NZ TRANSPORT AGENCY
WAKA KOTAHI

Roads of national significance

16 20 Western Ring Route – Waterview Connection

Assessment of Air Quality Effects

Beca

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1. Summary Statement

In support of the notices of requirement for land designations and applications for resource consents (for discharges into air from road construction actvities, concrete batching and rock crushing) under the Resource Management Act 1991 (RMA), the NZ Transport Agency (NZTA) has commissioned Beca Infrastructure Limited (Beca) to assess the potential air quality impact associated with the Waterview Connection Project (the Project). Through the Project, the NZTA proposes to construct, operate and maintain the motorway extension, including a tunnel portion, of SH20 from Maioro Street (New Windsor) to connect with State Highway 16 (SH16) at the Great North Road Interchange (Waterview). In addition, the Project provides for increased capacity on the SH16 corridor. The road tunnels will be provided with a mechanical ventilation system which will discharge via ventilation stacks at each end of the tunnel alignment.

In undertaking this assessment, Beca has followed the procedures outlined in the Ministry for the Environment's Good Practice Guide for Assessing Discharges to Air from Land Transport (2008) and the draft NZTA Standard for Producing Air Quality Assessments for State Highway Projects (2010).

Dispersion modelling has been used as the primary tool to quantitatively assess pollutant concentrations associated with the motorways, the tunnel and changes in the existing roading network as a result of the Project. The dispersion model inputs of vehicle emission rates and traffic volumes have been derived using traffic modelling and the Auckland Regional Council's (ARC) Vehicle Emissions Prediction Model v3 (VEPM) emission factors. Potential effects have been assessed by comparing predictions against relevant health-based National Environmental Standards for Air Quality (AQNES), New Zealand Ambient Air Quality Guidelines (NZAAQG) and Auckland Regional Air Quality Targets (ARAQT). These air quality criteria are designed to protect the health of the most vulnerable individuals in the community. The AQNES is currently under review and undergoing consultation following proposed amendments. The currently proposed amendments are not considered to impact the criteria used in this assessment.

The potential air quality impacts have been predicted for a 'base year' of 2006 and for two future years, 2016, and 2026. For the years 2016 and 2026, the emission scenarios have considered both "Do Nothing" (i.e. the Project not being undertaken) and the "With Project" scenario (i.e. the NZTA's proposed development option). The assessment has focused on the relative impacts that the 2016 and 2026 emission scenarios will have on the existing air quality, when compared to the existing baseline as modelled in the 2006 emission scenario.

The potential effects of carbon monoxide (CO), fine particles (PM_{10} and $PM_{2.5}$), nitrogen dioxide (NO_2) and benzene have been considered in the assessment. Conservative existing (background) levels of CO, PM_{10} and NO_2 have been derived using ambient air quality data collected at two locations within the Project area, the ARC's monitoring stations and the NZTA passive sampling programme. Background benzene concentrations have been derived from the results of the NZTA passive sampling programme. A background $PM_{2.5}$ concentration has been estimated from concentrations recorded at the ARC's Kingsland, Penrose and Takapuna monitoring stations.

Dust will also be generated during the construction phase of the Project. Due to the close proximity of sensitive receptors, including residential premises and childcare facilities, to the proposed construction footprint for the Project, a high standard of emissions control and management will be employed to adequately avoid or mitigate the effects of discharges of construction dust. A draft Construction Air Quality Management Plan (CAQMP) has been prepared, which is designed to form the basis for specific management plans to be prepared by contractors. Once finalised, this CAQMP and the specific management plans prepared by contractors will detail methods to be used to mitigate discharges of contaminants into air from the construction of the Project.

The construction programme for the Project requires that concrete batching and rock crushing plant be located very close to the tunnel portals. Through the use of appropriate emissions control and good on-site management, adverse effects that may otherwise be caused by discharges of dust from concrete batching or rock crushing will be adequately avoided or mitigated. Recommended mitigation and monitoring measures have been detailed in a draft Concrete Batching and Rock Crushing Plant Management Plan (CBRCPMP), which will form part of a Construction Environmental Plan (CEMP) for the Project.

The key conclusions of this air quality assessment are as follows:

- People living, working or spending time (e.g. at school or in reserves) close to most of the existing busy arterial routes through the Project area will have a reduced exposure to vehicle related contaminants as a result of the Project, than would occur without the Project.

- The operation of the tunnel will improve air quality in many parts of the Project area, due to the emissions being taken off local roads and being vented and dispersed higher in the atmosphere. Tunnel vents 25m high are designed to provide effective and efficient dispersion of vehicle emissions. Moving the traffic through tunnels and venting the emissions means better air quality than would exist with the same traffic volumes using local roads.

- Some locations are predicted to slightly increase the exposure of people living, working or spending time in the Project area to vehicle related contaminants above the “Do Nothing” scenario (i.e. without the Project), due to the southern surface portion of SH20 south of the tunnels and increased flows on the existing section of SH20 at Mt Roskill. However, exposure levels in all areas will comply with the AQNES which are designed to protect the health of the most vulnerable individuals in the community. The predicted exposure levels for $PM_{2.5}$ may, due to conservative ambient baseline assumptions, slightly exceed the ARAQT at some locations close to SH20. There is no AQNES for $PM_{2.5}$.

- In terms of regional effects, the Project is expected to have an insignificant effect on Auckland’s regional air quality, despite a slight increase in vehicle kilometres travelled overall, due to improvements in traffic flow through the Project area combined with the continuing improvements in vehicle emissions generally.

