17. Air quality

17.1 Introduction

Air quality is a key consideration in assessing the overall benefits and impacts of a major public transport infrastructure project. Motor vehicle emissions are identified as the predominant source of air pollutants in the south-east Queensland region (DERM 2008) and the trend of increasing private car use is expected to produce greater pressure on air quality in the Sunshine Coast in the future. On a regional level, the proposal to improve public transport between Caloundra and Maroochydore is expected to reduce the growth in private car use through the delivery of a fast and reliable express bus service between these two towns via Nicklin Way and the Sunshine Motorway.

The Caloundra to Maroochydore corridor consists of a roadway which varies from two to four lanes. General traffic on this roadway is the source of the majority of air pollutants in the study corridor. Air quality should be considered as part of the Concept Design and Impact Management Plan (CDIMP) for the following reasons:

- the potential air quality issues associated with the construction of new bus lanes, bus stops and bus stations
- the potential emissions from extra buses using the new bus lanes
- the potential benefits and opportunities in reducing overall traffic emissions due to the projected shift from the use of private to public transport.

17.2 Methodology

The scope of this study was to prepare a desktop-based air quality impact assessment as part of a CDIMP for the proposed CoastConnect — Caloundra to Maroochydore corridor on the Sunshine Coast. The proposed improvements to the corridor would include the following:

- dedicated on-road cycle lanes
- bus priority lanes
- bus stations in key activity areas and bus stop upgrades
- bus queue bypasses and bus priority signal at bus stops.

Figure 17-1 illustrates the sections of the proposed project corridor.

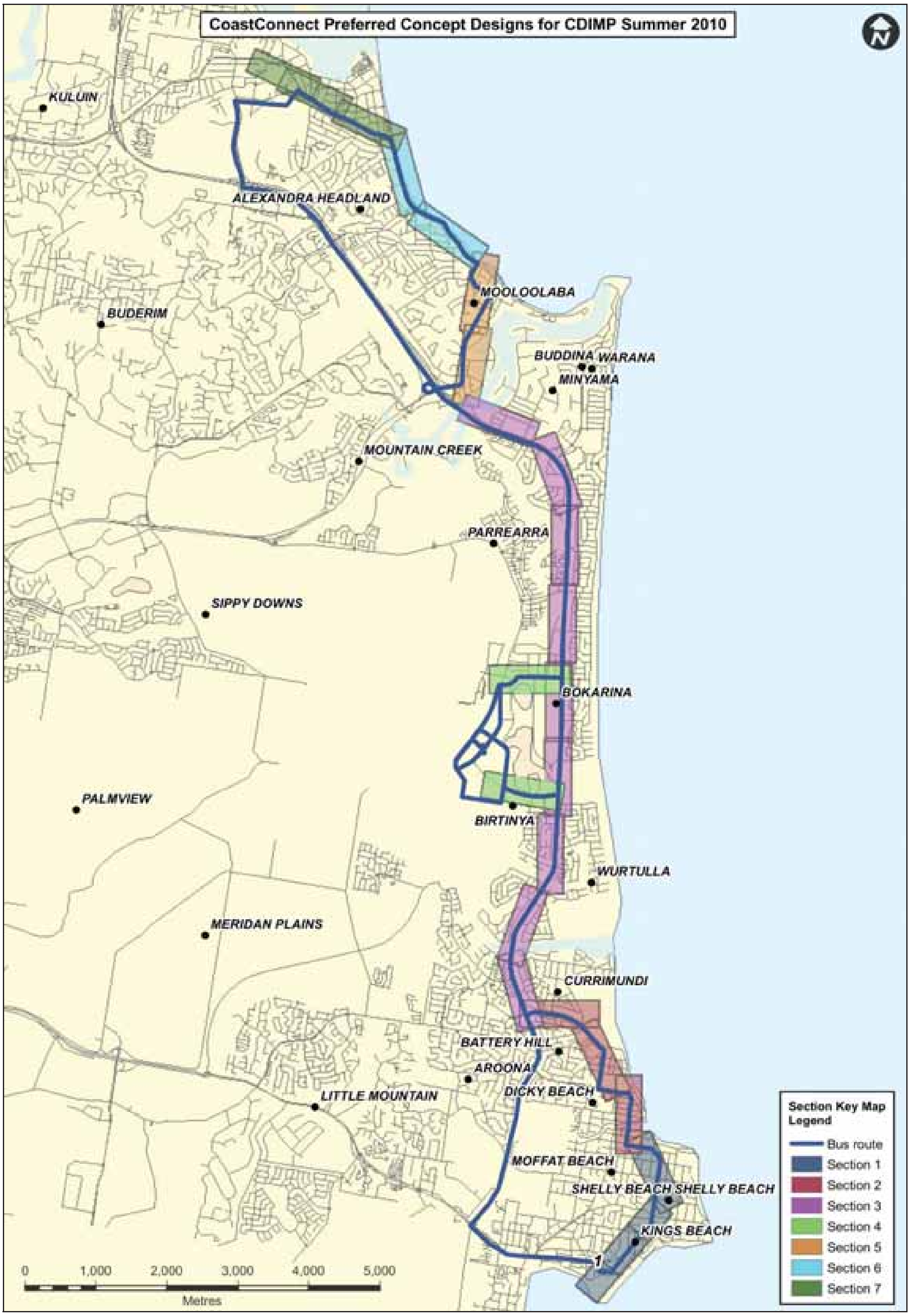

Figure 17-1: Sections of proposed project corridor

The air quality assessment included the following:

- review relevant environmental policy and air quality legislative measures
- access (where possible) and collate existing meteorological, air quality and emission studies for the area
- identify and assess significant pollutant sources for the area
- assess the influence of topography and meteorology on air quality and the dispersion of air pollutants
- assess the potential impact from the traffic emissions
- compare the results with relevant guidelines and legislation
- compile a concise statement of air quality impacts
- develop recommendations for mitigation and management of air quality impacts (if required).

17.2.1 Air quality goals and standards

National and Queensland ambient air quality goals relevant to emissions from motor vehicles have been adopted for the air quality section on this report. These standards were established to protect the health of local communities and minimise potential annoyance from the construction and operation of new and upgraded developments and infrastructure.

The identified national goals are based on the recommendations of the National Health and Medical Research Council (NHMRC 1995) and the National Environmental Protection (Ambient Air Quality) Measure (NEPM 1998) prepared by the National Environmental Protection Council (NEPC). The NEPM goals are long-term reporting descriptors.

Queensland's ambient air quality goals are provided in the Environmental Protection Agency (EPA) document Environmental Protection (Air) Policy 2008 as administered under the *Environmental Protection Act 1994*. The adopted air quality standards/goals for this air quality assessment are presented in Table 17-1.

