Section 8

NOISE AND VIBRATION

8. Noise and Vibration

The purpose of this Section is to assess potential noise and vibration impacts from construction and operation of the Project on surrounding sensitive receivers and develop appropriate mitigation measures.

8.1 Methodology

In establishing construction and operational noise level goals the following legislation and guidelines have been considered:

- *Environmental Protection Act* 1994;
- *Environmental Protection (Noise) Policy* 1997;
- *Environmental Protection Regulation* 1998;
- EPA *Noise Measurement Manual* (2000)
- EPA Ecoaccess Guideline: Planning for Noise Control Guideline (EPA, 2004);
- EPA Ecoaccess Guideline: Noise and Vibration from Blasting (March 2006); and
- EPA Ecoaccess Draft Guideline: Noise – Assessment of Low-Frequency Noise
- Queensland Rail Code of Practice – Rail noise management (2007)

Terms and general explanation of noise and vibration are contained in the Appendix O - Glossary.

8.1.1 Sensitive Receiver Locations

In this assessment the definition of a noise-sensitive receiver has been adopted from the definitions given in the EPP(Noise) Policy1997 and the Terms of Reference for the Project, including:

- Any places of work, recreation or worship;
- Dwelling units (comprises houses, duplexes, multiple dwellings, accommodation units, relatives apartments, retirement villages, motels, aged care accommodation, hostels, and so on);
- Child care centres;
- Schools;
- Libraries;
- Kindergartens;
- Colleges, universities or other educational institutions; and
- Hospitals surgeries, or other medical institutions.

As described in Section 7, a total of 55 sensitive receivers were identified within 2 km of the preferred alignment, and are shown in Map 24 – Sensitve Receivers Noise and Vibration in the Map Folio. Receivers were not separately identified for Wandoan township, although they are presented in Map 25 – Noise Level Contours Wandoan L_{eq} and Map 26 – Noise Level Contours Wandoan L_{max} in the Map Folio for the Wandoan township (refer to Section 8.5.4).

8.1.2 *Measurement Locations*

Ambient noise levels were measured at four locations over a seven day period commencing Monday 19 May 2008, as shown in Map 24 – Sensitve Receivers Noise and Vibration in the Map Folio. Given the extensive length of the Project the noise loggers were spread out along the study area with the intention of measuring noise levels of the differing environments.

The following is a description of each monitoring location and dominant noise sources:

- Location A: The noise logger was placed within a road reserve in an open paddock on a property approximately 2 km from Banana. Potential noise sources at this location included the nearby traffic (Barfield Road and rail), wind, grass and insect noise;
- Location B: The logger was placed in an open paddock of a property approximately 30 km south of Banana. Potential noise sources at this location included farming equipment, wind, Leichhardt Highway (approximately 500 m away), grass and insect noise;
- Location C: The logger was placed in an open paddock of a property approximately 130 km south of Banana. Potential noise sources at this location included farming equipment, wind, grass and insect noise; and
- Location D: The logger was placed in the vicinity of buildings at the bowls club in Wandoan. Potential noise sources at this location included local road traffic, Leichhardt Highway traffic, human noise from related activities at the club, wind, grass and insect noise.

The selected noise monitoring locations were considered to be representative of the typical ambient noise environment throughout the study area.

The noise sensitive receivers that were considered to be approximately represented by the noise monitoring undertaken at these locations are shown in Table 8-1.

The locations of these sensitive receivers and noise monitoring locations are shown in Map 24 – Sensitive Receivers Noise and Vibration in the Map Folio.

Table 8-1: Noise Monitoring Locations Approximately Representing Noise Sensitive Receivers

Location	Noise Sensitive Receivers
Location A	1 to 8
Location B	9 to 16
Location C	17 to 51
Location D	52 to 55

8.1.3 *Instrumentation*

Unattended noise monitoring was undertaken using four environmental noise loggers, all under current calibration. The monitoring locations, make, model and serial numbers are shown in Table 8-2.

Table 8-2: Unattended Noise Monitoring Instrumentation – Locations

Location	Make/Model	Serial Number
Location A	ARL EL315	15-299-424
Location B	ARL EL315	15-299-433
Location C	ARL EL315	15-004-045
Location D	ARL EL215	194651

A Norsonic 132 Type 1 precision sound level meter (serial #132-2812), under current calibration, was used during attended monitoring for the purpose of calibrating the noise model and validating the unattended noise monitoring data.

All noise logging instruments were set to measure 'A-weighted' sound pressure levels with 'fast' weighted time response, and measurement interval of 15 minutes. The ARL EL-315 and EL-215 noise loggers typically have a noise floor of 25 dB(A) and 28 dB(A) respectively.

Measurement of the existing noise environment was undertaken in general accordance with Australian Standard AS 1055-1997 *Description and Measurement of Environmental Noise* and the Queensland EPA *Noise Measurement Manual* (EPA, 2000).

Monitoring results were analysed for the day, evening and night periods. The planning for noise control definition of day, evening and night is as follows:

- Day 7:00 pm – 6:00 pm
- Evening 6:00 pm – 10:00 pm
- Night 10:00 pm – 7:00 am

All instruments were used to monitor L_{Amax}, L_{Amin}, L_{Aeq} L_{A10} and L_{A90} statistics over a 15 minute measurement period, with a fast time constant and A-weighting.

8.1.4 Rail Noise Modelling

Rail noise impacts from the Project have been predicted with the propriety noise modelling software SoundPlan version 6.5 using the Kilde 130 Nordic method. The Kilde 130 method is the standard rail noise modelling method to be used for rail noise modelling in Queensland, as used by QR Ltd. Modelled noise levels have taken into account the noise attenuation associated with topography and rail formation. Assumptions adopted for the modelling are set out in Section 8.5.3.

8.2 Ambient Noise and Vibration

Background levels of noise recorded for the study area are summarised in Table 8-3, with graphs of results for each location shown in Appendix J. As the Project is located in a rural area, the main source of ambient noise is from traffic on local roads, the Leichhardt Highway and farming machinery. Wildlife, including insects, birds and animals will also be a contributor to background noise. There were no major vibration sources noted during the site visits carried out in the study area.