- Air quality monitoring of the operational effects of the Project will be undertaken in order to demonstrate compliance with the relevant in-tunnel air quality standards and ambient air quality standards. This ambient air quality monitoring will be undertaken at two monitoring stations (i.e. one near to each tunnel ventilation station). Ambient air quality will be monitored in real time and will be run continuously for at least 12 months but preferably 24 months, in order to account for inter-annual variability in meteorological conditions.

- An extensive construction dust monitoring programme is proposed, utilising regular visual monitoring in all areas, continuous monitoring of TSP at a number of locations, continuous meteorological monitoring at three locations and procedures for prompt responses to potential complaints from the public and regulatory authorities.

2. Description of Project

In 2009 the NZTA confirmed its intention that the 'Waterview Connection Project' would be lodged with the Environmental Protection Authority as a Proposal of National Significance. The Project includes works previously investigated and developed as two separate projects: being the SH16 Causeway Project and the SH20 Waterview Connection. The key elements of the Project are:

- Completing the Western Ring Route (WRR) (which extends from Manukau to Albany via Waitakere);
- Improving resilience of the SH16 causeway between the Great North Road and Rosebank Interchanges to correct historic subsidence and "future proof" it against sea level rise;
- Providing increased capacity on the SH16 corridor (between the St Lukes and Te Atatu Interchanges);
- Providing a new section of SH20 (through a combination of surface and tunnelled road) between the Great North Road and Maioro Street Interchanges; and
- Providing a cycleway throughout the surface road elements of the Waterview Connection Project corridor.

Detailed descriptions of the various aspects of the project are given in Chapters 4 and 5 of the Western Ring Route: Waterview Connection Assessment of Environmental Effects, August 2010 and technical appendices. The following sections of this report present a summary description of those aspects of the Project that directly relate to discharges of contaminants into air, including the proposed widening of roads, new road construction and tunnel ventilation.

2.1 Summary of Project by Sector

The Project sector diagram (Figure 2.1) provides an overview of the extent and works for the Waterview Connection Project.

Western Ring Route: Waterview Connection (SH16-20) - Sector Diagram

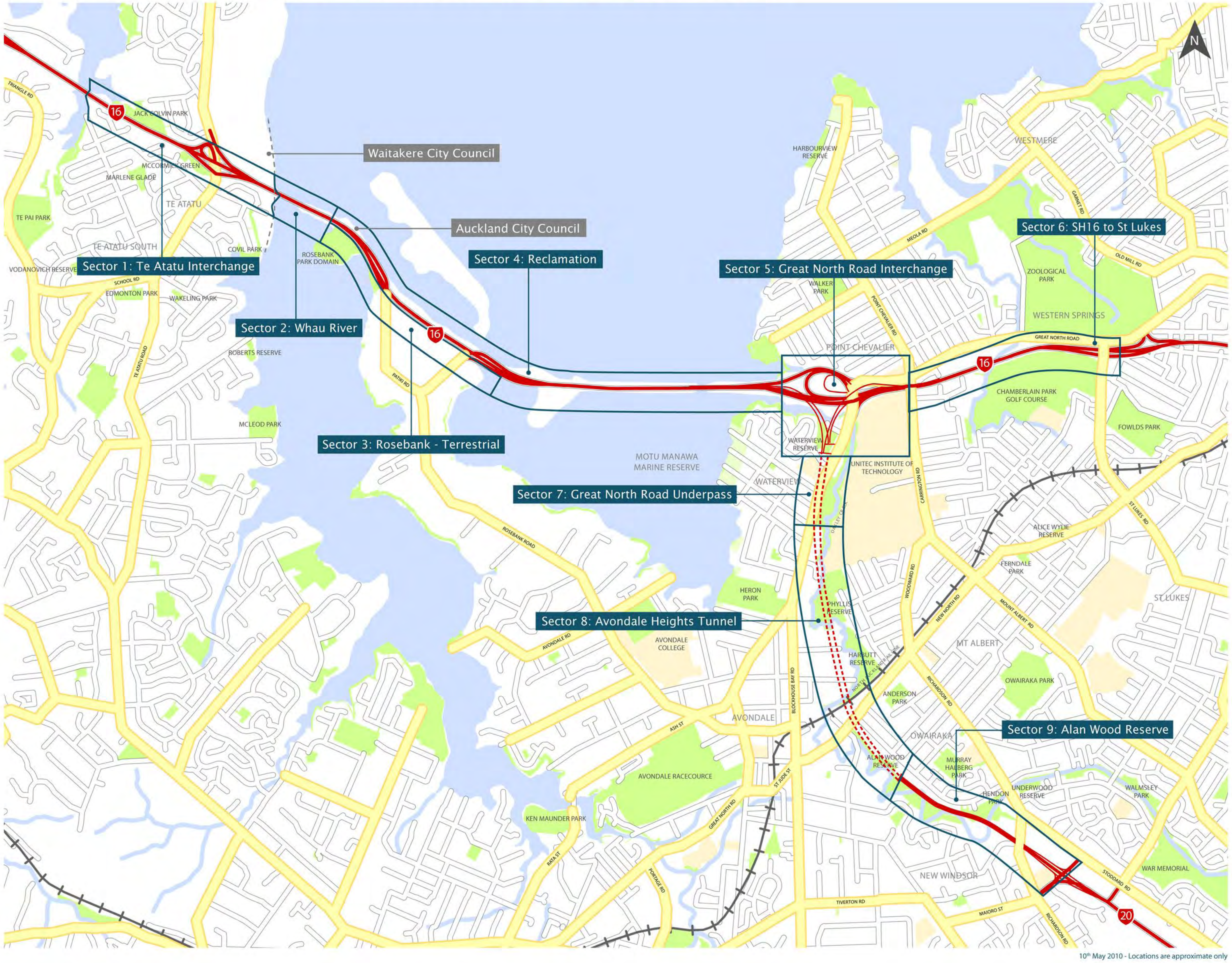


Figure 2.1 - Project Sector Diagram

In summary, the Project includes the following (these relate to 'sectors' identified in the Project sector diagram):