Table 17-1: Adopted ambient air quality goals/standards

Pollutant	Averaging Period	Goal1	Source
Nitrogen dioxide	1 hour	250 µg/m^3	EPP (Air)$^{2, 5}$, NEPM^2
	Annual mean	62 µg/m^3	NEPM, EPP (Air)^5
Carbon monoxide	1 hour	30 mg/m^3	WHO^3
	8 hours	11 mg/m^3	NEPM^2, EPP (Air)^5
Benzene	annual	10 µg/m^3	EPP (Air)^5
PM$_{10}$^{4}	24 hour	50 µg/m^3	NEPM^2, EPP (Air)^5

Notes: 1: µg/m^3 — micrograms per cubic metre; mg/m^3 = milligrams per cubic metre; mg/m^2/day = milligrams per cubic metres per day
2: NEPM and the EPP (Air) 2008 allows for no more than 5 exceedances in any given year for PM$_{10}$ and no more than 1 exceedance in any year for CO and NO$_2$, 3: WHO — World Health Organisation
4: PM$_{10}$ — particulate matter ≤ 10 microns in aerodynamic diameter 5: health and wellbeing

The values presented in Table 17-1 are ambient air quality goals for the pollutants assessed. Wherever possible, cumulative assessment of air quality impacts (from general traffic and buses) is required.

17.2.2 Sensitive receptors

The nearest sensitive receptors along each section of the corridor have been broadly identified in Table 17-2.

Table 17-2: Sensitive receptor locations

Section	Roads[1]	Type of receptor
1	Cooma Terrace	Multi-unit residential
	Knox Avenue	As above
	Moreton Parade	As above
	Edmund Street	As above/low density residential
2	Rinaldi/Roderick/Buccleugh/Elizabeth streets	Low density residential
2	Beerburum Street	Mixed use/low density and multi-use residential
2	Cooroy Street	Low density residential
2	Buderim Street	Low density residential/community purpose
3	Nicklin Way	Low density residential/multi-unit residential/community purpose/mixed-use residential
4	Lake Kawana Boulevard	Wetlands/green space
6	Alexandra Parade	Multi-unit residential/mixed-use residential
7	Aerodrome Road/Horton Parade	Regional business centre

Notes:

1 — Name of roads/routes through which corridor passes

A new hospital (Sunshine Coast University Hospital) is proposed to be located on Lake Kawana Boulevard with nearby links to an integrated bus and rail station. The year of opening is not known at the date of writing.

17.3 Preliminary analysis

17.3.1 Existing situation

Corridor-wide considerations

Existing air quality and meteorology

Air quality and meteorological conditions have been referenced from a number of sources including Queensland Environmental Protection Agency (EPA) measured air quality monitoring data and the Bureau of Meteorology (BoM) data.

The following data sets have been used for this study:

- EPA Mountain Creek station, Mountain Creek State Primary School, Lady Musgrave Drive (lat: -26.6917, long: 153.1044): nitrogen dioxide (NO_2) and particulate matter (PM_{10}).
- EPA Brisbane Central Business District (CBD) station, 110 George Street Brisbane (lat: -27.4731, long: 153.0252): benzene, carbon monoxide (CO), nitrogen dioxide (NO_2); and Queensland University of Technology, 2 George Street Brisbane (lat: -27.4775, long: 153.0282): particulate matter (PM_{10}).
- BoM Maroochydore Aero (040861) (lat: 26.60S, long: 153.09E): meteorological conditions recorded from 1994–2009.
- BoM Caloundra Signal Station (040040) (lat: 26.80S, long: 153.15E): meteorological conditions recorded from 1899–1992.

Ambient air quality data

The existing air quality within the study area can be described as characteristic of an urban environment where the dominant emissions are from traffic along the route. The area surrounding the proposed corridor comprises a combination of residential and commercial land uses. There are no major pollutant-generating activities in the immediate study area. Local, minor sources of dust include a combination of residential activities and dust generated on local and arterial roads. Emissions from motor vehicles would therefore be a primary contributor to the air quality in the local setting.

Data for the Brisbane CBD and Mountain Creek air monitoring stations have been used to provide an indication of pollutant levels along the route sections. Although this data is not site specific, it is considered suitable for use as a conservative estimate of typical (or indicative) ambient air quality for the study area and has been adopted as indicative existing background air quality levels for the project area.

Background data for the Brisbane CBD and Mountain Creek stations are presented in Table 17-3 for the years 2000 to 2006.

Table 17-3: Measured background levels at Brisbane CBD and Mountain Creek air monitoring stations

Year	Pollutant (ug/m^3)					
	Brisbane CBD				Mountain Creek	
	Benzene	CO	NO_2	PM_{10}	NO_2	PM_{10}
	1 year	8 hour (mg/m^3)	1 hour	24 hour	1 hour	24 hour
2000	12.1	3.09	106.4	60.6	nd	nd
2001	5.43	3.78	100.7	50.1	nd	nd
2002	7.67	2.86	106.4	162.1	68.4	146.9
2003	8.31	3.09	114	101.4	62.7	68.9
2004	nd	3.78	127.3	56.6	77.9	66.6
2005	nd	nd	nd	nd	60.8	62.9
2006	nd	nd	nd	nd	66.5	39.8
Qld goal	10	11	250	50	250	50

Note: nd — no data available

General comments on the results presented in the table are discussed below:

- Benzene

Benzene levels were measured at the Brisbane CBD station between 2000 and 2003. The maximum concentration of 12.1 µg/m^3 recorded in 2000, exceeded the EPP (Air) 2008 goal of 10 µg/m^3. This level was recorded prior to stringent measures implemented to reduce vehicle emissions. All other measurements during these years were satisfactory.

- Carbon monoxide (CO)

CO has been measured at the Brisbane CBD station between 2000 and 2004. The results indicate that the Queensland air quality goal of 11 mg/m^3 was not exceeded. The maximum 8-hour concentration occurred in 2001 and 2004 and did not exceed its air quality goal.

- **Nitrogen dioxide (NO_2)**

NO_2 was recorded at Mountain Creek for 2002 to 2005 and at the Brisbane CBD station between 2000 and 2004. The 1-hour concentrations were below the EPA air quality goal for both stations during these years.

- PM_{10}

PM_{10} levels were measured at Mountain Creek for 2002 to 2005 and at and Brisbane CBD between 2000 and 2004 using the tapered measurement oscillating meter (TEOM) or the hi-volume air sampler. The maximum concentration at the Brisbane CBD station exceeded the EPP (Air) 24-hour period goal in all years between 2000 and 2004. At the Mountain Creek station the 24 goal was exceeded in all years between 2002 and 2005. PM_{10} levels during 2006 were satisfactory. For both stations the number of exceedances in a given year did not exceed the EPP (Air) 2008 limit of 5 exceedances per year.

Existing industrial sources

A search of the national pollution inventory (NPI) database (www.npi.gov.au) 2007–2008 has indicated six sources for Maroochydore reporting emissions. The sources in order of greatest contribution to the air quality of the area include architectural surface coatings, fuel combustion lawn mowing, domestic/commercial solvents and aerosols, and other minor contributors. Caloundra's emissions inventory demonstrates similar inputs.

Ambient air quality levels for the regional air sheds are not expected to be adversely influenced by existing industrial sources.

