7. Air Quality

This section provides a summary of the air quality assessment 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 air quality report is included in Volume 4 Appendix AD Rail Air Quality Assessment.

7.1 Introduction

7.1.1 Approach

The potential for the Project (Rail) to impact air quality has been assessed by:

- Identifying the environmental values to be protected or enhanced
- Determining the indicators associated with project emissions that have the potential to compromise the environmental values. For the assessment of air quality impacts associated with the Project (Rail), the most important air pollutant of concern is particulate matter
- Considering the existing air quality in the region
- Predicting ground-level concentrations of air pollutants in the surrounding areas, due to the Project (Rail) construction and operations, using emission estimation and air dispersion modelling techniques that have been approved for use by the environmental regulators
- Comparison of incremental and combined pollutant ground-level concentrations against the air quality objectives identified for the Project (Rail)

7.1.2 Study Area

For the purposes of the Project (Rail) air quality assessment, the alignment has been divided into three sections. Modelling to assess potential impacts as a function of distance away from the alignment has been undertaken for each section. Site specific meteorological datasets for each section of the Study Area were developed and validated against the regional climatic conditions. The sections are illustrated in Figure 7-1 and defined as:

- Western section – Project (Mine) to the Cassiopeia homestead (chainage 185 km – 137 km)
- Central section – Cassiopeia homestead to Diamond Creek (chainage 137 km – 69 km)
- Eastern section – Diamond Creek to the rail connection with the QR National rail system, south of Moranbah (chainage 69 km – 0 km)

7.1.3 Air Quality Assessment Criteria and Environmental Values

The Environmental Protection (Air) Policy 2008 (Air EPP) applies to the air environment of Queensland and identifies the environmental values to be enhanced or protected in the state. The environmental values to be enhanced or protected relate to:

- The health and biodiversity of ecosystems

- Human health and wellbeing
- Aesthetics
- Agricultural use

Schedule 1 of the Air EPP defines air quality objectives for indicators such that environmental values are enhanced or protected.

National air quality standards and goals are specified by the Environment Protection and Heritage Council, formerly known as the National Environment Protection Council (NEPC). The National Environment Protection (Ambient Air Quality) Measure (Air NEPM) specifies national ambient air quality standards and goals for six criteria air pollutants – nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), ozone, particulates (as PM_{10} and $PM_{2.5}$) and lead. The National Environment Protection (Air Toxics) Measure (Air Toxics NEPM) provides monitoring investigation guidelines, principally for large cities with significant traffic emissions, for five compounds classified as air toxics – benzene, benzo(a)pyrene, formaldehyde, toluene and xylenes.

Air quality standards, goals and monitoring investigation levels of indicators specified in the Air NEPM and Air Toxics NEPM have been adopted as air quality objectives in the Air EPP.

The most important air pollutant associated with emissions from the Project (Rail) is particulate matter. Particulate matter can impact each of the environmental values identified in the Air EPP, particularly human health and wellbeing (as respirable fine particles) and amenity (as deposited dust). For this assessment, several size fractions of particulate matter have been assessed as total suspended particulate (TSP), PM_{10}, $PM_{2.5}$ and deposited dust.

Odorous air emissions are not generally associated with locomotives and coal haulage as the concentrations of odorous substances such as NO_2, SO_2 and volatile organic compounds (VOCs) have relatively low odour thresholds and are generally not detected at concentrations below their health-related air quality objectives. Consequently, odour impacts have not been considered further in the assessment.

Impacts to air quality have been assessed against the relevant Air EPP objectives for particulate matter. The objectives of TSP, PM_{10} and $PM_{2.5}$ are compared against the cumulative air quality impact of the Project (Rail) combined with the ambient background level. Due to the rural location and large separation distances between the rail line any significant sources of combustion related emissions, similar to that which are released from locomotives (NO_2, SO_2, CO and VOCs), such as industrial areas and urban centres, the background concentrations of these substances was considered to be negligible. For the purposes of the air quality impact assessment, combustion related gaseous emissions have been assessed in isolation with the background concentrations assumed to be zero.

Air quality objectives for deposited dust are not included in the Air EPP. In these circumstances, it is appropriate to review air quality standards and goals in other national and international jurisdictions to obtain a suitable assessment criterion. For the assessment of deposited dust, the NSW Office of Environment and Heritage (OEH) impact assessment criterion has been used. The NSW OEH *Approved methods for the modelling and assessment of air pollutants in NSW* (2005) document provides impact assessment criteria for a project's incremental contribution of deposited dust at sensitive receptor locations of 2 g/m^2/month (insoluble solids, annually averaged), as well as a maximum total deposited dust level of 4 g/m^2/month (insoluble solids, annually averaged) inclusive of

background. The NSW Approved Methods assessment criteria of 4 g/m^2/month is equivalent to 130 mg/m^2/day, while the Queensland DEHP recommended amenity guideline is 120 mg/m^2/month.

The air quality objectives and criteria used in the assessment are presented in Table 7-1.