Table 8-3: Noise Monitoring Results – All Locations

Location	Period	RBL1 LA90, 15 min (dB(A))	Average LA10, 15 min (dB(A))	Average LAeq, 15 min (dB(A))
Location A	Day	25.7	38.0	38.6
	Evening	24.5	36.0	34.5
	Night	23.5	32.8	31.2
Location B	Day	27.2	45.6	43.9
	Evening	31.6	43.8	42.4
	Night	23.6	34.0	35.4
Location C	Day	28.3	42.3	45.6
	Evening	27.2	34.8	33.9
	Night	26.6	29.2	29.2
Location D	Day	32.1	45.4	44.0
	Evening	31.9	43.6	41.8
	Night	26.8	39.4	36.9

Note: Rating background noise level (RBL) is defined in the EPA Guideline: *Planning for noise control*.

8.3 Construction Noise Assessment

8.3.1 Construction Noise Criteria

At present there are no legislative requirements regarding the emission of construction noise in Queensland. However, guidance may be sought from the following documents:

- *Environmental Protection (Noise) Policy* 1997;
- *Environmental Protection Regulations* 1998;
- *ASNZ 2107:2000 Acoustics – Recommended Design Sound Levels and Reverberation Times for Building Interiors;* and
- *Queensland Rail Code of Practice – Railway Noise Management (2007).*

Environmental Protection (Noise) Policy 1997

The environmental values to be enhanced or protected under this EPP (Noise) are the qualities of the acoustic environment that are conducive to:

- The wellbeing of the community or a part of the community, including its social and economic amenity; and
- The wellbeing of an individual, including the individual's opportunity to have sleep, relaxation and conversation without unreasonable interference from intrusive noise.

Section 11 of the Policy also provides a numerical value to determine an acoustic quality objective as follows:

- The "acoustic quality objective" is the objective of achieving an ambient level of LAeq 55 dB(A) or less for most of Queensland's population living in residential areas;

- It is intended that the acoustic quality objective be achieved as part of progressively achieving the object of this policy over the long term; and
- It is not intended that, in achieving the acoustic quality objective, any part of the existing acoustic environment be allowed to significantly deteriorate.

For the acoustic quality objective the ambient level in a residential area is measured over 24 hours as the L_{Aeq} outside a dwelling in the area.

For general traffic travelling to and from site on public roads (excluding haul traffic which will be addressed in Section 8.5) noise impacts from the road should not exceed 63 dB(A) $L_{10(18hour)}$.

Environmental Protection Regulation 1998

The EP Act and EPP (Noise) provide a guide to the control of noise emissions from activities. Further to this, the *Environmental Protection Regulation 1998* categorises noise offences for construction activities (Division 4, Subdivision 1 under Offences, 6W Building work) as follows:

A builder or building contractor must not carry out building work on a building site in a way that makes or causes audible noise to be made from the building work:

- On a Sunday or public holiday, at any time, or
- On a Saturday or business day, before 6:30 am or after 6:30 pm.

AS/NZS 2107:2000

The standard AS/NZS2107 provides recommended internal noise levels within various buildings including residential, schools and health facilities. The recommended levels for typical rooms are presented (in part) in Table 8-4. The standard does not present recommended internal day-time noise levels for residential buildings substantially separated from roads. The majority of the alignment is located away from minor roads, therefore this standard may not be appropriate for assessing the noise impacts from construction.

Table 8-4: AS/NZS2107 Internal Noise Levels

Building Type	Room	Internal Noise Level L_{eq} dB(A)	
		Satisfactory	Maximum
Residential – near minor roads	Living	30	40
	Sleeping	30	35
Residential – near major roads	Living	35	45
	Sleeping	30	40
Health	Consulting rooms	40	45
	Lobby	40	50
Education	Teaching spaces	35	45
	Office areas	40	45

For residential buildings, living areas can be assumed to be day-time criteria, while sleeping areas can be assumed as night-time criteria.

As these are recommended internal noise levels they need to be transformed into external noise limits. This is achieved by the addition of the noise reduction due to the building façade to the internal noise level. *Planning for Noise Control* (EPA, 2004) states that a partially open window can achieve a 10 dB(A) noise reduction from outside to inside. Therefore, an external limit will be 10 dB(A) higher than the internal limit e.g. a residence near a minor road would have an external limit of 50 dB(A) L_{eq} for the living room (day-time) and 45 dB(A) L_{eq} for a bedroom (night-time). Table 8-5 presents the external noise levels.

Table 8-5: AS/NZS 2107 External Noise Criteria

Building Type	Room	Internal Maximum Noise Level L_{eq} dB(A)	External Noise Level L_{eq} dB(A)
Residential – near minor roads	Living	40	50
	Sleeping	35	45
Residential – near major roads	Living	45	55
	Sleeping	40	50
Health	Consulting rooms	45	55
	Lobby	50	60
Education	Teaching spaces	45	55
	Office areas	45	55

Summary of Applicable Noise Criteria

Table 8-6 presents the applicable permitted hours of construction.

Table 8-6: Summary of Permitted Construction Hours

Source	Details
EPP (Noise)	No time restrictions discussed
EPR 1998	6:30 am and 6:30 pm Monday to Saturday with no audible works on Sunday or public holidays
AS/NZS2107	No time restrictions discussed, however, criteria change

Table 8-7 presents the adopted external noise criteria at various types of buildings from construction related noise. It is worth noting that if any works are conducted sufficiently far from receivers then they will be inaudible. If the works are inaudible, then the time restrictions do not apply.

Table 8-7: AS/NZS2107 External Noise Levels

Building Type	Room	External Noise Level L_{eq} dB(A)
Residential – near minor roads	Living	50
	Sleeping	45
Residential – near major roads	Living	55
	Sleeping	50
Health	Consulting rooms	55
	Lobby	60

Building Type	Room	External Noise Level L_{eq} dB(A)
Education	Teaching spaces	55
	Office areas	55

For residential buildings, living areas can be assumed to be day-time criteria, while sleeping areas can be assumed as night-time criteria.

8.3.2 Construction Noise Sources

At this stage, only preliminary information is available regarding anticipated fleet numbers and types of vehicles to be used for the clearing, earth works, track laying, etc. Based on the information available, several situations have been modelled to provide an indication of potential noise impacts from these activities. Several distinct construction activities have been investigated, these are as follows:

- Earthworks (clear and grub, foundations, cut/fill);
- Drainage works (culverts including upstream downstream protection);
- Structures (foundations, abutments, piers, headstock, deck units);
- Pavements (capping layer, road reconstruction/diversions); and
- Track works.

The assumed equipment sound power levels and vibration levels used in the construction noise and vibration assessment are shown in Table 8-8.