Meteorology

Air quality impacts are influenced by regional meteorological conditions, primarily in the form of gradient wind flow regimes, and by local conditions generally driven by topographical features in the form of drainage flows. Topography, wind speed and wind direction all affect potential dispersion and transport of plumes.

Data for the meteorological station at the existing Maroochydore Aero station and the now decommissioned Caloundra Signal station have been obtained from the Bureau of Meteorology website (www.bom.gov.au).

Details of the historical meteorological file are presented in Table 17-4.

Table 17-4: Historical meteorological data for Maroochydore aero and Caloundra signal stations

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Maroochydore Aero (040861) — Lat: 26.60S, Long: 153.09E (1994–2009)[1]													
Mean max. temp. (°C)	28.6	28.6	27.6	25.6	23.3	21.2	20.8	21.6	24	25.4	26.7	28.1	25.1
Mean min. temp. (°C)	21.3	21.2	19.8	16.8	13.7	11.4	9.3	9.9	13	15.7	17.9	19.8	15.8
Mean rainfall (mm)	118.2	176.6	119.8	153.9	174.3	119.1	74.1	83.3	64.4	70.6	96.4	136.5	1388.1
Highest daily rainfall (mm)	91	160	102	130.4	127	161.2	73.4	192.2	85.4	95	108	110	192.2
Mean 9 am rel. hum. (%)	73	73	74	75	76	76	73	69	65	66	67	70	71
Mean 3 pm rel. hum. (%)	71	71	69	68	65	64	59	60	63	67	68	70	66
Mean 9 am wind speed (km/h)	19.4	18.7	18.2	17.3	15.8	15.3	14.8	15.9	17	18.2	18.9	18.6	17.3
Mean 3 pm wind speed (km/h)	24.2	23.4	23.1	21.2	19.2	18.4	18.9	21.3	23.8	24.2	24.4	24.2	22.2
Caloundra Signal (040040) — Lat: 26.80S, Long: 153.15E (1899–1992)[2]													
Mean max. temp. (°C)	27.6	27.2	26.4	24.6	22.2	19.8	19.3	20.3	22.3	24.1	25.4	27	23.8
Mean min. temp. (°C)	21.4	21.2	19.9	17.4	14.9	11.7	10.8	11.6	13.9	16.5	18.5	20.3	16.5
Mean rainfall (mm)	176.6	202.4	208	172.9	170.3	102.4	89.9	60.8	54	81.1	113.3	143.6	1578.1
Highest daily rainfall (mm)	177.8	344.9	185.4	160	163.8	234.4	239.2	88.9	99.1	154.7	280.6	241.3	344.9
Mean 9 am rel. hum. (%)	74	78	78	79	79	74	71	68	66	68	71	72	73
Mean 3 pm rel. hum. (%)	71	72	72	70	69	63	61	60	62	67	71	71	67
Mean 9 am wind speed (km/h)1	18.8	21.6	19.2	16.1	16.6	17.4	16.7	15.2	15.5	16	18	17.1	17.4
Mean 3 pm wind speed (km/h)	25.9	27.9	26.3	23.1	20.7	19.2	20.1	20.7	23.5	24.7	26.6	26.2	23.7

Note 1: Data from 1970–1992; Note 2: Data from 1994–2009.

Temperature

The highest mean maximum monthly temperatures for the region range occur during the summer months (December to February). The highest mean temperature of 28.6°C was measured during January and February at the current Maroochydore station. The decommissioned station recorded its highest temperature of 27.6°C in January.

Mean minimum monthly temperatures occurred in July at both stations with recorded temperatures of 9.3°C (existing Maroochydore) and 10.8°C (decommissioned Caloundra) respectively.

It is unlikely that lower temperatures during the winter months would have an adverse impact on the operation of the proposed upgrade.

Rainfall

Typically the majority of rainfall within the project area falls in the summer and autumn months, with February and May being the wettest months at both stations. The highest daily fall of 192.2 mm occurred at Maroochydore Aero in August, and 344.9 mm at Caloundra Signal station in February.

Average annual rainfall is 1,388.1 mm at the existing Maroochydore station which falls over approximately 162 days in the year. At the decommissioned Caloundra site, the average annual rainfall is 1,578.1 mm which fell over 120.4 days.

Humidity

The relative humidity (RH) levels at both stations are consistently higher at 9 am than at 3 pm. Generally, relative humidity is lowest in the months of winter and early spring (i.e. July to October), and highest during summer and autumn (December to May).

Higher relative humidity levels occur during the summer and autumn months for all stations presented. Maximum RH levels of 76% (existing) were recorded during May and June; and 79% (decommissioned) occurred in April and May. The lowest RH levels of 59% (existing) and 60% (decommissioned) were recorded in July and August respectively.

Wind speed

Graphical representations of monthly mean wind speeds (9 am and 3 pm) and wind direction are presented in Appendix N. Reference to wind speed data collected by the BoM indicates that mean 9 am and 3 pm wind speeds are relatively consistent throughout the year with small increases during the spring and summer months. Wind speeds are diurnal in nature with lower speeds experienced in the morning (9 am) and higher speeds in the afternoon (3 pm). Wind speeds at 3 pm demonstrate greater variability than the 9 am wind speeds for both stations and fewer calm conditions.

The lowest morning wind speeds occur during the autumn and early winter months and highest morning wind speeds occur during the summer months.

The lowest mean 9 am and 3 pm wind speed recorded was 14.8 km/h (existing) and 15.2 km/h (decommissioned) during the months of July and August respectively, and the highest mean 9 am and 3 pm wind speed being 24.4 km/h (existing) and 27.9 km/h (decommissioned) during the months of November and February respectively.

The combination of an active wind regime and varying rainfall events increases the potential for surface abrasion by vehicular movement, leading to particulate entrainment and dispersion.

Wind direction

The prevailing annual wind direction for the 9 am and 3 pm data sets at both Brisbane stations are presented in Table 17-5.

Table 17-5: Historical wind direction information

Station	Dates	Percentage calm conditions	Time	No. of obs.[1]	Prevailing wind direction
Maroochydore (existing)	1994–2009	1.0	9 am	5029	South
		<0.5	3 pm	5034	East-south-east
Caloundra (decommissioned)	1899–1992	10.0	9 am	8076	South-west
		2.0	3 pm	8076	East-south-east

Note 1: Obs. — observations

The predominant 9 am wind direction at the Maroochydore station is east to south-east during summer, southerly during autumn and winter and variable throughout spring. The predominant 9 am wind direction at the Caloundra station is east to south-east during summer, southerly and south-westerly winds during autumn and winter and variable throughout spring.

The wind direction for the 3 pm data set changes to north-easterly and easterly during spring; and easterly and south-easterly during summer, autumn and winter at the existing Maroochydore station. At the decommissioned Caloundra station, winds are predominantly from the eastern vector during summer, shifting south-east during autumn and winter before shifting north-east during spring.

The project should be assessed with regard to how the prevailing wind direction and highest wind speeds may affect the operation of the project and associated impacts on nearby receptors.