Table 7-1 Air Quality Objectives and Assessment Criteria used in the Assessment

Indicator	Environmental value	Air Quality Objective	Period
TSP	Health and wellbeing	90 µg/m^3 [a]	1 year
PM_{10}	Health and wellbeing	50 µg/m^3 [a] [b]	24 hours
$PM_{2.5}$	Health and wellbeing	25 µg/m^3 [a]	24 hours
		8 µg/m^3 [a]	1 year
Deposited Dust	Protecting aesthetic environment	2 g/m^2 [c] [d]	1 month
		4 g/m^2 [c] [e]	1 month
Benzene	Health and wellbeing	10 µg/m^3 [a]	1 year
Carbon Monoxide	Health and wellbeing	11,000 µg/m^3 [a]	8 hours
Formaldehyde	Health and wellbeing	54 µg/m^3 [a]	24 hours
	Protecting aesthetic environment	110 µg/m^3 [a]	30 minutes
Nitrogen dioxide	Health and wellbeing	250 µg/m^3 [a] [f]	1 hour
		62 µg/m^3 [a]	1 year
	Health and biodiversity of ecosystems	33 µg/m^3 [a]	1 year
Sulphur dioxide	Health and wellbeing	570 µg/m^3 [a] [f]	1 hour
		230 µg/m^3 [a] [g]	1 day
		57 µg/m^3 [a]	1 year
	Protecting agriculture	32 µg/m^3 [a]	1 year
	Health and biodiversity of ecosystems (for forests and natural vegetation)	22 µg/m^3 [a]	1 year
Toluene	Health and wellbeing	4,100 µg/m^3 [a]	24 hours
		4,10 µg/m^3 [a]	1 year
	Protecting aesthetic environment	1,100 µg/m^3 [a]	30 minutes
Xylenes	Health and wellbeing	1,200 µg/m^3 [a]	24 hours
		950 µg/m^3 [a]	1 year

[a] Queensland Air EPP (2008)
[b] Five exceedances of the 24-hour average are allowed
[c] NSW Approved Methods for the modelling and assessment of air pollutants in NSW (2005)
[d] Maximum increase in deposited dust level, based on annual average of monthly observations
[e] Maximum total deposited dust level, based on annual average of monthly observations
[f] A one hour exceedance is allowed on one day each year
[g] One exceedance of the 24-hour average is allowed

7.2 Description of Environmental Values

7.2.1 Ambient Air Quality and Monitoring

7.2.1.1 Overview

Ambient air quality monitoring is generally carried out in regions of significant population and where that population may be exposed to significant quantities of air pollutants from a range of sources such as motor vehicle traffic and industry including mining. The location of the Project (Rail) corridor in central Queensland is remote and well separated from population centres that would contribute significant levels of air pollutants above ambient conditions such as gaseous air pollutants emitted from industrial and motor vehicle fuel combustion sources. Conversely, the location of the Project (Rail) in a dry, inland environment means the ‘natural’ dust load is considered to be important for the assessment.

No background air quality monitoring had been conducted in the Project (Rail) corridor prior to the preparation of this impact assessment. A review of publicly available data for central Queensland has been carried out to provide background concentrations for use in the cumulative air quality impact assessment.

7.2.1.2 Particulates

Region specific ambient background concentrations of PM_{10} were determined for use in the cumulative air quality impact assessments at the western and eastern ends of the Project (Rail). For the Moranbah area at the eastern end of the Project (Rail), information published in the Caval Ridge Coal Mine Air Quality Impact Assessment Report (URS, 2009) was used. Based on an 18 month monitoring period, a 70^{th} percentile statistic of 18.8 µg/m^3 was applied as a background concentration of PM_{10}. For comparable monitoring sites in the Galilee Basin, a 70^{th} percentile PM_{10} value of 11.0 µg/m^3 was found to be suitable for use in the cumulative assessment of the western end of the rail corridor.

Due to the lack of regionally specific data for TSP and $PM_{2.5}$, comparable background data was derived using suitable PM_{10} to TSP and $PM_{2.5}$ to PM_{10} ratios. The United State Environmental Protection Agency (USEPA, 1998) suggests a PM_{10} to TSP ratio of 50 per cent is applicable for ambient conditions such as those found in the Project (Rail) area. This is due to an inland Queensland region that experiences a higher proportion of suspended particulates originating from soil disturbance, rather than industrial or combustion emission sources that generate a higher ratio of fine and ultrafine particulates less than 2.5 µm . The assumed level for background TSP has been set at 37.6 µg/m^3 for the eastern end of the Project (Rail) and 22.0 µg/m^3 for the western end.

For the respirable particle fraction of $PM_{2.5}$, background $PM_{2.5}$ level has been set at a ratio of 30 per cent to the background PM_{10} level. This is based on a lower estimate from NEPC work that found that the ratio varies “*depending on season and location, and can range from 0.3 to 0.9*” (NEPC, 2002). The lower end of the spectrum is justified in assessing the Project (Rail) since soil dust sources in this agricultural/grazing environment are remote from urban populations involving high emission contributions from combustion process, including vehicles. The assumed level for background $PM_{2.5}$ has therefore been set at 5.6 µg/m^3 for the eastern end of the Project (Rail) and 3.3 µg/m^3 for the western end.

Since the dust deposition criterion involves insoluble matter averaged over a 30 day period (equivalent to an average deposition rate of 130 mg/m^2/day), measurements of these were sought in available literature. Data from the Ensham Central Project (Katestone Environmental, 2006), located within the Bowen Basin, has been used. This project is to the east and has been applied to the eastern portion of the Project (Rail). The rolling annual average from a site that showed consistently lower deposition rates had a range from 0.09 to 1.6 g/m^2/month. The higher end of the range would be suitable for the eastern section of the Project (Rail) with the lower level assumed representative for the western section.

7.2.1.3 Gaseous Compounds

Due to the inland location and lack of any concentrated form of emission sources (such as industrial, urban or combustion sources), the ambient background levels of gaseous pollutants was considered to be negligible, at a level of zero.

7.2.1.4 Odorous Compounds

Due to the inland location and lack of any concentrated form of emission sources (such as intensive animal husbandry or waste water), the ambient background levels of odours was considered to be negligible, at a level of zero.

7.2.2 Local Meteorology

7.2.2.1 Overview

The Project (Rail) is 189 km and stretches across inland central Queensland from the Project (Mine) in the west toward Moranbah to the east, connecting with the Goonyella rail system south of Moranbah. There is expected to be some variability in the climate and prevailing meteorology between the east and west of the Project (Rail). The western end near the Project (Mine) is situated in the drier, inland of central Queensland while the eastern end near Moranbah is situated closer to the range and east coast. The available climatic statistics indicate that the eastern end of the Project (Rail) is considered as a 'sub-tropical' climate and, due to the inland nature of the region skewing rainfall monthly totals to summer (wet season) rather than winter (dry season), there is a sub-classification of ‘moderately dry winter’.

