Chapter 12 Air quality

This chapter assesses the impact of the Proposal on local air quality. Relevant air quality criteria, existing air quality, construction and operational impacts and mitigation measures along the route of the Proposal and in the built-up areas of Johns River and Kew are discussed.

12.1 Approach to assessment

This assessment of the Proposal's air quality impacts is based on computer modelling to determine pollutant dispersion from traffic emissions and to predict ground-level concentrations of the relevant vehicle exhaust components in the area close to the highway. The principal air pollutants considered are:

- carbon monoxide (CO) - when inhaled, reduces the oxygen carrying capacity of the blood and can cause headaches, fatigue, stress, respiratory problems and even death at very high levels
- hydrocarbons (HC) - when emitted from vehicle exhausts, hydrocarbons react with nitrogen oxides in the presence of sunlight to form photochemical oxidants (i.e. ozone) which can irritate the eyes and respiratory system, and adversely affect plants; some HCs are thought to cause cancers
- nitrogen oxides (NO_x) - effects include decreased lung function, lung inflammation, increased sensitivity of asthma patients to asthma triggers, increased susceptibility to respiratory infections
- particulate matter (PM_{10}) - can penetrate into the lungs and cause increased rates of respiratory illnesses and symptoms, decreased lung function, excess mortality from heart and lung disease
- lead (Pb) - builds up in the body causing damage to the nervous system and kidneys, and can cause altered neurobehavioural function in children.

HC were not modelled for this assessment as no air quality criteria exist for this pollutant and they do not generally pose a problem in rural environments. Lead was also omitted from predictive modelling as fuel containing lead is no longer available.

12.1.1 Air quality criteria

Air quality criteria exist at the international, national and state/territory levels. These criteria are essential to assess the significance of measured and predicted air pollutant concentrations likely to result from the Proposal. The Environment Protection and Heritage Council (formerly National Environment Protection Council) developed a set of ambient air quality standards as part of the National Environment Protection Measures (NEPM) for adoption at the national level. Table 12-1 provides the NEPM criteria for the pollutants relevant to the construction and operational road traffic emissions for the Proposal.

International air quality criteria for CO were based on World Health Organisation (WHO) guidelines to enable a more comprehensive assessment of the existing air quality data. These are 87 ppm for a 15-minute averaging period and 25 ppm for a 1-hour averaging period.

At the state level, the NSW DEC (formerly EPA) provides air quality goals under the 2001 *Action for Air* initiative. Some pollutant criteria are consistent with NEPM goals, however many are more stringent. The *Action for Air* goals are classed as 'interim' as they were first published while the NEPM criteria were being finalised. Table 12-2 presents those air quality goals relevant to road traffic emissions.

Table 12-1 NEPM air quality standards 1998 and variation 2003

Pollutant	Averaging period	Maximum concentration	Goal within 10 years maximum allowable exceedences
Carbon monoxide	8 hours	9.0 ppm	1 day a year
Nitrogen dioxide	1 hour 1 year	0.12 ppm 0.03 ppm	1 day a year nil
Photochemical oxidants (as ozone)	1 hour 4 hours	0.10 ppm 0.08 ppm	1 day a year 1 day a year
Lead	1 year	0.50 µg/m^3	nil
Particles as PM_{10}	1 day	50 µg/m^3	5 days a year

Source: Environment Protection and Heritage Council

Table 12-2 NSW DEC air quality goals

Pollutant	Averaging period	*Action for Air* interim goal	Long-term reporting goal
Nitrogen dioxide	1 hour 1 year	0.125 ppm 0.03 ppm *	0.105 ppm none
Photochemical oxidants (as ozone)	1 hour 4 hours	0.10 ppm * 0.08 ppm *	0.08 ppm 0.06 ppm
Particles as PM_{10}	24 hours 1 year	50 µg/m³ * none	none 30 µg/m³

* Same as NEPM
Source: *Action for Air* (NSW DEC 2004)

The NSW DEC also provides criteria for dust fallout. These criteria are based on the levels at which dust becomes a nuisance and consequently perception of dust is an important factor. Therefore the goals were developed through determining levels where dust creates nuisance impacts and levels where dust is unacceptable. The criteria were then formed by considering the annual average dust deposition for an area and subtracting this from the dust deposition nuisance level to obtain the maximum acceptable increase. These criteria are provided in Table 12-3.

The existing dust fallout in the study area is likely to be in the order of 2 g/m² per month where no extenuating circumstances (such as bushfires) are occurring. Therefore the acceptable dust deposition criterion for residential and other areas along the route is less than a 2 g/m² per month increase. The appropriate goal for the Proposal is a total dust deposition rate of 4 g/m² per month measured on an annual basis.

Table 12-3 NSW DEC dust fallout criteria converted to g/m^2/month

Existing dust fallout level	Maximum acceptable increase over existing fallout	
	Residential	Other
0 - 2 g/m² per month	2 g/m² per month	2 g/m² per month
2 - 3 g/m² per month	1 g/m² per month	2 g/m² per month
3 - 4 g/m² per month	0 g/m² per month	1 g/m² per month

12.2 Meteorology and existing air quality

12.2.1 Meteorology

The nearest Bureau of Meteorology monitoring stations with data that can be considered to represent the meteorological conditions in the study area are at Port Macquarie (Hill Street Monitoring Station 60026) and Taree (Radio Station 2RE Monitoring Station 60030), approximately 25 km northeast and 35 km south of the study area respectively. Slight climate differences exist between the two towns, as Port Macquarie is located on the coast and Taree is approximately 16 km inland. Rainfall records are kept at Kendall (Monitoring Station 60020), which is located within the study area.

Wind data

Based on wind rose data from the Bureau of Meteorology, the prevailing wind direction at both Port Macquarie and Taree is as shown in Table 12-4. Average 9am wind speeds are 3.9 m/s in Port Macquarie and 1.9 m/s in Taree, whilst 3pm wind speeds are 5.6 m/s and 3.5 m/s respectively. However conditions such as topography and land use along the proposed route have a strong impact on local wind conditions.