Table 8-8: Typical Construction Equipment Sound Power Levels

Plant Item	Sound Power Level (at Source) dB(A) re 1pW
Dump truck	114
Road truck	108
Excavator	116
Backhoe	116
Trencher	107
Bulldozer	120
Scraper	118
Grader	116
Water cart	105
Compactor	120
Roller	112
Concrete paver	114
Rock breaker	120
Jackhammer	114

Plant Item	Sound Power Level (at Source) dB(A) re 1pW
Rock drill	124
Ballast tamper machine	111
Pile driver (impact)	133
Concrete pump	114

The sound power levels are sourced from the following references:

- AS/NZS2436 – 1981 *Guide to Noise Control on Construction, Maintenance and Demolition Sites*;
- *Transit Noise and Vibration Impact Assessment* FTA-VA-90-1003-06, Federal Transit Administration, Department of Transportation USA, May 2006;
- Vibrations from Blasting, David Siskind; 1st edition, ISEE, 2005; and
- Information from past projects and information held in library files.

It can also be assumed that there will be some noise contribution from vehicles using access routes for the transport of materials, equipment and workforce personnel.

8.3.3 Construction Noise Impacts

At this stage of the Project, limited information is available regarding the specific composition of potential construction fleets.

Other noise sources associated with construction of the rail line such as concrete batching plant(s) and construction camps will be assessed for their proximity to noise sensitive receivers once their location is confirmed as part of the detailed design stage. Should potential impacts on noise sensitive receivers be apparent, site-specific noise impact assessments and noise management programs will be undertaken as appropriate.

To provide an assessment of the potential noise impacts from construction activities to sensitive locations, several situations have been modelled giving potential noise impacts at various distances. The equipment used in each of the cases has been assumed, actual details may vary as the engineering design construction methodology is refined.

As outlined in Section 8.3.2 the minimum external criterion for day-time construction activities adopted for this Project is 50 dB(A) L_{eq}.

Earthworks

The following scenario assumes that a bulldozer and a grader are working in close proximity to each other. Table 8-9 presents the predicted noise levels at various distances.

Table 8-9: Predicted Noise Levels – Earthworks

	Receiver Distance (m)						
	100	200	400	600	800	1,000	2,000
Bulldozer SWL dB(A)	120	120	120	120	120	120	120
Grader SWL dB(A)	116	116	116	116	116	116	116

	Receiver Distance (m)						
	100	**200**	**400**	**600**	**800**	**1,000**	**2,000**
Total SWL dB(A)	121	121	121	121	121	121	121
Geometric spreading attenuation dB	-48	-54	-60	-64	-66	-68	-74
Ground effects dB[2]	-2.6	0.5	5.2	7.9	9.6	10.9	14
Atmospheric attenuation dB[3]	0.1	0.2	0.4	0.6	0.8	1	2.1
Predicted Noise level at Receiver dB(A)	**76**	**67**	**56**	**49**	**45**	**42**	**31**

Drainage

The following scenario assumes that a scraper and an excavator are working in close proximity to each other. Table 8-10 presents the predicted noise levels at various distances.

Table 8-10: Predicted Noise Levels – Drainage

	Receiver Distance (m)						
	100	**200**	**400**	**600**	**800**	**1,000**	**2,000**
Scraper SWL dB(A)	118	118	118	118	118	118	118
Excavator SWL dB(A)	116	116	116	116	116	116	116
Total SWL dB(A)	120	120	120	120	120	120	120
Geometric spreading attenuation dB	-48	-54	-60	-64	-66	-68	-74
Ground effects dB[3]	-2.6	0.5	5.2	7.9	9.6	10.9	14
Atmospheric attenuation dB[3]	0.1	0.2	0.4	0.6	0.8	1	2.1
Predicted Noise level at Receiver dB(A)	**75**	**65**	**55**	**48**	**44**	**40**	**30**

Structures

The following scenario assumes that an impact pile driver and a concrete pump are working in close proximity to each other. Table 8-11 presents the predicted noise levels at various distances.

Table 8-11: Predicted Noise Levels – Structures

	Receiver Distance (m)						
	600	**800**	**1,000**	**1,200**	**1,400**	**1,500**	**2,000**
Pile driver SWL dB(A)	133	133	133	133	133	133	133

[2] Ground effects and atmospheric attenuation are based on CONCAWE attenuations at 250Hz

	Receiver Distance (m)						
	600	**800**	**1,000**	**1,200**	**1,400**	**1,500**	**2,000**
Concrete pump SWL dB(A)	114	114	114	114	114	114	114
Total SWL dB(A)	133	133	133	133	133	133	133
Geometric spreading attenuation dB	-64	-66	-68	-70	-71	-72	-74
Ground effects dB[3]	7.9	9.6	10.9	11.8	12.5	12.8	14
Atmospheric attenuation dB[3]	0.6	0.8	1	1.3	1.5	1.6	2.1
Predicted Noise level at Receiver dB(A)	**61**	**57**	**53**	**50**	**48**	**47**	**43**

Pavements

The following scenario assumes that a grader, a water truck and a flat drum roller are working in close proximity to each other. Table 8-12 presents the predicted noise levels at various distances.

Table 8-12: Predicted Noise Levels – Pavements

	Receiver Distance (m)						
	100	**200**	**400**	**600**	**800**	**1,000**	**2,000**
Grader SWL dB(A)	116	116	116	116	116	116	116
Water truck SWL dB(A)	114	114	114	114	114	114	114
Roller SWL dB(A)	112	112	112	112	112	112	112
Total SWL dB(A)	119	119	119	119	119	119	119
Geometric spreading attenuation dB	-48	-54	-60	-64	-66	-68	-74
Ground effects dB[3]	-2.6	0.5	5.2	7.9	9.6	10.9	14
Atmospheric attenuation dB[3]	0.1	0.2	0.4	0.6	0.8	1	2.1
Predicted Noise level at Receiver dB(A)	**74**	**64**	**53**	**47**	**43**	**39**	**29**

Trackworks

The following scenario assumes the operation of a grader, ballast tamping machine and a dump truck are working in close proximity to each other. Table 8-13 presents the predicted noise levels at various distances.

