9. Noise and Vibration

This section provides a summary of the noise and vibration investigation undertaken, and the potential impacts identified, in regards to the Project (Rail) during construction and operation. The assessment was undertaken in accordance with the requirements of the Terms of Reference (ToR) and a table cross-referencing these requirements is provided in Volume 4 Appendix C ToR Cross Reference Table. A detailed noise and vibration report is included in Volume 4 Appendix AF Rail Noise and Vibration Report.

9.1 Introduction

A noise and vibration impact assessment for the construction and operation of the Project (Rail) has been undertaken. A summary is presented below. Assessment of noise and vibration relevant to the Project (Mine) is provided in Volume 2 Section 9 and Volume 4 Appendix U Mine Noise and Vibration.

9.1.1 Legislation, Policies and Guidelines

The noise and vibration assessment has been informed by the following legislation, policies and/or guidelines:

- The *Environmental Protection Act 1994* (EP Act)
- The Environmental Protection (Noise) Policy 2008 (EPP Noise)
- Queensland Rail's Code of Practice for Railway Noise Management (QR, 2007)
- The Planning for Noise Control Guideline (PNC) (DERM Ecoaccess, 2004)
- The World Health Organisation (WHO) Guidelines for Community Noise (1999)
- The DERM Assessment of Low Frequency Noise Guideline (Ecoaccess, 2006)
- The British Standard (BS) 6472: 2008, Guide to evaluation of human exposure to vibration in buildings Part 1: Vibration sources other than blasting
- BS 5228-2:2009, Code of practice for noise and vibration on construction and open sites – Part 2: Vibration
- German Standard (DIN) 4150-3: 1999, Structural Vibration – Part 3: Effects of vibration on structures
- Noise and Vibration from Blasting Guideline (EPA, 2006)

9.1.2 Approach and Methodology

9.1.2.1 Overview

The construction and operation of the Project (Rail) has the potential to cause noise and vibration impacts on the surrounding environment. This report assesses potential impacts associated with noise and vibration generated during the construction and operation of the Project (Rail) by:

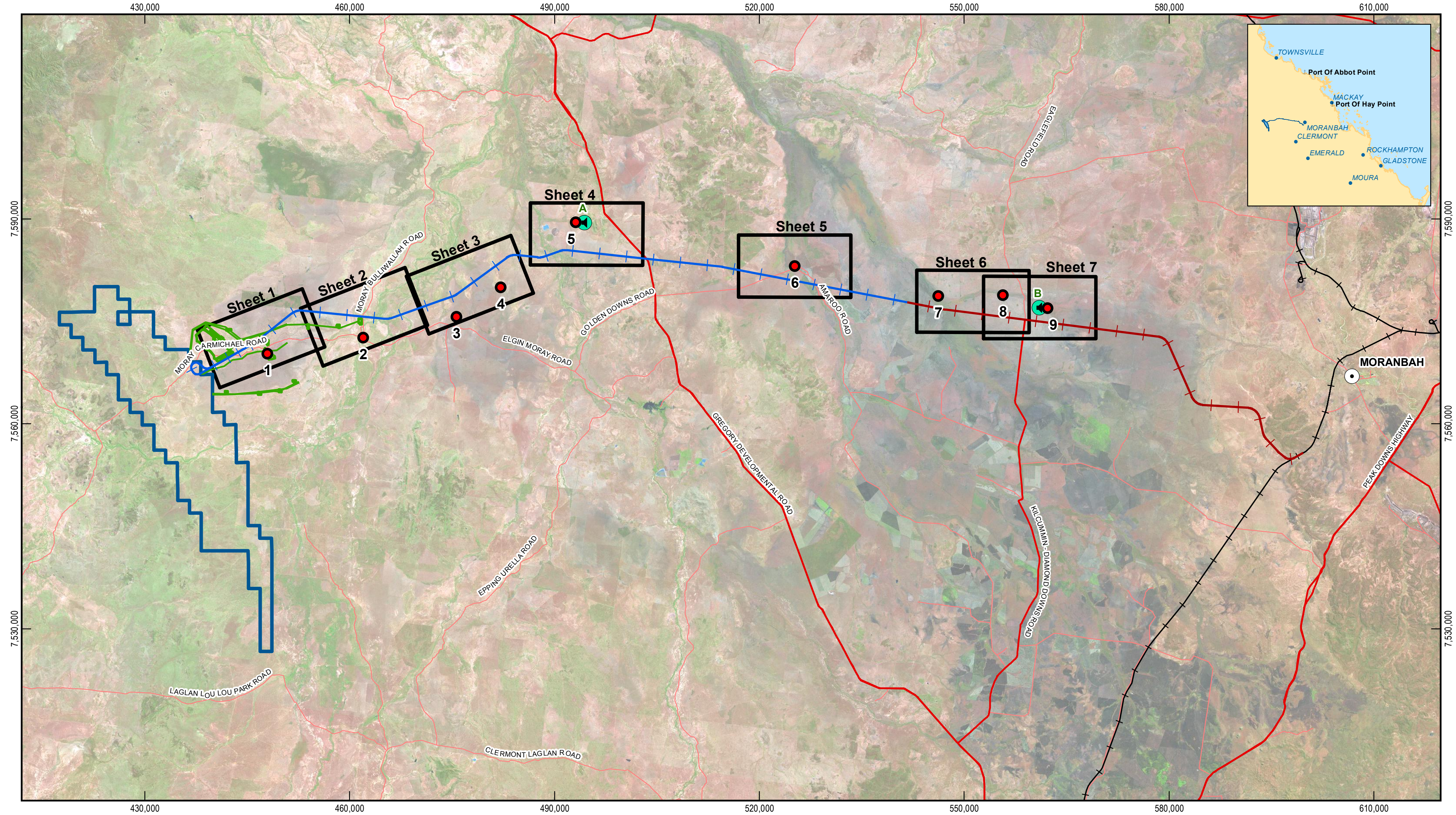
- Reviewing the existing noise and vibration environment
- Addressing the acoustic requirements detailed in the Project terms of reference in relation to the construction and operational phases of the Project (Rail)

- Undertaking acoustic modelling using Computer Aided Noise Abatement (CadnaA) software and modelling rail traffic noise using the Nordic Rail Traffic Noise Prediction Method
- Evaluating the potential construction and operational noise and vibration impacts at sensitive locations in terms of planning levels identified in the EPP Noise, Queensland Rail Code of Practice and other standards and guidelines as applicable
- Defining noise and vibration goals by which potential construction and operational noise and vibration impacts at sensitive locations may be evaluated and assessed
- Evaluating and assessing the extent of resulting impacts and the scope for the reduction of these impacts through reasonable and feasible mitigation strategies
- Recommending appropriate impact mitigation measures

Monitoring was conducted at two locations in the vicinity of the Project (Rail), shown as Location A and Location B on Figure 9-1, at distances of 4.2 km and 1.9 km from the Project (Rail).

Locations selected are considered representative of the acoustic environment for the nearest potential sensitive receptors located in the vicinity of the Project (Rail). The monitoring locations were also chosen as being a safe and secure place for staff and unattended equipment, minimising the risk of theft, vandalism, or damage by natural causes. Land access permission also contributed to the final selection of the locations.

Background and ambient noise monitoring was conducted. Background noise levels were assessed using a combination of unattended and attended noise monitoring. Vibration measurements to monitor ground vibration peak particle velocity (PPV) were undertaken at the same locations.