The available climatic statistics also show that while the western end is close to a grassland (hot winter drought) climate, as found at Hughenden, the Carmichael climatic record for monthly rainfall averages suggest that the western end of the Project (Rail) is still within the ‘sub-tropical’ classification as found to the east.

7.2.2.2 Air Temperature and Relative Humidity

The temperature regime at the eastern end of the Project (Rail) has been characterised using BoM information collected at Moranbah Water Treatment Plant. The range in monthly mean temperatures at Moranbah indicate daytime summer temperatures are mostly in the low to mid 30s, while the lowest temperatures occur during winter nights, dropping to between 5 and 15^{o}C with a mean centred near 10^{o}C. The temperature records of the last 24 years show values ranging from 2^{o}C to 45.0^{o}C. ‘Hot days’, with temperatures exceeding 35^{o}C, can be expected up to 51 days per year. ‘Frost days’, with temperatures below 2^{o}C are rare with an expected return rate of less than once per year.

Relative humidity is highest in the mornings and during the month of February and lowest in the late spring (September and October) mornings and afternoons.

The temperature regime at the western end of the Project (Rail) has been characterised using BoM information collected at Twin Hills Post Office. The range in monthly mean temperatures at Twin Hills indicate daytime summer temperatures are mostly in the low to mid 30s with winter overnight temperatures dropping to between 5 and 10^{o}C. The temperature record of approximately 20 years shows values ranging from -3.2^{o}C to 43.8^{o}C. 'Hot days', with temperatures exceeding 35^{o}C, can be expected up to 75 days per year. 'Frost days', with temperatures below 2^{o}C can be expected up to 10 days per year. Relative humidity is highest in the mornings and during the month of March and lowest in the late spring mornings and afternoons. Not surprisingly, the gradient of temperature and humidity from east to west suggests a hotter summer (24 extra 'hot days' at Twin Hills compared to Moranbah) and colder winter nights associated with a drier climate (lower humidity) moving further away (westward) from the coast.

7.2.2.3 Rainfall

Analysis of rainfall statistics from the Moranbah Water Treatment Plant, Twin Hills Post Office and Carmichael (BoM, 2011) indicate a clear pattern of decreasing rainfall moving inland. The rain record from the Carmichael site is limited (2003 to 2010 with several incomplete monthly records), however, the records indicate annual rainfall in the range of 252 to 700 mm, with an average during complete years of 457 mm. The annual sum of monthly averages is 524 mm. Hughenden is further north-west, and hence inland and in a Grassland climate (rather than subtropical) with an annual average of 492 mm. This suggests that the Carmichael rain record to date is on the dry side and the reality may be closer to the higher estimate above rather than the lower. Even at 500 to 530 mm of annual rain, the western end of the Project (Rail) is drier by at least 20 per cent than experienced at Twin Hills and Moranbah to the east.

Twin Hills has an annual average rainfall of 610 mm over an 80 year record while Moranbah averaged 604 mm over 38 years. The range of annual rainfall at Twin Hills is 218 mm to 1,477 mm, and at Moranbah is 281 mm to 1,109 mm per year.

The annual mean rainfall at all three sites is dominated by convectively driven rainfall during the warmer months. December through February rainfall accounts for 57 per cent of the annual mean rainfall at Carmichael, 50 per cent at Twin Hills and 51 per cent at Moranbah.

7.2.2.4 Wind Speed and Direction

There is limited Automatic Weather Station (AWS) information from BoM sites along the Project (Rail) corridor. A comparison of the annual distributions of winds in the wider region has been provided in Volume 4 Appendix AD Rail Air Quality Assessment. The winds have been derived through meteorological modelling at Cassiopeia (west) and Moranbah (east). The distributions indicate that the east-south-east trade winds have become more evenly spread through the eastern directions as the trade winds move further inland away from the coastal influences. This may also be a reflection of how often the Queensland inland trough is found to influence the more eastern site rather than on the drier inland side of the trough out to the west. The assessment of winds illustrates how the wind regime subtly changes across the wider region. It can also be seen that the model has performed well in simulating the dominant easterly wind patterns.

7.2.2.5 Atmospheric Stability

Atmospheric stability describes the vertical movement of air and can be classified into six categories according to the Pasquill-Gifford scheme:

- A, B and C for unstable conditions (very, moderate and slight, respectively)
- D for neutral stability
- E and F for stable conditions (moderate and slight, respectively)

Nocturnal conditions are dominated by F-class stability due to the prevailing light winds (36.4 per cent and 31.2 per cent of the year at Cassiopeia and Moranbah, respectively). Under these conditions, air pollutants are emitted into an atmosphere where plume dispersion is relatively poor due to the light wind stable conditions. During the day, unstable conditions occur for 39.6 per cent and 37.8 per cent of the time at Cassiopeia and Moranbah, respectively. At Moranbah, the prevailing winds are predominantly from the east-southeast, while at Cassiopeia, the unstable conditions are spread wider with winds having components from both the south-east and north-east quadrants. During unstable conditions, the vertical movement of air driven by convective process raises the height of the mixed layer and provides for conditions that are more favourable for the dispersion of ground level fugitive sources such as coal trains. Notwithstanding this, as the wind speed increases, mechanical mixing processes are increased along with the rate of emission from fugitive dust sources.

7.2.2.6 Mixing Height

The height of the mixed layer is an indicator of vertical dispersion potential of the atmosphere and is a mixture of mechanical and convective influences. Convective conditions dominate during the day in a near desert climate especially as temperatures are often high in summer. Even the sub-tropical climate in winter has daytime temperatures often above 20^{o}C. Conversely, the night-time mixing height is dominated by the formation of temperature inversions on the vast majority of nights with associated F-class stability.