Topography

When assessing the impact potential from a ground level source of air pollutants, it is important to consider local drainage flows. The movement of cold air down a slope (generally under stable atmospheric conditions) is referred to as katabatic drift and can result in plume entrapment and poor dispersion of airborne pollutants and the potential to cause greater off-site impacts. Katabatic drift would follow the topography of the site.

The route of the proposed corridor passes primarily through an urban area between Caloundra and Maroochydore. The topography is either flat or gently undulating (e.g. along Alexandra Parade) along the route. Therefore significant occurrences of katabatic drift are not expected to occur.

17.3.2 Potential benefits, impacts and typical mitigation measures

Corridor-wide considerations

Potential construction impacts

During the construction phase, generation of dust could affect the local ambient air environment.

Atmospheric dust arises from the mechanical disturbance of granular material exposed to the air. Dust generated from these open sources is termed ‘fugitive’ because it is not discharged to the atmosphere in a confined flow stream. Common sources of fugitive dust include unpaved roads, aggregate storage piles, and heavy construction operations, all of which would be evident during the construction phase of the proposed upgrade.

Fugitive dust generation is caused by:

- pulverisation and abrasion of surface materials by application of mechanical force through implements (wheels, blades)
- entrainment of dust particles by the action of turbulent air currents, such as wind erosion of an exposed surface.

Given the transient nature of the proposed construction works, a qualitative assessment of particulate matter impacts has been carried out.

Conservative estimates of dust-generating potential were primarily based on guidance provided in the United States Environment Protection Agency (USEPA) document, *Compilation of air pollutant emission factors* (1995). Emission factors applied relate to the dust-generating potential for varying sources and modes of operation.

Particulate emissions would be associated with a number of mobile sources and potential wind erosion of freshly exposed areas. It has been assumed that intensive daytime construction works would be carried out, with dust-generating potential limited to short-term periods of intensive work.

An indicative breakdown of anticipated sources and dust-generating activities follows. The assumptions made may require verification upon selection of the preferred construction schedule:

- Dust loading from aggregate material on trucks may result in emission rates of 0.04 kilograms per tonne of total suspended particulates (TSP) and 0.01 kilograms per tonne of PM_{10}. The loading of 10 by 15 cubic metre capacity trucks over a 10-hour working day would result in a total of 150 cubic metres or approximately 300 tonnes, of material per day. Dust generation from dust-loading would, therefore, be expected in the range of 12.0 kilograms of TSP to 3.0 kilograms of PM_{10} per day.
- Operation of a bulldozer (or scraper) could result in emission rates of 2.3 kilograms per hour of TSP and 0.5 kilograms of PM_{10}. During a typical 10-hour working day, dust generation from a bulldozer would be expected in the range of 23.0 kilograms of TSP to 5.0 kilograms of PM_{10} per day.
- Emissions of dust from the movement of vehicles on unsealed roads have been estimated at values of 1.4 kilograms per vehicle per kilometre of TSP and 0.5 kilograms per vehicle per kilometre of PM_{10}. Two dust movements per hour, travelling an average of 1,500 metres could be expected to result in dust generation of 42 kilograms per day of TSP to 15 kilograms per day of PM_{10} over a 10-hour working day.
- Wind erosion from exposed surfaces may occur for disturbed areas. Dust entrainment rates from exposed surfaces would vary with wind gusts, threshold wind speeds, friction velocities, precipitation events, silt loading and the number of disturbances that restore the erosion potential. Dust emissions from exposed surfaces could be expected to range between 0.4 kilograms per hectare per hour of TSP to 0.2 kilograms per hectare per hour of PM_{10} (NSW Minerals Council 2000). Over a nominal 1,000 metre by 200 metre area (20 hectares) and a 10-hour working day, dust generation from exposed surfaces could be expected between 80 kilograms of TSP to 40 kilograms of PM_{10}.

The air quality impact of a fugitive dust source primarily depends on the quantity and drift potential of the dust particles injected into the atmosphere. In addition to large dust particles that settle out near the source (often creating a local nuisance problem), considerable amounts of fine particles are usually also emitted and dispersed over far greater distances. PM_{10} represents a relatively fine particle size range and, as such, is not overly susceptible to gravitational settling. PM_{10} particulate matter, therefore, contributes to the concentration of dust levels in the surrounding ambient air environment.

The potential drift distance of particles is governed by the initial injection height of the particle, the terminal settling velocity, the reflection co-efficient and the specific gravity of the particle(s). The degree of atmospheric turbulence is also important. The total amount of dust generated would depend on the properties of the soil material (silt and moisture content), the activities undertaken and the prevailing meteorological conditions.

From the above, the worst-case total dust levels generated over a 10-hour construction day were calculated to be between 157 kilograms of TSP to 63 kilograms of PM_{10} over a typical work area of 1,000 metres by 200 metres. Although the qualitative construction air impact assessment cannot provide a statement of compliance with current air quality goals, the anticipated levels of particulate matter are not considered excessive.

Received impacts would be expected to decrease significantly with distances from the source. Negligible dust impacts from the construction works would be anticipated beyond 200 metres from the work areas.

During unfavourable meteorological conditions, such as dry and windy conditions, dust emissions may be higher and would require specific corrective measures. The construction environmental management plan (CEMP) would identify triggers and procedures for dealing with these conditions.

Notwithstanding the above, the calculated dust loads generated over a typical construction day are small and would not be expected to result in reduced local air quality at the nearest potentially affected receptors, given the implementation of the recommended safeguards.

Potential operational impacts

A quantitative assessment of air quality impacts from traffic emissions has been undertaken. The anticipated operational impacts have been assessed with consideration to existing air quality levels, land uses and traffic flow conditions for a number of identified time horizons. Predicted air quality impacts and emission profiles for identified traffic volumes have been compared for 2016 and 2026 conditions with and without the proposed project proceeding.

Model characteristics/approach to modelling

Estimates of incremental air quality impacts were made through the use of the CALINE4 dispersion model. Concentrations of carbon monoxide, nitrogen oxides, hydrocarbons and particulate matter likely to be produced in the vicinity of the proposed project were determined. CALINE4 uses Gaussian diffusion algorithms with a mixing zone concept that characterises pollutant dispersion from a low-level line-based source (e.g. a roadway).

Maximum 1-hour (and where relevant 8-hour) concentrations were predicted for identified pollutants. CALINE4 has the limitation that long-term 24-hour and annual averages cannot be predicted. In the case of particulate matter predictions, 1-hour levels were used as a worst-case representation of 24-hour impacts (to allow comparison with adopted ambient air goals).

Nitrogen dioxide impacts were assessed by assuming a conversion rate of 20 % by weight from nitric oxide to nitrogen dioxide. Although the conversion value would be expected to change depending on the time of day and distance from the curb, the 20 % ratio is generally consistent with works presented within the document, *Air quality monitoring program* (RTA 1997).