Table 8-13: Predicted Noise Levels – Trackworks

	Receiver Distance (m)						
	100	**200**	**400**	**600**	**800**	**1,000**	**2,000**
Grader SWL dB(A)	116	116	116	116	116	116	116
Ballast tamper SWL dB(A)	111	111	111	111	111	111	111
Dump truck SWL dB(A)	114	114	114	114	114	114	114
Total SWL dB(A)	119	119	119	119	119	119	119
Geometric spreading attenuation dB	-48	-54	-60	-64	-66	-68	-74
Ground effects dB[3]	-2.6	0.5	5.2	7.9	9.6	10.9	14
Atmospheric attenuation dB[3]	0.1	0.2	0.4	0.6	0.8	1	2.1
Predicted Noise level at Receiver dB(A)	**74**	**64**	**53**	**47**	**43**	**39**	**29**

The previous scenarios presented in Table 8-9, Table 8-10, Table 8-12 and Table 8-13, indicate that the noise limit of 50 dB(A) L_{eq} is generally predicted to be achieved at 600 m from the activity in all cases. The situation presented in Table 8-11 includes the use of a pile driver which has a significantly larger sound power level then the other equipment modelled results in a greater radius at which the noise limit is achieved. Activities involving a pile driver should not be conducted within 1,200 m of sensitive receivers without appropriate mitigation.

8.3.4 Construction Noise Mitigation

Construction Noise Control Strategies

The following noise mitigation measures are recommended to reduce potential construction noise impacts at sensitive receivers surrounding the Project. Where any construction activity is located a large distance from a sensitive receiver, the noise levels are likely to be lower than the criteria. Where this is the case, no noise mitigation measures will be required.

AS/NZS2436-1981 *Guide to Noise Control on Construction, Maintenance and Demolition Sites*, details noise control measures that can be used in order to reduce construction noise levels. Specifically, Table E1 to E3, Appendix E, from AS/NZS 2436 suggests possible strategies to reduce noise from typical construction equipment show the relative effectiveness of various forms of noise control treatment. Tables E2 and E3 from AS2436-1981 are reproduced (in part) in Table 8-14 and Table 8-15 respectively.

Table 8-14: Typical Examples of Noise Reduction taken from AS2436-1981

Type of Machine	Typical Treatment	Typical Reduction in Noise Level after Treatment dB(A)
Diesel concrete mixer	Acoustic silencer	5
Diesel concrete mixer	Enclosure of the engine	7
Tracked loading shovel	Better silencer	10
Pneumatic concrete breaker	Muffler and screen	20
Pneumatic concrete breaker	Hydraulic system	25
Pneumatic breaker	Fabric muffler	6
Pneumatic breaker	Rubber silencer	6
Diesel compressor	Silencer and enclosure	20
Crawler mounted rock drill	Silencer and enclosure	20
Small pneumatic hand grinder	Exhaust silencer	13
0.5 tonne pneumatic hoist	Diffuser	27
Piling (sheet steel)	Screen drop hammer driver	37
Piling (sheet steel)	Vibrating driver	18

Table 8-15: Relative Effectiveness of Various Forms of Noise Control taken from AS2436-1981

Control By	Noise Reduction Possible in Practice, dB(A)
Screening	7-10
Enclosure	15-30
Silencing	5-10
Substitution by alternative process	15-25

In practice, machinery varies significantly and noise controls would need to be designed specifically for the item of plant in question, with consideration for distances to sensitive receivers.

Construction Noise Mitigation Measures

The following noise mitigation measures will help minimise noise impacts at residential properties surrounding the Project:

- Maintain mechanical equipment;
- Switch off equipment that is not in use to avoid unnecessary noise emissions;
- Avoid concurrent operation of equipment with high noise emissions where close to residences;
- Consider time restrictions for construction works with high noise emissions close to residences;
- Consult with residents with regard to the timing and likely noise emissions from construction activities; and
- Implement a complaints resolution procedure, such that complaints are thoroughly investigated and control measures implemented where appropriate.

8.3.5 Traffic Noise During Construction

Details of the traffic volumes associated with the project construction program have been estimated in Section 10.3.6. In general terms, traffic noise impacts will be limited to the designated access roads associated with the work camps and the construction sites.

Although exact traffic volumes are yet to be determined, it is expected that the traffic volumes associated with the Project would not be sufficient to warrant a comprehensive road traffic noise investigation.

8.4 Construction Vibration Assessment

8.4.1 Construction Vibration Criteria

Vibration criteria are defined for both:

- Buildings; and
- Amenity.

It is common practice to set vibration limits for general construction works to protect buildings against damage at:

- Residences — 5 mm per second
- Heritage buildings and sensitive structures — 2 mm per second

Amenity criteria, to protect occupants of buildings from discomfort, are however more stringent. A number of British, German and Australian standards can be referenced with respect to protecting amenity, including (but not limited to):

- NSW EPA ENCM (Section 174);
- AS 2670 *Evaluation of Human Exposure to Whole-body Vibration*;
- BS 6472 1992 *Evaluation of Human Exposure to Vibration in Buildings* (1 Hz to 80 Hz);
- BS 7385 1990 *Evaluation and Measurement for Vibration in Buildings*; and
- DIN 4150-3 1999 *Structural Vibration Part 3 Effects of Vibration on Structures*.

The following amenity criteria (as summarised in Table 8-16 and described below) are taken from the former NSW Department of Environment and Conservation's *Assessing Vibration; a technical guideline*, published in February 2006 (the Guideline). This document provides criteria based on the BS 6472-1992, *Evaluation of human exposure to vibration in buildings* (1-80Hz).

The Guideline classifies vibration and its associated effects as continuous, impulsive or intermittent as follows:

- Continuous vibration is uninterrupted for a defined period (usually throughout day-time and/or night-time). This type of vibration is assessed on the basis of weighted Root Mean Square (RMS) acceleration;
- Impulsive vibration is a rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than two seconds; and

- Intermittent vibration can be defined as interrupted periods of continuous (e.g. a drill) or repeated periods of impulsive vibration (e.g. a pile driver), or continuous vibration that varies significantly in magnitude. It may originate from impulse sources (e.g. pile drivers and forging presses) or repetitive sources (e.g. pavement breakers), or sources that operate intermittently, but which would produce continuous vibration if operated continuously (for example, intermittent machinery and traffic passing by).

Continuous vibration may be classified by continuous sources such as steady road traffic or some machinery including tunnel boring machines.

Potential impulsive vibrations may include activities that create up to three distinct vibration events in an assessment period, for example dropping of heavy equipment or occasional loading and unloading.

Intermittent vibration can be defined as interrupted periods of continuous or repeated periods of impulsive/continuous vibration. Examples include trains, impact pile driving, forging machines and jack hammers.

Section 2.3 of the Guideline states: "*Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted RMS acceleration values of the vibration in each orthogonal axis are preferred (BS 6472)*".

Table 8-16 details preferred and maximum values for continuous and impulsive vibration taken from Table 2-2 of the Guideline.