Table 12-4 Wind direction data

Location	Prevailing wind direction	
	Summer (9am and 3pm)	Winter (9am and 3pm)
Taree	North-east/south-west (summer) South-east (winter)	West (summer) South-west (winter)
Port Macquarie	South-west (summer) North-east (winter)	North-east (summer) South-west (winter)

Source: Bureau of Meteorology

Temperature, humidity and rainfall

Taree tends to have hotter summers and slightly cooler winters than Port Macquarie. It is reasonable to assume this represents the range of conditions over the region and study area, and consequently averages of the two locations are used.

The average annual minimum temperature is 13°C and the average annual maximum is 22.1°C. February is the hottest month recorded with an average maximum of 25.8°C and July is the coldest month with an average minimum of 7.2°C.

Annual average humidity across the two towns is 77% at 9am and 70% at 3pm. February and March are reported to have the highest humidity with a 9am average of 81% and August typically has the lowest with an average of 63%.

The mean monthly rainfall recorded by the Kendall Monitoring Station 60020 is 115.1 mm. On average there are between 11 and 14 rain days per month during summer and between 7 and 10 rain days per month in winter. The highest monthly mean rainfall occurs in March with 177.4 mm and the lowest mean monthly rainfall occurs in August with 64.2 mm. The average annual rainfall recorded is 1,381.5 mm.

12.2.2 Existing air quality

Site-specific air quality monitoring of carbon monoxide (CO) was undertaken in five locations along the route of the Proposal between 29 September and 5 October 2000. Concentrations of CO were measured at five-minute intervals. A meteorological station was also established at the Kew Court Motel site to record peak and five-minute average wind speed, peak and five-minute average wind direction, and peak and five-minute average temperature during the entire seven-day sampling period.

The monitoring period included a time of peak traffic on 2 October 2000 when there was a public holiday coinciding with the end of school holidays and conclusion of the Sydney 2000 Olympic Games. Conditions occurred during this period that would give rise to 'worst case' scenarios such as peak traffic and poor dispersion conditions including light winds blowing nearly parallel to the road. Table 12-5 provides details of monitoring locations, CO levels recorded and their assessment with respect to air quality criteria.

CO was monitored as it is a characteristic motor vehicle emission. No other emissions were monitored because it was not considered necessary in a rural area that generally has low pollutant levels. Other emissions have been assessed on a pro rata basis relative to CO.

Table 12-5 Existing route air quality monitoring results

Monitoring location and speed zone	Details	Average time interval	Average maximum recorded CO levels (ppm)	Compliance with criteria*
Kew Court Motel 60 km/h	29 September to 5 October 2000. 8 m from southbound traffic lane on the eastern side of the Pacific Highway, 80 m south of the main intersection Kew.	15 minute 1 hour 8 hour	12.7 5.1 3	Complies with NEPM & WHO
Kew, west side of Pacific Highway 60 km/h	Established for the afternoon of Monday 2 October 2000 while easterly winds prevailed. 18 m from the northbound traffic lane and approximately 150 m from Kew Court Motel.	15 minute 1 hour	3.3 <1	Complies with NEPM & WHO
Kew, 14 Glen Haven Drive 80 km/h	29 September to 5 October 2000. Background air quality site. Over 660 m from the Pacific Highway and 70 m from the kerb in a very quiet cul de sac.	all intervals	0	Complies with NEPM & WHO
Johns River Community Hall 80 km/h	29 September to 5 October 2000. 9 m from the southbound traffic lane on the eastern side of the Pacific Highway immediately outside the Community Hall.	1 hour 8 hour	0.9 1	Complies with NEPM & WHO
Johns River, opposite Community Hall 80 km/h	Established for the afternoon of Monday 2 October 2000 while easterly winds prevailed. 18 m from the northbound traffic lane.	15 minute 1 hour 8 hour	3 <1 <1	Complies with NEPM & WHO

* see Section 12.1.1

12.3 Estimation of emissions

12.3.1 Modelling

The CALINE4 dispersion model was used to estimate the concentrations of CO, NO_2 and PM_{10} that are likely to be produced in the vicinity of the Proposal. It is based on the Gaussian diffusion equation and employs a mixing zone concept to characterize pollutant dispersion over the roadway. This model can determine concentrations at receptor locations downwind of 'at grade', 'fill', 'bridges' and 'cut section' of highways located in relatively uncomplicated terrain. CALINE4 is widely used in Australian roadway studies and was validated for Australian conditions in 1994 by Williams et al. for the RTA.

12.3.2 Estimating emissions

The assessment for emissions estimation involved the identification of worst-case conditions that comprise 1-hour peak traffic flow, combined with the poorest dispersion conditions (very light winds). Traffic flow was assumed to be constant (at peak levels) along the route.

Traffic volumes in each direction on the Proposal were modelled for two scenarios: the existing (baseline) scenario for the year 2002; and for the future years of the scheme 2011 and 2021. Traffic data forecasts were taken from Working Paper No. 1.

Seven receptors were selected within the study area as representative of areas on which to base the assessment of air quality. All receptors selected were located either close to the route of the existing highway or to the alignment of the Proposal. Figure 12-1 illustrates the locations of the representative receptors within the study area.

The estimated peak hour traffic emissions based on the predicted traffic volumes are shown in Table 12-6.

CALINE4 requires the ambient concentration of ozone (O_3) in the study area to determine forecasts of NO_2. No O_3 monitoring was undertaken in the study area and a conservative value equal to NEPM criteria (0.1 ppm) was used.

12.4 Approach to impact assessment

Air quality studies are concerned with the presence or absence of airborne pollutants that have the potential to adversely affect human health and the environment. The main potential source of atmospheric pollutants arising from use of the Proposal is from vehicle emission.

The impact of the Proposal during operation on local air quality would primarily relate to exhaust emissions from vehicles travelling along the highway as well as those on the local road network where there could be changes in traffic volumes and levels of congestion. However, reference to the available traffic data for the area shows that local congestion is not projected to be a problem during the Proposal design life and is not addressed further in this Chapter.