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Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Potential Sensitive Receptor
- Potential Noise Logger
- Town
- State Road
- Local Road
- Other Rail Network
- Rail (West)
- Rail (East)
- Mine (Onsite)
- Mine (Offsite)

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Carmichael Coal Mine and Rail Project
Project (Rail)
Predicted Rail Noise Contours, Potential Sensitive Receptors and Monitoring Locations

Job Number 41-25215
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Figure 9-1

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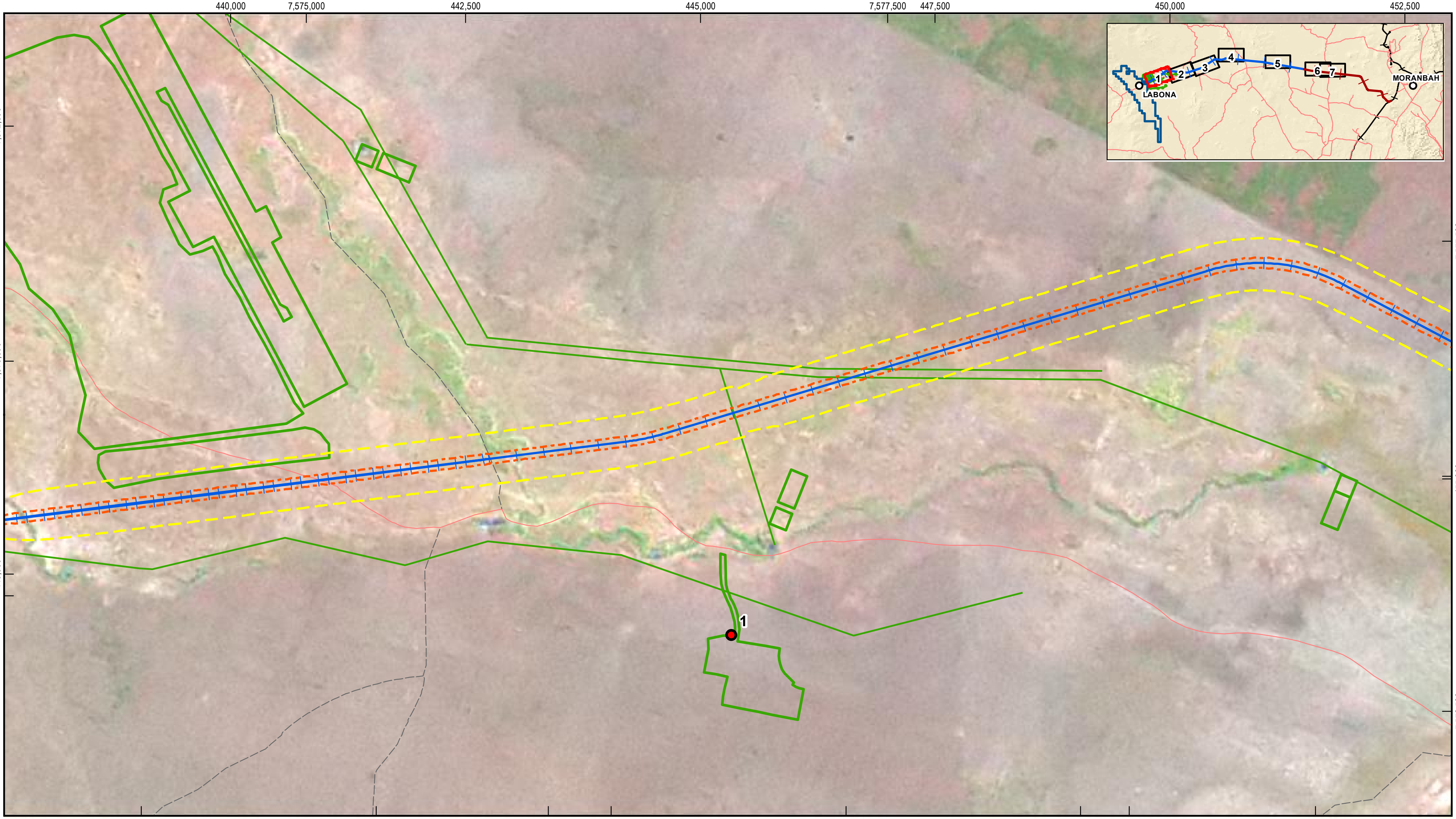
Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: GHD: Noise Logger/Sensitive Receptor Locations (2012); DERM: DEM (2008); DME: PC1690 (2010), EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Localities, Railways, Roads (2007); Adani: Alignment Opt9 Rev3 (SP1&2) (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: AF, JVC



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LEGEND

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Figure 9-1
Sheet 1

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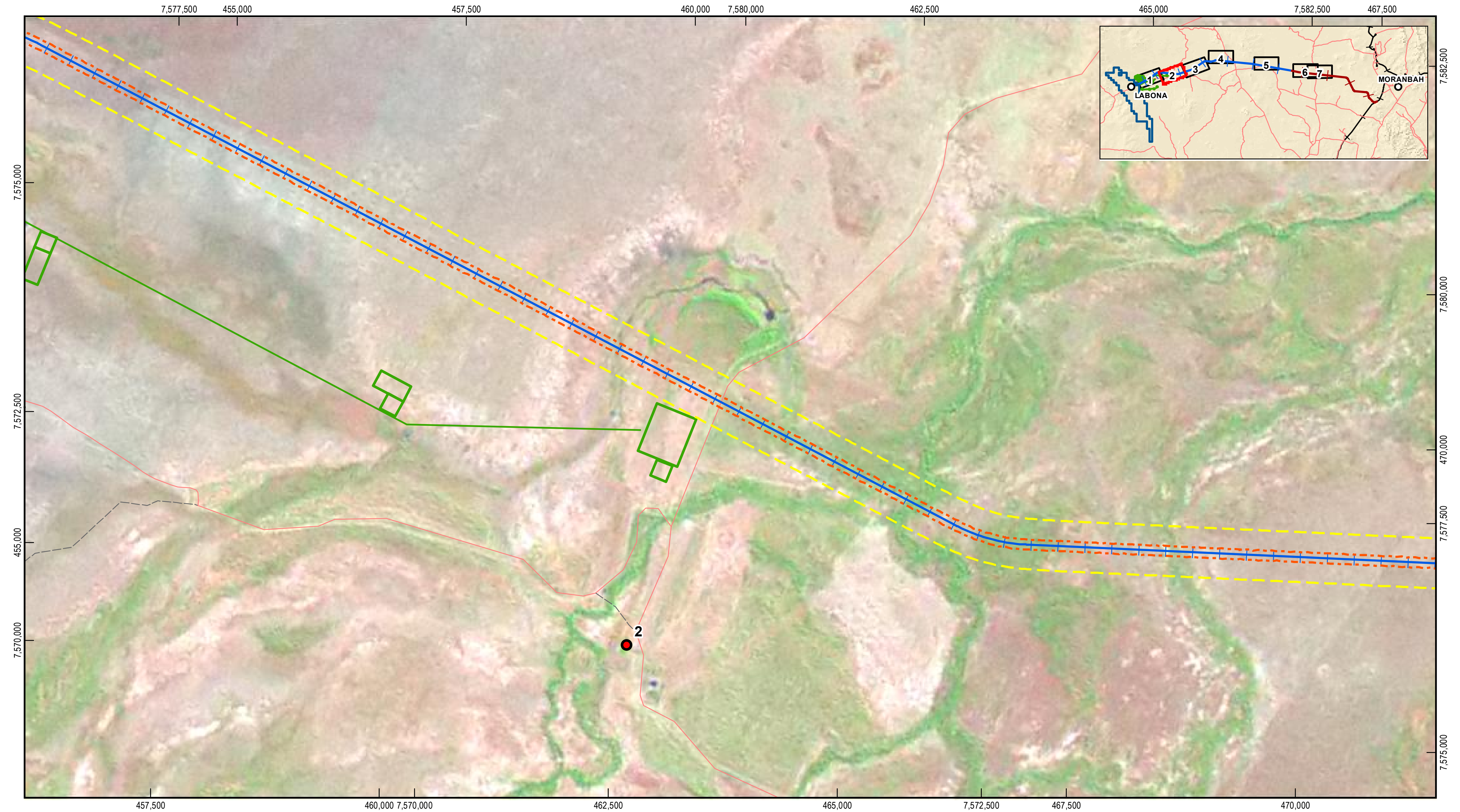

