ground vibration and airblast overpressure from blasting.

The predictive formulae provided by the standard require certain parameters to be fitted from field data. Data from mines similar to the proposed Wandoan operations have been used to derive values for these prediction parameters. The formulae from the standard have then been used to estimate the distance that would be required for the ground vibrations and airblast overpressure to attenuate below the limits recommended by the EPA Guideline.

The ground vibration and airblast overpressure levels predicted for sensitive sites identified in the Project area have been compared with the levels recommended in the EPA Guideline. Changes have been made to mining and/or blasting practices where these estimates indicated that the levels recommended in the EPA Guideline might be exceeded. These analyses have allowed rules to be developed for the design of blasting operations to ensure that sensitive sites will not be subjected to ground vibrations or airblast overpressure levels that exceed the EPA recommended guidelines.

2.3 Limitations

The actual mechanisms responsible for the generation of ground vibration and airblast overpressure are very complex and depend on a number of factors which are not readily controlled by the blast practitioner. These include:

- the actual detonation times of each charge within the range of normal scatter for commercial delay detonators
- the state of confinement of the charge (dynamic burden) at the moment of detonation
- damage to the rock mass from previously firing charges or
- the detailed attenuation characteristics of the medium (ground or air) through which the ground or air-borne vibrations travel to the sensitive receptor.

The actual ground vibration and airblast overpressure levels generated by mine blasting operations are inevitably subject to significant statistical scatter. Sophisticated mathematical models are available to take some of the factors listed above into consideration when estimating the likely impacts from particular blast designs. When calibrated using reliable data from the same ground conditions, these models can be used to 'tune' blast designs to reduce ground vibration and airblast overpressure levels and to modify the frequency of ground vibrations at given target locations.

It is not appropriate to apply these sophisticated models to the predictions required for this study because of the absence of any actual performance data from the site. Quoting from AS 2187.2 Appendix J:

In the absence of either field data or the opportunity to conduct blasting trials in the region of interest, it is possible to estimate likely ground vibration and airblast levels using simple charge weight scaling laws. Such laws incorporate the charge weight per delay and the distance from the blast to the monitoring location. Two site parameters are assumed and these influence the peak level and the rate of decay for the levels.

However, the use of field data from similar operations to those proposed for Wandoan allows the site parameters to be estimated rather than simply assumed. The statistical distributions typical of ground vibration and airblast data can also be used to refine these parameters so that the probability that a blast may exceed either 5 mm/s Peak Vibration Velocity (PPV) or 115 dB (linear) airblast overpressure levels can be estimated. This approach allows proposed blasts to be tested against the EPA Guideline of no more than one blast in ten (i.e. less than 10% of blasts) exceeding the nominated limits.

This approach assumes that the operations are undertaken to a high standard of design and implementation and that there are no unusual ground conditions or adverse atmospheric effects that could exacerbate the resulting environmental impacts. These operating standards will be required by the mine's Blast Management Plan (as recommended in AS2187.2). The Blast Management Plan requires the environmental impact of each blast to be specifically considered in its design and implementation. In practice the requirements of this plan will be included in the more extensive site standard operating procedures and the blasting contractor's Blast Management System.

Using this approach, the application of the estimation formulae in AS 2187.2 can provide quite reasonable guidance to the blasting practices required to meet the criteria recommended in the EPA Noise and Vibration Guideline for the blasting effects at nearby sensitive sites.

3. Existing environment

3.1 Current level of disturbance

No blasting operations are currently carried out at the site of the Project and so the current level of ground or air-borne vibration from blasting is zero.

3.2 Ground conditions

3.2.1 Topography

Most of the areas to be mined within the Project have been cleared for agricultural purposes and are predominantly used for grazing and crops. The mining areas consist of extensive, undulating to nearly flat terrain incised by ephemeral streams producing a series of ridges and small river valleys across the Project area. The coal resources tend to be located within the ridges between the water courses. Elevations range from 240 m to 295 m AHD across the site.

3.2.2 Site geology

General description

Golder Associates (2008) summarise the site geology of the Project area as follows:

The Wandoan coal measures are part of the Surat Basin which extends more than 400 km from Brisbane to Wandoan. Coal mines currently operating in the Surat Basin include Wilkie Creek, New Acland, Commodore and Kogan Creek.

The Roma geological map sheet (1:250,000 series) indicates the bedrock geology in the Wandoan area is of Middle to Late Jurassic age. The geological map also indicates the presence of alluvial deposits bounding each of the larger water courses (Juandah Creek, Halfway Creek, Mud Creek, Wandoan Creek), as well as the presence of sub-artesian bores in the area. Detailed geological studies of the site have been undertaken and reported by Xstrata and are summarised here to provide background for the regional setting.

The coal reserves are contained within the Juandah Coal Measures, which are part of the Walloon Subgroup. A summary of the stratigraphic sequence in which the coal measures lie is as follows:

Table 3-1: A summary of the stratigraphic sequence in which the coal measures lie

Age	Formation	Lithological description	Coal units
Late Jurassic	Gubberamunda sandstone	Fine to coarse sandstone with minor siltstone and mudstone	
Middle to late Jurassic	Westbourne formation	Siltstone, sandstone, mudstone	
	Springbok sandstone	Sandstone	
Middle Jurassic	Walloon coal measures (Walloon	Juandah coal measures	Kogan Macalister upper

Age	Formation	Lithological description	Coal units
	subgroup)	Tangalooma sandstone Taroom coal measures	Macalister lower Wambo Iona Argyle Auburn Bulwer upper Bulwer lower Condamine
	Eurombah formation	Sandstone, conglomerate, mudstone	

The Juandah Coal Measures typically comprise clayey sandstones, interbedded with siltstone, mudstone and coal, with coal deposition more frequent towards the top of the fining cycles. The major seam groups and their splits are generally continuous over the deposits with seam thicknesses varying laterally.

The deposition of these sediments is understood to have occurred in a cyclic fashion which has been linked to changes in the global sea level. These cycles progress from braided streams, meandering streams to finally swamps, lakes and deltas to produce a fining upwards sequence. Stone bands within the coal horizons are thought to represent overbank deposits which were laid down during periods of flooding.

The overburden is generally characterised by soft sediments with the depth of weathering ranging from 4 m to 25 m, with an average depth of approximately 12 m. The only strong rocks in the overburden are understood to be thin ironstone and lensoidal calcified sandstone bands which are generally less than 1 m thick. Exploration drilling has found that the overburden is generally harder than the overburden.

The Roma geological map sheet and previous CSR reports indicate the coal units are located on the eastern limb of a south plunging regional structure known as the Mimosa syncline. The sediments are largely undisturbed, with no regional faults or igneous intrusions detected by the exploration program to date. The coal seams are relatively flat lying with a regional dip of approximately 0 to 2 degrees to the south west. Locally steeper dips are encountered, which are interpreted to be the result of differential compaction around sandstone bodies.

Geotechnical properties

Golder Associates (2008) have completed a draft geotechnical evaluation for open pit mining at Wandoan. Their report is based on a review of work by previous holders of the exploration leases, an inspection of a trial pit excavated in the early 1980s and the logging and testing of core and geophysical surveys of six geotechnical bore holes drilled in 2007. The locations for these boreholes were selected by the Wandoan Joint Venture in consultation with Golder to intersect target mining areas across the study area.

The upper overburdens are reported to consist of weathered sediments varying from 10 to 25 m thick. The unweathered overburden is reported to consist of clayey sandstone, grading to finer siltstone and mudstone over the coal seams. The coal seams are relatively flat dipping, with a regional dip of 1° to 2° to the south-west. Zones of coal and thin partings can be from a few metres to up to 15 m in thickness, with both coal and partings varying in thickness laterally. The interburdens between the coal seams comprise variable thicknesses of siltstones and mudstones with inter-beds of sandstones.

Rock strengths are described as being low strength to a depth of 20 to 30 m below ground level. Fresher overburdens and interburdens are described as being of medium strength. Laboratory tests have resulted in values of around 4 MPa unconfined compressive strength for the weathered overburdens and coal, and 15 MPa to 20 MPa for the fresher siltstones and mudstones. This indicates that the rock mass to be blasted in the Wandoan operations will be of lower strength than is generally encountered in the major Queensland open pit mines and considerably weaker than encountered in similar operations in New South Wales.

Golder reports that the dominant discontinuities encountered in the vertical drill holes were sub-horizontal bedding features. Relatively few steeply inclined joints were encountered indicating that, where present, these features are widely spaced. Some bedding plane shears were observed, but these are not likely to have a significant impact on blasting performance. The fracture frequencies observed in cores ranged from zero to two per metre with isolated zones of five to 12 fractures per metre at depth.

This description indicates that a weak weathered surface zone 10 to 25 m thick overlies medium strength, bedded but sparsely jointed siltstones and mudstones to the coal. Minor high strength calcite cemented bands have been observed in some drill holes but are not expected to affect the overall blasting characteristics of the overburden. Coal and parting materials are also of modest strength, with interburdens possibly marginally stronger than the fresh overburdens.

A program of further work has been recommended by Golder to define the geotechnical conditions in different mining areas of the Project in greater detail. This additional work will be necessary to finalise the design of the pit slopes but is unlikely to result in an interpretation of the blasting characteristics that would significantly alter the character of the blasting operations required, and hence the environmental outcomes expected from these blasts.

3.2.3 Groundwater

Golder Associates (2008) report that the groundwater table tends to lie between RL 220 m and RL 257 m, which is between 20 and 40 m below ground surface. The coal seams were interpreted to be acting as confined aquifers, and significant variation in piezometric pressure in different coal and inter-seam horizons indicated poor connectivity.

Golder Associates (2008) suggest there will be little groundwater storage in the aquifers and that once exposed by mine workings they are likely to drain quickly. Relatively dry conditions are therefore expected to be experienced in most pits other than from water derived from direct rainfall. However, some mining pits may receive drainage from nearby saturated zones of alluvium leading to some groundwater being encountered in blast holes.

3.3 Sensitive receptors

3.3.1 Definition

The EPA Guideline for Noise and Vibration from Blasting defines a 'noise sensitive place' as being:

- a dwelling
- a library, childcare centre, kindergarten, school, college, university or other educational institution
- a hospital, surgery or other medical institution
- a protected area or an area identified under conservation plan as a critical habitat or an area of major interest, under the *Nature Conservation Act 1992*
- a marine park under the *Marine Parks Act 1982*
- a park or garden that is open to the public (whether or not on payment of money) for use other than sport or organised entertainment.

Parsons Brinkerhoff (PB) have surveyed the Study Area and identified the 'noise sensitive places' or sensitive receptors that may experience disturbance from blasting operations. Those places likely to be sensitive to blasting operations are identified on Figure 3.1 and are briefly described in the following sections.