- **SH16** - Between Te Atatu and St Lukes Interchanges, the following key elements of work will be undertaken:
  - Significant improvements and reconfiguration of the Te Atatu Interchange to accommodate additional lanes and to provide for bus shoulder and priority for buses and other High Occupancy Vehicles (HOVs) (Sector 1).
  - Raising the surface of the causeway between the Great North Road Interchange west to Rosebank Road Interchange to improve the security of SH16 (Sector 4).
  - Additional lanes between the Te Atatu and Great North Road Interchanges to provide four lanes east and westbound and a bus shoulder in each direction (Sectors 1 to 4).
  - Additional westbound lanes from Rosebank Road Interchange and Great North Road Interchange, to create a total of four eastbound lanes, five westbound lanes plus a dedicated bus shoulder (Sectors 3 and 4).
  - The Great North Road Interchange will increase in functionality to allow for vehicle movements travelling to and from SH20 onto SH16 (both east and westbound). The proposed interchange will largely retain the functionality of the existing Great North Road Interchange. However, while the west-bound off-ramp from SH16 will be retained, this will only provide for traffic travelling southbound onto Great North Road. People travelling from SH16 northbound (e.g. towards Point Chevalier) will need to exit SH16 at the St Lukes Interchange (Sector 5).
  - Additional lanes will be provided between the Great North Road Interchange and St Lukes Interchange (in the east) (Sector 6).

Table 2.1 details the assumed widening on SH16 and which year this has been included in the With Project Option for 2016 and 2026; interchange upgrades are assumed at Lincoln Road and Te Atatu Road interchanges.

Table 2.1 – Future Capacity of SH16 after Proposed Widening

Section	Number of Lanes			
	2006	2016/2026 Do Nothing	2016 With Project	2026 With Project
Westbound				
St Lukes to Great North Road	3	3	4	4
Through Great North Road Interchange	3	3	3	3
Great North Road to Rosebank	3	3	5	5

Section	Number of Lanes			
	2006	2016/2026 Do Nothing	2016 With Project	2026 With Project
Rosebank to Patiki	3	3	4	4
Patiki to Te Atatu Road	3	3	4	4
Te Atatu Road to Lincoln Road	2	2	3	3
Lincoln Road to Royal Road	2	2	2	3
Royal Road to Westgate	2	2/3	3	3
Eastbound				
Westgate to Royal Road	2	2/3	3	3
Royal Road to Lincoln Road	2	2	2	3
Lincoln Road to Te Atatu Road	2	2	3	3
Te Atatu Road to Patiki	3	3	4	4
Patiki to Rosebank	3	3	4	4
Rosebank to Great North Road	3	3	4	4
Through Great North Road interchange	3	3	3	3
Great North Road to St Lukes	3	3	4	4

- **SH20** - between the Great North Road Interchange (with SH16) and the Maioro Street Interchange, a new State highway alignment will be provided over a length of approximately 5km with a capacity for three traffic lanes in each direction. The following key elements of work will be undertaken:

  - A new interchange will be built at the Great North Road Interchange to provide motorway-to-motorway connections between SH16 and SH20, while maintaining the existing connections between Great North Road and SH16 at this interchange. The existing cycleway will be retained and the existing interchange will be reconfigured (Sector 5);

  - Between the Great North Road Interchange and the Alan Wood Reserve the alignment will be two 3-lane tunnels (one in each direction), each approximately 2.5 km in length (Sectors 7 and 8). A tunnel ventilation station and ventilation stack will be located at each end of the tunnel alignment.

  - The alignment between the Avondale Heights Tunnel (Sector 8) and the Maioro Street Interchange (Sector 9) is ‘at-surface’, alongside the existing land set aside for rail (the Avondale Southdown Line Designation), for a length of around 1800m.

  In both 2016 and 2026, the proposed SH20 Waterview Connection is assumed to be a 6-lane motorway, with north facing ramps at the Maioro Street interchange (the south facing ramps and bridge are currently under construction), and joining to SH16 at the Great North Road interchange with east and west facing ramps.

The potential air quality effects of the proposed changes to SH16, SH20 and the existing roading network are discussed in Sections 8.1 and 8.2.

2.2 Proposed Tunnel Ventilation System

To meet requirements for road tunnel health and safety (i.e. in-tunnel air quality, visibility and the removal of smoke), the road tunnels will be provided with a mechanical ventilation system to:

- Maintain in-tunnel air quality (including visibility) by providing sufficient fresh air intake for the control of vehicle pollutant concentration to acceptable levels;
- Provide portal emissions control and adequate atmospheric emissions dispersion;
- Control the spread of fire smoke, enabling safe occupant egress under fire conditions and to facilitate an effective emergency response.

The ventilation system comprises a longitudinal in-tunnel ventilation system, an exhaust ventilation system and smoke extraction system. The longitudinal in-tunnel ventilation system will comprise reversible jet fans to be installed along the ceiling of each tunnel.

The ventilation system has been designed to have the capacity to be operated with no portal emissions during normal operation and during peak traffic periods. Due to the significant energy costs of operating the system in this manner continuously, the option to operate the tunnels with limited portal emissions during periods of very low traffic flows (e.g. middle of the night) has also been included as part of this assessment (refer Section 2.5 and Section 8.4).