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Figure 9-1
Sheet 2

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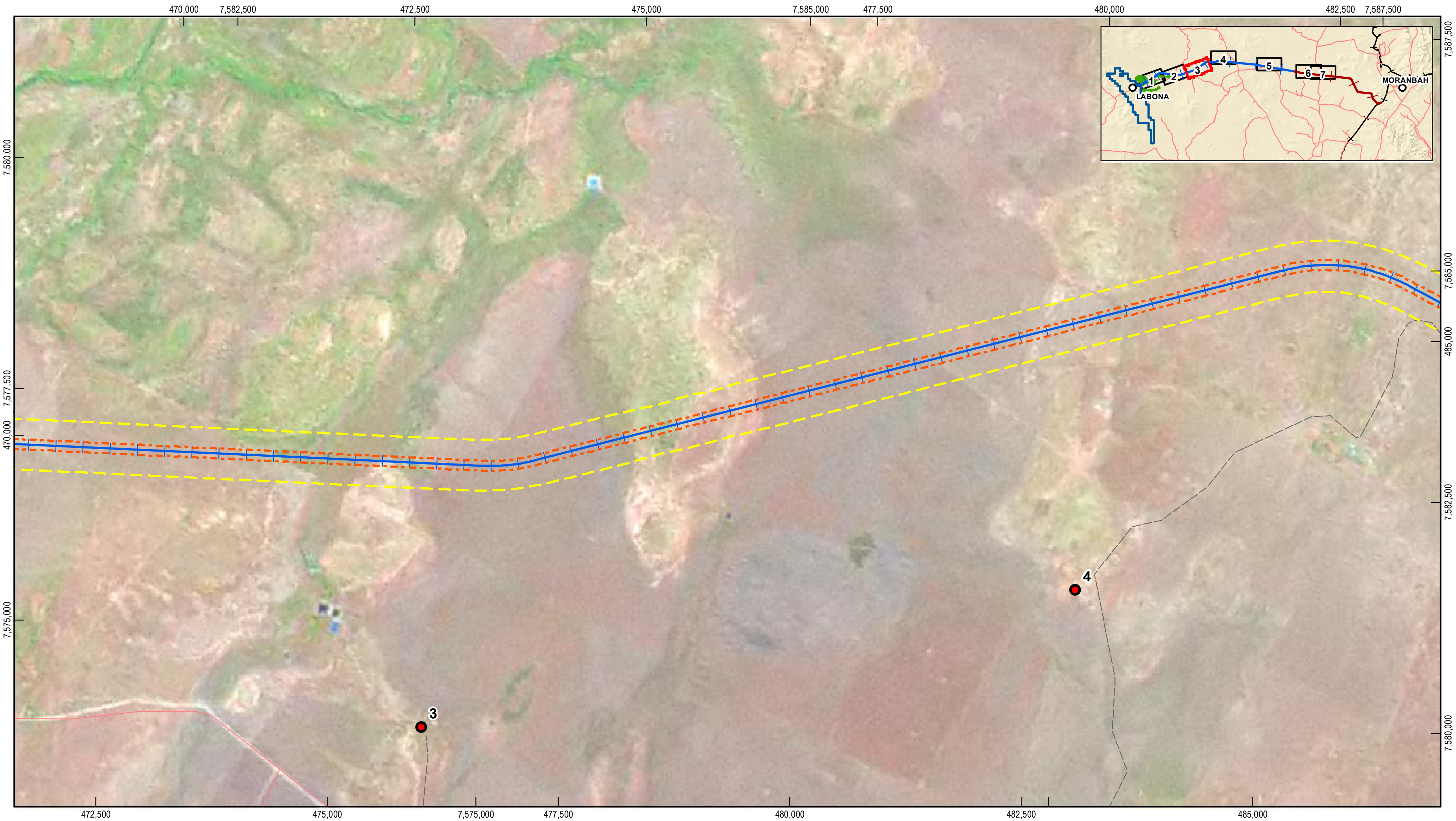

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Figure 9-1
Sheet 3

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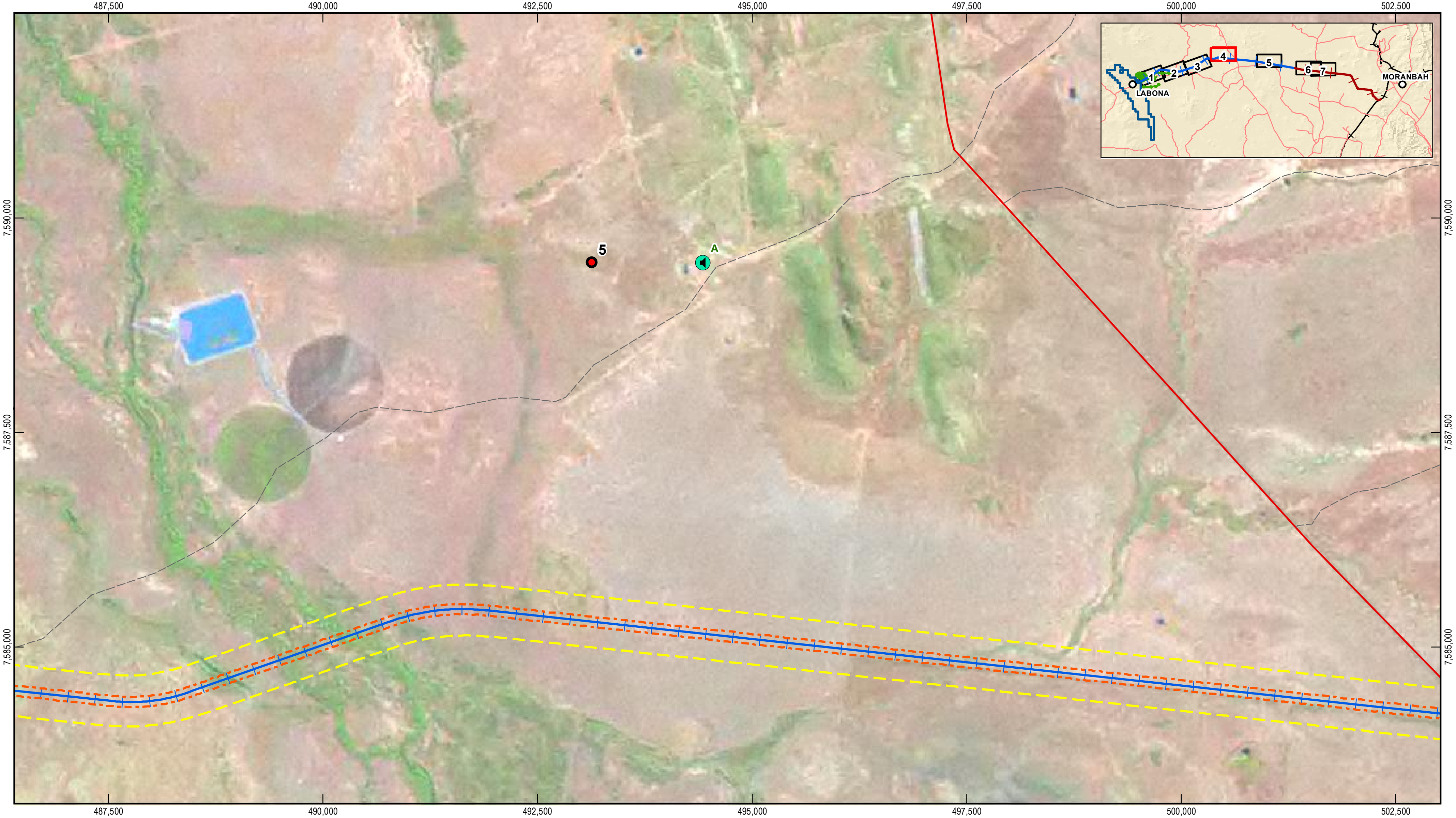