Town

The township of Wandoan lies to the immediate east of the Project and contains a number of dwellings and town facilities that would be regarded as sensitive receptors of ground vibration or airblast over pressure. For this study, the town is regarded as a single sensitive receptor with its boundary being the Leichhardt Highway on the western side of the town.

Telstra communications tower

A Telstra communications tower (MLA-47 on Figure 3.1) is located approximately 420 m west of the Leichhardt Highway adjacent to the town. This tower could lie within a few hundred metres of the operations in the Frank Creek Pit, and although not coming under the definition of a 'noise sensitive place', it will be necessary to ensure that its safety and performance is not adversely affected by the mining operation.

Abattoir

An abattoir (MLA-740 and MLA-741) is located on the western side of the Leichhardt Highway between the town and the planned Frank Creek Pit.

Cemetery

The Wandoan cemetery (MLA-705) lies approximately 5 km north of the town on the western side of the Leichhardt Highway. It lies approximately 1,200 m from the north end of the proposed Leichhardt Pit and as such represents one of the closest sensitive receptors to the mine workings.



Figure 3-1
Sensitive vibration and airblast receptors.

Houses and farm buildings

The study area is populated with farm properties that incorporate residential dwellings, sheds and other agricultural facilities and services. Many of these will be purchased by the WJV, but those that will remain independent of the Project have been considered in the analysis of the ground vibration and airblast impacts of the Wandoan blasting operations.

Services — roads, power lines and pipelines

Services such as roads, power lines and pipelines will experience some level of ground vibration and airblast overpressure from blasting. These have been considered in the assessments made in this study.

Groundwater bores

There are a number of groundwater bores in the Project area and the potential impact of ground vibration on these has been considered in the assessments made in this study.

4. Description of proposed development

4.1 Mining areas

4.1.1 Pits

A number of separate pits have been defined for the mining operation as shown on Figure 4-1. These have been selected based on the quality of the coal and the costs required to mine and wash it to meet the sales specification. The pits are each named after local properties or features and can be broadly sub-divided into eastern and western groups. Development will begin in the centre of the eastern group of pits, followed by the development of the western group eight years later. Production focus will then be shared between the two main areas with the final years of the Project concentrating on the western and southern pits.

4.1.2 Production schedule

The Project has been planned to operate over a thirty year life. The initial mining activities will involve the development of the Austinvale Pit. Initial development will take place on both the eastern and western boundaries of the pit and progress towards the centre. Mining will commence in the north of the Woleebee Pit in Year 2 of the project. In Year 3, development will begin on the western side of the Frank Creek Pit. The Frank Creek Pit will be completed by Year 5 when operations commence in the Mud Creek Pit. Mining will be completed in the Austinvale Pit in Year 9 and this production capacity will be transferred to the Summer Hill and Turkey Hill Pits. Production capacity then transfers between these pits from time to time to optimise the access to coal and production costs.

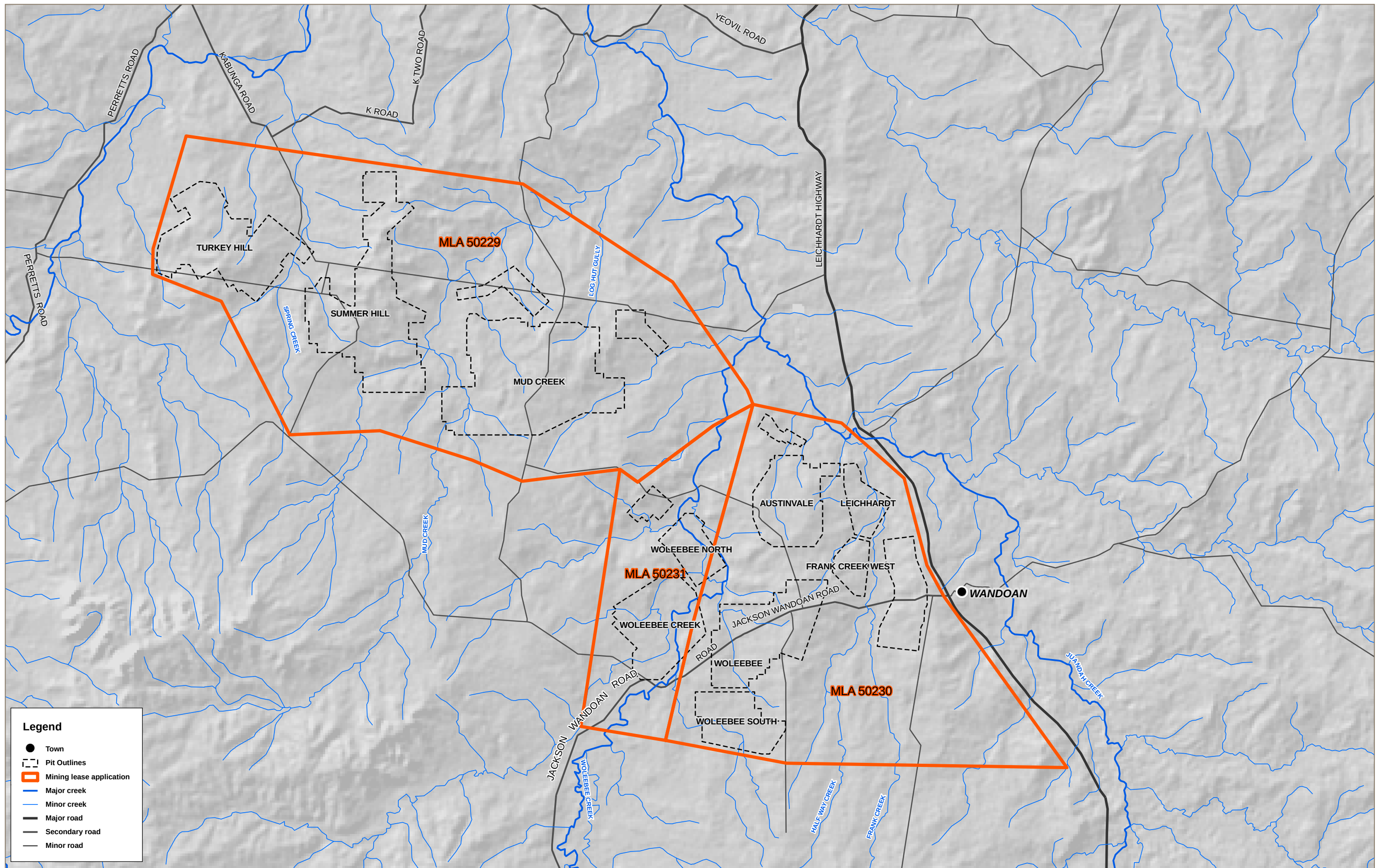
The broad area of the Project and the high rate of extraction mean that the mining operation will only be in the proximity of any particular sensitive receptor for a limited period of time. This means that although the Project will have at least a 30 year life, the operations will only directly impact each external sensitive receptor for a much shorter time.

4.2 Mining method

4.2.1 Resource characteristics

The coal resource at Wandoan is characterised by complex coal zones that contain varying thicknesses of coal and parting. The upper coal zone is quite shallow (15 m to 30 m) over much of the resource with a lower economic coal zone often a similar distance below the first. Pits will initially be quite shallow and mine a thick coal and parting zone.

Xenith Consulting Pty Ltd (Xenith) has provided a number of schematic sections through the Wandoan Pits to assist in the planning of the blasting operations. Figure 4-2 shows a west-east section through the southern part of the Austinvale pit where the first mining operations will be undertaken. The sections are plotted with an exaggerated vertical scale showing the height above sea level of each horizon. The planned mining strips are shown across the bottom of the section and the different strata are shown in different colours for each strip. Overburden is light green, coal is black and interburdens are dark green or blue. Partings are dark grey and the floor material is light grey.



J:\A442-ENG\PROJ\2133006C__Wandoan_prelea\10_GIS\Projects\Env\Technical Report\Blasting\Figure 4-1 Pit layout.mxd

Source: Roads, QLD State Digital Road Network (2004); Towns, creeks 1:250K Topo, Geoscience Australia (2006)



Figure 4-2 shows that the initial depth to coal on either side of the pit is barely 10 m and increases to approximately 30 m in the centre of the pit. Accordingly, this pit will be mined from either side towards the centre. A two-seam operation will be required in the western side of this pit with up to 28 m of interburden to be removed below the first coal zone.

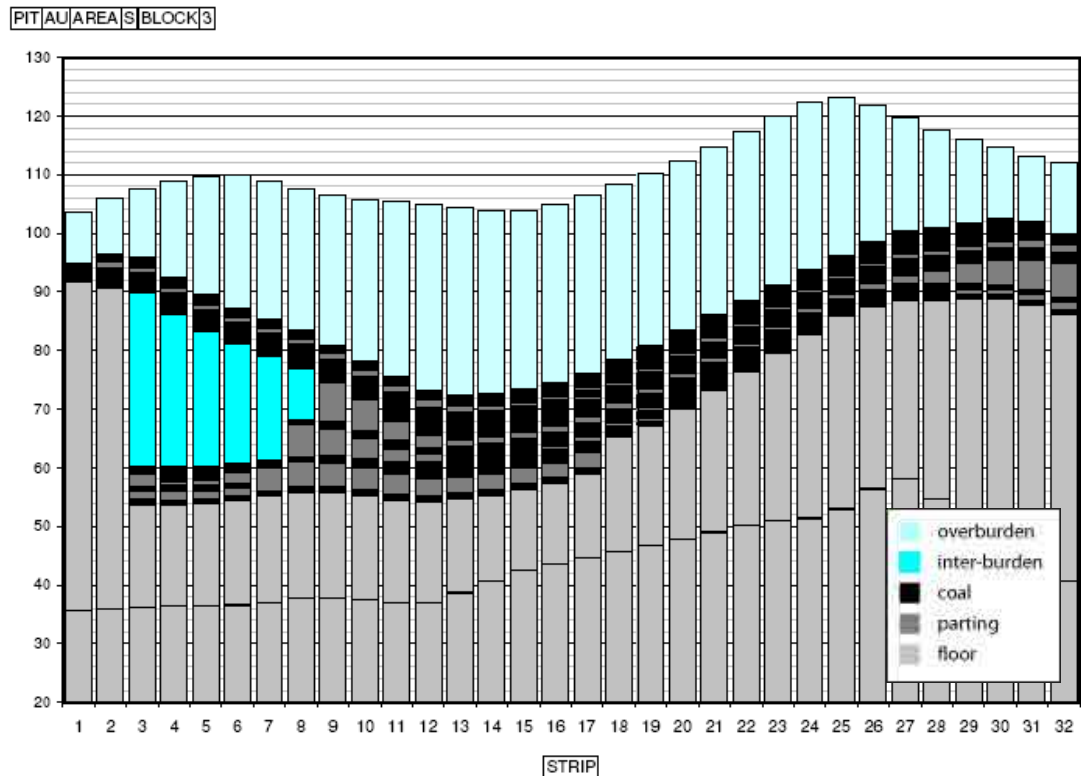


Figure 4-2: Schematic west-east section through the southern half of the Austinvale Pit

Figure 4-3 shows a schematic north–south section through the western side of the Mud Creek Pit and indicates that the initial operations will be shallow, then later develop into a two seam operation and then later involve overburden thicknesses in excess of 50 m. These variations are typical of the Wandoan deposit and must be accommodated by the blasting operation.