The volumes of air extracted from the tunnels, and the consequent discharge velocities have been calculated to manage visibility and contaminant concentrations within the tunnels, based on traffic volumes derived from the EMME/3 traffic model and ventilation parameters derived by PIARC (URS, 2010).

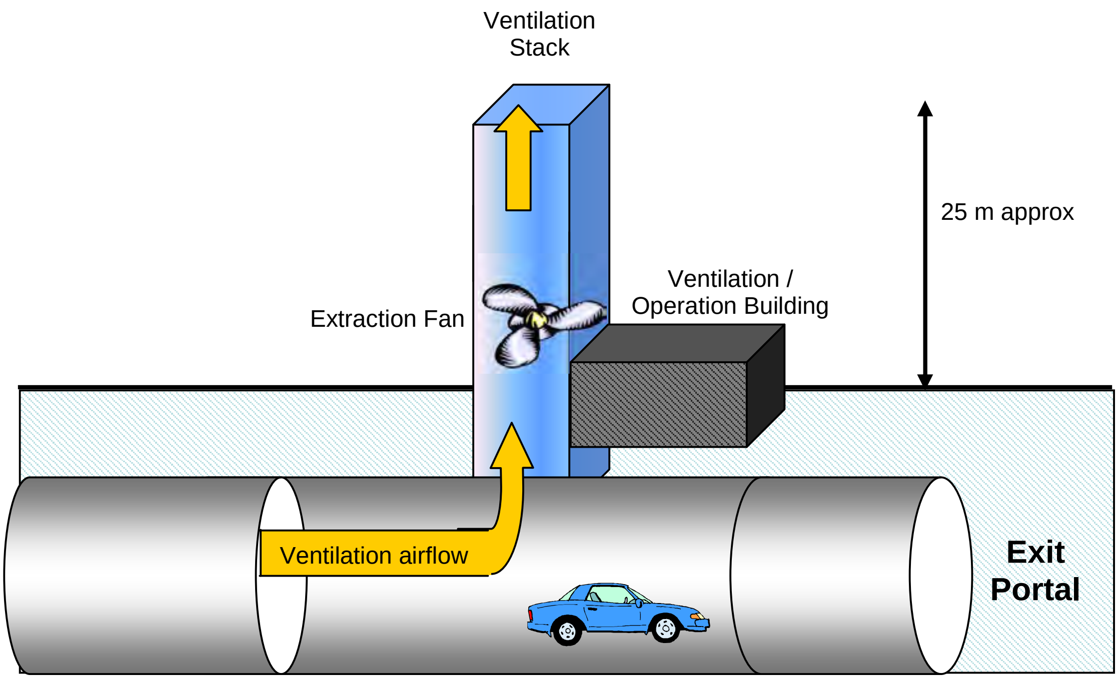
The ventilation system design has been designed to meet the NZTA in-tunnel air quality limits of:

- 87 ppm (15 min rolling average) for CO, and
- 1.0 ppm (15 min rolling average) for NO_2

The ventilation system design will also ensure that the CO limit of 30ppm (8 hour rolling average) is met.

A schematic of the proposed ventilation system is shown in Figure 2.2.

Figure 2.2 - SH20 Waterview Ventilation Layout Schematic



2.3 Proposed Tunnel Vents

As part of the ventilation system, ventilation stations will be constructed at each end of the combined tunnel alignment. The ventilation stations will house the fans and control systems which operate the ventilation system. Prior to reaching the exit portal, the air from inside the tunnel is discharged through a ventilation stack at each of two ventilation stations. The ventilation stack height has been selected to optimise dispersion and is based on a concept design of 25 m above final ground level. The basis for selection of this stack height is discussed in Section 11.3.

The proposed northern portal and ventilation stack are to be located at the northern end of Sector 7 close to the intersection of Herdman Street and Great North Road (refer Figure 2.3 and for full drawing refer to Plan Set F.2 Operation Scheme Plan Sheet 13, Drawing No: 20.1.11-3-D-N-910-113).