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Figure 9-1
Sheet 4

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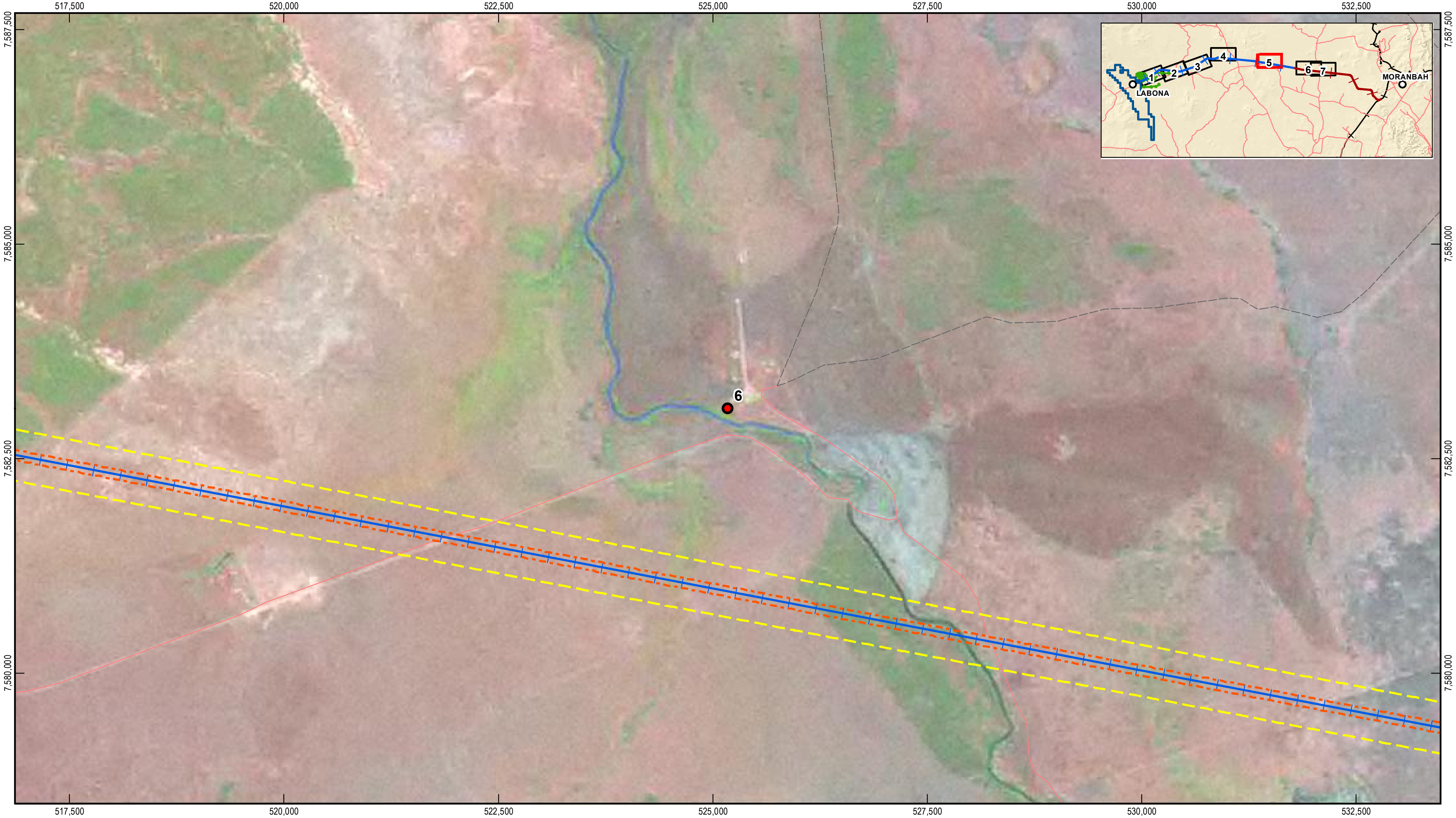

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Figure 9-1
Sheet 5

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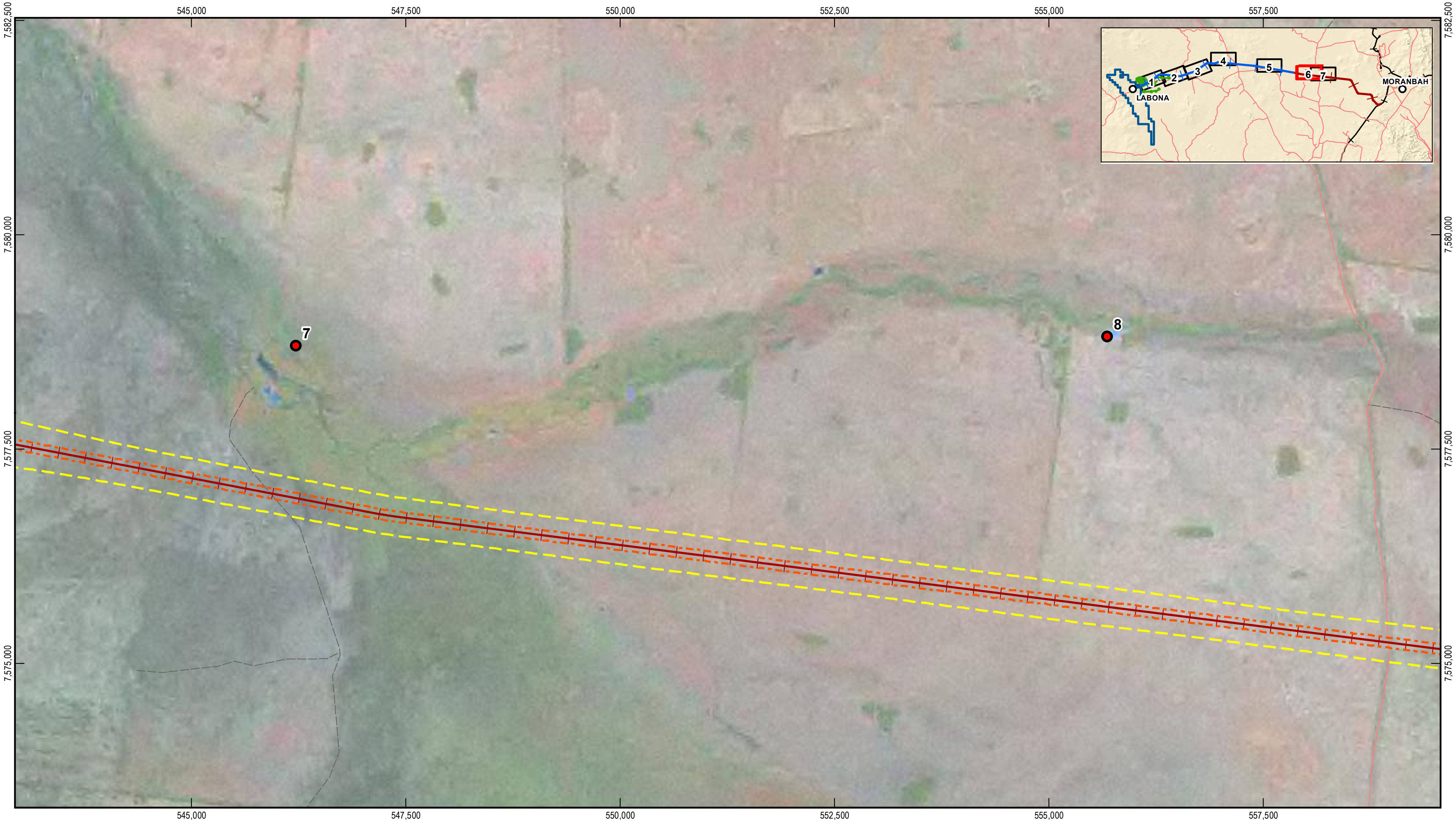