For the derived mixing heights at Cassiopeia and Moranbah, following can be noted:

- The eastern site has a higher mean wind speed (3.58 m/s compared to 2.71 m/s) which produces more mechanical mixing
- Minimum daytime mixing heights were in the range of 50 to 640 m. This is reasonable considering at least some days are likely to be cloudy and overcast
- Night-time mixing heights were as low as 50 m during the calmest periods but could reach to above 1,500 m during nights with strongest winds

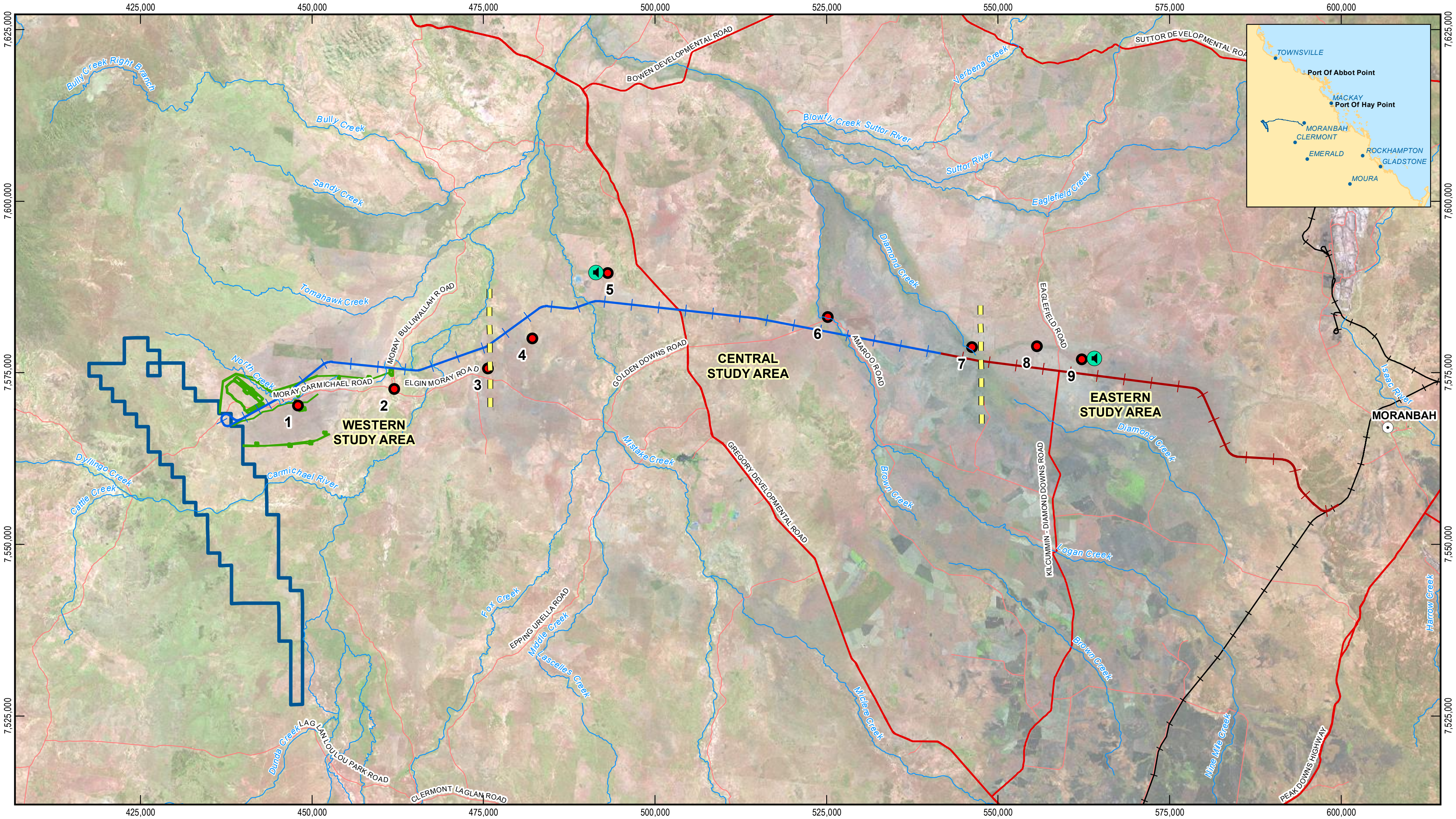
7.2.3 Sensitive Receptors

Nine sensitive receptors were identified within a distance of 5 km of the Project (Rail) corridor. The sensitive receptor locations are detailed in

Table 7-2 and Figure 7-1. The nearest receptor to the Project (Rail) is situated 1.6 km to the north of the rail line. To the south side of the railway line, the nearest receptor is the mine workers accommodation village at a distance of 2.45 km.

Table 7-2 Summary of 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 camp
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
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



1:750,000 (at A4)

0 5 10 15 20 25

Kilometres

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

N

LEGEND

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

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Project (Rail) Study Area
and Potential Sensitive Receptors

Job Number	41-25215
Revision	B
Date	11-09-2012

Figure 7-1

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

7.3 Potential Impacts and Mitigation Measures

7.3.1 Overview

The construction and operation of the Project (Rail) has the potential to cause air quality impacts on the surrounding environment. Potential impacts have been identified and analysed on the basis of a desktop analysis combined with modelling based on the construction and operation methods, regimes and equipment proposed to be used.

7.3.1.1 Dispersion Modelling

The line-source Gaussian model AUSROADS V1.0 was used to predict ground-level pollutant concentrations for the assessment of impacts to air quality. The Project (Rail) was split into three sections for modelling to assess impacts as a function of distance away from the alignment. This methodology was selected as the nearest known sensitive receptor to the alignment is more than 1 km away at a distance of 1.6 km.