Construction dust and related traffic and plant exhaust emissions may also be of concern but are rarely significant when compared with other traffic emissions in an area and would be temporary and short term in nature.

No consideration has been given in this study to the impact of pollutants from sources other than the Proposal except in the case of dust at Johns River where there is no reticulated water supply.

12.4.1 Construction impacts

The principal sources of air pollution during construction of the Proposal include:

- dust from topsoil stripping and earthworks
- exhaust emissions from construction traffic, plant and machinery.

Dust emissions

Dust emission is the generic term used to describe the processes by which particulate matter is lifted from a surface to enter suspension in the atmosphere. This may occur by wind blow or mechanical abrasion. Uncontrolled dust emissions that take place directly to atmosphere are referred to as fugitive emissions.

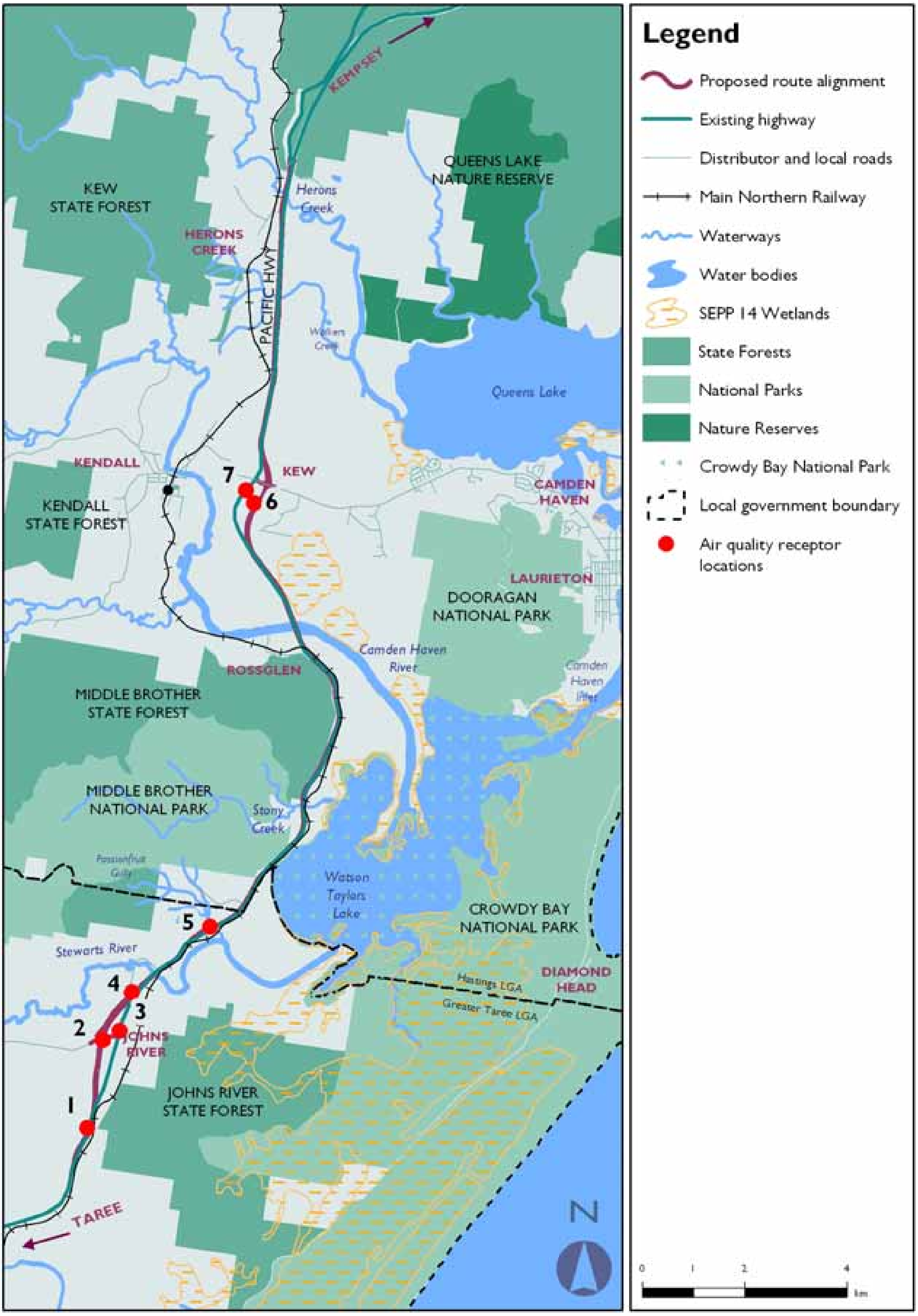

Figure 12-1 Air quality measurement receptor locations

Table 12-6 Estimated peak hour traffic emissions[1] for the Proposal

Pollutant	Carbon Monoxide (CO) (ppm)	Nitrogen Dioxide[2] (ppm)	Fine Particulate Matter (PM_{10}) (µg/m³)
Criterion	25[3]	0.12[4]	50[5]
Receptor 1 - Station 730, 30 m to nearest carriageway			
2002 Existing	0.4	0.03	3.0
2011 with upgrade	0.2	0.05	1.8
2021 with upgrade	0.2	0.05	1.4
Receptor 2 - Station 2500, 20 m to nearest carriageway			
2002 Existing	0.0	0.00	0.1
2011 with upgrade	0.3	0.07	2.6
2021 with upgrade	0.2	0.07	2.0
Receptor 3 - Johns River township (existing highway), 300 m to nearest carriageway			
2002 Existing	0.7	0.09	6.1
2011 with upgrade	0.0	0.00	0.1
2021 with upgrade	0.0	0.00	0.1
Receptor 4 - Station 3700, 55 m to nearest carriageway			
2002 Existing	0.3	0.04	2.5
2011 with upgrade	0.2	0.05	1.8
2021 with upgrade	0.2	0.05	1.4
Receptor 5 - Station 5700, 20 m to nearest carriageway			
2002 Existing	0.6	0.07	4.6
2011 with upgrade	0.4	0.09	3.2
2021 with upgrade	0.3	0.09	2.5
Receptor 6 - Station 15350, 15 m to nearest carriageway			
2002 Existing	0.0	0.0	0.0
2011 with upgrade	0.3	0.07	2.5
2021 with upgrade	0.2	0.08	2.0
Receptor 7 - Kew township (existing highway), 200 m to nearest carriageway			
2002 Existing	1.1	0.12	8.4
2011 with upgrade	0.2	0.03	1.1
2021 with upgrade	0.2	0.04	1.0