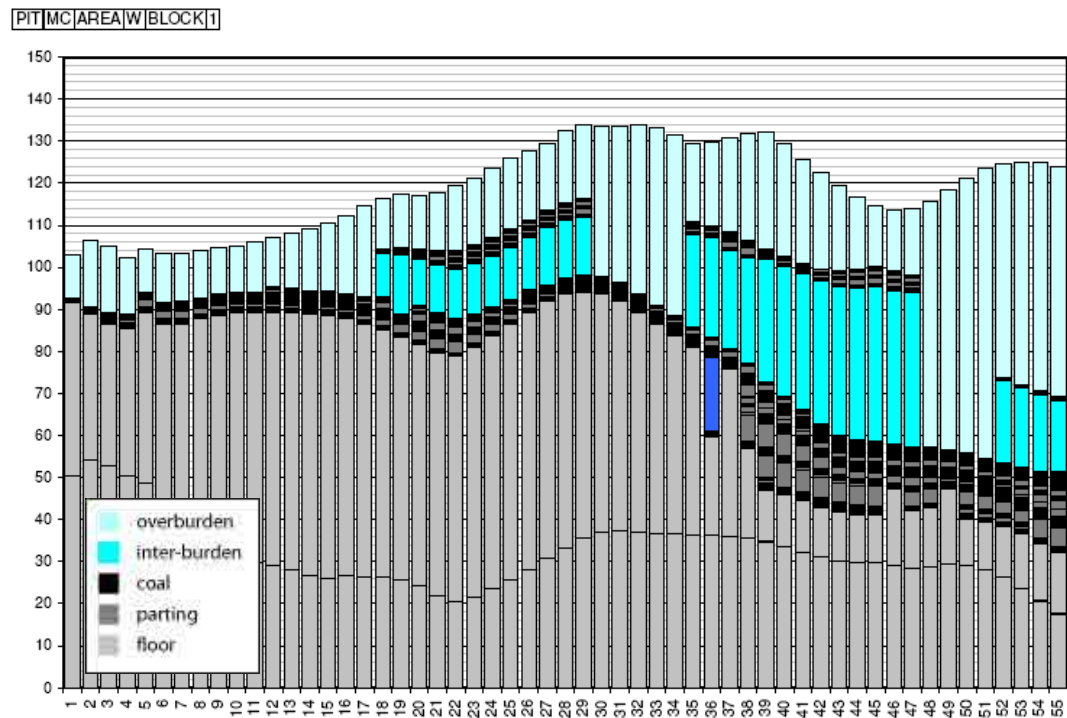


Figure 4-3: Schematic north-south section through the western side of the Mud Creek Pit

4.2.2 Equipment

Draglines

Large walking draglines (100 m³) will be the principal type of machine to remove the overburden. Up to five of these machines will be used to expose the coal zones. Blasting for draglines must be undertaken over the full depth of the material to be excavated by the dragline.

Excavator and truck

Hydraulic excavators and trucks will be used for overburden removal in some mining areas where the horizon thickness, location relative to sensitive receptors or the mining schedule does not suit the use of draglines. Blasting for hydraulic excavators can be carried out in a number of separate benches defined to suit the size of the excavator and the location of the coal seams to meet environmental requirements.

Front end loaders and bulldozers

The coal seams and thin partings within the coal zone are not planned to be blasted. These horizons will be ripped using a bulldozer if required and excavated using hydraulic excavators or front end loaders.

4.2.3 Pit geometry

There will be a very wide range of horizon thicknesses to be blasted from a few metres to more than 60 m in later years. Ripping shallow mid-burdens and partings will also be a routine feature of the operation.

Mining will take place in strips nominally 80 m wide. Golder has recommended pit slope angles as follows:

- weathered material at 45°
- unweathered overburden and mid-burden
 - less than 24 m high at 76°
 - between 24 m and 36 m high at 70°
 - over 36 m in height at 63°
 - a 5 m berm is recommended between weathered and unweathered materials.

It is unlikely that blastholes will remain stable in the modest strength strata at Wandoan if drilled at more than 70° from the horizontal. This means that blast holes cannot be drilled parallel with the pit walls for bench heights greater than 36 m. Shorter stab holes will be required in both the front and the back of deep blasts to control the breakage in these areas.

Individual blasts are likely to range in length from about 300 m up to around 1,000 m. Larger blasts may be possible in some circumstances. The large scale of the draglines selected for the operation and shallow overburden and interburden horizons over most of the deposit will require a rapid rate of advance for each machine. Substantial areas of ground will need to be blasted ahead of each machine, encouraging the use of large blasts.

4.3 Blasting operations

4.3.1 Role of blasting

The purpose of blasting in a mine is to prepare the in-situ rock for excavation. The rock has to be broken into fragments that are small enough for the dragline or excavator to load and handle efficiently. In addition, the resulting muckpile must be of sufficient looseness to allow the dragline or excavator bucket to readily work through the muck to fill its bucket. The muckpile must also be left in a suitable shape for the particular type of machine scheduled for its excavation.

Achieving the required fragmentation should not be difficult in the Wandoan overburden and interburden materials because of their modest strength. The principal blasting objectives will therefore be to generate looseness in the muck and to avoid unnecessary damage to the underlying coal or adjacent pit walls.

4.3.2 Blasting characteristics of Wandoan overburden and interburden

The energy required to satisfactorily fragment and loosen a rock mass is basically related to:

- the strength of the rock substance which affects how much energy and the rate at which this energy must be applied to generate the fractures required to achieve the required fragmentation
 - the strength of the Wandoan rock mass is quite low indicating the need for quite modest blasting intensity

- the structure or the size of the intact rock blocks within the rock mass which influences the larger fragments generated by the blast and the amount of energy required to achieve the target fragmentation
 - the Wandoan rock mass is quite sparsely structured and can be expected to contain quite large in-situ blocks
 - the low rock substance strength should ensure adequate blast fragmentation provided blast patterns do not involve excessive blast hole spacing.
- the density of the rock which affects how much energy is required to displace the rock
 - the density of the sandstones, siltstones and mudstones is quite modest at about 2.3 t/bcm.
- the confinement of the bench when it is blasted with fully confined blasts requiring greater blasting intensities to achieve the same excavation performance as blasts subjected to less confinement. Wandoan blasts will vary in terms of the confinement they will experience:
 - full bench blasts for a dragline will generally be able to utilise a free face and be relatively unconfined
 - the confinement of shovel benches will increase as the bench height reduces and the benefit of any free face will be reduced.
- the extent of groundwater, which will affect the choice of explosive that can be used:
 - most mining areas at Wandoan are expected to be dry, allowing the use of ANFO or diluted ANFO explosives
 - areas of the Woleebee, Leichhardt and Frank Creek Pits may encounter some wet areas where their strata are hydraulically connected to near-by saturated alluvials.

Overall, the Wandoan overburdens and interburdens should require quite modest blasting intensity to achieve satisfactory excavation performance. Powder factors between approximately 0.3 kg/bcm and 0.4 kg/bcm should provide adequate blast breakage and movement provided that drill hole diameter is reduced in shallower benches to avoid the use of excessive charge spacing.

Cast blasting is often employed in dragline strip mines. This involves increasing the blasting intensity in the front rows of dragline blasts in order to throw a proportion of the blast volume into its final spoil position. This reduces the proportion of the overburden material that has to be actually handled by the dragline. Cast blasting is not planned for the Wandoan operations because:

- the majority of the overburden benches are relatively shallow, providing limited opportunity for cast
- the rock substance is relatively porous and lacks stiffness, reducing the displacement velocities likely to be generated
- the shallow slope angles required for the higher benches cannot be matched by the blast hole drill making it very difficult to achieve the required intensity of explosive energy in the front blast burdens.

The powder factors planned for Wandoan blasts can be compared with typical values used in other major coal mining areas in Australia as follows:

- Wandoan — 0.3 kg/bcm to 0.4 kg/bcm
- Bowen Basin — 0.4 kg/bcm to 0.6 kg/bcm
- Hunter Valley — 0.5 kg/bcm to 0.7 kg/bcm.

4.3.3 Blast designs

Overburden and interburden blasts

Table 4-1 summarises the nominal blast designs prepared for Wandoan overburden and interburden blasts. ANFO explosives have been assumed for all blasts.

Table 4-1: Nominal blast designs for Wandoan overburden and interburden

Bench Height m	Hole Diameter mm	Hole Angle deg	Stemming m	Stand Off m	Air Deck m	Charge per hole kg	Burden m	Spacing m	Powder Factor kg/bcm
3	127	90	2.0	0	0	10	2.8	3.2	0.38
5	127	90	2.5	0	0	26	3.5	4.0	0.37
7.5	165	90	3.5	0.5	0	61	4.5	5.2	0.35
10	165	90	3.5	1	0	95	5.0	5.8	0.33
15	229	70	5.0	2	0	295	7.0	8.7	0.32
20	229	70	6.5	2	0	422	7.5	9.0	0.31
30	270	70	8.0	2	0	1011	9.0	12.0	0.31
40	270	70	8.0	3	0	1455	10.0	12.0	0.30
50	270	70	8.0	3	3	1809	10.0	12.0	0.30

The designs have been prepared for blasting in a wide range of bench heights. It is unlikely to be economic to blast benches less than 3 m in thickness and so this is the minimum height for which a design has been prepared. Larger hole diameters are used in higher benches because this allows fewer blast holes to be used while maintaining a reasonable distribution of explosive energy within the blast volume. Vertical blast holes are used in shallow benches as the working faces can be safely trimmed back close to vertical. Angled blast holes are used in higher benches so that the energy distribution adjacent to the angled bench face can be kept as even as possible. Drill hole spacing has been limited to a maximum of 12 m even in very deep blasts to avoid the formation of large blocks in this sparsely jointed rock mass.

Coal and partings

The coal seams and minor partings within the coal zone are not planned to be blasted. If they cannot be excavated without blasting then they will be ripped by a bulldozer to loosen the material for excavation.