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Figure 9-1
Sheet 6

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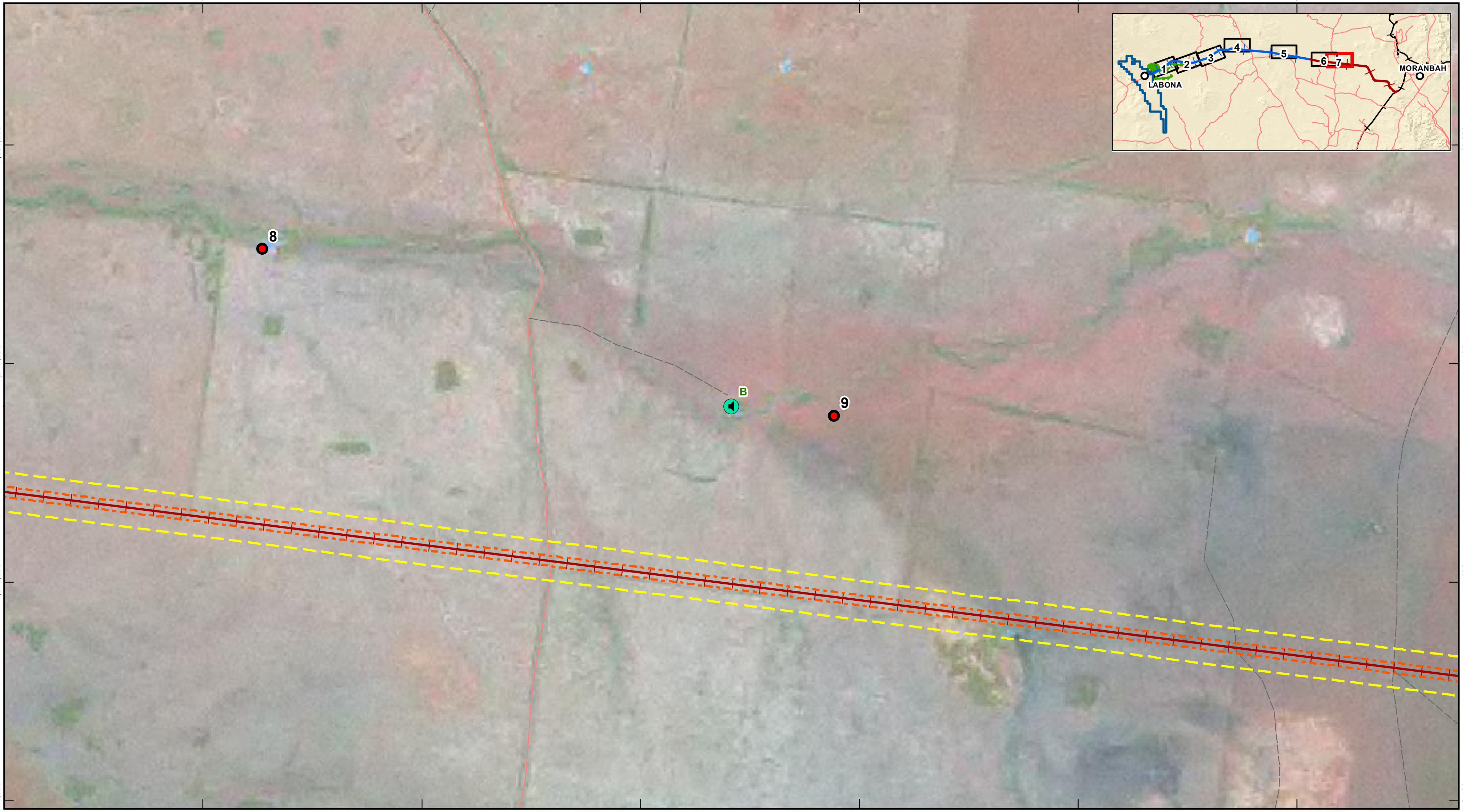

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Figure 9-1
Sheet 7

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9.1.2.2 Noise Criteria

Rail noise criteria adopted from Queensland Rail's Code of Practice for Railway Noise Management (QR, 2007) has been used for assessment purposes as follows:

- 65 dB(A) –assessed as the 24 hour average equivalent continuous A-weighted sound pressure level (L_{Aeq})
- 87 dB(A) - assessed as a single event maximum sound pressure level (L_{Amax}) - defined as the arithmetic average of maximum levels from the highest 15 single events over a given 24 hour period

The requirement to meet indoor design level noise criteria to achieve an average maximum sound level between 10:00 pm and 6:00 am of 45 decibels (dBA) is not considered applicable to the Project (Rail) as this criterion applies only to new sensitive land uses, that is development around infrastructure (such as rail), rather than for infrastructure around the development. This approach has been used in recent similar projects in QLD and has been recognised and accepted by DERM.

In Queensland, it is generally accepted that construction activities should be in accordance with general building work hours as described under Section 440R – "Building Work" of the EP Act. Under the EP Act, no audible noise is permitted:

- 6:30 pm to 6:30 am – Monday to Saturday
- Sundays and public holidays

For construction works extending outside these hours, reference is made to the World Health Organisation (WHO) Guidelines for Community Noise (1999) for quality of sleep, maximum internal noise levels, which should not exceed 45 dB(A). Based on a typical building façade noise reduction of 10 dB(A) through a partially open window, the external criterion of 55 dB(A) is recommended for sleep disturbance, assessable at four metres from the building façade.

9.1.2.3 Vibration Criteria

The Noise and Vibration from Blasting (EPA, 2006) guideline recommends that 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.

The guideline provides assessment criteria for blasting noise and vibration limits as shown in Table 9-1 and adopted for this assessment.

Table 9-1 Guideline Blasting Limits

Airblast Overpressure	Ground Vibration
115 dB(lin) peak	5 mm/s Peak Particle Velocity (PPV)
Must not be more than 115 dB(lin) peak for nine out of any ten consecutive blasts initiated, regardless of the interval between blasts, but never over 120 dB(lin) peak for any blast.	Must not exceed a peak particle velocity (PPV) of 5 mm/s for nine out of any ten consecutive blasts initiated, regardless of the interval between blasts, but never over 10 mm/s for any blast.

In the absence of specific Queensland or Australian guidelines relating to human comfort criteria for vibration, criteria have been adopted with consideration to the British Standard (BS) 6472: 2008, Guide to evaluation of human exposure to vibration in buildings Part 1: Vibration sources other than blasting.

Typically, rail activities generate ground vibration of an intermittent nature. Under BS 6472-1: 2008, intermittent vibration is assessed using the vibration dose value (VDV). Table 9-2 includes acceptable values of vibration dose for residential receptors for daytime and night-time periods

Table 9-2 Vibration Dose Value Ranges and Probabilities for Adverse Comment to Intermittent Vibration ($m/s^{1.75}$)

Location	Low probability of adverse comment[1]	Adverse comment possible	Adverse comment probable[2]
Residential buildings 16 hour day (0700 – 2300 hrs)	0.2 to 0.4 ($m/s^{1.75}$)	0.4 to 0.8 ($m/s^{1.75}$)	0.8 to 1.6 ($m/s^{1.75}$)
Residential buildings 8 hour night (2300 to 0700 hrs)	0.1 to 0.2 ($m/s^{1.75}$)	0.2 to 0.4 ($m/s^{1.75}$)	0.4 to 0.8 ($m/s^{1.75}$)

Notes:

1 Below these ranges adverse comment is not expected.

2 Above these ranges adverse comment is very likely.

Currently, there is no Australian Standard that sets the criteria for the assessment of building damage caused by vibration. Guidance of limiting vibration values is attained from reference to German Standard 4150-3: 1999, Structural Vibration – Part 3: Effects of vibration on structures. Table 9-3 presents the short-term vibration guideline values.

Table 9-3 Guideline Values for Vibration Velocity to be Used When Evaluating the Effects of Short-Term Vibration on Structures

Guideline Values for Velocity, vi(t)[1] [mm/s]				
Line	Type of Structure	Vibration at the Foundation at a Frequency of		
		1Hz to 10 Hz	10Hz to 50Hz	50Hz to 100Hz[2]
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design.	20	20 to 40	40 to 50
2	Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 to 8	8 to 10

Notes:

1 The term vi refers to vibration levels in any of the x, y or z axes.

2 At frequencies above 100Hz the values given in this column may be used as minimum values.

German Standard DIN 4150-2: 1999 provides guidance on safe vibration levels for buried pipe work. Table 10 within DIN 4150-2 details the limits for short-term vibration, as presented in Table 9-4.

Table 9-4 DIN 4150 Part 3 – Damage to Buried Pipes – Guidelines for Short-term Vibration

Pipe Material	Guideline values for velocity measured on the pipe (mm/s)
Steel (including welded pipes)	100
Clay, concrete, reinforced concrete, metal (with or without flange)	80
Masonry, plastic	50

9.2 Description of Environmental Values

9.2.1 Sensitive Noise Receptors

The land use in the vicinity of the Project (Rail) is rural in nature. Potential sensitive receptors identified within approximately 5 km of the Project (Rail) are listed in Table 9-5 and the locations shown in Figure 9-1 (refer Section 9.1.2). The proposed workers accommodation village and industrial precinct have also been included as sensitive receptors to the Project (Mine) operations.

Table 9-5 Potential Sensitive Receptors

Potential Receptors	Easting	Northing	Approximate Distance from the Project (Rail) (m)	Description/Comment
1	448007	7570210	2,450 (south)	Project (Mine) workers accommodation village
2	462027	7572602	3,300 (south)	Homestead
3	475674	7575617	3,000 (south)	Homestead
4	482139	7579957	3,000 (south)	Homestead
5*	494429	7589482	4,200 (north)	Homestead (Monitoring location A)
6	525174	7583086	2,000 (north)	Homestead
7	546218	7578704	1,600 (north)	Homestead
8	555680	7578811	3,000 (north)	Homestead
9*	561038	7577015	1,900 (north)	Homestead (Monitoring location B)

*Denotes monitoring location.