Notes: 1. Emission factors (highway/freeway) provided by NSW DEC (Charles Xu, 6 December 2002).
2. A highly conservative forecast that assumes an ambient background for O_3 of 0.1ppm.
3. WHO criteria
4. NEPM criteria
5. NEPM daily criterion

The ability of dust to become and remain airborne and disperse in the atmosphere is determined by both internal parameters (i.e. shape, size and chemical and physical composition) and external parameters (i.e. wind speed and atmospheric stability, and energy supplied by emission force). Studies have indicated that large particulate matter comprising typically 95% of total fugitive dust emissions, return to the surface within 60-90 m of the emission source. Smaller dusts in the size range 10-30 μm in diameter are the second most abundant class of particles found on or around construction sites, and may travel up to 250 m and exceptionally up to 500 m from source before depositing back to the surface.

Fugitive dust would be generated from earthworks associated with construction of the Proposal and it can cause a nuisance to residences and businesses, usually by soiling surfaces. The quantity of dust generated would be dependant on the silt and moisture content of the soil, the types of operations undertaken, the exposed area, frequency of water spraying and speed of machinery. The major sources of dust during construction of the Proposal would be from construction equipment (such as dozers, excavators, scrapers, and trucks) and wind erosion.

It is appropriate to consider goals for dust deposition during the construction period. This is assessed in relation to what is considered an acceptable increase in dust deposition over the existing background level (see Section 12.1.1). Existing deposition levels in the study area are likely to be relatively low, less than 2 g/m^2 per month. Accordingly, the Proposal goal for the construction period is a total deposition rate of 4 g/m^2 per month, measured on an annual basis.

Sensitive receptors

Potential nuisance from dust impacts associated with construction of the Proposal would most likely be experienced at sensitive receptors (i.e. businesses and residences) within 250 m of major cut and/or fill operations. Major cut and/or fill operations would be carried out at the following locations (see Figures 6-1A to 6-1N):

- Johns River bypass – major cut of height 14 m at mid-point Station 1550
- Stewarts River crossing – major fill of 6.5 m at mid-point Station 3800
- Lake section – various major cuts between Stations 4750 to 10050
- Camden Haven River crossing – major cut and fill at mid-point Stations 12400 and 13100
- Kew bypass – major cut sections between Stations 14700 and 16250.

A few rural residential properties are located within 250 m of major cut or fill operations along the Lake section and the Camden Haven River crossing respectively.

Of greatest sensitivity to potential dust impacts are the townships of Johns River and Kew, which are located within 250 m of major cut and fill construction associated with the bypasses.

Dust particles deposited under prevailing wind conditions could accumulate on the roofs of houses located within 250 m of the proposed construction areas and ultimately find their way into rainwater tanks. Concern was raised during the consultation process by residents of Johns River and rural dwellings along the Proposal route who rely on rainwater tanks for potable water supplies. Dust deposition on roofs is likely to be negligible provided a variety of mitigation measures and management techniques are implemented (see Section 12.6) to minimise dust propagation during construction of the Proposal. In addition, the progressive nature of construction would mean that construction would only exist near a particular residence or concentration of residences for a defined period of time – perhaps up to six months, although this would depend on the construction process and timing adopted.

It is anticipated that the small amounts of dust that may accumulate on roofs would not affect water supplies as the natural treatment processes within rainwater tanks, such as sedimentation, would treat the water to a sufficient standard for potable use. In addition, residents who rely on rainwater tanks for domestic supply generally undertake periodic cleaning and flushing of tanks.

No dust monitoring is currently carried out in the study area. In order to determine baseline background dust levels prior to the commencement of construction, at least three dust monitoring gauges would be installed two months prior to construction works on the boundaries of residences most likely to be affected. Assessment of the changes in dust production during construction and the compliance with guidelines could then be readily made and action taken based on these assessments.

Exhaust and other emission impacts

There would be a temporary increase in traffic on the highway during construction. Polluting effects from construction plant and vehicles would be minimised by ensuring that all plant and vehicles are serviced regularly and maintained in optimum condition such that exhaust and other emissions meet or surpass existing NSW DEC standards to ensure no breach of Section 124 of the POEO Act 1997 or clause 9 of the *Protection of the Environment Operations (Clean Air) Regulation 2002*.

Odour and HC emissions would occur during pavement spray sealing work and line painting. However, these impacts would be of a short duration only and are unlikely to cause any significant impact.

Batching plants

If the established ready mixed concrete and asphalt suppliers in the region are not able to provide fully the material quantities required for construction of the roadway, concrete and/or asphalt batching plants would need to be established on site (see Chapter 7). Air pollution, especially due to fine particulates/dust, is most likely during transport and the transferral of concrete and asphalt constituents into storage and processing facilities.

Potential odour emissions could be an issue during the loading of asphalt, however odour should not occur off-site of well managed and located asphalt plants. Minor spillages may also occur whilst filling concrete mixers and bitumen tankers with their respective contents and at transferral points at the construction site. These spillages are unlikely to cause any adverse impacts to the local airshed.

Mitigation techniques can be successfully implemented at all stages of asphalt and concrete production and are listed in Section 12.6.

12.5 Operational impacts

The Proposal would result in improved air quality in the Johns River and Kew townships, as the majority of traffic that previously used the existing highway through these towns would use the new bypasses.