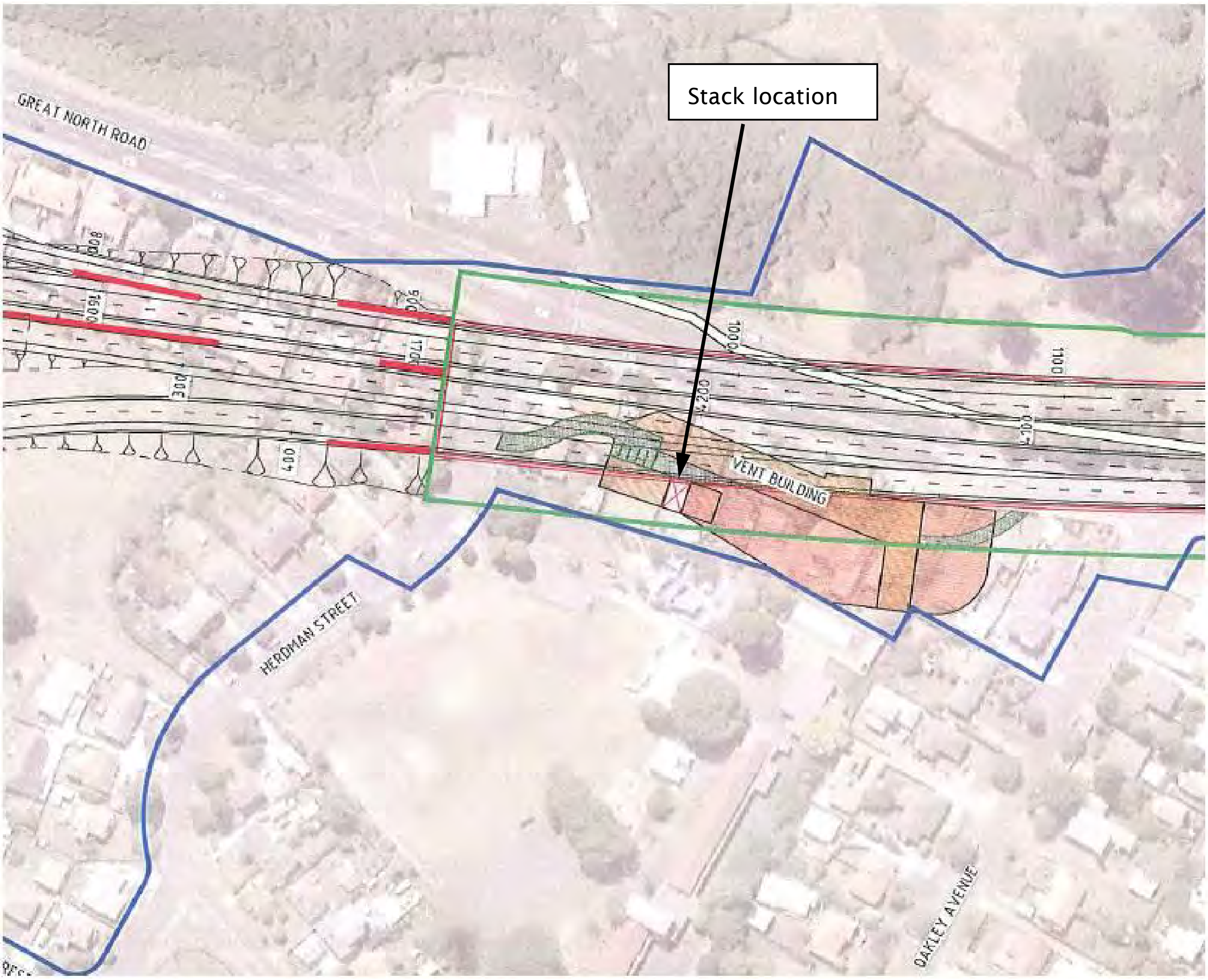


Figure 2.3 - Northern Ventilation Stack Location

The proposed southern tunnel portal and ventilation stack location is located within the existing Alan Wood reserve, at the southern end of Sector 8, near the head of a valley, and approximately 40m above sea level (refer Figure 2.4 and for full drawing refer to Plan Set F.2 Operation Scheme Plan Sheet 17, Drawing No: 20.1.11-3-D-N-910-117).

The potential effects of air discharges from the ventilation stacks are discussed in Section 8.3.