As Figure 9-1 shows, the area in the vicinity of the proposed Project (Rail) is sparsely populated with few identified potential sensitive receptors. The nearest identified sensitive receptor in relation to the Project (Rail) is approximately 1.6 km away.

9.2.2 Background Noise

Noise monitoring results at both monitoring locations are typical of a rural environment with low background noise levels, during day (7:00 am to 6:00 pm), evening (6:00 pm to 10:00 pm) and night (10:00 pm to 7:00 am) periods.

Unattended monitoring results are provided summarised in Table 9-6. Background noise levels during night-time periods consistently fall to below 25 dB(A) at Location A and to a lesser extent at Location B. The rating background level (RBL) for each period at Location A homestead is 25 dB(A), 27 dB(A) and 21 dB(A), for day, evening and night, respectively. At Location B homestead the RBL for each day, evening and night period, respectively, is 31 dB(A), 31 dB(A) and 27 dB(A).

The ambient noise level (L_{Aeq}) for each period, respectively, at Monitoring Location A homestead was recorded as 45 dB(A), 47 dB(A) and 44 dB(A). At Monitoring Location B homestead, the ambient noise level for each period, respectively, was recorded as 48 dB(A), 41 dB(A) and 43 dB(A).

Table 9-6 Summary of Unattended Noise Monitoring Results

Monitoring Location	Background L_{A90} dB(A)			Ambient L_{Aeq} dB(A)		
	Day (7:00 am – 6:00 pm)	Evening (6:00 pm – 10:00 pm)	Night (10:00 pm – 7:00 am)	Day (7:00 am – 6:00 pm)	Evening (6:00 pm – 10:00 pm)	Night (10:00 pm – 7:00 am)
Location-A	25	27	21	45	47	44
Location-B	31	31	27	48	41	43

Attended noise monitoring results are summarised in Table 9-6 and indicate that generally higher noise levels at Location B homestead can be attributed to the influence of birdlife and wind in foliage. Noise levels at Location A homestead were influenced by intermittent noise associated with cattle.

Table 9-7 Summary of Attended Noise Survey Results

Monitoring Location	Period Date	Duration (mins)	Time	dB(A) L90	dB(A) Leq	Comments (instantaneous Noise Levels dB(A))
Location-A	26/08/11	15	12:20	23.8	31.3	◗ Air conditioning unit barely audible (< 30) ◗ Insects (23-45) ◗ Cattle (27-41)
Location-B	26/08/11	15	15:30	28.5	37.0	◗ Birds (<30-40) ◗ Insects (<30-32) ◗ Cattle (35-37) ◗ Wind in foliage (34-41) ◗ Dog bark (45-46)

9.2.3 Background Vibration

Measured ground vibration results indicate very low ground vibration levels (in the order of 0.1 mm/s) at all locations which confirms the lack of perceivable vibration at all sites.

Baseline vibration results are tabulated in Table 9-8. Similar levels of existing ground vibration are expected along the length of the Project (Rail).

Table 9-8 Vibration Measurement Results – Peak Particle Velocity (mm/s)

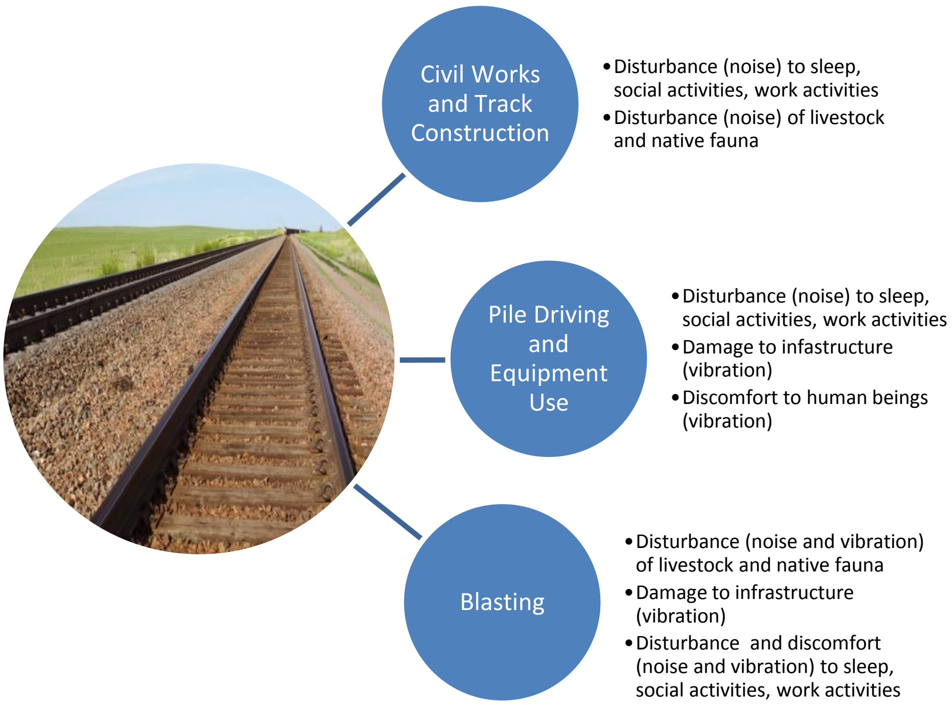
Monitoring Location	Date/Time	Direction			Sum	Observations
		Trans	Vert	Long		
Location-A	06/09/2011 08:22	0.0794	0.0635	0.0794	0.0926	No perceivable ground vibration
Location B	06/09/2011 07:25	0.0952	0.0794	0.0794	0.0966	No perceivable ground vibration

9.3 Potential Impacts and Mitigation Measures

The construction and operation of the Project (Rail) have the potential to cause noise and vibration impacts on the surrounding environment.

Potential construction impacts have been identified and analysed on the basis of a desktop analysis considering the construction methods and equipment proposed to be used. Figure 9-2 provides a conceptual overview of the potential construction impacts of the Project (Rail).

Figure 9-2 Conceptual Overview of Potential Impacts



9.3.1 Construction Phase

9.3.1.1 Civil Works and Track Construction

Potential Impact

Construction activities, such as civil works including: earthworks, drainage construction, haul road and access track construction, maintenance and bridgework construction as well as track construction (including: track laying, signalling installation and communications installation).

Civil works and track construction will have the potential to adversely impact on noise sensitive receptors through:

- Disturbance to sleep, social activities and/or work activities
- Disturbance of native fauna and livestock

The predicted construction noise for combined plant operation during each activity has been calculated at increasing distances from the Project (Rail) and is shown in Table 9-9. Noise generated by construction plant dissipates over distance. Predicted noise levels at a one kilometre distance from the Project (Rail) range from 49 dB(A) to 53 dB(A). At a three kilometre distance, the range is 39 dB(A) to 44 dB(A). Construction activities such as impact piling are predicted to generate the highest sound pressure levels at distance.

Table 9-9 Predicted Construction Noise over Distance, dB(A)

Activity	Overall sound power level dB(A)	Distance (m)						
		50	100	250	500	1000	2000	3000
Civil Works[1]	119	77	71	63	57	51	45	41
Track Works	121	79	73	65	59	53	47	44
Quarries and Borrow Pits	117	75	69	61	55	49	43	39

1 Excludes pile driving impact noise

The two nearest sensitive receptors to the Project (Rail) are at distances of 1.6 km and 1.9 km, respectively. Predicted construction noise levels at these receptors are provided in Table 9-10. Minimum predicted noise levels at these locations are in the order of 38 dB(A). Maximum predicted noise levels are in the order of 49 dB(A), excluding impact piling activities. Impact piling is predicted to generate higher noise levels in the order of 61 dB(A), however is largely confined to civil works associated with river crossings.

Table 9-10 Predicted Construction Noise for the Nearest Sensitive Receptors dB(A)

Receptor	Distance from investigation corridor (m)	Civil works (excluding impact piling)	Track Works	Impact Piling
1	2,450	43	45	57
2	3,300	40	43	55
3	3,000	41	44	55
4	3,000	41	44	55
5	4,200	38	41	53
6	2,000	45	47	59
7	1,600	46	49	61
8	3,000	41	44	55
9	1,900	45	48	59

The daytime background noise level in the vicinity of the nearest sensitive receptors is typical of a rural setting and measured to be in the order of 31 dB(A). The ambient daytime noise level is in the order of 48 dB(A).