The operational impacts on air quality in the vicinity of the Proposal were assessed through a comparison of the predicted ground-level concentrations of vehicle emissions to air quality goals and other air quality criteria.

The maximum 1-hour average increase in ground-level concentrations of CO, NO_2 and PM_{10} for seven key receptors were predicted (see Table 12-6). The model was set to determine the worst-case wind condition and peak traffic conditions.

12.5.1 Carbon monoxide (CO)

The existing and predicted average background levels of CO from other sources are low and well below the WHO (25 ppm) goal. WHO guidelines were used as no Australian state or national source provided CO goals at the hourly level. The modelling undertaken (see Table 12-6) shows that CO emissions would decrease at five of the receptors and slightly increase at the remaining two (Nos 2 and 6). The predicted levels at all receptors remain well below the WHO criteria.

12.5.2 Nitrogen dioxide (NO_2)

Results differ slightly for predicted changes to NO_2 concentrations when compared with CO levels. The primary reason for this is that improvements in vehicle emissions technology are not expected to be as prominent for oxides of nitrogen as they are for CO. Consequently, NO_2 concentrations are expected to increase for receptors Nos 1, 2, 4, 5 and 6 as the effects of the new highway alignment being positioned closer to these receptors are forecast to outweigh reductions from improved emissions technologies. The remaining receptors (Nos 3 and 7) are expected to experience a decrease in NO_2 concentrations, as they are located in the towns of Johns River and Kew respectively. The Proposal would bypass these towns and remove the major source of NO_2.

It should be noted that receptors Nos 3 and 7, located within the towns of Kew and Johns River, represent the majority of sensitive receptors in the study area.

Despite the slight increases for most receptors, the predicted NO_2 levels would still be below NEPM goals (0.12 ppm). These predictions do not fully take into account the benefits of catalytic converters or controls on diesel vehicles. Predicted levels are therefore likely to be higher than those that would actually occur once the Proposal is operational. Predictions are also likely to overestimate the actual increase in NO_2 from the Proposal due to the conservative estimates of O_3 levels (0.1 ppm) that was used for calibration when forecasting this element.

12.5.3 Particulate matter (PM_{10})

All receptors except for Nos 2 and 6 are predicted to experience a decrease in PM_{10}. The reasons are the same as for CO, with receptors Nos 2 and 6 recording almost zero background PM_{10} concentrations (0.1 and 0 µg/m³ respectively) during the 2002 monitoring. The Proposal would be located closer to these two receptors causing a slight increase in concentrations.

Available guidelines only provide criteria for concentrations of PM_{10} measured at the daily interval. Despite predictions being made at the hourly level, PM_{10} concentrations at all receptors along the Proposal are unlikely to exceed the historical 24-hour or interim NSW DEC and NEPM goals in 2011 and 2021. Exceedence of the DEC goals is unlikely due to the lack of other dust-generating sources in the vicinity of the Proposal. The predicted 1-hour increase in PM_{10} at the most affected receptor (3.2 µg/m³) is significantly less than the daily criterion (50 µg/m³). The hourly average values represent worst-case emission levels and are significantly higher than daily average values.

12.5.4 Greenhouse issues

The RTA is committed to ensuring that its environmental goals and policies are consistent with those outlined in the 1992 *Intergovernmental Agreement on the Environment* (Australian Department of the Environment and Heritage 1992) that addresses the greenhouse effect and other environmental issues. This commitment is facilitated through a number of strategies and initiatives as documented in the annual RTA environment reports (such as *RTA Environment Report 2003* [RTA 2003c]) addressing greenhouse gas emissions and energy consumption in relation to road transport.

Approximately 12% of NSW's total greenhouse gas emissions are estimated to be attributable to the transport sector (NSW DEC 2004). RTA programs that encourage better vehicle maintenance and hence optimal fuel economy will be beneficial. The RTA continues to engage in other strategies to encourage the tightening of vehicle emissions standards. Greenhouse gas emissions (i.e. CO_2) from motor vehicles are directly proportional to fuel consumption.

An estimate of greenhouse emissions for both the Proposal and the do-nothing option on the existing highway has been prepared using the following methodology. The analysis does not take into account emissions associated with vehicles travelling on any side or intersecting roads.

Projected traffic volumes

Traffic volume projections are those presented in Section 4.4 of this EIS. The opening date for the Proposal was assumed to be 2012 and a period of 30 years from the opening date was used for the analysis. It has been assumed the traffic volumes would increase at the same rate for the existing highway do-nothing and Proposal options evaluated.

Heavy vehicle composition

The volume and proportion of heavy vehicles varies depending on the type of day (weekday, weekend and holiday) and time of day (daytime, evening and late night/early morning). The percentage of heavy vehicles based on the above categories has been determined through the application of a daily profile of heavy vehicle composition.

This was achieved by classifying every date in the base case into the three broad categories of weekday, weekend and holiday. Because the Proposal length is subject to significant holiday peak flows, the top 30 days with the highest daily traffic volumes in the base year were defined as part of the holiday periods. This 30-day period was selected as it covers the area of the volume versus time graph beyond which there is a clear change in the relationship slope.

The daily profiles of heavy vehicle compositions for an average weekday and weekend day were extracted from available vehicle classification counts. These profiles provide an estimate of the hourly heavy vehicle composition on the Pacific Highway in any given day.

Due to the large increases in traffic volumes during holidays, an additional holiday period profile was generated. This has been done to reflect the decrease in the proportion of heavy vehicle movements during holidays and it has been assumed to be the same as the weekend profile.

Relationship between greenhouse gas emission and travel speed

The amount of greenhouse gas emitted from a vehicle is proportional to the amount of fuel used and Table 12-7 illustrates the relationship for various fuel types.