Wall control

Overburden and interburden blasts will need to be controlled to avoid generating damage to the new highwall formed by the excavation of the blasted muck. It is conventional practice in Australian open pit dragline mines to fire a pre-split blast on the alignment of the new highwall to create a line of fracture to which the dragline can excavate. The pre-split also creates a leakage path for explosion gases, thereby reducing the probability that these gases will enter the rock mass structure in the new wall and cause damage that may affect future stability.

Pre-split blasts are most effective in brittle, massive rock. The Wandoan rock is massive, but relatively soft and not particularly brittle. It is unlikely that the overburdens at Wandoan will pre-split effectively, particularly the weathered material in the upper 10 m to 25 m of most

pits. The shallow stable bench angles in the deeper walls prevent blast holes being drilled on the alignment of the wall, again making pre-splitting inappropriate.

Pre-split blasts may be effective in the stronger interburdens under the first coal zone in a two pass operation. However, for this to be possible there must be sufficient space for a drill to sit behind the new batter line to drill the holes. This will necessitate an off-set bench between the upper coal zone and the interburden strip. In addition, there will need to be sufficient time between the exposure and mining of the first coal horizon and the blasting of the next horizon for the pre-split to be fired. It may be difficult to achieve this separation in the production schedule given the generally high production rates expected from each pit.

For the purposes of this study it is assumed that the new highwall will be formed by placing additional blast holes in the back of the blast and modifying the charge placement and initiation timing to reduce the likelihood of damage to the new highwall. As pre-split blasts are often the greatest source of ground vibration and airblast overpressure at a mine site, this decision should reduce the probability that Wandoan blasts will generate an environmental nuisance from airblast overpressure or ground vibrations.

5. Potential impacts

5.1 Environmental impacts from blasting

5.1.1 Impacts

There are a number of potential environmental impacts from open pit blasting including:

- fly-rock
- ground vibration
- airblast overpressure
- dust
- fume
- leaching of chemicals into the groundwater system.

The first three of these impacts are addressed in this report and the last three are dealt with by specific reports that form part of the Wandoan EIS. Similarly, vibration impacts from road transport affected by the project is addressed in the transport study.

In addressing the issues of fly-rock, ground vibration and airblast overpressure, it is important to note that there is no conflict between the actions and practices required to achieve satisfactory blasting outcomes for the mining operation and achieving compliance with environmental requirements. Blasting practices that lead to poor environmental outcomes also threaten mining performance and it is in the interests of the mine to adhere to these practices. For example, blasts that generate excessive fly-rock also tend to produce high airblast levels. Fly-rock is accompanied by the early release of high pressure explosion gases which reduces the effective amount of work that the explosive can apply to break and loosen the rock for excavation. Such blasts are likely to result in poor fragmentation and tighter digging in the lower part of the mine bench, both of which are undesirable from a mining perspective.

No significant blasting activities are anticipated during the construction phases of the project, but if required, would be subject to the same environmental restrictions as the much larger mine production blasts.

5.1.2 Fly-rock

Issues

Fly-rock is the undesirable excessive displacement of rock as a result of the uncontrolled venting of explosion gases. An important objective of blast design is to contain the explosion energy within the blast volume in order to maximise the extent of useful work done on the rock. The orderly and controlled displacement of the muckpile is therefore a desirable blast outcome.

A number of factors contribute to the occurrence of fly-rock. These include:

- unanticipated weaknesses in the rock structure
- insufficient burdens on blast holes
- insufficient stemming length or the use of poor quality stemming
- blast pattern shapes or initiation sequences that generate excessive confinement.

Industry standard blast design practices take these factors into consideration. However, the variability of the rock mass to be blasted means that there is always the potential for some rock to be ejected from the blast area.

Management

The management of fly-rock from open pit blasting begins with the detailed design of each blast. The design of each blast needs to address the issues identified in the previous section and the implementation of the design in the field needs to be of a standard that ensures that these basic requirements are routinely achieved. Even so, it is essential that an adequate exclusion zone is provided around each blast to ensure that personnel and equipment are safe from any fly-rock that may occur.

Theoretical models are available to predict the distance that rock may be ejected from a given blast design. However, the large number of variables that might affect the predicted outcome means that these prediction formulae should be used only as a guide. The actual distance adopted needs to be based on documented experience at a site and consideration of the particular circumstances of each blast.

Exclusion zones

Exclusion zones are discussed in Australian Standard AS 2187.2. All blasts require the establishment of an exclusion or evacuation zone prior to firing the shot. The size of the exclusion zone needs to be such that all fly-rock and debris will be contained within the zone. An exclusion zone can comprise an inner zone, which is established prior to the commencement of loading the shot, and an outer zone that is established prior to the final initiation connections being made. The purpose of an inner zone is to allow work to continue in the surrounding areas during charging.

The requirements for an exclusion zone are components of the mine's Blast Management Plan. For blasting operations where the zone is contained within the property boundaries then standard procedures can be developed and implemented for each blast. Where the exclusion zone extends on to neighbouring properties then specific investigations and liaison is required with the affected persons.

The size required for the exclusion zone is directly related to the actual blasting activity being carried out and the surrounding environment. Australian Standard AS2187.2 requires that a 'competent' person determine the size of the zone through consultation with other stakeholders. The zone that is defined needs to be practical and designed so that access can be reliably controlled given the access points and nature of the landscape involved.

Formal risk management assessments should be undertaken to determine the approach to be used for each type of blast in a mine. Documentation of actual performance and investigation of any incidents are important components of this approach. Based on published experience, zones extending twice the calculated fly-rock travel distance are often adopted for the protection of equipment and double this distance (i.e. four times the calculated distance) is often used for the exclusion of personnel.

Xstrata Coal Queensland adopts a standard exclusion zone of 600 m from open pit blasts in their existing open pit operations. There are no particular circumstances or conditions that have been identified in the future Wandoan operations that suggest that this practice should change. However, in practice it will be necessary for the exclusion zone to be reviewed on a blast by blast basis as required by the Blast Management Plan.

5.1.3 Ground vibration

The nature of ground vibrations from blasting

An explosive confined in a blast hole transforms rapidly into high temperature and high pressure gases. These gases exert very large stresses on the walls of the blast hole which generate the blast breakage sought from the blast. Some of the energy imposed on the rock is consumed by this breakage, but some continues to propagate away from the blast hole. As the energy spreads away from the blast hole it reduces in intensity as it is spread over a larger and larger area of rock. When the intensity of the stress wave falls below that needed to break the rock (a few metres from the blast hole) it continues to propagate as elastic waves and leaves the rock undamaged.

There are different mechanisms by which these waves can travel through the rock, but they are each attenuated (i.e. lose energy) as they travel and spread further from the blast hole. Rayleigh waves, which propagate on the ground surface like waves in the ocean, suffer less attenuation than the other waveforms and so tend to be the dominant form of ground disturbance more than a few hundred metres from a blast. The stress wave causes local displacement of the ground surface, but leaves the rock through which it travels unchanged after it passes.

The ground disturbance occurs as a sequence of individual waves or displacements. The actual vibration event from a mine blast can be very complex because there are usually many blastholes involved and the disturbance from each blast hole will interact with that of its neighbours. The rate at which these waves are experienced (their frequency) reduces as the disturbance travels away from the blast. Vibration frequencies of more than 1,000 Hz (cycles per second) may be experienced close to a blast, while this may reduce to only 10 or 20 Hz at a distance of 1,000 m.

Ground vibrations experienced some distance from mine blasts are quite different in character from earthquakes or most man-made vibrations. Most mine blasts take less than one second to fire. Because these signals spread as they travel and because there will also be some “echoes” of the actual waves, the vibration experienced at distance from a blast may last for two or three seconds. Earthquakes can last for tens of seconds, and vibrations from machinery can be continuous.

Far field blast vibrations involve very small displacements (fractions of a millimetre) relative to earthquakes which can involve displacements of hundreds of millimetres. Studies undertaken by the US Bureau of Mines (Siskind, D.E., Stag, M.S., Kopp, J.W., Dowding, C.H., 1980 and Siskind, D.E., Stochura, V.J., Stag, M.S., Kopp, J.W., 1980) and the Australian Coal Association Research Program (Richards, A.B. and Moore, A.J., 2002) confirm that vibration levels five to ten times the EPA licence limits are required to cause damage to common domestic buildings. The usual licence limits are based on avoiding annoyance or nuisance and are very conservative in terms of potential damage.

Measurement and reporting

It is possible to measure the displacement, the velocity or acceleration of the ground during a vibration event. The most appropriate parameter to measure depends on the reason the measurement is being taken. Ground vibrations are usually measured in terms of the velocity of the ground rather than its displacement or acceleration. There are two reasons for this:

- the velocity of each particle of rock can be related theoretically to the stress generated in the rock and this stress can be related to the potential for causing damage
- the particle velocity can be readily measured using simple monitors called geophones.

The vibration experienced by the ground surface is in three dimensions. Instruments to measure these vibrations (geophones) act in one dimension. Three geophones set up to measure three orthogonal directions (say up and down, across from side to side and in and out) will record enough information about the vibration event to allow the actual three dimensional wave form to be calculated. The peak value from these three measurements (at the same moment in time) is called the Peak Particle Velocity (PPV) which is measured and calculated in mm/s. This peak value is considered to be the best indicator of the magnitude of the vibration experienced at a particular location.

There are established protocols for the design of the monitors used for these measurements, the installation of the instruments and the processing of results. The frequency of the vibration is also important and the standard monitors will provide this information. The behaviour that any structure will display in response to ground vibrations from blasting will be influenced by the frequency of the vibration and the dynamic characteristics of the structure.

Factors that influence vibration levels

The basic factors that affect the ground vibration levels that will be experienced at any location are:

- the quantity of explosive in each blast hole
- the confinement of the blast hole
- the interaction between vibration events from different blast holes
- the transmission characteristics of the strata between the blast and the point of observation
- the distance between the blast and the point of observation.

The larger the blast hole diameter, the higher the bench and the greater the density of the explosive then the greater the mass of explosive in each blast hole. This means that the detonation of each blast hole will impose a greater amount of energy on the surrounding rock. The actual timing of the detonation of each blast hole controls how the vibrations from each hole will interact (either add or subtract from each other) as they travel towards the point of observation. In a suitably designed blast, more of the explosive's energy will be applied to breaking and loosening the burden rock and less energy will be available to generate nuisance ground vibrations.

Strong, stiff rock will have better transmission characteristics than soft, plastic soils or clay and so the nature of the strata between the blast and the point of observation has a controlling influence on the resulting vibrations. The actual transmission path can be very complex and involve multiple conversions between transmission modes, reflections from harder strata, diffraction and attenuation on rock structures. Complex mathematical models have been developed to describe these mechanisms, but in practical terms the modelling of these phenomena depends on calibration using actual field data.