Hydrocarbon impacts were assessed by adopting benzene as the key component of emissions that required assessment. Hydrocarbon analysis of vehicle exhausts, petrol and petrol vapour presented in *Atmospheric hydrocarbons in Sydney: Compositions of the sources* (Nelson and Quigley 1982) indicated a benzene component, by mass, of 2.6% in petrol and 5 % in vehicular exhaust. A 5 % benzene component has been adopted for this study.

Three off-set distances (10, 20 and 50 m) from the near-side roadway were assessed. Model scenarios were assessed for 2016 and 2026 conditions, with and without the project. Two-way traffic flow and associated emission rates were adopted.

A wind speed of 0.5 metres per second was selected with a worst-case wind angle (and standard deviation) of 45°. An atmospheric stability class of 7, a mixing height of 1,000 m and an ambient temperature of 20°C were also adopted for all predictions.

Constant traffic flows were assumed (at peak AM or PM levels) along each identified section of road.

Model input parameters

Traffic flow rates along each section of the route vary between daytime, evening and night time periods, with day of the week and with month. The road use is mixed, with substantial local traffic and long-distance transport (both commercial and tourist vehicles).

Data provided from the transport modelling for this project has been adopted. PM peak flows for the proposed project are presented in Table 17-6. This data was provided by the traffic consultant.

Section 1 between Caloundra and Sugar Bag Road has not been assessed quantitatively in this chapter as there are no plans to upgrade this part of the corridor.

Table 17-6: Baseline and predicted traffic volumes at specific locations along the proposed corridor (vehicles per hour)

Year	Parameter	Nicklin Way between Buderim St and Coora Cresc[1]		Nicklin Way between Moondarra Dr and Spinnaker Bvd[2]		Between Kawana Island Bvd and Jinang St[3]	
		With project	Without project	With project	Without project	With project	Without project
2006	PM Peak	2631		1697		3225	
2016	PM Peak	3772	3717	3331	3377	3031	2987
2026	PM Peak	3764	3833	3709	3835	3850	3953

Table 17-7: Baseline and predicted traffic volumes at specific locations along the proposed corridor (vehicles per hour)

Year	Parameter	Nicklin Way between Jessica Bvd and Pt Cartwright[4]		Alexandra Pde between Okinja Rd and Katoa St[6]		Horton Pde between First Ave and Maud St[7]	
		With project	Without project	With project	Without project	With project	Without project
2006	PM Peak	3922		2070		3311	
2016	PM Peak	4004	4039	2149	2090	2797	2911
2026	PM Peak	4600	4716	2495	2474	3297	3300

Note: Each section refers to a specific part of the selected transport corridor. Note 1: Section 2, Note 2: Section 3, Note 3: Section 3, Note 4: Section 3, Note 5: Section 5, Note 6: Section 6, Note 7: Section 7.

Emission rates

An assessment of emission rates from operating vehicles is outlined below. Pollutants considered include carbon monoxide, oxides of nitrogen (as nitrogen dioxide), hydrocarbons (as benzene) and particulate matter (PM_{10}). Sulfur dioxide (SO_2) is not a major emitter from buses or other motor vehicles and has not been assessed as part of this project.

Estimated emissions are required as input into a computer dispersion model to predict ground level pollutant concentrations at distances from the roadside and compared to air quality criteria. The general approach to derive total pollutant emissions from a road section is to multiply the total number of vehicles on the specific road section by the pollutant emission per vehicle (the emission factor). The following sources of emission factors have been referenced:

- a report by commissioned by Environment Australia — *Review of fuel quality requirements for Australian transport* — included an estimation of vehicle emission factors for the Australian capital cities up to 2020 (Environment Australia 2000). The study included the adoption of the European Union’s Euro vehicle emissions standards for petrol and diesel vehicles, and the reduction of petrol volatility. These emission factors have been adopted for petrol-fuelled cars
- the New South Wales Department of Environment and Climate Change (NSW DECC) Motor Vehicle Emissions Protection System (MVEPS). This database distinguishes emissions from bus-fuelled with Compressed Natural Gas from those fuelled with diesel for selected future years. The CNG data from this database has been used for the buses. The diesel data has also been used for Heavy Goods Vehicles
- bus emission data collated by Queensland University of Technology and representative of the Sunshine Coast fleet. The diesel data from this database has been used for the buses.

Adopted vehicle emission factors for free-flowing traffic is presented in Table 17-8.

Table 17-8: Adopted vehicle emission factors (grams per vehicle-kilometre)

Vehicle type	Pollutant type			
	CO	NO_x	HC	PM_{10}
Petrol vehicles 2010 (surrogate for 2016)	9.330	1.400	0.790	0.080
Petrol vehicles 2020 (surrogate for 2026)	4.280	1.130	0.560	0.090
Heavy duty vehicles 2006 (surrogate for 2016)	3.947	12.43	0.531	0.245
Heavy-duty vehicles 2016 (surrogate for 2026)	2.335	7.799	0.372	0.090
Diesel buses (100% load for all years assessed))	6.900	24.800	0.690	0.840
CNG buses (100% load for all years assessed)	2.800	8.200	0.280	0.100

Notes: CO — carbon monoxide; NO_X — oxides of nitrogen (as NO_2)
HC — hydrocarbons (as benzene)
PM_{10} — Particulate matter ≤ 10μm [microns] in aerodynamic diameter

For ease of assessment, this study assessed potential emission rates for the factors presented in Table 17-8 with the assumption that the 2006 data closely represents 2016 and the reported 2020 data provides a reasonable representation of 2026 conditions. Given that vehicular emissions typically reduce over time (with improvements in fuel and combustion technologies), the adopted approach is considered to provide emission rates that are conservative. Based on information received from Department of Transport and Main Roads, the bus fleet composition was assumed to comprise a fleet of 70 % diesel and 30 % CNG powered buses in 2016 and a 100% CNG-powered bus fleet in 2026.

Emission rate estimates have been calculated with consideration of the modelled traffic flow data. Emission estimates were based on emission rates for passenger petrol vehicles, diesel heavy-duty vehicles, and diesel and CNG buses. Emission rates per vehicle are expected to decrease between 2016 and 2026 based on improved fuel and combustion technologies. Calculated peak hour emission rates are provided in Table 17-9. Emissions of pollutants from the surrounding road network have not been considered in this assessment as the impact of the proposed project is expected to be minor.

Model results

Maximum predicted hourly ground-level concentrations of key pollutants due to emissions from vehicles only (without background contributions), estimated at 10 m, 20 m and 50 m from the kerbside, both with and without the proposed project, are summarised in Tables 17-10 and 17-11. These are compared to the relevant health-related air quality guidelines to determine the potential for adverse impacts on nearby receptors.

Residences may be located as close as 10 m from the kerb of the road, and this has been taken to represent worst-case conditions.