Table 12-7 Point source emission factor for CO_2

Fuel Type	kg/l $CO_{2\ eq}$
Diesel	2.7
Passenger Leaded/Unleaded	2.5
LPG[(1)]	1.6

Source: Table 3 of *AGO Factors and Methods Workbook* (Australian Greenhouse Office 2004)
Note 1 Not used in modelling

The amount of fuel consumed is a function of vehicle speed. Details of this relationship have been sourced from European Environment Agency Technical Report No 49 *COPERTIII – Computer programme to calculate emissions from road transport* (Ntziachristos and Samaris 2000). Appended to this technical report are tables providing a wide range of information on vehicle performance and its relation to emissions. In particular, Tables 5.7 and 5.19 show speed dependency consumption factors for petrol passenger cars and heavy-duty diesel trucks. For the purpose of analysis, typical vehicles have been assumed to be a petrol car of over two litres engine capacity and a diesel truck of weight greater than 32 tonnes. Fuel consumption in grams per kilometre for each class of vehicle may be then calculated from the following formulae of Tables 5.7 and 5.19:

- Cars: $181.85 – 3.398V + 0.0209\ V^2$ (speed range validity: 12.7 – 130 km/h)
- Trucks: $1855.7V^{-0.4367}$ (speed range validity: 0 – 58 km/h)
  $0.0765V^2 - 11.414V + 720.9$ (speed range validity: 58 – 100 km/h)

These relationships are graphed in Figure 12-2 based on densities of 0.737 g/ml for petrol and 0.827 g/ml for diesel fuel for the purpose of conversion to consumption in litres. These densities have been obtained from ExxonMobil material safety data sheets for Mobil products 'Aus Spec Unleaded Petrol' and 'Mobil Diesel Plus' (Exxon Mobil 2002 and 2003).

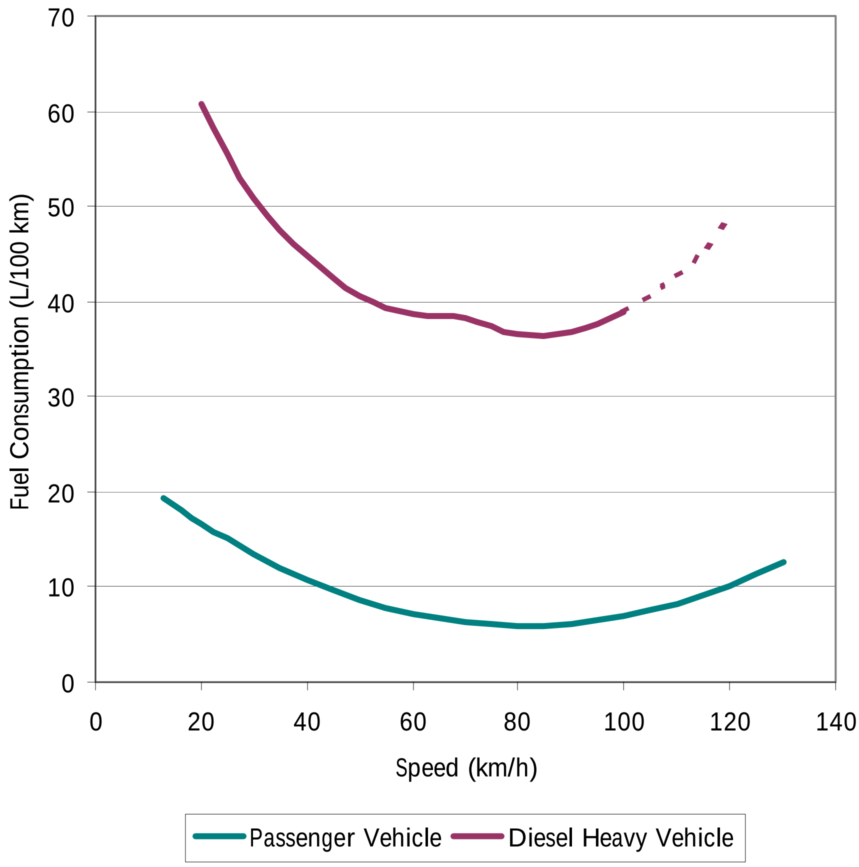

Figure 12-2 Relationship between fuel consumption and speed

In general, the most economical consumption of fuel occurs when both vehicle types are travelling at approximately 80 km/h. Fuel consumption increases for both higher and lower speeds.

It may be argued that European conditions and vehicles do not replicate those in Australia and, in using only the two consumption/speed relationships graphed, many other factors arising from vehicle and road conditions have not been taken into account. The purpose of undertaking the greenhouse gas emission calculation was to determine the difference in performance between the do-nothing case and the Proposal. For this purpose, the use of the two relationships is considered to provide an adequate indication of differential performance.

Level of Service and average travel speed

The LoS concept has been used as the basis for the capacity analysis from which average speeds may be hypothesised. The level of service for each hour in the analysis period was determined by comparing the projected hourly flow rates and the maximum hourly service flow rates of the option analysed.

The service flow rates for the existing highway and the proposed upgrade to dual carriageway were determined using the methodology provided in Part 2 - Roadway Capacity - of the *Guide to Traffic Engineering Practice* (AUSTROADS 1988). Thus, the average travel speed for each LoS was determined.

As the existing highway has various speed zones within the study area, average travel speeds are determined for the speed zones of 100 km/h, 80 km/h and 60 km/h. It should be noted that the AUSTROADS guideline only outlines average travel speeds for a rural two-lane two-way road section with a design speed of 100 km/h. To determine the average travel speed at various level of service for different speed zones, the maximum travel speeds (i.e. the speed limits) of the other speed zones have been proportioned in accordance with the average travel speeds given in the guidelines. In the case of the 60 km/h speed zone through the township of Kew, a conservative maximum travel speed of 35 km/h has been assumed to simulate the impacts of the signalised intersection in the area.

Table 12-8 summarises the total service flow rate and average travel speed for each direction under the various levels of service.