Predicting ground vibrations from blasting

Australian Standard AS2187.2 recommends that the following formula be used to estimate the vibration levels expected from blasting at a site for which no actual 'calibration' records are available.

$$V = K_g \left(\frac{R}{Q^{1/2}} \right)^{-\beta}$$

Where:

- V is the ground vector peak particle velocity in mm/s
- R is the distance between the blast and the point of measurement in metres
- Q is the maximum instantaneous charge (MIC) in kilograms
- K_g and β are constants related to the site and rock properties for estimation purposes.

Australian Standard AS 2187.2 recommends that for blasting in typical conditions to a free face (i.e. not involving excessive confinement) and in the absence of site specific data, that the following equation is used:

$$V = 1140 \left(\frac{R}{Q^{1/2}} \right)^{-1.6}$$

The MIC has traditionally involved calculating the weight of explosive expected to detonate in any 8 ms time window. The actual length of time over which different charges will contribute to the vibration levels at any given moment will depend on the geometry of the blast and the detailed initiation sequence. In the absence of any better information the 8 ms window is a reasonable first assumption. For most large scale open pit blasts it is common for four to six blast holes to initiate within an 8 ms window.

Because a large number of factors affect the actual PPV value that will be experienced from any blast it is common for the actual values to be quite scattered. The distance from the blast divided by the square root of the MIC is called the 'scaled distance' for vibration analysis and it is against this parameter that vibration results are usually plotted. Figure 5-1 shows an example from a coal mine in Queensland that shares similar (albeit somewhat stronger) ground conditions and overburden thicknesses to the Wandoan Coal Project.

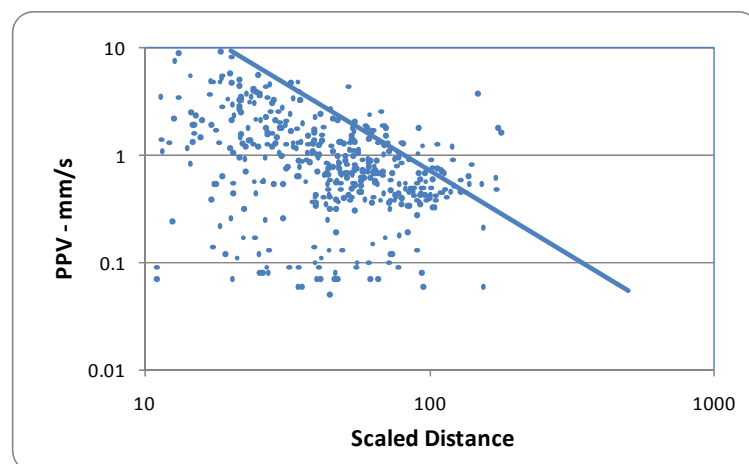


Figure 5-1: Scaled distance plot of vibration data from a Queensland open pit coal mine

Also shown on Figure 5-1 is the line representing the formula recommended by the Australian Standard and adopting a value for Kg of 1140 and a value for β of -1.6. Analysis of the data on Figure 5-1 indicates that these parameters describe the 90th percentile of the data set; i.e. 10% of the data values plot above this line. The MIC used for these calculations was based on an analysis of the number of blast holes designed to detonate within an 8 ms window.

Figure 5-1 suggests that the formula recommended by the Australian Standard can be used with some confidence to determine the distance from any blast to the distance at which the vibration level will have fallen to (say) 5 mm/s. Given that the sort of scatter shown is inevitable, the distances calculated using this approach should be such that no more than one blast in 10 should exceed the PPV limit of 5 mm/s.

Ground vibration predictions for Wandoan

Blasts to be fired in the Wandoan mining operation will require a wide range of bench heights, blast hole diameters and charge weights. Blasts in shallow benches will inevitably be more confined than the blasts in higher benches for the dragline, where the free face can be used to advantage. Smaller scale blasts will also tend to involve the detonation of a greater number of holes within an 8 ms time window than the larger dragline blasts.

Table 5-1 summarises inputs to the estimation of ground vibration for a range of Wandoan blast designs. Also shown is the distance at which 9 out of 10 blasts should generate 5 mm/s PPV or less.

Table 5-1: Summary of PPV calculations for distance to 5 mm/s

Bench Height m	Charge per Hole kg	Holes per Delay	MIC kg	Kg	Beta	Distance to 5 mm/s m
3	10	6	60	1140	-1.6	231
5	26	6	156	1140	-1.6	372
7.5	61	5	305	900	-1.6	448
10	95	5	475	850	-1.6	540
15	295	4	1180	700	-1.6	754
20	422	4	1688	650	-1.6	861
30	1011	4	4044	500	-1.6	1131
40	1455	4	5820	500	-1.6	1357
50	1809	4	7236	500	-1.6	1513

As a guide, these distances can be plotted against bench height to enable a simple estimate of the distance to the limiting vibration value for a blast in any bench height as shown on Figure 5-2. The bumps in the curve result from the step changes in assumptions used for different blast designs.

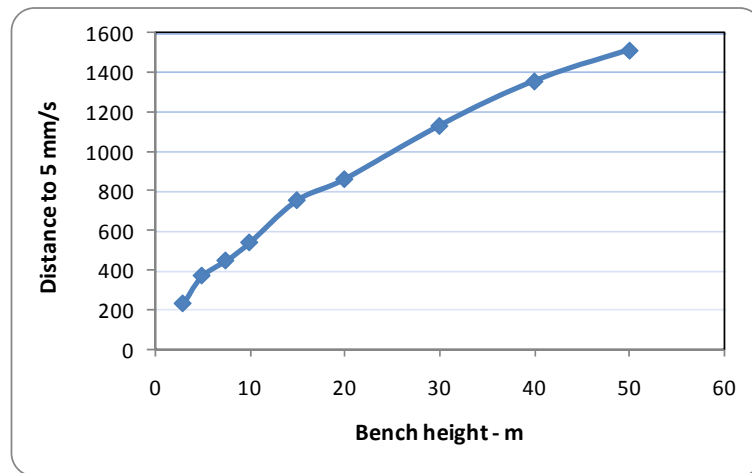


Figure 5-2: Relationship for simple estimation of distance to 5 mm/s PPV

5.1.4 Airblast overpressure

The nature of airblast overpressure

Airblast overpressure is defined as a transient increase in air pressure above the ambient value. Most scientific investigation has focussed on the detonation of explosives in air as is usually the case for military explosives. In a mining context, airblast is the superposition of impulsive air pressures, both positive and negative, generated as a result of the detonation of an explosive confined in the ground. The resulting pressure wave travels as vibrations in the air at the local speed of sound.

The five generally recognised sources of airblast are:

- vibration of the free face
- the physical movement of rock
- the escape of gases from the rock surface
- ejection of stemming material
- detonation of exposed explosive.

Each of these mechanisms is a function of the blast design, the accuracy of its implementation and the characteristics of the rock mass. Any feature of the blast that allows the detonation of unconfined explosive or the escape of high pressure gases will lead to the generation of relatively high frequency noise. The impulsive movement of a rock face or ground surface will tend to generate a lower frequency pulse in the air. Contributions from all possible sources are combined in generating airblast overpressure.

The propagation of airblast in the far field is affected by atmospheric conditions and the terrain. As airblast generally consists of sound waves with very long wavelengths (10 m to 300 m) it is very difficult to screen its effects using vegetation or other barriers. The actual damping provided by the atmosphere is very low, due to the characteristically low frequency (1-20 Hz) of the vibrations. It is important to recognise that, characteristically, most of the energy in airblast is at frequencies below the human threshold of hearing. This means that airblast is seldom heard, although secondary effects such as the rattling of windows or roofing iron will probably be audible.

The medium through which the airblast travels (i.e. the atmosphere) is constantly changing. This significantly complicates the prediction of airblast effects. Particular atmospheric conditions can focus the energy of an airblast in local areas leading to anomalously greater effects than normally expected.

The most important factors affecting the propagation of airblast are wind speed, wind direction, barometric pressure and atmospheric temperature. A temperature inversion occurs when the temperature increases with altitude, rather than the normal decrease with altitude. This warmer upper layer of air can refract the airblast energy back to the ground. The airblast amplitude at ground level will then be the sum of the refracted sound wave and the direct sound wave. This occurs most frequently in the evening, at night, and early in the morning, when the weather will be hazy, visibility low and there will be little or no wind. Blasting during these conditions is more likely to result in higher levels of airblast being generated.

Measurement and reporting

Airblast overpressure is measured in Pascals (N/m²). The pressures generated by mine blasting can vary over a wide range. The response of the human ear is roughly logarithmic with sound pressure level and so it is conventional to use a logarithmic (decibel) scale for the reporting of sound pressure level. Sound levels, L_p , are usually reported with respect to a reference pressure of $p_o = 20 \times 10^{-6}$ Pa which is regarded to be the lower limit of human hearing for young people for sounds with a frequency of 1,000 Hz. The sound pressure level is defined as:

$$L_p = 20 \log \left(\frac{p}{p_o} \right)$$

Where:

- L_p is the sound pressure level in dB
- p is the measured pressure level in Pascal
- p_o is the reference pressure of 20×10^{-6} Pa.

Audible noise is generally reported in dBA where the amplitude of the recorded signal is weighted to emphasise the audible frequencies. For airblast effects, sound pressure levels should be expressed in terms of dB(linear) where the amplitude of the signal is treated equally for all frequencies. This ensures that the energies below 20 Hz are adequately represented in the recorded data. The Australian Standard AS2187.2 describes the basic requirements for correctly measuring airblast.

Factors that influence airblast overpressure

The basic factors that affect the airblast overpressure levels from a mine blast are:

- the quantity of explosive in each blast hole
- the exposure of initiation components (surface detonators or detonating cord)
- the confinement provided to the explosive affecting:
 - the velocity with which the ground surface or bench face moves as a result of the blast and
 - the velocity with which explosion gases might escape from the confinement of the blast bench.

- the interaction between airblast events from different blast holes
- the atmospheric conditions between the blast and the point of observation
- the distance between the blast and the point of observation.

Some disturbance to the air surrounding a blast is inevitable. However, a well controlled blast in which there is minimal ejection of stemming and the orderly displacement of a free face should generate minimal audible or inaudible noise. Controlling airblast overpressure is strongly dependent on avoiding stemming blow-outs, face bursts or cratering. This can be achieved by applying sound design and field implementation standards. Even so, some degree of gas escape is common, and its probability increases with an increase in charge weight.

Blasting in adverse weather conditions is also likely to increase the airblast overpressure experienced from any blast. As no control can be exerted over the atmosphere this means that blasting must be scheduled to avoid poor weather conditions if higher airblast levels are to be avoided.