Table 8-16: Preferred and Maximum Weighted RMS Values for Continuous and Impulsive Vibration Acceleration (m/s^2) 1 – 80 Hertz

		Preferred Values		Maximum Values	
Location	**Assessment Period**	**z-axis**	**x- and y-axes**	**z-axis**	**x- and y-axes**
Continuous Vibration					
Critical areas	Day or night-time	0.0050	0.0036	0.010	0.0072
Residences	Day-time	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or night-time	0.020	0.014	0.040	0.028
Workshops	Day or night-time	0.04	0.029	0.080	0.058
Impulsive Vibration					
Critical areas	Day or night-time	0.0050	0.0036	0.010	0.0072
Residences	Day-time	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day or night-time	0.64	0.46	1.28	0.92
Workshops	Day or night-time	0.64	0.46	1.28	0.92

Notes:

1. Day-time is 7 am to 10 pm and night-time is 10 pm to 7 am.
2. Critical areas include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specified above. Stipulation of such criteria is outside the scope of this policy, and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1992.

Section 2.4 of the Guideline describes the method of assessment for intermittent vibration. Intermittent vibration is assessed using vibration dose values (VDV's). The VDV is given by the fourth root of the integral with respect to time of the fourth power of the acceleration after it has been weighted. The use of the fourth power method makes VDV more sensitive to peaks in the acceleration waveform. The vibration dose is fully described in BS 6472-1992.

The VDV is calculated from the overall weighted RMS acceleration in each orthogonal axis over the frequency range 1 to 80 Hertz.

Table 8-17 details preferred and maximum values for VDV taken from Table 2-4 of the Guideline.

Table 8-17: Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Day-time		Night-time	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Critical areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes:

1. Day-time is 7 am to 10 pm and night-time is 10 pm to 7 am.
2. Critical areas include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are indicative only, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas. Source: BS 6472-1992.

8.4.2 Construction Vibration Sources

The assumed equipment vibration levels used in the construction vibration assessment are shown in Table 8-18.

Table 8-18: Typical Construction Equipment Vibration Levels

Plant Item	Vibration Level at 25 m PPV mm/s (RMS2 m/s^2)
Dump truck	0.3(0.011)
Road truck	0.5(0.018)
Excavator	0.6(0.021)
Backhoe	0.6(0.021)

Plant Item	Vibration Level at 25 m PPV mm/s (RMS2 m/s^2)
Trencher	0.3(0.011)
Bulldozer	0.4(0.014)
Scraper	0.3(0.011)
Grader	0.3(0.011)
Water cart	0.1(0.004)
Compactor	0.9(0.032)
Vibratory roller	0.9(0.032)
Concrete paver	0.1(0.004)
Rock breaker	0.35(0.013)
Jackhammer	0.2(0.007)
Rock drill	0.4(0.014)
Pile Driver (impact)	6.4(0.2265)

Notes:

1. PPV refers to the Peak Particle Velocity.
2. RMS refers to the approximate Root Mean Square acceleration.

Equipment without vibration levels are considered to have negligible vibration input. The vibration data have been sought from a number of sources including:

- AS 2436 – 1981 *Guide to Noise Control on Construction, Maintenance and Demolition Sites*;
- Transit Noise and Vibration Impact Assessment FTA-VA-90-1003-06, Federal Transit Administration, Department of Transportation USA, May 2006;
- Vibrations from Blasting, David Siskind; 1st edition, ISEE, 2005; and
- Information from past projects and information held in library files.

8.4.3 Construction Vibration Impacts

In general, the vibrations caused by construction works are likely to be classified as intermittent. A worst case assessment was conducted using the highest vibration sources presented in Table 8-19[3], the pile driver (impact) and the vibratory roller. Table 8-19 and Table 8-20 show predictions of the pile driver impact and the vibratory roller levels.

It was assumed that the mitigation measures associated with construction noise would confine the use of this equipment to regular day-time construction hours. It was also assumed the all sensitive receivers fell into residential category; as such a single criterion set was derived as displayed in Table 8-19 and Table 8-20.

[3] These pieces of equipment may not necessarily be used in the construction of this project but provide conservative predictions for other equipment with less severe vibration impacts.

Table 8-19: Vibration Levels for a Pile Driver at Various Distances

Distance from Source (metres)	Approximate RMS Vibration Level (m/s^2)	Criteria VDV (m/s$^{1.75}$)		VDV (m/s$^{1.75}$) for various operation durations (hours)				
		Preferred	Maximum	1	2	4	6	8
20	0.317	0.2	0.4	3.4	4.1	4.8	5.4	5.8
40	0.112	0.2	0.4	1.2	1.4	1.7	1.9	2.0
60	0.061	0.2	0.4	0.7	0.8	0.9	1.0	1.1
80	0.040	0.2	0.4	0.4	0.5	0.6	0.7	0.7
100	0.028	0.2	0.4	0.3	0.4	0.4	0.5	0.5
120	0.022	0.2	0.4	0.2	0.3	0.3	0.4	0.4
140	0.017	0.2	0.4	0.2	0.2	0.3	0.3	0.3
160	0.014	0.2	0.4	0.2	0.2	0.2	0.2	0.3

Table 8-20: Vibration Levels for a Vibratory Roller at Various Distances

Distance from Source (metres)	Approximate RMS Vibration Level (m/s^2)	Criteria VDV (m/s$^{1.75}$)		VDV (m/s$^{1.75}$) for various operation durations (hours)				
		Preferred	Maximum	1	2	4	6	8
20	0.044	0.2	0.4	0.5	0.6	0.7	0.7	0.8
40	0.016	0.2	0.4	0.2	0.2	0.2	0.3	0.3
60	0.008	0.2	0.4	0.1	0.1	0.1	0.1	0.2
80	0.005	0.2	0.4	0.1	0.1	0.1	0.1	0.1

The maximum VDV criteria are predicted to be met for unmitigated impact pile driving with a separation distance to residences of between 100 m and 140 m depending on activity duration, and for vibratory rollers at 60 m.

Given that all residential receivers occur at distances greater than 60 m, it is unlikely that vibration guidelines for building damage will be exceeded during construction.

The criteria for human comfort are more stringent than those for building damage, it is clear that the criteria for building damage are predicted to be achieved. For pile driving the separation distance for amenity is expected to be 200 m. For vibratory rolling the separation distance for amenity is expected to be 80 m.