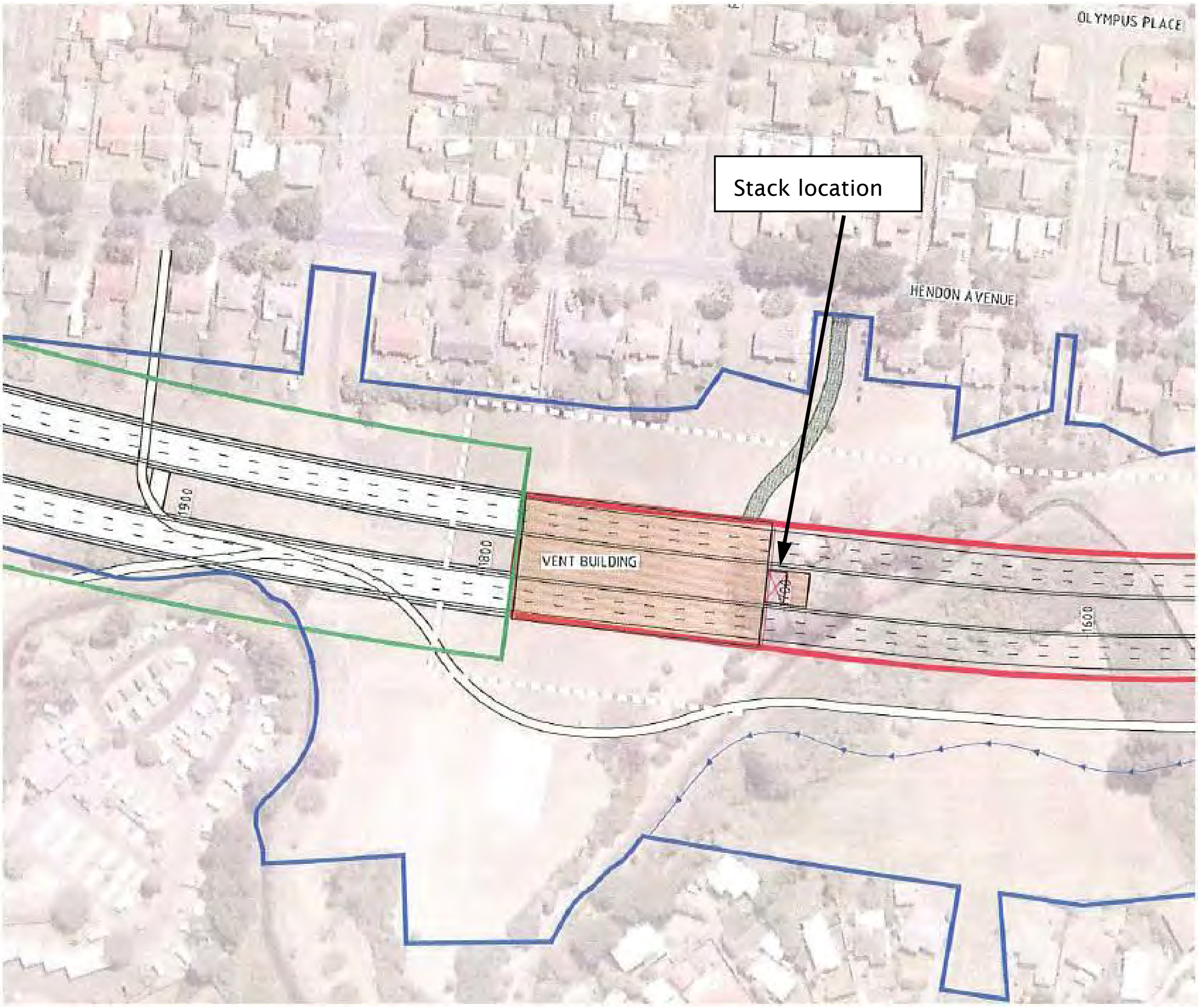


Figure 2.4 - Southern Ventilation Stack Location

2.4 Tunnel Operating Philosophy

A complete description of the tunnel operating philosophy can be found in the "Concept Design Report: Waterview Tunnel, M&E Service Provisions", URS, March 2010. A summary is presented here:

During normal operation:

- Jet fans will automatically operate to generate sufficient airflow to control in-tunnel concentrations of CO. CO is used as the indicator inside the tunnel as it is the contaminant that is most reliable to measure. For vehicle emissions it is strongly correlated with the other main contaminants and provides a good level of indication for control decisions.

- As the measured level of CO increases, banks of jet fans will be sequentially operated to increase the in-tunnel airflow. CO air-monitoring sensors and air velocity sensors will be installed close to the upstream tunnel air extract point.

- Up to four vent station exhaust fans will be run to meet the required extraction flow rate for portal emission and in-tunnel CO control.

- At vehicle speeds greater than approximately 20km/h, the tunnels become self ventilating as a result of the vehicle induced air flow (piston effect). However to assist in portal emission control, jet fans located upstream of the traffic exit portal (but downstream of the tunnel ventilation stack) will be operated in the reverse direction.

The ventilation system will be configured to run the optimal number of exhaust fans/jet fans for the most energy efficient operation. The options and benefits of operating the ventilation system in an energy efficient manner are described in more detail in the Western Ring Route – Waterview Connection: Greenhouse Gas Assessment (Beca, 2010c).

In the event of fire conditions, the fire smoke will be drawn through a separate high level smoke extraction duct and discharged via an emergency smoke exhaust.

A discussion of the design alternatives that were considered during the design process relating to tunnel ventilation systems, stack height and locations and alternative methods for managing vehicle emissions from tunnels is given in Section 11.

2.5 Tunnel Portal Emissions

The philosophy behind the design of the tunnel ventilation system aims to ensure that air quality within the tunnels is safe for vehicle occupants. As noted in Section 2.4 of this report, jet fans located upstream of the traffic exit portal will be capable of being operated in the reverse direction to prevent discharges via the portals during normal operation. However, under conditions of very low traffic volumes, for example during the early hours of the morning, vehicle exhaust emissions will be minimal. At these times, it may be appropriate to cease mechanical ventilation to conserve energy and allow ventilation to occur via the natural piston effect induced by vehicles as they travel though the tunnel. At these times, without the mechanical ventilation system operating, there would be no discharge via the ventilation stacks; instead, in-tunnel air will be discharged via the portals.

The potential effects of discharges of contaminants to air from the tunnel portals is discussed in Section 8.4 and in a separate technical report (APPENDIX I).

3. Methodology

3.1 Report Structure

This assessment report provides information on the following:

- Description of the Project (Section);
- Air quality standards and guidelines relevant to this Project (Section 3.4);
- Methods used for determining pollutant emissions and assessing the impacts (Section 3);
- Statutory matters for consideration in assessing air quality impacts of the Project (Section 4);
- Review of existing land use and meteorological conditions and existing air quality in the area (Section 5);
- Vehicle emissions modelling used to predict future vehicle related emissions and used as inputs to the dispersion modelling assessment (Section 6);
- Use of dispersion modelling to predict exposure levels to vehicle related contaminants (Section 7);
- Interpretation and analysis of predicted air quality impacts from vehicles (Section 8);
- For the operational effects of the Project, proposed post project monitoring, discussion of possible mitigation measures and a description of the alternatives that were considered during the development of the project concept design (Sections 9, 10 and 11).
- Description of potential impacts of dust generated during Project construction stages (Section 12).
- Effects assessment relating to the concrete batching plant and rock crushing operations. (Section 13).

3.2 Approach to Assessment of Effects

The pollutants of most concern associated with vehicle emissions and which may have adverse health effects on the surrounding community are carbon monoxide (CO), nitrogen dioxide (NO_2), inhalable particulate matter (PM_{10} and $PM_{2.5}$) and benzene.

The potential air quality impacts are assessed in this report using air pollutant dispersion modelling techniques in conjunction with measured ambient air quality monitoring data. The assessment is equivalent to a “Tier 3” Assessment described in the Ministry for Environment’s (MfE) Good Practice Guide for Assessing

Discharges to Air from Land Transport (MfE, 2008) (hereafter referred to as MfE Transport GPG) and the draft NZTA Standard for Producing Air Quality Assessments for State Highway Projects (NZTA, 2010) (draft NZTA Air Quality Standard).