Predicting airblast overpressure for mine blasts

Measured airblast values are subject to significant statistical scatter. This arises from the many variable factors that govern the generation of an airblast event, its transmission and attenuation as it travels to the point of observation. The most practical approach to dealing with this variability is to routinely monitor blasting operations and to consider the target limits as statistical rather than absolute boundaries.

Sophisticated models of airblast have been developed and applied to the analysis of blast designs to minimise airblast effects. The principal of super-position can be applied to build up a full airblast waveform from a measured waveform from an individual blast hole. However, these sophisticated models cannot account for the variability observed in the transmission of the airblast and the influence of unplanned blasting 'problems'.

A plot of airblast levels in dB(linear) against scaled distance will usually produce a reasonable straight line relationship. It should be noted that this is in fact a log-log plot because the decibel scale is, in itself, logarithmic.

The formula recommended by AS 2187.2 is of the form:

$$P = K_a \left(\frac{R}{Q^{1/3}} \right)^\alpha$$

Where:

- | | |
|----------------|--|
| P | is the sound pressure level in kilopascals |
| R | is the distance from the blast in metres |
| Q | is the maximum instantaneous charge in kilograms |
| K _a | is a site constant |
| α | is a site exponent. |

The distance divided by the cube root of charge weight is called the scaled distance for the analysis of airblast. Figure 5-3 shows a plot of airblast overpressure values against scaled distance for a Queensland open pit coal mine. The plot displays scatter which is typical of the phenomenon.

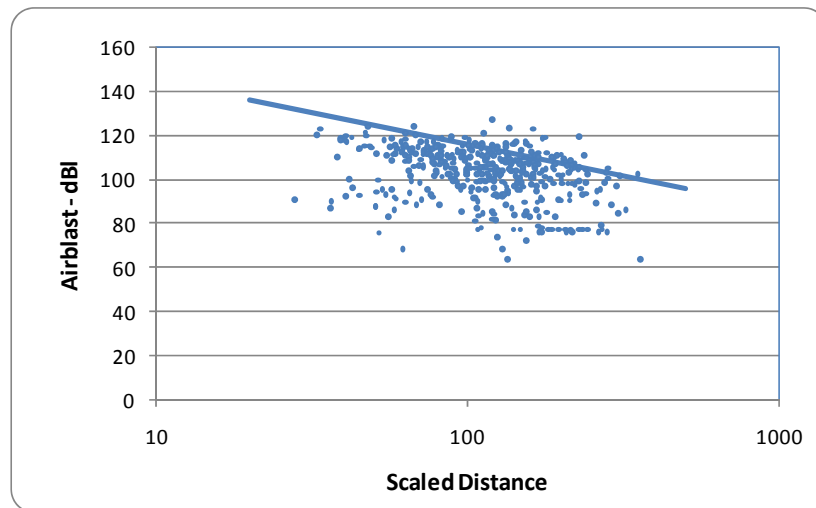


Figure 5-3: Scaled distance plot of airblast overpressure data from a Queensland open pit coal mine

Also shown on Figure 5-3 is the line representing a value for K_a of 10 and a value for α of minus 1.45 in the airblast estimation formula in AS2187.2. These values were derived to represent the 90th percentile of the data in that only 10% of the observations exceed the value predicted by this line. The resulting formula:

$$P = 10 \left(\frac{R}{Q^{1/3}} \right)^{-1.45}$$

has therefore been used in this Study to estimate the distance from a blast where the airblast overpressure can be expected to be 115 dB(linear) or less on 9 out of 10 occasions.

Airblast predictions for Wandoan

Table 5-2 summarises inputs to the estimation of airblast overpressure for a range of Wandoan blast designs. Also shown is the distance at which nine out of 10 blasts should generate no more than 115 dB(linear) and 120 dB(linear).

Table 5-2: Summary of airblast overpressure calculations

Bench Height m	Charge per Hole kg	Holes per Delay	MIC kg	K_a	Alpha	Distance to 115 dBl m	Distance to 120 dBl m
3	10	6	60	10	-1.45	423	284
5	26	6	156	10	-1.45	582	391
7.5	61	5	305	10	-1.45	727	489
10	95	5	475	10	-1.45	843	567
15	295	4	1180	10	-1.45	1142	768
20	422	4	1688	10	-1.45	1287	865
30	1011	4	4044	10	-1.45	1722	1157
40	1455	4	5820	10	-1.45	1944	1307
50	1809	4	7236	10	-1.45	2090	1405

As a guide, these distances can be plotted against bench height to enable a simple estimate of the distance to the limiting airblast overpressure value for a blast in any bench height as

shown on Figure 5-4. The bumps in the curve result from the step changes in assumptions used for different blast designs.

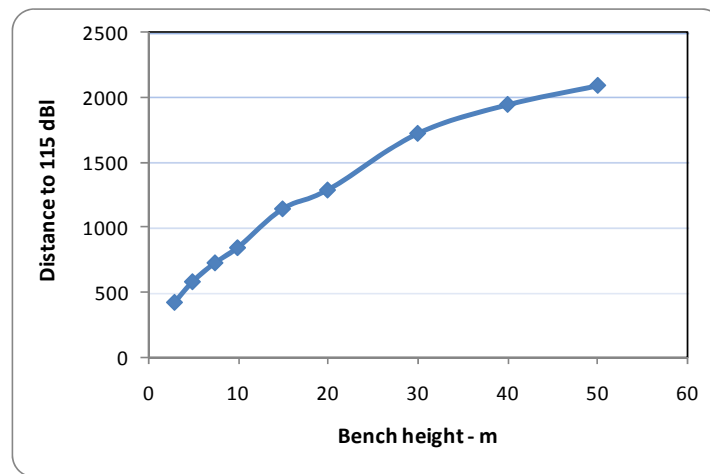


Figure 5-4: Relationship for simple estimation of distance to 115 dBI airblast overpressure

5.1.5 Impacts from Wandoan blasting operations

Summary of analyses

Inspection of Table 5-1 and Table 5-2 show that the distance to the recommended ground vibration limit is about 70% of the distance to the recommended airblast overpressure limit. This means that if the airblast overpressure criteria are satisfied, then the ground vibrations will be safely within the requirements. Figure 5-5 shows a plan of the MLAs for the Wandoan Project and the planned mining areas. Also shown is the boundary around each mining area representing the distance required for the airblast overpressure from blasting to fall to 115 dB(linear).

There are a number of areas where the impacts from blasting are predicted to exceed the recommendations of the EPA Guideline on noise and vibration from blasting. These are discussed in the following sections.

Leichhardt Highway

The Leichhardt Highway has been adopted in this study as the boundary of the township of Wandoan which is regarded as a single sensitive site. Based on the proposed mining plans, the limits for fly rock, ground vibration and airblast overpressure all cross the highway adjacent to the central area of the Frank Creek Pit. Figure 5.5 indicates that the airblast overpressure limit is likely to be exceeded in the western half of the township in Year 5 of the Project.

Telstra communications tower

A Telstra communications tower is located approximately 300 m from the final highwall planned for the Frank Creek Pit. At this distance the tower could be exposed to ground vibrations of approximately 40 mm/s PPV at frequencies between 30 and 100 Hz during the fifth year of the Project.

Abattoir

The abattoir lies within the potential fly-rock zone from blasts undertaken in the final strips of the planned Frank Creek Pit and would be subjected to airblast levels that exceed the EPA Guideline requirements.

Wandoan Cemetery

The Wandoan Cemetery is about 1,200 m from the north end of the Leichhardt Pit and may receive airblast levels between 115 dB(linear) and 120 dB(linear) from the blasting operations in the northern area of this pit. This area is scheduled to be mined during Years 13 to 18 of the Project schedule.

Houses and farm infrastructure

Figure 5-5 identifies a number of houses and farm facilities lying outside the MLAs that may experience airblast overpressures greater than 115 dB(linear). These are summarised on Table 5–3.

Table 5-3: Summary of affected properties

Receptor number	Receptor type	Location	Years affected
MLA-374 and MLA-367	A house and shed complex	Approx 1,000 m north of the Austinvale North Pit	Years 1 and 2
MLA-595 and MLA-596	A house and shed complex	Approx 900 m south west of the Turkey Hill Pit	Years 9 and 10
MLA-355	A house	Approx 1,500 m south of the Mud Creek Pit	Years 26 to 30
MLA-361	A house	Approx 2000 m south of the Mud Creek Pit	Years 26 to 30
MLA-309, MLA-298, MLA-301 and MLA-303	A house and three shed complex	Approx 1,500 m west of the Woleebee Creek Pit	Years 26 to 30
MLA-552 and MLA-551	A house and shed complex	Approx 1,900 m south west of the Woleebee Creek Pit	Years 26 to 30
MLA-531, MLA-541, MLA-548 and MLA-554	Four sheds (feedlot)	Approx 900 m south west of the Woleebee South Pit	Years 26 to 30
MLA-505 and MLA-578	A house and shed complex	Approx 500 m south east of the Woleebee South Pit	Years 26 to 30

Mine Infrastructure Area, powerlines, pipelines, railway and bores

Circumstances will arise within the MLAs and within the Mine Infrastructure Area (MIA) where the Project's facilities will be impacted by the fly rock exclusion zone or subjected to ground vibrations or airblast levels above those recommended by the EPA Guideline for disturbance caused by noise and vibration from blasting. These circumstances can be readily managed by the WJV but this may involve some temporary disruptions to normal production and business activities.