7.3.1.2 Assessment Scenarios

The air quality impact assessment has been made for:

- Particulate matter associated with locomotive combustion engines combined with coal wagon fugitive releases. A cumulative assessment of particulate matter as TSP, $PM_{10,}$ $PM_{2.5}$ and dust deposition from the Project (Rail) has been made with the inclusion of background levels
- All other air pollutants released from the Project (Rail), such as NO_2, SO_2, CO, formaldehyde, benzene, toluene and xylenes associated with locomotive combustion engines, have been assessed in isolation

7.3.2 Emissions during Construction

The emissions during the construction phase of the Project (Rail) will primarily consist of:

- Dust emissions from mechanical ground disturbance by construction and maintenance vehicles and equipment
- Wind erosion of exposed and/or disturbed soils, i.e. dust emissions from exposed disturbed soil surfaces under high wind speeds
- Exhaust emissions from a range of motor vehicle, mobile and stationary plant

Potential particulate emission sources during the construction phase are expected to include the following works:

- Land clearance for site preparation
- Earthworks and excavation and where required, pneumatic rock-breaking
- Top soil and soil/gravel/crushed rock handling (stockpiling, loading, dumping)
- Leveling and grading of disturbed soil surfaces
- Placement of ballast
- Laying of concrete sleepers and rail

- Construction and administrative vehicles travelling over unsealed sections of road or localised unconsolidated surfaces
- Wind erosion of unconsolidated surfaces such as unstable/uncovered cleared land and stockpiles.

Emissions associated with motor vehicles, mobile and stationary plant diesel engine exhausts also comprise PM_{10} and $PM_{2.5}$. Engine exhausts are also the only source of non-particulate air emissions from the construction phase, and include NO_X, CO and trace quantities of SO_2 and VOCs. The small scale and transient nature of the construction-related emissions in this isolated rural environment means that construction phase emissions are considered to be minor, in comparison to emissions from diesel locomotives and fully loaded coal wagons during the rail line operation phase. As the separation distance between the rail line and the nearest sensitive receptor is 1.6 km at a single point along the corridor, a quantitative assessment of the potential air quality impact of engine exhaust emissions during the construction phase has not been carried out.

7.3.3 Mitigation Measures - Construction

While dust generated by construction activities is unlikely to impact air quality at sensitive places in the region, measures to mitigate the generation of dust emissions will be investigated and applied through the Project (Rail) Environmental Management Framework (refer Section 13 Draft Environmental Management Plan), which will include a dust management plan.

7.3.4 Emissions during Operation

7.3.4.1 Overview

Potential sources of air emissions from the operational phase of the Project (Rail) include:

- Exhaust emissions from diesel powered locomotive engines, including fine particulate material
- Fugitive coal dust emissions from uncovered coal wagons in transit (loaded or unloaded), any leakage from delivery doors, residual coal dust on wagon sills, couplings, shear plates and bogies of wagons and wind erosion of spilled coal in the corridor. Control measures to mitigate the emission of dust from loaded and unloaded coal trains will be put in place in accordance with the recommendations stated in the QR Network (2010) *Coal Dust Management Plan*

Relevant exhaust emissions from diesel engines include:

- NOx – assessed as NO_2
- CO
- SO_2
- PM_{10} and $PM_{2.5}$
- Trace hydrocarbons, including: formaldehyde, benzene, toluene, and xylene

The assessment of particulate matter requires the addition of the two sources of particulates from both diesel exhausts and the fugitive coal sources. Particulate emissions have been assessed as TSP, PM_{10}, $PM_{2.5}$ and deposited dust.

7.3.4.2 Locomotive Emissions

For the purpose of this analysis, existing 83 Class (3000 brake horse power (bhp)) and 71 Class (5000 bhp) have been used rather than the nominated 'Tier 2/3' narrow gauge and standard gauge locomotive currently under development.

The applicable manufacturing and emission standards for the locomotives operating during the Project (Rail) were not defined at the time of the air quality assessment. Locomotive air emissions have been estimated using emission factors identified in the US Locomotive Emission Standards, DieselNet (2008). Locomotive emission factors used in the assessment are based on the Tier 0, Tier 1 and Tier 2 emission standards, as identified in Table 7-3. This assessment indicated that the oldest (Tier 0) and biggest locomotives (5000 bhp) would produce the most emissions.

Table 7-3 Line-Haul Locomotive Emission Standards

Emission Standard	Hydrocarbons (g/bhp-h)	CO (g/bhp-h)	NOx (g/bhp-h)	Particulate matter (g/bhp-h)
Tier 0	1.00	5.0	8.0	0.22
Tier 1	0.55	2.2	7.4	0.22
Tier 2	0.30	1.5	5.5	0.10

Source: DieselNet, 2008

The 83 Class locomotives are rated at 3,000 bhp (brake horse power) and, with four locomotives per train, will be able to obtain speeds of up to 100 km/h when unloaded and a maximum speed when loaded of 80 km/h. These will be operated in a line-haul mode and emissions as grams per power output are listed in Table 7 3. It is worth noting that these emission standards are lower than comparable Non-road Diesel Engines of equivalent power.

For diesel engines, all of the particulate matter can be considered to consist of the PM_{10} fraction (USEPA, 2009). A further reasonable assumption is that 98 per cent of the PM_{10} is the finer $PM_{2.5}$ fraction (NPI, 2008a). The range of operating power of the locomotive types and the operating speeds can be used with the above data to give emissions in grams per Vehicle Kilometre Travelled (g/VKT) for a single locomotive. Based on an assumption of the quantity of locomotives in each train, emission rates for each air pollutant can be estimated.

NO_X emissions, as presented in Table 7-3, are assessed against the Air EPP objectives at sensitive receptor locations as ground-level concentrations of NO_2. For this assessment, an NO_2 to NOx ratio of 20 per cent has been assumed as less than 10 per cent of NO_X emissions are generally released from fuel combustion sources such as diesel engines, with further conversion of nitric oxide (NO) to NO_2 taking place in the atmosphere through photochemical oxidation processes. This photochemical process is dependent on the availability of sunlight and VOC substances in the atmosphere and takes place during plume transport with peak levels of conversion occurring after 10-15 km. Consequently, a NO_2 to NOx conversion rate of 20 per cent for receptors situated within 1 to 5 km of the rail line is considered conservative.