The aim of this technical assessment is to assess the likely effects of exhaust emissions from vehicles using the widened SH16 and the new sections of SH20 on air quality and the environment, and to assess the likely effects of discharges of dust from the construction of the project on the environment. The bulk of this report focuses on the technical assessment of the effects of vehicle exhaust emissions. The effects of discharges of construction dust are addressed in section 12 of this report. An assessment of the effects of the proposed concrete batching and crushing plants required during the construction stages of the Project is included in Section 13 of this report.

This report assesses the effects of the Project on all members of the community, particularly those considered to represent the most vulnerable, e.g. school children and the elderly or infirm. Exposure levels are predicted through modelling and compared with the AQNES and relevant human health based air quality criteria (ref Section 3.4) which are designed to protect the health of the most vulnerable individuals in the community.

In addition to the direct effects of exhaust emissions from vehicles travelling on surface roads, the effects of vehicle exhaust emissions discharged via the tunnel ventilation stacks have also been assessed.

A series of mathematical models have been used to derive traffic data predictions and predict air quality impacts. The various models and their inputs and outputs are summarised in Table 3.1. Further discussion of these models and the reasons for selecting them are presented in sections 5.5.1 and 6.6 of this report.

Table 3.1 – Summary of Mathematical Models used in this Assessment

Model Name	Type and Purpose	Inputs	Outputs
Vehicle Emissions Prediction Model (VEPM)	Emission prediction model	EMME/3 outputs (Traffic volumes, speeds, %HCV) Emission factors	Vehicle emissions rates (g/km and g/s)
CALMET	High resolution meteorological model	Meteorological data from surface and upper air stations	Detailed meteorology across the study area – wind speed & direction, temperature, mixing heights etc
CALPUFF	Puff dispersion model used for predicting ground level concentrations of pollutants	Emission rates Tunnel ventilation air flows Meteorology Background air quality monitoring data	Pollutant concentrations for specified averaging periods

Model Name	Type and Purpose	Inputs	Outputs
AusRoads	Gaussian dispersion model used for predicting ground level concentrations of pollutants from surface roads	Emission rates Traffic volumes, speeds, % Heavy commercial vehicles (HCVs) Meteorology Background air quality monitoring data	Pollutant concentrations for specified averaging periods
Graz Lagrangian Model (GRAL)	Atmospheric dispersion model developed specifically for the assessment of tunnel portal emissions	Emission rates Traffic volumes, speeds, %HCV Meteorology	Pollutant concentrations for specified averaging periods

All of these models and tools are up to date and the latest versions have been used. With the exception of the GRAL model, all are recommended and supported by the ARC. The GRAL model, which was developed specifically to assess tunnel portal emissions, has been used for the first time in New Zealand on this Project and was selected based on the wider number of validation studies that have carried out using this software (refer Appendix I).

The assessment has focussed on characterising the relative impact that the Project is likely to have on future air pollutant levels taking into account changes over time in the composition and performance of the vehicle fleet and predicted traffic volumes. In the analysis, the potential air quality impacts have been predicted for a 'base year' (2006) and for two future years. For the years 2016 and 2026 the emission scenarios have considered both "Do Nothing" (i.e. the Project not being undertaken) and the "With Project" option. A total of five scenarios have been assessed for this report, as follows:

- **Current - 2006 Base Year** – used for validation of air dispersion modelling (which is based on meteorology and measured background concentrations for 2007) and to provide a 'baseline' against which to compare future effects both with and without the Project. Traffic flow predictions for 2006 have been used in this assessment, based on 2006 Census data, fully validated against a statistical analysis of traffic flows for 2006 (Beca, 2010b).

- **2016 With Project** – representative of the year of opening; this utilises 2007 meteorology and background concentrations, but includes traffic flows and fleet composition predicted for 2016 (and therefore includes the impact on traffic flows of other roading projects in the region that are scheduled for completion by 2016).

- **2016 Do Nothing** – for comparison with the 2016 With Project scenario; this differs from the 2016 With Project scenario in that it assumes, in addition to the Project not being constructed, other associated projects (for example widening of SH16 north of Te Atatu) have also not been completed (although it is assumed that other projects, unrelated to the WRR, have been completed).

- **2026 With Project** – representative of increased traffic volumes and likely improvements in the vehicle fleet ten years after opening; similar to the 2016 With Project scenario, but includes traffic flows, fleet composition and completed roading projects predicted for 2026.

- **2026 Do Nothing** – for comparison with the 2026 With Project scenario; as for the 2016 Do Nothing scenario, this assumes that the Project has not been constructed and associated projects have not been completed.

The sensitivity of the receiving environment, predicted traffic volumes and emission rates, background concentrations, predicted ground level concentrations of contaminants and the effects of these contaminants on human health are considered in detail in Sections 5 to 8 of this report.

3.3 Overview of Assessment Layers

Figure 3.1 below illustrates the assessment layers and some of the terminology used in this report. The figure schematically shows how 'air quality', i.e. the concentrations of a given pollutant at a given location, also termed the 'cumulative effect', is constructed from the sum of two or three contributions. In summary:

- The objective of the assessment is to estimate the cumulative effect of all layers for each scenario and compare that to the assessment criteria.

- The 'Baseline' scenario is the cumulative air quality for the 2006 base year.

- The 'Background' layer consists of a contribution from emission sources unrelated to the Project (such as domestic heating, industrial sources and traffic on roads unaffected by the Project). The magnitude of the background is not explicitly modelled in this assessment, but is quantified using monitoring data, as described in Section 5.