The adopted WHO criteria for night-time sleep disturbance of 55 dB(A) L_{max} external to the dwelling is predicted to be met at all receptors, expect for when impact piling is used. The use of impact piling will be restricted to day-time hours only (refer Section 9.1.2.2).

Given the intermittent, mobile and short-term nature of construction noise, the estimates are considered conservative. They represent the maximum possible distances over which an acoustic impact may be observable during quiet ambient conditions. If such impacts were to occur, they would likely be intermittent and infrequent. Furthermore, the construction of the rail track is transient in nature, exposing individual receptors for short periods of time (usually in the order of days or weeks). Noise impacts would reduce as the rail construction progresses along the route away from receptors.

Based on the above findings, it is not anticipated that construction of the rail corridor will cause adverse noise impacts at identified receptors.

Management and Mitigation Measures

While construction noise levels are unlikely to cause adverse impacts, it is considered that implementation of management measures will further facilitate minimisation of potential impacts arising from the construction of the Project (Rail). In particular noise controls should be implemented during high noise generating activities, such as pile driving, or when construction activities are required to be undertaken outside of the standard daytime working hours.

The following reasonable and practical measures will be considered (having due regard for operational health and safety constraints) in developing ways to minimise the potential of unreasonable noise during the construction of the Project (Rail):

- Locate mobile plant (e.g. compressors, generators), concrete batching plants and construction camps as far as practicable away from the nearest potential sensitive receptors
- Construction activities generating noise above ambient levels in the vicinity of the nearest noise sensitive places (within 2 km of the Project (Rail)) should, wherever possible and practicable, be confined to general work hours of 6:30 am – 6.30 pm Monday to Sunday
- Where it is necessary for such activities to be carried out outside standard day-time working hours, potentially impacted receptors will be notified in advance of the activities (at least one week before)
- Due to the potential for sleep disturbance, it is recommended that, impact pile driving should only be undertaken during the “standard day-time working hours” listed above unless prior consultation has occurred with potentially affected sensitive receptors
- Direct principal noise sources (e.g. exhausts) away from noise-sensitive places as far as possible
- Fitting of equipment with effective and properly maintained noise suppression equipment consistent with the requirements of the activity, where possible
- Ensure equipment utilised is maintained and operated as per manufacturers’ specifications
- Minimise the use of warning devices to within operational health and safety constraints
- Co-ordination of loading/unloading of material activities to be within standard day-time working hours wherever practicably possible
- Encourage construction operators to have equipment that includes noise performance as a selection criterion at the time of purchase
- Refine construction noise and vibration predictions (as necessary) once a construction methodology for detailed design has been determined and implement and manage further controls through development of a Construction Noise Management Plan

9.3.1.2 Pile Driving and Use of Construction Equipment

Potential Impact

While blasting normally generates the highest levels of ground vibration, construction activities and equipment such as pile driving can also lead to high vibration levels resulting in infrastructure damage. Assessment of potential vibration impacts is needed to minimise potential adverse impacts on the surrounding sensitive receptors. Ground vibration caused by blasting is addressed below.

The predicted ground vibrations at various distances for typical construction equipment are shown in Table 9-11.

Table 9-11 Predicted Construction Equipment Vibration Levels

Plant Item[1]	Human Perception Preferred Criteria *(Maximum Criteria)*		Predicted Ground Vibration Levels (mm/s PPV)				
	Day	Night	10 m	30 m	50 m	100 m	300 m
Pile Driving (Impulsive)	8.6 *(17.0)*	2.8 *(5.6)*	21.0	4.0	1.9	0.7	0.1
15t Roller	0.28 *(0.56)*	0.2 *(0.4)*	7.5	1.4	0.7	0.2	<0.1
Dozer	0.28 *(0.56)*	0.2 *(0.4)*	3.3	0.6	0.3	0.1	<0.1
7t compactor	0.28 *(0.56)*	0.2 *(0.4)*	6.0	1.2	0.5	0.2	<0.1
Rock Breaking	0.28 *(0.56)*	0.2 *(0.4)*	7	1.3	0.6	0.2	<0.1
Backhoe	0.28 *(0.56)*	0.2 *(0.4)*	1	0.2	0.1	<0.1	<0.1

Table 9-11 indicates vibration levels of 0.1 mm/s or less at a distance of approximately 300 m. This is well below the adopted vibration criteria for all nominated plant items, including pile driving. The nearest identified sensitive receptor to the Project (Rail) is located 1.6 km from the rail corridor. Therefore, it is unlikely that ground vibration as a result of construction activities and equipment (excluding blasting) will adversely impact potentially sensitive receptors.

Furthermore, vibration levels produced by construction activities within the rail corridor are expected to be well below the most stringent structural damage criteria of 3 mm/s at receptors located at distances greater than 50 m.

Management and Mitigation Measures

While construction vibration levels are unlikely to cause adverse impacts, it is considered that implementation of the following management measures will further facilitate minimisation of potential impacts arising from the construction of the Project (Rail):

- Where required, undertake pre-construction building and infrastructure surveys on properties potentially susceptible to vibration damage from construction of the railway
- Monitor vibration levels during construction to prevent sustained vibration levels causing unacceptable loading

[1] NSW RTA Environment noise management manual

9.3.1.3 Blasting

Potential Impact

The need for blasting is not yet determined and is dependent on further geotechnical investigations. It is however, not considered likely at this stage for the Project (Rail). In the event that blasting is required for excavations of sections of the Project (Rail) the most likely effect is airblast overpressure.

Potential adverse impacts to sensitive receptors may include:

- Disturbance of native fauna and livestock
- Damage to property and infrastructure as a result of vibration

Blast impacts (airblast overpressure and ground vibration) have been predicted at sensitive receptors, based on a Maximum Instantaneous Charge (MIC) of 50 kg and are shown in Table 9-12.

Predictions indicate that with a MIC of 50 kg and average ground conditions, the ground vibration criterion is met at all receptors. Predicted airblast overpressure levels have the potential to exceed the recommended blasting criteria by 2.5 dB(L) at the nearest sensitive receptor under adverse conditions (k_a = 100), if blasting was to take place at the closest location to this sensitive receptor.

While blasting is considered unlikely to cause adverse impacts to potentially sensitive receptors, potential blasting mitigation measures are provided.

Table 9-12 Predicted Blast Impacts

Receptor	Distance from Project (Rail) (m)	Estimated Airblast Overpressure, dB(Linear)*		Estimated Ground Vibration, PPV (mm/s)*	
		k_a = 10	k_a = 100	K_g = 800	K_g = 1600
1	2,450	92.1	112.1	0.1	0.1
2	3,300	88.4	108.4	0.0	0.1
3	3,000	89.6	109.6	0.0	0.1
4	3,000	89.6	109.6	0.0	0.1
5	4,200	85.3	105.3	0.0	0.1
6	2,000	94.7	114.7	0.1	0.2
7	1,600	97.5	117.5	0.1	0.3
8	3,000	89.6	109.6	0.0	0.1
9	1,900	95.3	115.3	0.1	0.2
Adopted criteria		115 dB(L)		5 mm/s PPV	

*Based on MIC 50 kg.

Management and Mitigation Measures

If required, blasting noise and vibration levels may be reduced by application of the following[2]:

- Reducing the MIC by using delays, reduced hole diameter and/or deck loading
- Changing the burden and spacing by altering the drilling pattern and/or delay layout, or altering the hole inclination
- Exercise strict control over spacing and orienting all blast drill holes
- Use minimum practicable sub-drilling which gives satisfactory toe conditions
- Investigate alternative rock-breaking techniques
- Establish times of blasting to suit local conditions
- Direction of detonator initiation away from near residences
- Once the exact location of blasting is known the distance to any potential receptors should be used for the charge mass estimate. Blast monitoring should be undertaken to assess compliance, determine the site constants and confirm the predictions. The blast design should ensure that the airblast overpressure and ground vibration limits are met at sensitive receptors.
- Undertake blasting only during standard day-time work hours. Adverse meteorological conditions such as temperature inversions and wind direction can significantly increase airblast overpressure levels. Temperature inversions are most common during night and early morning periods, therefore should not affect blasting during the recommended standard hours.
- Undertake airblast overpressure monitoring during the initial blasts to assist with the optimisation of the blast parameters and confirmation of predictions. MIC and stemming height together with other blast parameters should be modified to achieve the airblast criteria.