Table 17-9: PM 1-hour emission rates (two-way)

Link assessed	PM 1-hour traffic flow (veh/h)			Emission rate by pollutant (kg/km/h)			
	Cars	Buses	HGVs	CO	NO_x	HC	PM_{10}
Section 2: Nicklin Way — between Buderim Street and Coora Crescent							
Baseline 2006	2,487	4	140	23.8	5.32	2.07	0.24
With project 2016	3,631	20	121	34.3	6.42	3.03	0.31
Without project 2016	3,576	21	120	33.8	6.36	2.99	0.31
With project 2026	3,654	20	90	15.9	4.99	2.09	0.34
Without project 2026	3,716	20	97	16.2	5.12	2.13	0.35
Section 3: Nicklin Way — between Moondarra Drive and Spinnaker Boulevard							
Baseline 2006	1,503	12	182	14.8	4.66	1.37	0.17
With project 2016	3,226	20	85	30.4	5.58	2.70	0.28
Without project 2016	3,271	20	86	30.8	5.65	2.74	0.28
With project 2026	3,597	20	92	15.7	4.95	2.06	0.33
Without project 2026	3,721	20	94	16.2	5.10	2.13	0.35
Section 4: Kawana Island Boulevard and Jinang Street							
Baseline 2006	3,039	10	176	29.1	6.69	2.57	0.29
With project 2016	2,934	20	77	27.7	5.10	2.47	0.25
Without project 2016	2,892	22	73	27.3	5.05	2.44	0.25
With project 2026	3,725	19	106	16.2	5.19	2.14	0.35
Without project 2026	3,822	21	110	16.7	5.35	2.20	0.36

Link assessed	PM 1-hour traffic flow (veh/h)			Emission rate by pollutant (kg/km/h)			
	Cars	Buses	HGVs	CO	NO_x	HC	PM_{10}
Section 3: Nicklin Way — between Jessica Boulevard and Point Cartwright							
Baseline 2006	3,717	12	193	35.5	7.90	3.13	0.35
With project 2016	3,877	40	87	36.6	6.90	3.33	0.34
Without project 2016	3,912	40	87	37.0	7.17	3.43	0.35
With project 2026	4,440	40	120	19.4	6.28	2.56	0.41
Without project 2026	4,557	40	119	19.9	6.50	2.63	0.43
Section 6: Alexandra Parade — between Okinja Road and Katoa Street							
Baseline 2006	1,996	14	60	19.0	3.89	1.71	0.19
With project 2016	2,049	32	68	19.5	4.03	1.83	0.19
Without project 2016	1,973	30	87	18.8	4.04	1.77	0.18
With project 2026	2,379	30	86	10.5	3.60	1.39	0.22
Without project 2026	2,361	28	85	10.4	3.56	1.37	0.22
Section 7: Horton Parade — between First Avenue and Maud Street							
Baseline 2006	3,189	5	117	30.2	6.04	2.62	0.29
With project 2016	2,731	16	50	25.7	4.53	2.27	0.23
Without project 2016	2,841	16	54	26.7	4.72	2.36	0.24
With project 2026	3,217	16	64	14.0	4.27	1.84	0.30
Without project 2026	3,218	16	66	14.0	4.28	1.84	0.30

Table 17-10: Maximum predicted incremental concentrations (2016)

Road assessed	Off-set distance (m)	Pollutant									
		CO — 1 hour (mg/m^3)		CO — 8 hour (mg/m^3)		NO_2 — 1 hour (µg/m^3)		Benzene — 1 hour (µg/m^3)		PM_{10} — 1 hour (µg/m^3)	
		Without upgrade	With upgrade	Without upgrade	With upgrade	Without upgrade	With upgrade	Without upgrade	With upgrade	Without upgrade	With upgrade
Section 2: Nicklin Way — between Buderim Street and Coora Crescent											
	10	1.37	1.37	0.45	0.46	84.8	85.6	0.017	0.017	11.0	11.1
	20	0.78	0.79	0.16	0.17	48.1	48.6	0.010	0.010	6.2	6.3
	50	0.43	0.43	0.01	0.01	26.4	26.7	0.005	0.005	3.4	3.5
Section 3: Nicklin Way — between Moondarra Drive and Spinnaker Boulevard											
	10	1.26	1.26	0.80	0.79	75.2	74.3	0.015	0.015	10.0	9.9
	20	0.71	0.69	0.46	0.45	42.7	42.2	0.009	0.009	5.7	5.6
	50	0.39	0.38	0.24	0.24	23.4	23.1	0.005	0.005	3.1	3.1
Section 4: Kawana Island Boulevard and Jinang Street											
	10	1.11	1.12	0.37	0.37	67.4	68.0	0.014	0.014	8.9	9.0
	20	0.63	0.64	0.13	0.13	38.3	38.7	0.008	0.008	5.1	5.1
	50	0.34	0.35	0.01	0.01	21.0	21.2	0.004	0.004	2.8	2.8
Section 3: Nicklin Way — between Jessica Boulevard and Point Cartwright											
	10	1.49	1.49	0.50	0.49	92.9	92.0	0.019	0.019	12.3	12.2
	20	0.85	0.84	0.18	0.18	52.6	52.2	0.011	0.011	7.0	6.9
	50	0.47	0.46	0.01	0.01	28.8	28.7	0.006	0.006	3.8	3.8

Road assessed	Off-set distance (m)	Pollutant									
		CO — 1 hour (mg/m^3)		CO — 8 hour (mg/m^3)		NO_2 — 1 hour (µg/m^3)		Benzene — 1 hour (µg/m^3)		PM_{10} — 1 hour (µg/m^3)	
		Without upgrade	With upgrade	Without upgrade	With upgrade	Without upgrade	With upgrade	Without upgrade	With upgrade	Without upgrade	With upgrade
Section 6: Alexandra Parade — between Okinja Road and Katoa Street											
	10	0.78	0.80	0.26	0.27	54.8	54.6	0.010	0.010	6.7	6.8
	20	0.45	0.46	0.09	0.10	31.8	31.6	0.006	0.007	3.9	4.0
	50	0.25	0.26	0.007	0.007	17.9	17.7	0.003	0.003	2.2	2.2
Section 7: Horton Parade — between First Avenue and Maud Street											
	10	1.09	1.04	0.69	0.67	62.9	60.4	0.013	0.013	8.6	8.3
	20	0.62	0.59	0.40	0.38	35.7	34.3	0.008	0.007	4.9	4.7
	50	0.33	0.32	0.21	0.20	19.6	18.8	0.004	0.004	2.7	2.6
Ambient air quality goal		**30 mg/m^3 — 1 hour**		**11 mg/m^3 — 8 hours**		**250 µg/m^3 — 1 hour**		**10 µg/m^3 — 1 year**		**50 µg/m^3 — 24 hours**	

Notes:

CO — carbon monoxide

PM_{10} — particulate matter with an aerodynamic diameter ≤10 microns

µg/m^3 — micrograms per cubic metre

NO_2 — nitrogen dioxide

mg/m^3 — milligram per cubic metre

Table 17-11: Maximum predicted incremental concentrations (2026)