Table 12-8 Capacity analysis

LoS	Existing highway (two-lane two-way rural)				Four-lane dual carriageway	
	Service flow rate (vehicles/ one lane/hour)	Average travel speed			Service flow rate (vehicles/ two lanes/hour)	Average travel speed
		100 km/h*	80 km/h	35 km/h		110 km/h*
A	165	91	73	32	1064	105
B	286	86	69	30	1597	85
C	461	82	66	29	2099	80
D	681	78	62	27	2572	64
E	1066	64	51	22	2957	48
F	-	32	26	11	-	24

* Part 2 - Roadway Capacity - of the *Guide to Traffic Engineering Practice* (AUSTROADS 1988)

Through the comparison of the projected hourly traffic volumes and maximum service flow rate, a level of service and an average travel speed is determined every hour in the 30-year analysis for each direction under do-nothing and proposed four-lane dual carriageway conditions.

Greenhouse gas emissions

Based on first principles and the point source emission factors outlined in Table 12-7, the estimated CO_2 emissions generated by vehicles per hour for each of the options have been determined using the following formula.

$$E_x = \sum_i \frac{T \times L_i}{100{,}000} (P_c \times F_{csi} \times 2.5 + P_t \times F_{tsi} \times 2.7)$$

- E_x = Total CO_2 emissions at LoS x (tonne $CO_{2\,eq}$ per hour)
- T = Projected traffic flow (vehicles/hour)
- L_i = Length of speed zone i (km)
- P_c = Proportion of cars
- P_t = Proportion of trucks
- F_{csi} = Fuel consumption for cars travelling at S_i (L/100 km)
- F_{tsi} = Fuel consumption for trucks travelling at S_i (L/100 km)
- S_i = Average travel speed for speed zone i at LoS x

This formula is applied to every hour in the 30-year analysis period, and based on the LoS and average travel speed previously determined, the total carbon dioxide emissions per hour have been estimated.

Figure 12-3 summarises the estimated annual CO_2 emissions produced for the two options evaluated in the 30-year period.

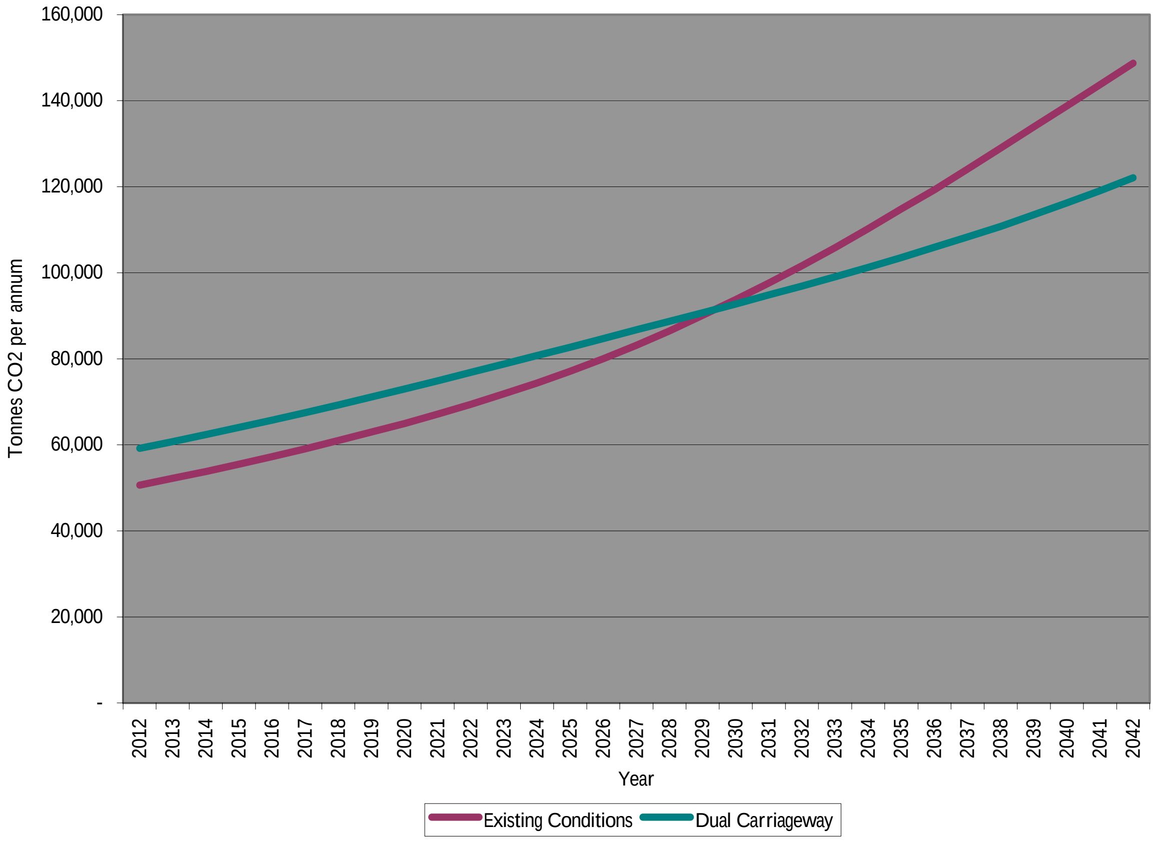

Figure 12-3 Projected annual CO_2 emissions

Over the 30-year analysis period, under the same projected traffic growth rate, it is estimated that 2,779,000 tonnes of CO_2 would be produced under do-nothing conditions of the existing highway and 2,722,000 tonnes of CO_2 under Proposal conditions – a difference of approximately 57,000 tonnes.

Emissions from fuel used during construction must also be taken into account. It is estimated that 15 million litres of diesel fuel will be used and this will produce around 41,000 tonnes of greenhouse gas. This is a comparatively small amount and even when added to the Proposal emissions from traffic using the highway does not alter the conclusion that over the projected 30-year life of the Proposal, it is expected to produce marginally less greenhouse gas than the do-nothing case. Furthermore, Figure 12-3 shows that by the end of the assumed 30 year operating life, the Proposal would be saving about 30,000 tonnes per year of CO_2 compared to the do-nothing case and that the amount of the annual savings would be increasing each year.