Sulfur dioxide emissions are highly dependent on the sulfur content of the diesel fuel used. It is assumed that the regulated low-sulfur diesel fuel will be used (maximum of 10 ppm as per Australian

Diesel Fuel Standard). SO_2 emissions were estimated by using 0.4 per cent of VOC emissions (as per the emission factor estimation for diesel powered locomotives (NPI, 2008b)). In a similar way, the benzene emission factor was estimated by its contribution to 8 per cent of total VOCs.

The Eastern Research Group (2011) provides estimating factors for relevant Hazards Air Pollutant (HAP) constituents using a speciation base of either PM_{10} or VOC. The following ratios were used for the (remaining) Air Toxic compounds of interest:

- Formaldehyde is 0.0945 per cent of PM_{10}
- Toluene is 0.32 per cent of VOC
- Xylene is 0.4 per cent of VOC

The locomotive diesel exhaust emissions per train are summarised in Table 7-4.

Table 7-4 Line-Haul Locomotive Emissions Operating Speed

Constituent	83 Class Locomotives			71 Class Locomotives		
	Tier 0	Tier 1	Tier 2	Tier 0	Tier 1	Tier 2
TSP	33	33	15.0	41.3	41.3	18.8
PM_{10}	33	33	15.0	41.3	41.3	18.8
$PM_{2.5}$	32.3	32.3	14.7	40.4	40.4	18.4
Benzene	51.8	28.5	15.5	48.6	26.7	14.6
CO	750	330	225	938	833	281
Formaldehyde	0.03	0.03	0.01	0.04	0.04	0.02
NO_2	240	222	165	300	278	206
SO_2	0.62	0.34	0.19	0.77	0.42	0.23
Toluene	0.51	0.28	0.15	0.63	0.35	0.19
Xylene	0.76	0.42	0.23	0.95	0.52	0.28

Units: g/VKT (vehicle kilometres travelled)

7.3.4.3 Fugitive Particulate Emissions from Loaded Coal Wagons

In addition to the fine particles emitted by the diesel locomotives, fugitive coal dust emissions from loaded coal wagons contribute the highest proportion particulate matter associated with the operation of the Project (Rail). Consequently, a combined assessment of coal wagon fugitive dust emissions, diesel locomotives and the ambient background has been carried out. In a similar manner to the locomotive exhaust emissions, coal wagon fugitive dust emissions are estimated as a mass emission (in grams) per VKT.

The net load per train is between 10,050, 16,072 and 24,000 tonne of coal consisting of 120 narrow gauge wagons with maximum load per wagon of 85 tonne. To reach the nominal maximum coal transport rate of 100 Mtpa for the Rail (west), an estimated 18 return trips each day will be required (i.e. 36 trips) where the net load per train is 24,000 tonnes of coal consisting of 240 wagons. For the

Rail (east) 60 Mtpa will be the maximum transport amount, equating to an estimated 18 return trips each day (i.e. 36 trips) where the net load per train is 10,050 tonnes of coal consisting of 120 wagons.

The emission factor of total coal dust from a moving, fully loaded coal train with no controls was calculated using the equation detailed in the Coal Dust study undertaken by Connell-Hatch (2008) for QR National, as shown below for g-TSP/km (tonne of loaded coal):

- Emission Factor (loaded coal train) = $0.0000378(V)^2 - 0.000126(V) + 0.000063$
- Where V is the speed of the train (km/h)

The speed of the train is greater than ambient wind speeds. Therefore, the primary mechanism for coal dust lift-off from coal trains is forced wind erosion of the coal surface. Other factors that contribute to emissions include mine-specific coal properties (dustiness, moisture content and particle size), wagon vibrations, coal load profile, exposure to wind and precipitation. Since these factors are essentially unquantifiable, a conservative 25 per cent spillage factor was applied to the emission factor. This therefore becomes a fugitive coal and dust re-entrainment emission factor enhancement that is due to displaced coal (other than windblown) from flat surfaces of the wagons and under-carriages.

For Project (Rail), the loaded trains will be hauling between 10,050, 16,072 and 24,000 tonne of coal each at a maximum speed of 80 km/h. This results in an estimated TSP emission factor of 2,957 g/VKT for each train. As there will be up to 18 trains per day, operating 320 days per year (at peak production), it is conservative to model this emission rate for each hour of the modelled year. The NPI (2011) PM_{10} to TSP ratio for wind erosion of coal stockpiles of 50 per cent was assumed in the calculation of PM_{10} emissions. The NPI (2011) does not provide a similar ratio for $PM_{2.5}$ to PM_{10}, so a conservative assumption of 50 per cent was used.

For the fully loaded train travelling east from the Project (Mine), the emission factors for dust (TSP, PM_{10} and $PM_{2.5}$) for a coal pay load were added to the corresponding diesel exhaust particulate emissions from the worst-case 71 Class locomotive with Tier 0 emission standard (41.3 g as per Table 7-4). Consequently, the total TSP emission rate for the fully loaded train was 2,998 g/VKT, i.e. 2957 + 41 (16,072 tonne pay load).

Accounting for Return Trips

In order to account for the return trips of empty trains, two train movements per hour past any given point along the corridor have been included in the short term modelling as a conservative assumption.

In addition to the movement of the fully loaded train, an empty train travelling west, i.e. returning to the Project (Mine) to be re-loaded, will pass the same point. These westbound empty train emissions need to be added to the eastbound full train emissions, considering the following:

- The empty westbound train is much lighter and therefore does not require the same power from the locomotives. Therefore, exhaust emissions will be lower
- The empty westbound train is travelling at a higher speed than the loaded eastbound train (100 km/h as compared to 80 km/h fully loaded) and as such, the emissions will not be directly proportional to the overall mass of the train, as drag air resistance is proportional to the square of the speed

Due to the reduced power requirements of the unloaded westbound train and the change in air resistance, locomotive emissions for the unloaded train have been estimated to be 58 per cent of a fully loaded eastbound train. The resultant locomotive emissions for all trains, both the loaded and empty, passing a single point used for assessing ambient air quality is determined by multiplying emissions in Table 7-4 by a correction factor of 1.58. With regard to the total TSP emissions from the Project (Rail), the emission factor was calculated to be 3,022 g/VKT. As such, particulate emissions from the worst-case, 71 Class locomotives with Tier 0 emission standard locomotives can be seen to be a small contributor to the overall particulate emissions from the railway operations.