8.4.4 Construction Vibration Mitigation

Construction Vibration Controls

Provided that the construction methodology, machinery and minimum separation distances discussed are consistent with those detailed in this EIS, vibration controls should not be required to meet the criteria at residential properties surrounding the Project.

If equipment other than the impact pile driver and the vibratory roller need to be used within 60 m of a sensitive receiver, further calculations can be completed when detailed construction plans are known.

Construction Vibration Strategies

Vibration emissions can vary significantly between equipment and constructions sites. The following vibration management strategies will help to ensure that the criteria are achieved at sensitive receivers surrounding the Project:

- Test equipment used on the Project to ensure that the site-specific vibration levels are compliant with regulatory criteria;
- Conduct vibration monitoring programs throughout the construction phase of the Project in order to ensure that the criteria are achieved;
- Consider consultation with residents when activities are likely to produce high levels of vibration; and
- Implement a complaints resolution procedure such that complaints are thoroughly investigated and appropriate control measures implemented where appropriate.

Alternative construction techniques may need be used in areas where the criteria cannot be achieved using the above management strategies.

8.5 Operational Rail Noise Assessment

8.5.1 Rail Noise Criteria

QR Ltd's *Code of Practice – Railway Noise Management* makes reference to the EPP(Noise) – Planning Levels as follows:

> *The EPP Noise nominates "planning levels" for a beneficial asset such as a railway which may be used as a guide in deciding a reasonable noise level for its use or operation. The EPP Noise recognises however that those levels may not be appropriate for an older railway. It envisages that it may be reasonable to apply the levels only in the long term to allow time to progressively reduce any significantly adverse effects on the environmental values from its operation. The planning levels are:*
>
> *a) 65 dB(A), assessed as the 24 hour average equivalent continuous A-weighted sound pressure level;*
>
> *c) 87 dB(A) assessed as a single event maximum sound pressure level; and*
>
> *d) Where appropriate, they are to be assessed 1 metre in front of the building façade of an affected noise sensitive place.*

Railway activities are defined as the use of premises for the purposes of constructing, maintaining and operating: rail transport infrastructure as per Schedule 6 of the *Transport Infrastructure Act* 1994 (reprint 1 July 2008).

8.5.2 Low-Frequency Noise from Trains

The noise emission spectrum of locomotive engines includes a noticeable amount of low-frequency noise energy. Although locomotive noise emissions depends on many factors including train speed, notch setting, track gradient, and rollingstock load, an indicative assessment of the possible extent of low-frequency noise impact can be estimated from measurements of train pass-bys.

Based on measurements of various QR Ltd locomotives in the greater Brisbane and rural Queensland areas, it is expected that low-frequency noise impact as defined in the EPA's Draft Guideline *Noise – Assessment of Low-Frequency Noise* would be typically limited to an extent of 1,200 m from the track alignment.

Since there are numerous residences within this distance form the rail alignment, this indicates that further consideration of low-frequency noise emissions will be required during detailed design of the Project.

8.5.3 Assumptions

The predicted noise emission levels used have been derived from rollingstock emission data obtained for existing coal operations in Queensland.

The train configuration and proposed traffic volumes were taken from the report prepared by Maunsell AECOM, *Surat Basin Rail Study: Operational Train Performance and Capacity Modelling.*

The following configuration was assumed to conservatively cover potential train configurations. The parameters of this configuration are as follows:

- Number of passing loops: ~8; and
- Maximum possible number of daily trains: ~22 (as assumed as 8 from south of Wandoan; 10 from the Wandoan Mine; and 4 from the vicinity of Taroom (to join at approximately chainage 64 km)).

The train modelled was assumed to be the 1.5 x standard Blackwater train, referred to as the reference coal train in the aforementioned train report. For the purposes of this study, a standard Blackwater diesel train is assumed to be configured with 4000 series diesel locomotives and 104 t coal wagons in the following arrangement:

2x4000 – 44x104 t – 1x4000 – 42x104 t – 2x4000 – 50x104 t

For a conservative estimate of rail noise trains were assumed to be travelling at the design limit of 80 km/hr, however, average train speeds are predicted to be closer to an average of 50 km/hr.

The noise modelling calculations have including the effect of shielding of noise due to terrain, sound absorption by ground covering, and the relative elevations of the noise sources and receivers. Other conditions which influence sound propagation including meteorological effects are intrinsically incorporated into the Kilde 130 modelling method.

8.5.4 Predicted Rail Noise Impacts

All sensitive receivers in the multi-user corridor were predicted to meet the operational criteria. These results are illustrated in Table 8-21 which shows predicted noise levels for each of these receivers.

Table 8-21: Predicted Noise Levels at Sensitive Receiver Locations

	L_{eq},24hr dB(A)	L_{max} dB(A)	Receiver	L_{eq},24hr dB(A)	L_{max} dB(A)
	Criteria Limit: < 65 dB(A)	Criteria Limit: < 87 dB(A)		Criteria Limit: < 65 dB(A)	Criteria Limit: < 87 dB(A)
1	49	68	**29**	52	70
2	50	68	**30**	51	70
3	51	68	**31**	53	73
4	55	74	**32**	49	68
5	58	77	**33**	46	64
6	50	68	**34**	43	61
7	50	69	**35**	43	60
8	51	69	**36**	45	65
9	47	63	**37**	47	66
10	52	70	**38**	41	57
11	55	74	**39**	52	72
12	50	68	**40**	51	72
13	48	67	**41**	45	65
14	53	72	**42**	50	68
15	51	70	**43**	45	64
16	46	64	**44**	45	64
17	46	65	**45**	51	71
18	44	63	**46**	51	70
19	45	63	**47**	45	63
20	52	71	**48**	50	69
21	50	69	**49**	47	66
22	50	68	**50**	49	69
23	29	44	**51**	46	66
24	52	71	**52**	54	78
25	48	66	**53**	*	*
26	50	69	**54**	47	73
27	41	61	**55**	43	67
28	53	73			

Note: Receiver 53 occurs within the proposed rail footprint and has therefore been excluded from further assessment.

Figure 8-1 and Figure 8-2 show how noise from the railway propagates across flat ground. The figures provide a cross-sectional view with the railway line axis located at 0 m transversely. The criteria are met at transverse locations to the right of the criteria band (light blue) in each case. Despite the lack of terrain considerations, the flat ground approximations are indicative of the receiver calculations as presented in Table 8-21above and the L_{eq} and L_{max} criteria for the operational railway are predicted to be met at approximately 40 m and 60 m respectively.