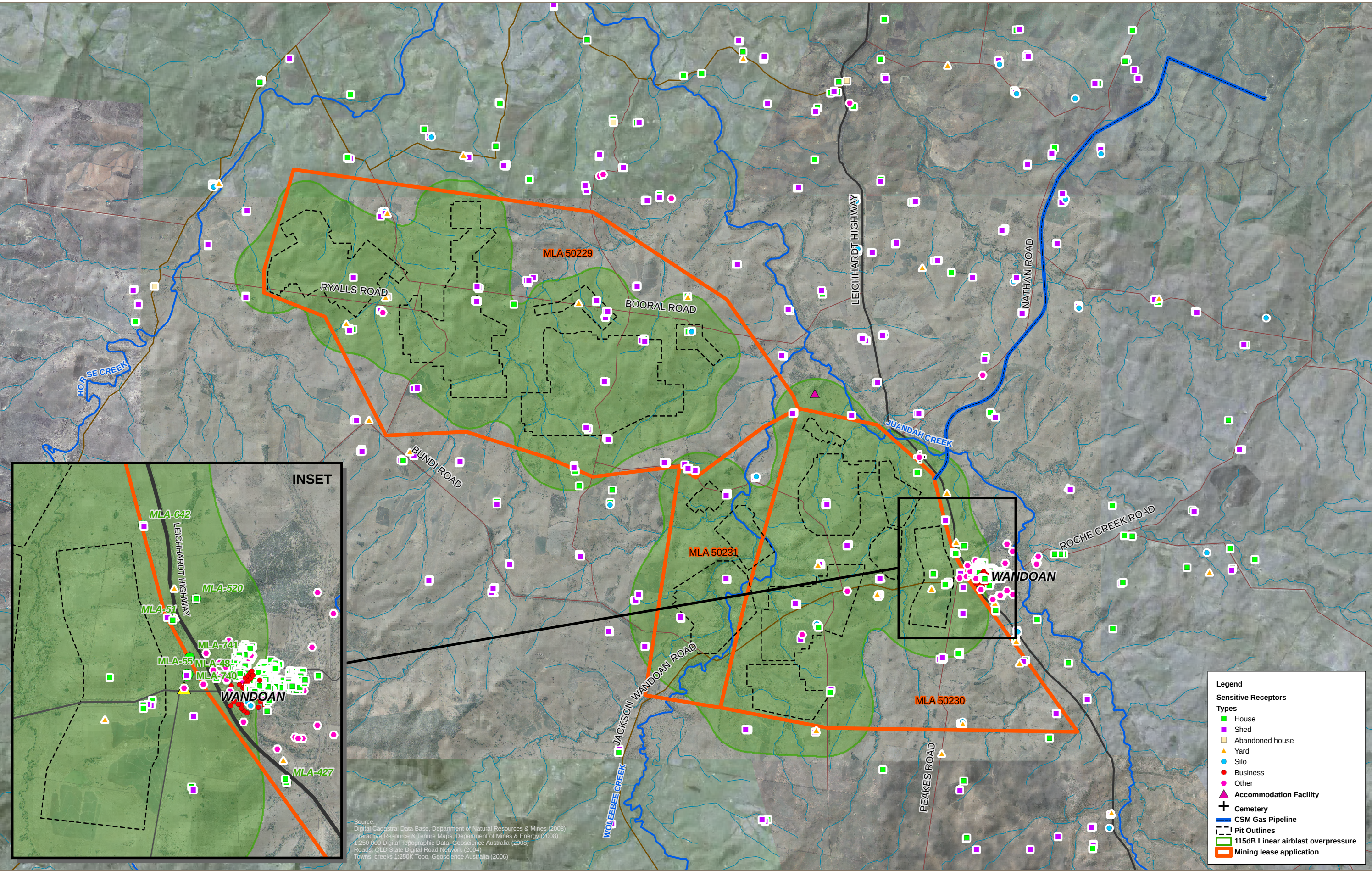
The mine's Blast Management Plan will need to ensure that mine electrical equipment is isolated and checked following near-by blasts and that powerlines, rail facilities and

structures are inspected for fly-rock damage following near-by blasts in keeping with normal industry practice.

The EPA criteria are based on nuisance to persons and not damage to structures or services. Richards and Moore (2002), Siskind et al (1980) and many others have found that physical damage to common structures is highly unlikely for blast vibration levels below 50 mm/s. This is 10 times the EPA Guideline limit for 9 out of 10 mine blasts. Services such as powerlines, pipelines and water bores will not be damaged by mine blasts even though some may be within the distance required to meet the EPA Guideline recommendations to avoid nuisance to persons.

A search of international technical literature has found little reference to damage to groundwater bores from mine or construction blasting. Some structured studies were conducted by the U.S. Bureau of Mines adjacent to coal mines in the Appalachia Mountains in response to public concerns (Berger, P.R. 1980). Their detailed investigations and site test work found no clear evidence of any affect on the stability or performance of water wells or bores, but did identify a number of likely (non-blasting) factors that may have affected well performance. The successful use of dewatering bores in close proximity to many coal and metalliferous mines is a clear indication that they are not particularly vulnerable to damage from near-by blasting.

Loads imposed by vibrations from mine blasts on infrastructure elements such as railway lines, pipelines and power lines are found to be much lower than the loads they experience in normal use and hence pose no threat to their safety or functionality (Siskind, D. et al 1994).



6. Mitigation measures

6.1 Fly rock

The current mine plans include dragline strips in the northern half of the Frank Creek Pit approaching the Leichhardt Highway to a distance of 500 m. The recommended exclusion zone for persons around a mine blast is 600 m and so it will be necessary to terminate blasting at least one strip earlier than planned to avoid any interruption to traffic on the highway.

A house south east of the Woleebee South Pit also lies 500 m from the corner of the pit. This house will be purchased by the WJV.

6.2 Ground vibration

The distance to the point where the ground vibration from a blast meets the EPA Guideline recommendations always lies inside the distance required to meet the airblast overpressure requirements. This mitigation measures needed to meet these recommendations for all sensitive sites has therefore been focussed on meeting the airblast criteria (Section 6.3) as this means that the ground vibration requirements will be readily achieved.

6.3 Airblast overpressure

6.3.1 Township of Wandoan

The mining operation originally planned for the Frank Creek Pit will impose unacceptable ground vibrations and airblast overpressures on the western half of the township of Wandoan. The original plan involved the use of a dragline to excavate the overburden to the first coal horizon in a single pass. This involves blasting overburden thicknesses of up to 26 m. Conventional blasting practices for this depth of overburden would involve large diameter blast holes and correspondingly high values for the maximum instantaneous charge.

The airblast overpressure experienced at the Leichhardt Highway from blasting in Frank Creek can be reduced to the levels required by the EPA Guideline on noise and vibration from blasting. This can be achieved by reducing the bench height and hence blast hole diameter and the maximum instantaneous charge. However, introducing multiple benches prevents the use of a dragline in this part of the pit, necessitating the use of truck and excavator or shovel mining methods.

It is recommended therefore that the mine plan in the Frank Creek Pit will be modified to use truck and excavator or shovel mining methods for the north eastern quarter of the pit. This may involve working benches as low as 7.5 m in height using 127 mm diameter blast holes. Adopting this mining method will reduce the distance to the point where the airblast overpressure will be below 115 dB (linear) back inside the Leichhardt Highway alignment. The PPV values generated at the Highway will also be below the limit of 5 mm/s.

Properties within the town closest to the Frank Creek operations will be identified by the WJV and condition surveys of these houses and associated structures will be undertaken subject to agreement with the landowners prior to them being affected by the operations.

Mining is scheduled to be undertaken in this area in Years 4 and 5 of the Project. These changes to the mining method will marginally increase the cost of mining from this area and will increase the length of time that the operation will remain relatively close to the town.

6.3.2 Wandoan Cemetery

Analyses indicate that the cemetery may experience some airblast overpressure values between 115 dB (linear) and 120 dB (linear) from blasts in the northern part of the Leichhardt Pit. This area is scheduled to be mined in Years 13 to 18 of the Project. The WJV proposes to monitor airblast and vibration levels closely as operations approach this area and manage the blasting operations to ensure that the airblast overpressure and ground vibration levels do not exceed the allowable limits.

The airblast and vibration limits in the EPA Guideline on Noise and Vibration from Blasting are based on avoiding nuisance to persons and are well below the levels of disturbance required to cause physical damage. The WJV will undertake a condition survey of the cemetery structures and monitor any changes that might be identified. They will also liaise with the managers of the cemetery to ensure that nearby blasts will not cause a nuisance to those visiting the cemetery. Feedback will be sought from the Community Reference Group with regard to any issues that arise.

6.3.3 Telstra communications tower

The reduced bench height required to limit the airblast overpressure in the township will significantly reduce the vibration levels experienced by the Telstra communications tower while mining in the eastern part of the Frank Creek Pit. The PPV at the base of the tower should reduce to approximately 10 mm/s with frequencies likely to remain above 15 Hz. Nevertheless, discussions with Telstra will be undertaken to determine whether the tower will be affected by the blasting operations and what mitigation or protection measures are required.

6.3.4 Abattoir

The abattoir lies within the zone between the Frank Creek pit and the Wandoan township. The WJV will consult with the owner of the abattoir (MLA-740 and MLA-741) with a view to reaching agreement on appropriate mitigation arrangements prior to the commencement of mining within the Frank Creek Pit.

6.3.5 Farm houses and farm structures

The owners of the eight farm houses and their associated buildings identified in Section 5.1.5 as being potentially subjected to airblast overpressures above the EPA Guideline recommendations are to be consulted by the Wandoan Joint Venture with a view to reaching agreement on appropriate mitigation arrangements prior to being impacted by the mining operation. Specifically:

- consult with the owner of the of the house (MLA-374) and shed (MLA-367) located approximately 1,000 m north of the Austinvale North Pit with a view to reaching agreement on appropriate mitigation arrangements

- reassess the potential impacts from blasting on the house (MLA-595) and shed complex (MLA-596) approximately 900 m south west of the Turkey Hill Pit based on operational experience prior to mining approaching the property (expected to be in Year 9 of the Project)
- consult with the owner of the of the houses 1,500 m (MLA-355) and 2,000 m (MLA-361) south of the Mud Creek Pit with a view to reaching agreement on appropriate mitigation arrangements prior to mining commencing in this area (expected to be during the final years of the Project)
- the house 1,500 m west of the Woleebee Creek Pit (MLA-309) has been purchased by the WJV and negotiations have commenced with the owners of the house 1,900 m south west of the pit (MLA-552) with a view to reaching agreement on appropriate mitigation arrangements prior to them being affected by the operations (expected to be prior to mining approaching the area in Years 28 to 30 of the Project)
- reassess the potential impacts of blasting on the feed-lot 900 m south west (MLA-531) and 500 m south east (MLA-505) of the Woleebee South Pit prior to mining approaching the properties (expected to be in Years 28 to 30 of the Project).

6.3.6 Mine Infrastructure, powerlines, pipelines, railway and bores

As discussed in Section 5.1.5 there will be times when mine infrastructure and services within the MLAs will be inconvenienced by near-by blasting operations. These impacts will be effectively managed through the mine's operating protocols and Blast Management Plan. Similar services outside the MLAs should not be at risk of damage from the mine's blasting operations.

6.4 General operating procedures and monitoring

Managing the blast environmental outcomes to the required levels will require a high standard of both design and field implementation. The WJV will routinely monitor and report on the environmental performance of their blasting operations. The locations and techniques selected for routine monitoring should comply with the requirements of AS 2187.2 but should include:

- a fixed monitoring location on the western side of the township
- a fixed monitoring location at the mine office or other major facility
- a fixed monitoring station at the town cemetery
- relocatable monitors placed adjacent to sensitive sites for the period that they may be affected by near-by mining operations.

Relocatable monitors would be placed adjacent to the Telstra communications tower and MLA-374 (a house north of the Austinvale North Pit) in the early years of mine operation. They would later be relocated to other potentially sensitive receptors as mining developed in their vicinity.