Accounting for Longer Term Averaging Periods

In undertaking the assessment of those substances with longer averaging periods, (i.e. daily and annual), the assumption of one train per hour eastbound (loaded) and one train per hour westbound (empty) is considered too conservative given that in actuality, there is less than one train per hour – i.e. 18 return trips per 24 hours.

Long term averaging period correction was not applied to the assessment of gaseous locomotive emissions as there are actually 18 return trips in a day (a total of 36 trips) in which gaseous locomotive emissions are produced. However, a long term averaging correction was made to coal dust emissions as there are only 18 trips per day of fully loaded trains, where wind erosion contributes over 98 per cent of the total particulate emissions. Therefore, the emissions for TSP, PM_{10} and $PM_{2.5}$ had a correction factor of 1.33 applied (18/24). With regards to the TSP example of above, the total modelled TSP emissions were 2266 g/VKT, i.e. (0.75 x [2957 + 1.58 x 41]).

When assuming 50 per cent of TSP coal dust is in the PM_{10} fraction, the emission factor for PM_{10} is 1,133 g/VKT, i.e. (0.75 x [0.5 x 2957 + 1.58 x 41]).

The $PM_{2.5}$ emission factor was calculated to be 567 g/VKT, i.e. (0.75 x [0.5 x 0.5 x 2957 + 1.58 x 41]).

7.3.5 Predicted Impacts

The assessment found that ground-level concentrations of all air pollutants released from the Project (Rail) are predicted to be well below the Air EPP objectives at the nearest sensitive receptor, (1.6 km from the rail line). The assessment also found that the Air EPP objectives are met for all air pollutants within the fence-line of the rail corridor with the exception of PM_{10} and $PM_{2.5}$, which were found to be the most important air pollutants in terms of the predicted ground-level concentration as a percentage of its air quality objective.

Measures to mitigate the emissions will be investigated and applied through the Project (Rail) Environmental Management Framework that will consider the recommendations made in the QR Limited *Coal Dust Management Plan* (QR Network, 2010).

7.3.5.1 Particulate Matter

The assessment found that the predicted maximum 24-hour average ground-level concentration of PM_{10} is 140 µg/m³, at the southern fence-line (i.e. 40 m to the south) in the western railway section. The nearest sensitive receptor in this section of line is located 2.45 km to the south. The ground-level concentration of PM_{10} is also predicted to diminish rapidly with distance from the rail line and is predicted to meet the Air EPP objective of 50 µg/m³ at approximately 100 m from the track centreline, and be well below the objective at the nearest sensitive receptors.

For $PM_{2.5}$, the maximum annual average ground-level concentration is predicted to be 21 µg/m³ at the southern fence-line of the central section of the Study Area. However, the annual average concentration is predicted to be below the Air EPP criterion at the nearest sensitive receptor location here being at a distance of 1.6 km.

7.3.5.2 Minor Air Pollutants

The assessment presented in Section 7.3.4.2 found that the most influential air pollutant emitted from the locomotive exhaust is NO_2. However, the highest level of NO_2 at any Project (Rail) fence line (i.e. 40 m away to south side of the western railway section) is 145 µg/m³, which is well below the Air EPP hourly objective of 250 µg/m³. Hence, NO_2 emissions from the Project (Rail) are not expected to be a significant detriment to the total NO_2 affected environmental values within the Project (Rail) area. In addition to this, predicted ground level concentrations decrease rapidly with distance away from the rail line. It is also worth reiterating that the nearest sensitive receptor is at least 1,400 m away from the Project (Rail).

7.3.5.3 Amenity Impact of Dust Deposition

The predicted maximum incremental dust deposition level is less than the NSW Approved Methods impact assessment deposition guideline equivalent of 2 g/m^2/month at and beyond 40 m from the track centre line.

Assuming a background dust deposition rate of 0.09 and 1.7 g/m^2/month (at 40 m and beyond from the track centre line) for the western and eastern ends of the railway, respectively, the total cumulative dust deposition rate is predicted to meet the NSW Approved Methods assessment criterion of 4 g/m^2/month and the Department for Environment and Heritage Protection (DEHP) assessment criterion of 2g/m^2/month.

7.3.5.4 Flora , Fauna, Pasture and Crop Impacts

Coal dust emissions from loaded coal trains are caused by wind erosion mainly dominated by train movement (speed), and have the potential to directly impact flora species and, to a lesser degree, fauna species adjacent to railway systems. Dust deposition on leaves can reduce the photosynthetic quality of the flora and impede plant growth and affect grazing productivity. Such an impact, if large enough, could degrade the health of the flora (native or pasture related) and cause plant dieback due to prolonged exposure. This in turn may reduce food resources for fauna communities.

There are currently no national or international objectives or standards set for the protection of non-human receptors from impacts associated with particulate emissions, such as the protection of agriculture or the health and biodiversity of ecosystems (including for natural, semi-natural or uncultivated areas). An environmental review was undertaken by Connell Hatch (2008) on the impacts of coal dust on flora and fauna, crops and livestock as part of the QR National coal dust management studies. It was determined that air quality objectives or standards to protect human health and amenity, such as the objectives stated in the Air EPP, were sufficient for the protection of flora, fauna, crops and livestock against dust impacts.,

Connell Hatch (2008) found that coal dust deposition on cotton crops at a rate of 500 mg/m²/day can be used as a threshold for adverse impacts on crops and vegetation. It has also been experimentally demonstrated that the feed preference, palatability, quantity of feed eaten and quantity of milk produced by dairy herds was not affected when feed contained coal dust at rates up to 8,000 mg/m^2/day (Connell Hatch, 2008).