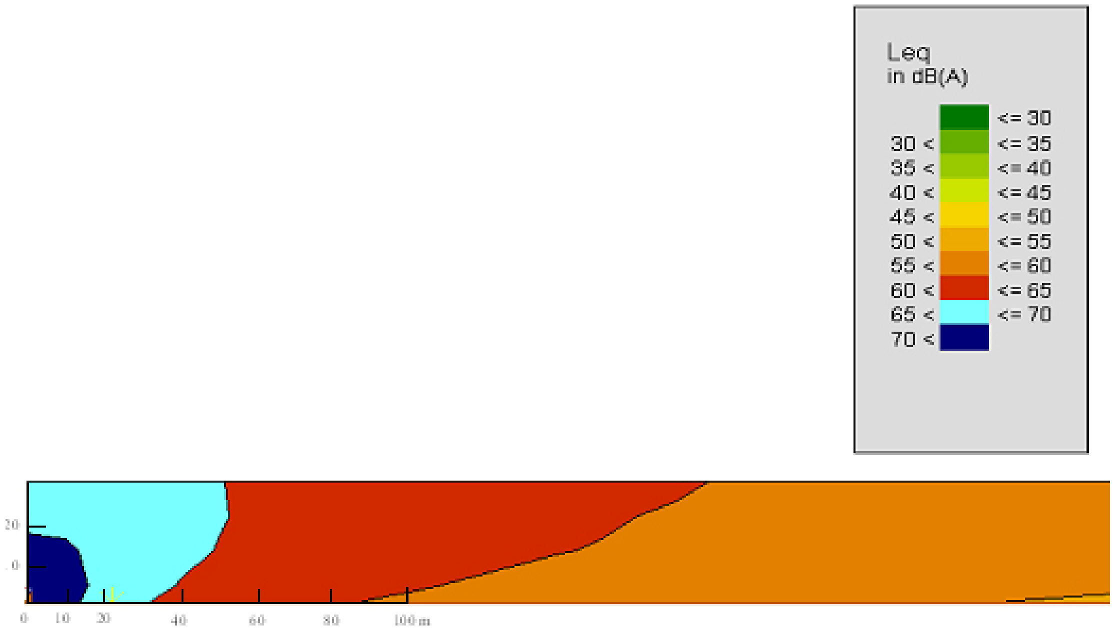

Figure 8-1: Typical L_{eq} Noise Cross Section for Rail Operations on Flat Terrain

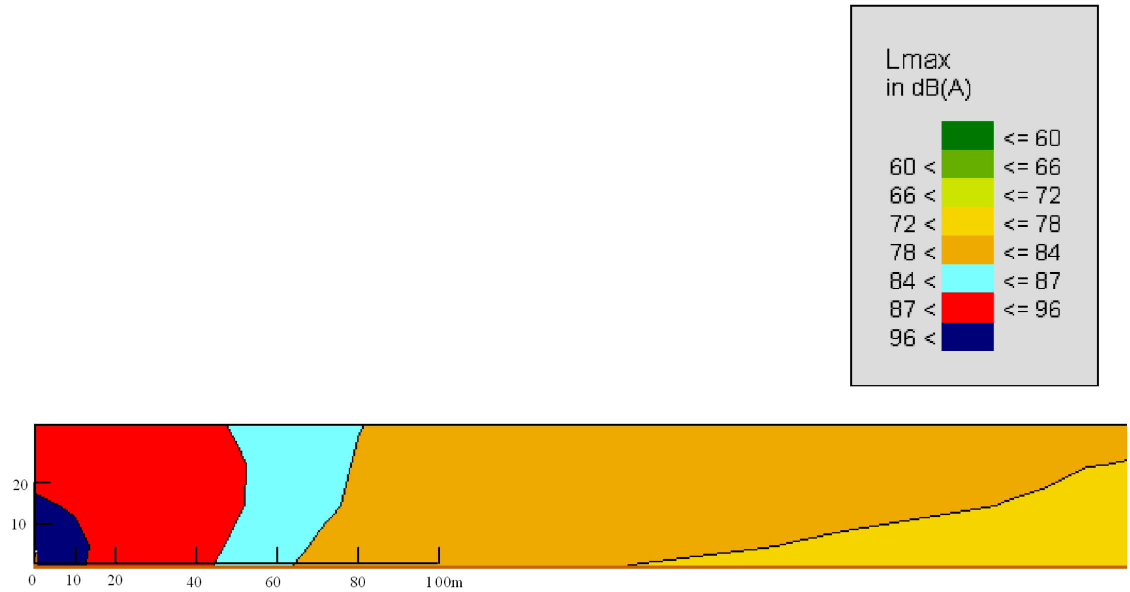

Figure 8-2: Typical L_{max} Noise Cross Section for Rail Operations on Flat Terrain

In addition to the cross-sectional noise modelling results presented above, noise contours specifically for the township of Wandoan were generated and are shown in Map 25 – Noise Level Contours Wandoan L_{eq} and Map 26 – Noise Level Contours Wandoan L_{max} in the Map Folio. The purpose of this assessment is to examine the worse-case scenario in relation to train volume and proximity of sensitive receivers. These maps show that no buildings will be subjected to noise levels from maximum train volumes on the Project of greater than 52 dB L_{eq} or 70 dB L_{max}. As with other sensitive receivers along the preferred alignment, all sensitive receivers within the Wandoan township were predicted to meet the operational criteria.

Although noise is not expected to exceed statutory limits, the Proponent has commenced discussions with a number of affected property owners independently of the EIS process and will conclude these negotiations in future.

Noise from Passing Loops

As identified in Section 2.4.10 it expected that up to 8 passing loops may be required along the SBR rail alignment for the current design capacity of 42 Mtpa. Currently the number of times per day when trains need to wait on the passing loops is unclear. Therefore only an indicative assessment can be undertaken.

The indicative noise level of a train idling at 40 m distance is approximately 65 dBA. This is approximately the same as the distance where compliance with the noise criteria for train movements is achieved.

Since noise attenuates at approximately 3 dB(A) per doubling from a line source, this means that in the locations of passing loops, the rail noise criteria of 65 dB(A) L_{Aeq}(24 hour) would be achieved at distances less than 80 m from the rail alignment.

8.5.5 Rail Noise Mitigation

Rail Noise Controls

All sensitive receivers are predicted to comply with the operational rail criteria assuming the Project operation and alignment occurs as modelled. The physical alignment, train configurations, frequency, speeds, etc., all have a bearing on the noise environment at sensitive locations and changes in these parameters will affect the noise levels received.