12.6 Mitigation measures

To reduce the extent of any adverse air quality impacts as much as possible in the future years of highway operation, the principal mitigation measure during the design phase was to select a route that would divert the highway away from sensitive receptors and to provide road conditions that would increase the efficiency with which vehicle engines operate. The Proposal has therefore been designed to incorporate bypasses of both Johns River and Kew - the two areas containing the highest concentration of sensitive receivers (but each with a population of less than 200 people (see Section 18-1). The concept design for the Proposal provides for continuous speeds consistent with legal limits and minimal changes in speed by eliminating constraints such as steep inclines and sharp bends. Stop/start urban conditions that affect vehicle speeds have been eliminated.

12.6.1 Construction

During construction, air pollution is most likely to be attributable to:

- emissions caused directly by construction traffic, excavating equipment and specialist road construction plant
- propagation of dust associated with topsoil stripping, earthworks and reinstatement.

Appropriate mitigation measures and design treatments to prevent or otherwise mitigate local air quality impacts during construction are outlined below.

Dust mitigation

Good site management is the key to effective dust control. This includes:

- preparation of an Air Quality/Dust Management Plan in accordance with RTA requirements for dust control facilitating:
    - the establishment of appropriate dust control practices and procedures
    - the efficient operation of these controls
    - the effectiveness of measures in controlling dust
    - transparency and amenability of auditing procedures
- dust gauge monitoring to assess the success of measures implemented
- establishing a complaints management system to acknowledge, assess and correct problems
- management of on-site haul routes incorporating:
    - the provision of stabilised surfaces for main site haul roads where practicable
    - ensuring all-weather surfaces for routes and vehicle waiting areas are kept clean where practicable
    - watering trafficked sections as appropriate
    - ensuring traffic is restricted to watered or treated haul roads where possible to prevent the inadvertent tracking or otherwise of construction vehicles and plant over areas of stripped or exposed ground
    - establishing and enforcing appropriate speed limits over unmade surfaces where dust is an issue
- undertaking roadside cleansing, including:
    - keeping public roads and footpaths clean from mud and dust as far as reasonably practicable
    - covering all vehicles carrying potentially dusty materials on public roads

- material storage management such as:
  - placing stockpiles of materials as far as reasonably practicable away from residential areas, places of public access and site buildings
  - pre-dampening, covering and revegetating long term stockpiles where possible
  - undertaking the mixing of large quantities of concrete in enclosed or shielded areas where practicable
  - establishing procedures for the spillage of dusty or potentially dusty materials including prompt clearance of any such spillage
- implementing operational controls including:
  - installation of wheel wash equipment to clean wheels and undercarriages of all vehicles entering and leaving construction or work areas
  - covering of all vehicle loads to and from the construction and work areas
  - enclosing shielding or providing filters on plant likely to generate excessive quantities of dust (e.g. dust extractors, filters and collectors on drilling rigs)
  - using windbreaks, netting screens or semi-permeable fences
  - stopping or relocating construction activities during periods of consistently high wind, i.e. 10 m/s average over a 10-minute period (35-40 km/h) until the wind velocity stops
  - seeding, planting or sealing completed works as soon as possible.

Cement concrete and asphaltic concrete batch plants

The following measures can help to maintain adequate air quality where batch plants are required for the manufacture of cement concrete and asphaltic concrete:

- using water sprays to reduce dust emissions during loading operations at the plant
- restricting drop heights for materials or products onto vehicles and conveyors
- enclosing conveyor and transfer points and damping of conveyor loads
- enclosing or shielding plant such as cement silos where possible
- spraying internal plant roads with a water cart.

Emission controls

Emissions from construction vehicles and plant can be mitigated by:

- ensuring construction plant, vehicles and equipment are serviced regularly and maintained in optimum condition so that exhaust emissions meet or surpass existing air quality standards
- preventing the unnecessary or inadvertent idling of engines.

Other measures

The following measures would help prevent any other sources of air pollution during construction:

- avoiding the on-site burning of any waste from construction activities unless agreed with the local councils and NSW DEC
- reducing the number of materials handling operations
- conducting on-site cutting and grinding operations with equipment and techniques that reduce emissions and incorporate dust suppression measures

- implement strategies to prevent, contain and manage any spills of volatile substances used during construction activities
- locating any odour producing construction plant away from sensitive receptors and ensuring odour producing activities, such as laying asphalt, will be undertaken in the minimum required time near sensitive receptors.

12.6.2 Operation

There is no effective mitigation of operational air quality impacts introduced by individual highway schemes. Principal mitigation measures relate to general improvements in road vehicle and fuel technologies. These are measures beyond the scope of this Proposal and may be effected through the implementation of initiatives for tighter vehicle emission and fuel quality standards as outlined in *Action for Air*.

12.7 Monitoring

Deposition monitors would be installed two months before the start of construction to determine existing and Proposal-related dust levels at sensitive receptors. Monitoring would be carried out during construction to assess compliance with NSW DEC goals. A minimum of three monitors would be required, ideally at the closest residences to locations of major earthworks.

12.8 Implications for ESD

12.8.1 Precautionary principle

The air quality assessment has been undertaken in line with relevant Australian and NSW DEC standards as discussed in this chapter. The assessment shows that all relevant air quality goals and standards would or can be met during construction and operation of the Proposal. Mitigation measures during the construction period have been identified to reduce impacts as and when necessary. Any serious or irreversible environmental damage is unlikely.

12.8.2 Intergenerational equity

If the Proposal proceeds, the air quality would improve for the majority of residents within the study area. Land use in the vicinity of the proposed road involves agriculture, National Park and State Forest activities with very few existing or likely future residents who would be affected by any changes in air quality associated with development of the Proposal.

12.8.3 Conservation of biological diversity

Good air quality is an essential element in the maintenance and enhancement of biological diversity. With the operation of the Proposal, all relevant air quality criteria would be met.

12.8.4 Improved valuation and pricing of environmental resources

Recognition of the ecological and economic importance of good air quality is essential to community and environmental well-being.