Road assessed	Off-set distance (m)	Pollutant									
		CO — 1 hour (mg/m^3)		CO — 8 hour (mg/m^3)		NO$_2$ — 1 hour ($\mu\text{g/m}^3$)		Benzene — 1 hour (mg/m^3)		PM$_{10}$ — 1 hour ($\mu\text{g/m}^3$)	
		Without upgrade	With upgrade	Without upgrade	With upgrade	Without upgrade	With upgrade	Without upgrade	With upgrade	Without upgrade	With upgrade
Section 2: Nicklin Way — between Buderim Street and Coora Crescent											
	10	0.66	0.64	0.42	0.41	66.1	64.4	0.012	0.012	12.2	11.9
	20	0.37	0.37	0.24	0.18	37.5	36.6	0.007	0.007	6.9	6.8
	50	0.20	0.20	0.13	0.13	20.6	20.0	0.004	0.004	3.8	3.7
Section 3: Nicklin Way — between Moondarra Drive and Spinnaker Boulevard											
	10	0.66	0.63	0.42	0.41	65.8	63.7	0.012	0.012	12.2	11.8
	20	0.37	0.36	0.24	0.24	37.4	36.2	0.007	0.007	6.9	6.7
	50	0.20	0.20	0.13	0.12	20.5	19.9	0.004	0.004	3.8	3.7
Section 4: Kawana Island Boulevard and Jinang Street											
	10	0.67	0.66	0.43	0.42	69.0	67.2	0.012	0.012	12.5	12.2
	20	0.38	0.37	0.25	0.24	39.2	38.1	0.007	0.007	7.1	6.9
	50	0.21	0.20	0.13	0.13	21.5	20.9	0.004	0.004	3.9	3.8
Section 3: Nicklin Way — between Jessica Boulevard and Point Cartwright											
	10	0.80	0.78	0.51	0.50	81.0	79.4	0.015	0.014	14.9	14.6
	20	0.46	0.44	0.29	0.29	46.0	45.0	0.008	0.008	8.5	8.3
	50	0.25	0.24	0.16	0.15	25.2	24.7	0.005	0.004	4.6	4.5

Road assessed	Off-set distance (m)	Pollutant									
		CO — 1 hour (mg/m^3)		CO — 8 hour (mg/m^3)		NO_2 — 1 hour ($\mu g/m^3$)		Benzene — 1 hour (mg/m^3)		PM_{10} — 1 hour ($\mu g/m^3$)	
		Without upgrade	With upgrade	Without upgrade	With upgrade	Without upgrade	With upgrade	Without upgrade	With upgrade	Without upgrade	With upgrade
Section 6: Alexandra Parade — between Okinja Road and Katoa Street											
	10	0.42	0.42	0.27	0.27	44.7	45.1	0.008	0.008	7.9	7.9
	20	0.24	0.24	0.16	0.16	25.6	25.8	0.004	0.004	4.5	4.5
	50	0.14	0.13	0.08	0.08	14.1	14.3	0.002	0.002	2.5	2.5
Section 7: Horton Parade — between First Avenue and Maud Street											
	10	0.57	0.57	0.36	0.36	55.3	55.1	0.010	0.010	10.5	10.5
	20	0.32	0.32	0.21	0.21	31.4	31.3	0.006	0.006	6.0	5.9
	50	0.17	0.18	0.11	0.11	17.2	17.1	0.003	0.003	3.3	3.3
Ambient air quality goal		**30 mg/m^3 — 1 hour**		**11 mg/m^3 — 8 hours**		**250 $\mu g/m^3$ — 1 hour**		**10 $\mu g/m^3$ — 1 year**		**50 $\mu g/m^3$ — 24 hours**	

Notes:
CO — carbon monoxide
NO_2 — nitrogen dioxide
PM_{10} — particulate matter with an aerodynamic diameter ≤10 microns
mg/m^3 — milligram per cubic metre
$\mu g/m^3$ — micrograms per cubic metre

Limitations of the modelling

The assessment technique adopted for this study provided a conservative estimate of air quality impacts. The CALINE4 downwind predictions are likely to be over-predicted for the following reasons:

- the model ignores, or only partly accounts for, horizontal and vertical variation in turbulence, wind speed and wind direction within the boundary layer
- the model assumes steady state conditions, precluding simulation of events such as inversion break-up fumigation
- the model ignores longitudinal diffusion (parallel to the plume axis), which restricts applications to wind speeds above about 0.5 m per second
- the complex flow in the wakes of obstacles cannot be precisely parameterised.

However, these limitations are well understood in the industry and the CALINE4 model is widely used by environmental regulators throughout Australia. It is generally understood that the CALINE4 model is suited to a wider range of applications than most other Gaussian Plume models.

Comment on predicted air impact profiles

- **Carbon monoxide**

Compliance with the adopted 1-hour goal of 30 milligrams per cubic metre was predicted to be achieved for all set-back distance assessed. With the proposed upgrade, little change in CO levels was predicted for both 2016 and 2026.

Predictions for the 8-hour pollutant levels were all well below the adopted ambient air quality goal of 11 mg/m^3 at all locations considered. Predicted pollutant levels are of similar levels or marginally change if the upgrade proceeds. Furthermore, the predicted results for 2016 are lower than those for 2026. This is probably due to assumed improvements in engine and fuel technology.

Given that the peak 8-hour incremental pollutant level was predicted at 0.80 mg/m^3 (with project, on Nicklin Way in 2016 at 10 metres), no cumulative carbon monoxide issues would be expected.

- **Nitrogen dioxide**

Compliance with the nitrogen dioxide (NO_2) 1-hour air quality goal was predicted for 2016 and 2026 with and without the project at each road section assessed and for all set-back distances from the road kerb-side.

For several of the locations assessed with 2016 flow conditions (sections 1, 2 and 4), pollutant levels are marginally higher if the project proceeds. The reason for this may be due to the predicted higher level of traffic along these sections if the project proceeds.

This may be due to the assumption that there would be an initial reluctance of car users to change their habits and commence using public transport.

In 2026, this increase has been reversed and pollutant levels are lower if the project goes ahead along all sections of the route.

The results also indicate that along most sections of the route, a decrease in NO_2 is predicted from 2016 to 2026 probably due to future improvements in emission controls for road vehicles and engine and fuel technology

No adverse cumulative issues are anticipated from the proposed project.

- **Benzene**

Compliance with the adopted annual goal (in the absence of a 1-hour goal) of 10 $\mu g/m^3$ was predicted at each off-set distance with the proposed upgrade (2016 and 2026).

The results indicated little change in predicted benzene levels with and without the upgrade for both 2016 and 2026 primarily due to a minimal change in traffic for both scenarios along the majority of sections along the route.

Predicted benzene levels for 2026 at all locations and set-back distances assessed are lower than 2016. This is primarily due to assumed improvements in engine and fuel technology.

Adverse cumulative impacts are not anticipated.

- **PM_{10}**

The predicted dust concentration levels were all well below the adopted air quality goal of 50 $\mu g/m^3$.

The predicted PM_{10} levels are in general of similar magnitude with and without the proposed upgrade for both 2016 and 2026. Predicted PM_{10} levels for 2026 are higher than 2016 at all locations assessed and at all set-back distances. This is primarily due to an increase in traffic (particularly cars) and a minimal change in car emission factors over the 10-year period.

No adverse cumulative issues are expected.