Connell Hatch (2008) reported on measured values along Queensland coal rail corridors as having coal deposition rates being well below the values indicated in the literature as potentially having an impact on crops and livestock. Moreover, observational records show that within the Project (Rail) alignment the highest values of about 90 mg/m²/day occur but quickly decrease with distance from the corridor, even being as low as one-third below the peak at 30 mg/m²/day at only 10 m from the tracks.

Coal dust deposition is unlikely to have a major impact on the native flora and fauna within the surrounding region given the low deposition rates at the boundary fences. No literature has been found on the impacts of coal dust on native flora and fauna communities, although the same conclusions are likely to be appropriate.

7.3.6 Mitigation Measures

While the air quality impact assessment of the Project (Rail) has found that air quality and dust deposition objectives would be met within close proximity of the rail line and that a negligible change in ambient air quality is expected at the identified sensitive receptor locations, measures to minimise particulate emissions from coal trains will be investigated. Measures to minimise particulate emissions associated with the construction and operation of the Project (Rail) have been identified in the QR Limited's *Coal Dust Management Plan* (QR Limited, 2010) and discussed in the Project (Rail) Draft Environmental Management Plan, Volume 3, Section 13.

The proposed implementation strategies to prevent or minimise any adverse air quality impacts to sensitive receptors during construction and operation of the Project (Rail) are outlined as follows:

Construction and Operation

- Vehicles, plant and equipment will be regularly serviced and comply with manufacturers' specifications

Construction

- Watering of construction site and access roads will be undertaken as required using water sprays
- Areas of exposed soil will be minimised
- Avoid movement or handling, or increase wetting, of soil material on days of high winds where visible dust clouds occur
- Any long term (longer than 2 weeks) soil stockpiles will be covered, stabilised and/or moistened as required to prevent generation of dust particulates

Operation

- The load-out facility will be requested to load wagons to the designed tolerance only. Overloading of wagons will be avoided
- Train speed will be optimised based on wagon class and coal supply (maximum loaded train speed of 80 km/h and unloaded train speed of 100 km/h)
- The coal train operators will collaborate with wagon suppliers to improve the design of coal wagons with regards to minimisation of coal dust emissions e.g. wagon sills, door mechanisms
- Electronically Controlled Pneumatic (ECP) braking will be considered for all new rolling stock

- Coal dust will periodically be removed from ballast and tracks
- The coal train operators will maintain clear and regular communication with community groups, councils, forums and individuals by listening to and discussing issues. Information on train-related coal dust mitigation initiatives being undertaken will be provided to the appropriate forums.
- Wagon washing will be considered to reduce coal dust emissions from empty wagons on the return trip to mine

In addition to the measures outlined above, an ongoing monitoring and reporting program will be implemented to ensure that all conditions of the EA are met. Further, a suite of corrective and preventative actions are proposed for both the construction and operational phase of the Project (Rail) where potential non-compliance may occur. These are discussed in detail in the Project (Rail) Draft Environmental Management Plan, Volume 3, Section 13.

7.4 Summary of Air Quality Assessment

An air quality impact assessment has been carried out according to the Project (Rail) ToR, using industry recognised emissions calculation and dispersion modelling techniques, to predicted ground-level concentrations of important air pollutants associated with emissions from locomotives and coal wagons operating in the rail corridor.

The small scale and transient nature of the construction-related emissions in this isolated rural environment means that construction phase emissions are considered to be minor, in comparison to emissions from diesel locomotives and fully loaded coal wagons during the rail line operation phase. As the separation distance between the rail line and the nearest sensitive receptor is 1.6 km at a single point along the corridor, a quantitative assessment of the potential air quality impact of engine exhaust emissions during the construction phase has not been carried out.

The most important air pollutant associated with the operational phase of the Project (Rail), i.e. both diesel locomotive exhausts and fugitive coal dust released from loaded wagons, was found to be particulate matter, which primarily consists of fugitive releases during the transportation of coal. Particulate matter concentrations at sensitive receptors identified in areas surrounding the rail line have been assessed as TSP, PM_{10}, $PM_{2.5}$ and deposited dust against the air quality objectives set out for the Project (Rail).

The assessment of impacts to humans found that the predicted change in air quality at sensitive receptor locations, the closest of which along the rail corridor is situated 1.6 km from the rail line, is negligible during the operational phase of the Project (Rail). For the most important air pollutant assessed, particulate matter, the ground-level concentration of PM_{10} is predicted to diminish rapidly with distance from the rail line and is predicted to meet the Air EPP objective of 50 µg/m³ at the nearest sensitive receptors and moreover be compliant with the objective at approximately 200 m from the track centreline.

Potential sources of air emissions from the operational phase of the Project (Rail) include exhaust emissions from diesel powered locomotive and fugitive coal dust emissions. Non-'dust' emissions from the locomotives included carbon monoxide, oxides of nitrogen (as nitrogen dioxide), sulphur dioxide, benzene and trace hydrocarbons. The assessment also found that the most important air pollutant emitted from the locomotives exhaust is NO_2. However, the highest predicted incremental 1-hour average ground-level concentration of NO_2 at any Project (Rail) fence line, the closest of which is 40 m away to south side of the western railway section, is 58 per cent of the Air EPP objective of 250 µg/m³. Assuming that the background level of NO_2 is negligible due to the lack of emission sources in the region, the combined impacts are expected to be well below the Air EPP criteria.

While the air quality impact assessment found that air quality objectives would be met within close proximity of the rail line, measures to minimise particulate emissions from the construction and operation of the Project (Rail) have been identified in the QR Limited's *Coal Dust Management Plan* (QR Limited, 2010). All practicable measures to minimise dust emissions will be incorporated into the Environmental Management Plan for the Project (Rail) (Volume 3 Section 13 Draft Environmental Management Plan).

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