At this stage ameliorative measures are not required however changes in the proposed operating conditions may result in mitigation requirements in the detailed design stage of the Project.

Rail Noise Management Strategies

The QR Ltd Code of Practice for Rail Noise Management describes several noise management strategies that are typically implemented for rail operations in Queensland. A number of strategies can be used to avoid intrusive noises with impulsive or tonal components:

- Limit horn use in accordance with the requirements of the Noise Code of Practice;
- Minimise unnecessary acceleration/deceleration;
- Ensure rail equipment is well maintained including the tracks;
- All silencing equipment, where installed, should be maintained to ensure that the design noise reductions are achieved;
- Residents should be consulted with regard to the timing and likely noise emissions from rail activities; and
- A complaints resolution procedure should be implemented, such that complaints are thoroughly investigated and appropriate control measures implemented where appropriate.

8.6 Effect of Noise on Terrestrial and Aquatic Animals and Avifauna

The effect of noise from the Project on domestic livestock and wildlife, including migratory species, has been assessed in Section 5.

8.7 Blast Noise and Vibration Assessment

In accordance with the ToR, this Section describes the noise and vibration impact from blasting activities that may occur during construction. At this stage of the Project, blasting, if it is required, will be restricted to areas in the vicinity of Cracow.

8.7.1 Airblast Overpressure and Blast Vibration Criteria

Noise and vibration resulting from blasting in Queensland is governed by the Environmental Protection Regulations (EPR) as subordinate legislation to the EP Act. The following excerpt from EPR details the legislated noise limits for noise and vibration from blasting.

Blasting Noise Exclusion

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

- *The airblast overpressure is no more than 115 dB(Lin) Peak for 4 out of any 5 consecutive blasts; and*
- *The ground vibration is:*
  - *a) For vibrations of more than 35 Hz – no more than 25 mm a second ground vibration, peak particle velocity; or*
  - *e) For vibrations of no more than 35 Hz – no more than 10 mm a second ground vibration, peak particle velocity.*

The EPA Guideline: Noise and Vibration from Blasting is used to set criteria in conditions of environmental authorities for activities such as mines and quarries and specifies recommended human comfort criteria for:

- Airblast overpressure level;
- Ground vibration peak particle velocity; and
- Times of blasting.

The criteria specified in the Guideline have been adopted to assess the impact of noise and vibration resulting from blasting. The relevant sections are as follows:

Airblast Overpressure

The noise from blasting is reasonable if measured outside the most exposed part of an affected noise sensitive place:

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

Ground Vibration

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 8 mm per second for nine out of any ten consecutive blasts initiated, regardless of the interval between blasts; and
- The ground-borne vibration must not exceed a peak particle velocity of 10 mm per second for any blast.

Times of Blasting

Blasting should generally only be permitted during the hours of 9:00 am to 3:00 pm, Monday to Friday, and from 9:00 am to 1:00 pm on Saturdays. Blasting should not generally take place on Sundays or Public Holidays. Blasting outside these recommended times should be approved only where:

- Blasting during the preferred times is clearly impracticable (in such situations blasts should be limited in number and stricter airblast overpressure and ground vibration limits should apply); or
- There is no likelihood of persons in a noise sensitive place being affected because of the remote location of the blast site.

8.7.2 Blast Noise and Vibration Prediction Methodology

Blasting calculations for airblast overpressure and ground vibration have been based on the prediction method described in Appendix I of AS 2187.2-2006 Explosives—Storage and use Part 2: Use of explosives.

The airblast overpressure predictions have been based on parameters given in Section J7.2 of the Standard for confined blasting. Airblast overpressure can increase rapidly if blasts are poorly confined and hence a 10 dB safety factor has been applied to blasting impact predictions. The areas of airblast impact have therefore been calculated based on a limit of 105 dB(linear).

The peak particle vibration has been based on the formula given in Section J7.3 of the Standard for the average peak particle velocity.

Specific details of blast patterns are currently unavailable and hence the assessment of potential impacts has been carried out for a large range of charge sizes.

The predictions have not considered the effect of topographic shielding or meteorological conditions and are only given as a guide for the identification of potential impact from blasting.

8.7.3 Predicted Impacts

The specific blasting locations, blast patterns and charge sizes will be decided during the detailed design phase of the Project. As the final blasting details are currently unknown, the following details approximate distance required to achieve criteria for various charge sizes.

Criteria for building damage are less stringent than those for human comfort and hence the criteria for building damage will be comfortably achieved by considering the adopted criteria.

Table 8-22 presents the distance at which the blasting noise and vibration criteria are predicted to be achieved for various charge sizes. As presented in Table 8-22, the distance required to achieve compliance with the airblast overpressure criterion are greater than those to achieve the vibration criteria and hence the buffer distance will be defined by the airblast overpressure.

Table 8-22: Predicted Buffer Distances required to achieve Noise and Vibration Criteria for Various Charge Sizes

Effective charge mass per delay (kg)	Predicted Distance to Achieve Criteria (m)	
	Predicted Airblast Overpressure Buffer Distance < 105 dB(linear)	Predicted Ground Vibration Buffer Distance PV < 5 mm/s
5	410	70
25	700	150
50	880	210
100	1,100	300
200	1,400	420
300	1,600	520
400	1,760	595
600	2,020	730
800	2,220	840
1000	2,390	940

8.7.4 Mitigation Measures

It is essential that site-specific noise and vibration predictions are undertaken once blast designs and geotechnical information are confirmed. Appropriate buffer zones should be identified to ensure that airblast overpressure is limited to acceptable levels. Blasting designs should be selected to ensure that the relevant criteria are achieved at residential properties surrounding the blast site.

Blasting vibrations and airblast overpressure should be monitored throughout the Project in order to ensure that the criteria are being achieved at the nearest sensitive receivers.

In addition to the above, the following management strategies are recommended:

- Airblast overpressure and vibration should be measured from a series of test blasts in order to establish appropriate propagation characteristics for the site and to increase the accuracy of blasting predictions;
- Meteorological conditions should be monitored and blasting should be avoided where conditions are likely to increase the impact to residents;
- Surveys should be undertaken of all critical properties, before and after blasting activities, to ensure that no damage occurs to structures located on the property;
- Time restrictions may be considered to ensure the minimum impact to residents;
- Consultation with affected stakeholders should be considered with regard to the timing of blasting activities; and
- A complaints resolution procedure should be implemented such that complaints are thoroughly investigated and blasting activities ceased or modified where appropriate.