9.3.2 Operation Phase

Potential Impact

Train movements have the potential to adversely impact on noise sensitive places through:

- Disturbance to sleep, social activities and/or work activities
- Disturbance of native fauna and livestock

Predicted results indicate that at the most affected sensitive receptor, operational rail noise levels are in the order of 14 dB(A) and 25 dB(A) below the acceptable noise criteria for steady sound levels and single event maximum sound levels, respectively. Noise levels at sensitive receptors are predicted to range between 40 - 51 L_{Aeq}, 24hr dB(A) and 51 - 62 L_{Amax} dB(A). Therefore, predicted rail noise levels are compliant with the Code of Practice for Railway Noise Management (QR, 2007) at all existing identified sensitive receptors, falling below the 65 L_{Aeq},24hr dB(A)and 87 L_{Amax} dB(A) criteria.

Table 9-13 shows predicted rail noise levels at identified noise sensitive receptors. Noise modelling contours are provided in Volume 4 Appendix AF for the proposed 100 Mtpa development scenario.

[2] It must be acknowledged that the design of the blast is undertaken by the appointed blast contractor and that the management measures are assumed only for the purpose of this assessment, and in the absence of more specific information.

Given the nearest sensitive receiver is 1.6 km from the Project (Rail), it is unlikely there would be adverse impact regarding operational vibration. Furthermore, recent vibration testing of coal trains in the Hunter Valley has indicated that there is low probability of adverse impact upon the human comfort or structures when located more than 40 m from the rail line (Vipac, 2009). Operational rail related vibration is expected to be negligible at all identified receptors.

Table 9-13 Comparison of Predicted Noise Levels at Identified Sensitive Receptors

Potential Sensitive Receptor	$L_{Aeq,24hr}$ dB(A)		L_{Amax} dB(A)	
	Noise Criteria*	Predicted Noise Level	Noise Criteria*	Predicted Noise Level
1		48		59
2		45		56
3		45		56
4		45		56
5	65	40	87	51
6		49		61
7		51		62
8		43		54
9		48		61

* Code of Practice for Railway Noise Management (QR National, 2007)

Management and Mitigation Measures

While predicted noise levels are compliant with the adopted QR criteria, it is considered that the following management measures (in line with the Code of Practice for Railway Noise management (QR, 2007)) will further facilitate minimisation of potential impact arising from the operation of the Project (Rail):

- Appropriate use of horns and warning devices will be included within driver training
- Maintenance activities and potential noise from maintenance facilities will be managed through operational controls developed specifically for the sites (e.g. maintenance yard, bad order sidings) and documented in a Noise Management Plan. Measures may include, for example, regular maintenance of equipment to facilitate operation within acceptable sound and vibration limits; limiting the dropping of containers and materials from heights; improved training and induction with regard to noise and vibration; reduce unnecessary revving and idling of engines; direct noise sources away from potential noise receptors; and locate mobile plant away from potential noise receptors as far as is practicable.
- Refine further noise modelling as the Project (Rail) design progresses and develop additional controls as appropriate. Although control measures would not be expected to be required, such measures may include installation of noise barriers and construction of embankments to deflect noise.

9.3.3 Terrestrial and Aquatic Fauna

Current research indicates that there are no government policies or widely accepted guidelines with regard to noise criteria for animals. However, information is provided in technical literature which is discussed below.

9.3.3.1 Native Fauna

The effect of noise on wildlife can be similar to the effects observed in humans. Noise can adversely affect wildlife by interfering with communication, masking the sounds of predators and prey, cause "stress" or avoidance reactions and (in the extreme) result in temporary or permanent hearing damage. Experiments have also shown that exposure to noise impulses throughout the night-time sleep period resulted in poorer daytime task performance by animals (see Fletcher & Busnel, 1978).

The learning ability of many animal species is discussed by Busnel (1971). The animal's initial reaction to a new noise source is fright and avoidance but if other sensory systems are not stimulated (for instance optical or smell), the animal learns quite quickly to ignore the noise source, particularly when it exists in the presence of man.

Migratory birds have the potential to be influenced by noise from the Project (Rail). Studies of birds (Larkin, 1996) have shown that they will habituate to loud noises that are not biologically meaningful for them. For example if the noise is associated with possible harm such as thunder on a cloudy day, birds will avoid it, but routine noises such as traffic will not disturb them. Examples are provided of sea-birds that voluntarily co-exist with relatively loud noise environments, such as around airports, and birds roosting on light-posts above busy motorways.

Attempts at using noise to deliberately scare birds away from an area, for example to protect farming crops, have been shown to grow less effective over time as birds habituate to the noise. Larkin suggests that keeping the noise as consistent as possible both in the sound produced and the frequency with which it occurs may also help mitigate its effects on birds.

Poole (1982) and Algers *et al* (1978) shows that birds tend to adapt to steady state noise levels, even of a relatively high level (in the order of 70 dB(A)). Given the predicted noise levels from the Project (Rail) are expected to be much less than this level, noise impacts on birds surrounding the Project (Rail) are considered acceptable.

9.3.3.2 Livestock

The noise goals provided in this report are based on human response and annoyance factors and, as such, are not applicable to livestock or other non-human receivers. However, it is recognised that sudden noise has the potential to startle or upset domestic livestock and pets. Heggies Pty Ltd conducted a literature review as part of their assessment of blasting noise impacts on livestock for the proposed Caval Ridge Coal Mine Project (Heggies, 2009). Heggies cites results from a study on the response of farm animals to sonic booms, which indicated that reactions of sheep, horses and cattle to sonic booms (125 dB to 136 dB) were considered slight to mild.

The study indicated that analysis of data from 42 herds did not show any evidence that flyovers or proximity to the ends of the active runways had an effect on the milk production of the herds. Animal installations were selected for observations on animal behaviour under sonic boom conditions. Numbers of animals observed in this study were about 10,000 commercial feedlot beef cattle, 100 horses, 150 sheep and 320 lactating dairy cattle. Booms during the test period were scheduled at varying intervals during the morning hours Monday to Friday of each week.

Results of the study showed that the reactions of the sheep and horses to sonic booms were slight. Dairy cattle were little affected by sonic booms (125 dB to 136 dB). Only 19 of 104 booms produced even a mild reaction, as evidenced by a temporary cessation of eating, rising of heads, or slight startle effects in a few of those being milked. Milk production was not affected during the test period, as evidenced by total and individual milk yield.

Heggies conclude that apart from the possibility of noise from blasting startling birds and therefore over time possibly changing where they nest, no adverse impacts on animals are predicted for this project. Given that there is no conclusive information available to confirm that should birds be startled they will change where they nest, noise impacts on animal life surrounding the Project (Rail) are considered acceptable.

9.4 Summary of Noise and Vibration Assessment

The potential noise and vibration impacts resulting from the construction and operation of the Project (Rail) was assessed.

Given the separation distance between construction work and the nearest sensitive receptors it is unlikely that any adverse noise impacts will occur during construction works. Calculations indicate construction activities such as impact piling will generate the highest sound pressure levels at distance.

Mitigation measures to minimise construction noise are outlined in Section 9.3.1. It is recommended that these are considered and implemented if high noise generating activities such as impact piling are conducted outside standard day-time working hours.

Vibration levels produced by rail corridor construction activities are expected to be well below the most stringent structural damage criteria of 3 mm/s at all identified receptors.

Given the distance to the nearest sensitive receptors, noise and vibration impacts from blasting are unlikely to occur under the majority of scenarios, under worst-case conditions it has been predicted that a marginal exceedance of the airblast overpressure criteria may occur at the nearest sensitive receptor when blasting is conducted at the closest point of the Project (Rail) to the receptor. Blasting mitigation measures have been recommended to assist in reducing the magnitude of the noise and vibration levels as well as the perception of vibration at sensitive locations. It is recommended that blast monitoring be considered to assess compliance and confirm the predictions and all residential receptors be informed when blasting is to be undertaken.

The assessment indicates that rail noise levels from the proposed corridor are expected to meet the 65 dB(A) $L_{Aeq,24hrs}$ and 87 dB(A) L_{max} noise targets at all identified sensitive receptors. Similarly, operational vibration targets will readily be met at all identified receptors.