Potential benefits

Overall, based on the predicted traffic figures, either no change or a marginal decrease in emissions to air and associated pollutant levels would be expected with the project go ahead. With the exception of PM_{10}, emissions and associated pollutant levels would further be expected to improve between 2016 and 2026 conditions due to improved fuel composition and associated combustion technologies.

Potential carbon monoxide, hydrocarbons (benzene), nitrogen dioxide and particulate matter levels are expected to be within acceptable levels at all receptor locations along each section of the route based on the predictive calculations.

With the proposed project, emission rates and associated pollutant levels are generally predicted to decrease or remain static (with a couple of notable exceptions previously discussed) when compared with levels without the project. Overall, it is anticipated that the proposed project would provide an overall minor net benefit to the air quality in the area. This is based on the assumption that a reliable and frequent bus service would reduce car dependency thereby slowing the growth in private vehicle use along the Sunshine Coast by encouraging motorists to take public transport.

Typical mitigation measures

- **Construction air quality**

The following mitigation measures (as a minimum) would be implemented for the proposed upgrade:

- undertaking a pre-construction air quality monitoring program to collate baseline conditions to be referenced during the construction phase air quality monitoring program
- monitoring for dust deposition and particulate matter concentration around the project area during the construction phase to determine compliance with relevant air quality goals
- considering prevailing wind directions when establishing construction compounds
- ensuring the construction contractor observes local meteorological conditions on a daily basis during construction. This may include the establishment of a meteorological weather station or wind-sock
- stabilising all disturbed areas or revegetating as soon as practicable to prevent or minimise wind blown dust. This may include progressive hydro-mulching of disturbed areas as works are completed. Revegetation in accordance with an approved landscape concept plan may also be required
- dampening unsealed traffic areas sufficiently, or chemically stabilising them during work hours to minimise wind blown or traffic-generated dust emissions
- employing water sprays, sprinklers and water carts, if needed, to adequately dampen work areas and exposed soils to prevent the emission of dust off site. These could be activated when wind speed is above a certain threshold e.g. 5–8 metres per second and would be switched on more regularly during periods of drier and windier weather. This would be dependent on securing permission for water usage from the Queensland Water Commission
- maintaining stockpiles and handling areas in a condition that minimises windblown or traffic-generated dust. Areas that may be inaccessible by water carts would be kept in a condition that minimises wind blown or traffic-generated dust using other means such a water cannons, overhead sprinklers, tarpaulins or dust sealants

- keeping construction equipment in a good operating condition. The equipment would be operable at all times with the exception of shut-down periods required for maintenance. Construction equipment would be properly maintained to ensure exhaust emissions comply with relevant legislation
- consulting with potentially affected receivers prior to and during major dust-emitting activities, if appropriate.

Other mitigation measures may include the following:

- developing an air quality subplan. The nominated construction contractor would be expected to develop the subplan, which would be included in the construction environmental management plan (CEMP). Required reporting, measurements and mitigation measures would be outlined as required
- where applicable, sweeping roads to remove deposited material that could generate dust
- avoiding or minimising dust-generating activities (particularly clearing and excavating) during dry and windy conditions
- imposing site speed limits on all construction vehicles — typically 40 km/h
- restricting vehicle and machinery movements to designated area during construction works
- using rumble grids and wheel-wash facilities at the site exit(s) to remove mud and dust from vehicles. Also washing down loaded trucks prior to leaving the site to ensure loose material is not tracked onto the adjacent paved road network
- covering vehicles transporting material to and from the site immediately after loading to prevent wind blown dust emissions and spillages. Securely fixing tailgates of road transport trucks prior to loading and immediately after unloading
- adequately storing all bulk materials.

- **Operational air quality**

No project specific control options are recommended.

Operational impacts associated with air quality can be effectively managed at source via vehicle fuel standards and vehicle maintenance and emissions testing. The preferred approach to addressing road based air quality impacts would be through state-wide or region-wide strategies such as progressive reduction of vehicle air emission standards, in-service inspections to ensure vehicle muffler/exhaust systems are well maintained and the integration of transportation and land-use planning. These strategies offer the most promise in addressing future potential air quality impacts.

In addition, it is anticipated that, over time, vehicle emissions would be reduced due to the progressive removal of less efficient vehicles from the roads, improved fuel composition and associated combustion technologies.

17.4 Future investigations

Although emissions from the proposed increase in buses along the Caloundra to Maroochydore route are not predicted to impact significantly on the nearest receptors, the air quality is likely to differ by the time the upgrade is constructed. This is due to continual improvements in fuel and engine technologies and the types of fuel used which is likely to reduce pollutant levels from cars, buses and heavy-duty vehicles.

Further investigations may be required closer to the construction date to determine existing air quality along the route. Ambient air monitoring can be undertaken for key pollutants at locations deemed to be most sensitive to traffic emissions. Further, air monitoring data from existing EPA air monitoring stations may provide a good indication of current or ‘at-build’ background air quality levels.

By the time the proposed project moves to the construction phase, surrounding land uses may differ to the existing situation e.g. the proposed Sunshine Coast University Hospital. A review of all sensitive receptors should be reviewed prior to commencement of the construction phase.

17.5 References

Department of environment and Resource and Management (DERM), www.epa.qld.gov.au

Environment Australia 2000, *Review of fuel quality requirements for Australian transport*, Canberra.

Environment Australia 2000, *Emissions estimation technique manual for aggregated emissions from motor vehicles*, 22 November 2000, version 1.0, Canberra.

Environmental Protection Agency 2008, Causes of Air Pollution, viewed on 14 May 2009 http://wwww.wpa.qld.gov.au/environments_management/air/air_qualitym_in_south_east_queensland/causes_of_air_pollition/.

Holmes Air Sciences 2007*, Air quality operations: Northern busway concept design and impact management plan, Royal Children’s Hospital to Kedron*, technical report no. 6A, Brisbane.

Katestone Environmental 2007, Air Quality Assessment for the Proposed Eastern Busway, Draft Concept Design and Impact Management Plan, Brisbane.

Nelson, P. & Quigley, S. 1982, *Atmospheric hydrocarbons in Sydney: Compositions of the sources*., Sydney.

National Environment Protection Council 1998, National Environmental Protection (Ambient Air Quality) Measure, Canberra.

National Environment Protection Council 2004, National Environmental Protection (Air Toxics) Measure, Canberra.

National Environment Protection Authority Council 1998, National Environmental Protection (Ambient Air Quality) Measure, Canberra.

New South Wales Department of Environment and Conservation 1997, *Metropolitan air quality study for Sydney — motor vehicle emission projection system*, Sydney.

New South Wales Minerals Council 2000, *Particulate matter and mining interim report*.

Roads and Traffic Authority 1997, *Air quality monitoring program*, Sydney.

Queensland Government June 2009, CoastConnect Caloundra to Maroochydore, Preview Concept Design and Impact Management Plan, Brisbane.

United States Environment Protection Agency 1995, *Compilation of air pollutant emission factors*, document AP-42., Washington D.C.