These monitors should be self-triggering and be capable of accumulating data for at least a week. The vibration and airblast results for each blast should be included in the blast performance report as a matter of routine. The data should be used to develop local predictive models of these impacts so that blast designs can be tuned to minimise disturbance and improve production performance. The monitoring program, data analysis,

reporting and modelling will form an integral part of the Blast Management Plan recommended under Australian Standard 2187.2. The Blast Management Plan will require procedures that will avoid blasting in unfavourable weather conditions such as during heavy cloud or rain, adverse winds or during temperature inversions. This plan will be developed as an integral part of the standard mine operating procedures prior to the commencement of mining operations.

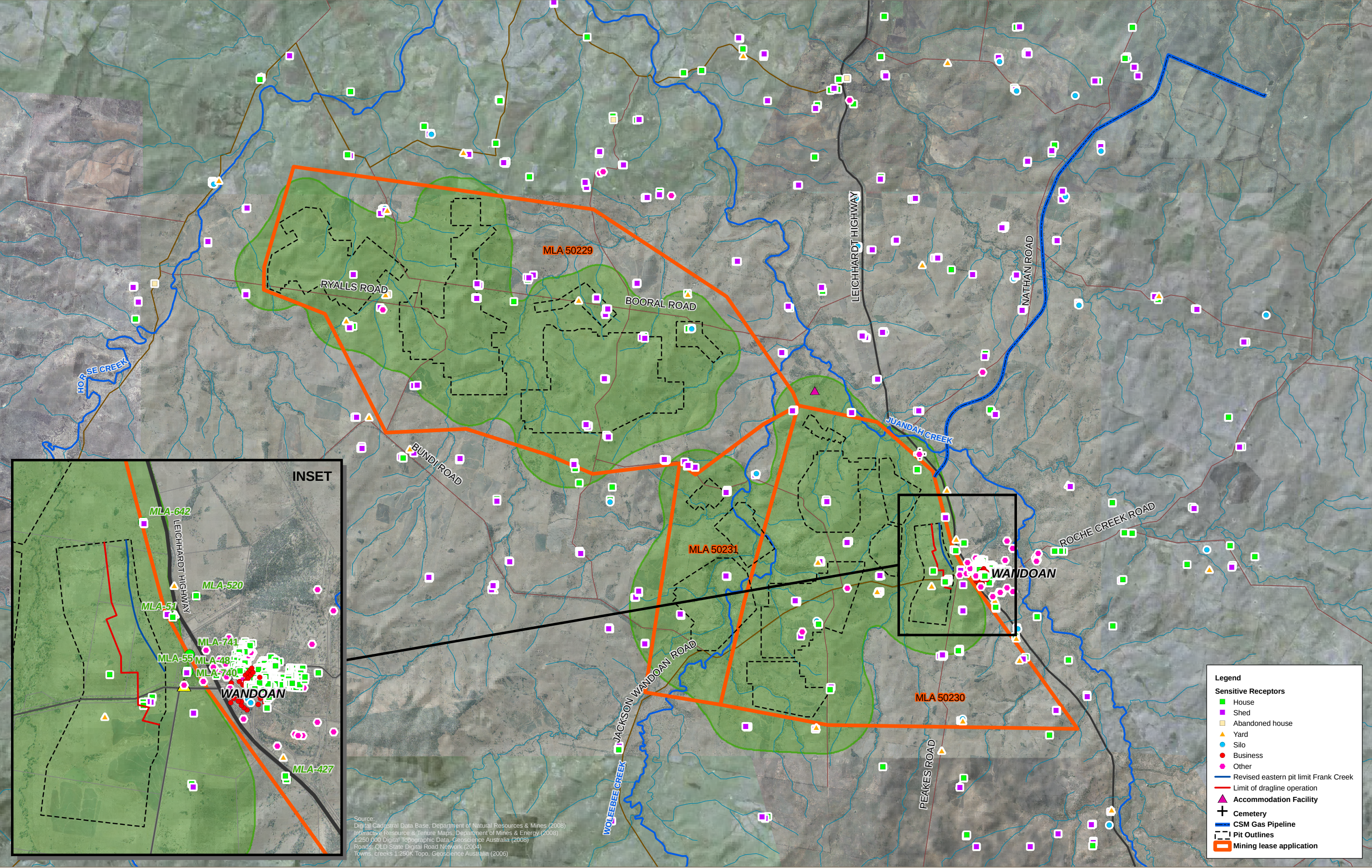
This approach should ensure that the impact of the blasting operations will be within the EPA Guideline limits for ground vibration and airblast for the sensitive receptors adjacent to the Project.

7. Residual impacts

The mitigating measures described in Section 6 will eliminate any fly-rock hazard at the Leichhardt Highway from operations in the Frank Creek Pit. These measures will also reduce the ground vibration and airblast overpressure levels experienced by each sensitive receptor outside the MLAs to within the EPA Guideline recommendations. The distance to the 115 dB (linear) airblast level resulting from these measures is shown on Figure 7-1. The Wandoan township lies outside the affected area.

The distance to the limiting ground vibration level of 5 mm/s lies approximately 70% of the critical distance required to manage the airblast effects. The ground vibration levels experienced by any sensitive receptor will therefore meet the EPA Guideline requirements.

On this basis the blasting operations at Wandoan should meet all of the required environmental targets.



8. Conclusions

The Wandoan Coal Project involves the development of a series of open pit coal operations coordinated to produce approximately 30 Mt of saleable coal over a 30 year mine life. The mining areas are contained within three MLAs to the west of the township of Wandoan.

The coal is to be mined from a number of seam groups and involves the removal of quite modest thicknesses of overburden, especially in the early years. Most overburden and interburdens will be excavated by draglines at quite high rates.

The overburdens and interburdens consist of mudstones and siltstones of quite modest strength. Geotechnical investigations to date indicate that the predominant structure is bedding with jointing relatively widely spaced. These properties indicate that powder factors between 0.3 kg/bcm and 0.4 kg/bcm should be sufficient to generate suitable muckpiles for the draglines. The range of depth of the horizons to be blasted will require the use of a range of drill hole diameters. Pit conditions are expected to be predominantly dry with some areas potentially affected by water fed from adjacent alluvial beds. Analyses undertaken for this study have been based on the use of ANFO for all blast designs.

An exclusion zone of 600 m is recommended during all blasting operations to avoid the risk of damage from fly rock. Original designs for the Frank Creek Pit approach were within up to 500 m of the Leichhardt Highway and it will be necessary to revise the design of the final pit highwall to remain 600 m from the Highway.

Dragline operating methods require the full thickness of the bench to be blasted in one operation. Overburden blasts designed in this way in the north eastern quarter of the Frank Creek Pit would generate excessive ground vibration and airblast overpressure in parts of the township of Wandoan. This can be prevented by adopting a truck and excavator or shovel mining method in this area and reducing the bench height to 10 m or less. Similarly, operations in the north east of the Leichhardt Pit near the cemetery could impose airblast levels approaching the EPA Guideline recommendations, but this can be managed using actual measured data to guide operations in this area.

Eight farm houses and their associated structures have been identified as potentially being exposed to airblast overpressure levels above the EPA Guideline recommendations. Consultation will be undertaken with the owners of these properties with a view to reaching agreement on appropriate mitigation arrangements prior to them being affected by the operations. Discussions will be required with Telstra to determine the impact of ground vibrations on a regional communications tower between the Frank Creek Pit and the Wandoan township.

Some of the Wandoan Joint Venture's infrastructure and facilities will be inconvenienced by their blasting operations but these impacts should be readily managed by the required Blast Management Plan. No services such as power lines, pipe lines, groundwater bores roads or railways outside the MLAs have been identified as being in any danger of damage from the Project's blasting operations.

A high standard of design and implementation will be required for the Project's blasting operations. This is required to both meet the production efficiencies required for the mining operations and the impact on the surrounding environment. Routine monitoring of

environmental performance will be undertaken to enable the Wandoan Joint Venture to manage these outcomes to ensure that they meet the EPA Guideline limits.

9. Summary of mitigation strategies

Recommended mitigation strategies to manage the potential impacts of the Project caused by blasting operations, as previously detailed in this assessment, are summarised below:

- the Eastern limit of the Frank Creek Pit must be no closer than 600 m from the Leichhardt Highway so that an effective fly-rock exclusion zone can be maintained west of the highway
- operations in the north east quarter of the Frank Creek Pit will need to be undertaken using truck and shovel techniques and reduced bench heights to limit the ground vibration and airblast overpressure to the EPA Guideline recommendations at the Leichhardt Highway and hence the Wandoan township
- consult with the owner of the abattoir (MLA-740 and MLA-741) with a view to reaching agreement on appropriate mitigation arrangements prior to the commencement of mining within Frank Creek Pit
- discussions need to be held with Telstra to determine the mitigation or management methods required to ensure that blast vibrations will not adversely affect the Telstra communications tower west of the Wandoan township
- operations in the north eastern corner of the Leichhardt Pit need to be managed using local monitoring data to ensure that blasting impacts do not exceed the EPA Guidelines at the cemetery
- consult with the owners of eight farm houses and associated buildings potentially affected by excessive airblast levels from near-by blasting with a view to reaching agreement on appropriate mitigation arrangements prior to them being affected by the operations.
- operations will need to be engineered and implemented to a high standard and routinely monitored so that local site based design rules can be used to guide the design and implementation of blasting operations near sensitive receptors.

10. References

Australian Standard 2187.2 – 2006, *Explosives — Storage and Use, Part 2: Use of explosives*, Standards Australia

Barrett, S, Morphet, R, 2008, *Geotechnical Evaluation for Open Pit Mining – Wandoan Coal Project, Wandoan, Queensland*, Golder Associates

Berger, P.R., 1980, Survey of blasting effects on ground water supplies in Appalachia, United States Department of Interior, Bureau of Mines, Philip R. Berger & Associates

Environmental Protection Agency (EPA) 2006, *Guideline Noise and vibration from blasting*, Queensland Government, Brisbane.

Richards, A.B., Moore, A.J., 2002, *Structure Response to Blast Vibration*, Australian Coal Association Research Program Project C9040, Terrock Consulting Engineers

Siskind, D.E., Stag, M.S., Kopp, J.W., Dowding, C.H., 1980, *Structure response and damage produced by ground vibrations from surface blasting*, USBM RI 8507

Siskind, D.E., Stochura, V.J., Stag, M.S., Kopp, J.W., 1980, *Structure response and damage produced by airblast from surface blasting*, USBM RI 8485

Siskind, D. et al., 1994, *Surface mine blasting near pressurised transmission pipelines*, US Bureau of Mines Report of Investigation.