- The 'Local Traffic' layer consists of a contribution from road traffic emissions on nearby roads affected by the Project. These emissions are modelled explicitly for all 5 scenarios, as reported in Sections 6 and 7.

- The 'Project' layer consists of the contribution of traffic emissions from the Project, i.e. the new surface sections of SH20, the tunnels and the upgraded sections of SH16. These emissions are modelled explicitly for the two With Project scenarios only, as reported in Sections 6 and 7.

There are a number of assumptions that underlie this assessment, along with consequential limitations. Some key assumptions and limitations are summarised below:

- As shown in Figure 3.1, this assessment assumes that the background is unchanged between baseline and future scenarios. This assumption is discussed in Section 5.

- Figure 3.1 illustrates an example in which the Local Traffic contribution is reduced between the Baseline and Future Scenario. This is likely to occur at many (but not necessarily all) receptors, due to changes in traffic characteristics (volume, speed, or fleet split) and/or due to changes in emission factors (improvements in engine/exhaust/fuel technology) over time. These changes may occur in both the Do Nothing and With Project scenarios, albeit to differing degrees.

- The magnitude of each layer (background, local traffic, Project) in each scenario is expected to be different for each receptor, and different for each pollutant. However, limitations in available data mean that it is assumed that the baseline for all pollutants (other than NO_2) is the same at all or most receptors. This is explained in more detail in Section 5.

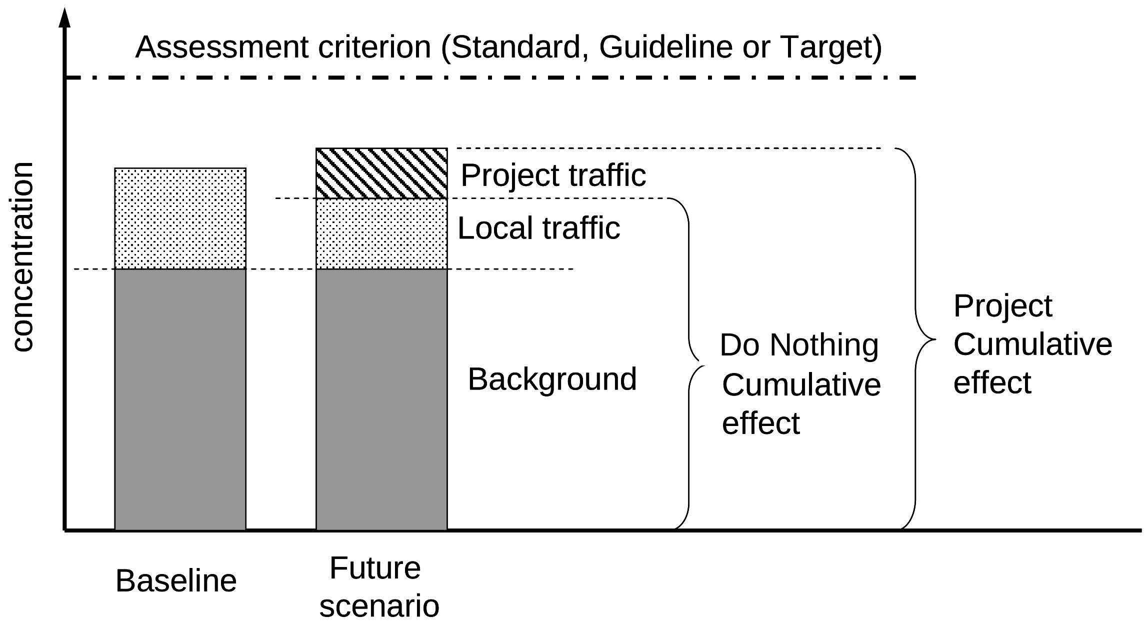


Figure 3.1 - Conceptual illustration of the layers and related terminology used in this assessment.

3.4 Air Quality Standards and Guidelines

Air quality standards and guidelines are used to assess the potential for air pollutants to give rise to adverse health or nuisance effects. The MfE Transport GPG recommends the following order of precedence when selecting suitable assessment criteria:

- New Zealand National Environmental Standards (AQNES)
- New Zealand Ambient Air Quality Guidelines (NZAAQG)
- Regional Air Quality Targets.

The recent (1 October 2009) amendments to the RMA strengthened the standing of the national environmental standards. In the Auckland region, the Auckland regional air quality targets (ARAQT) are the same as the NZAAQG with the exception that the ARAQT includes a target for $PM_{2.5}$ whereas the NZAAQG includes $PM_{2.5}$ as a monitoring threshold only, not a guideline. For the contaminants being considered within this assessment, there are relevant New Zealand National Environmental Standards, Ambient Air Quality Guidelines and Regional Air Quality Targets[1]. These are set out in the following sections of this report.

3.4.1 National Environmental Standards

The Resource Management (National Environmental Standards Relating to Certain Air Pollutants, Dioxins and Other Toxics) Regulations 2004 (as amended) (AQNES) were prepared under Sections 43 and 44 of the RMA and are designed to protect public health and the environment of New Zealand by, among other things, setting concentration limits for criteria air pollutants. These concentration limits (air quality standards) came into force on 1 September 2005.

The air quality standards for PM_{10}, CO, NO_2, ozone and SO_2 are summarised in Table 3.2.

Table 3.2 – National Environmental Standards for Ambient Air Quality

Pollutant	Threshold concentration[2]	Averaging period	Permitted exceedances (per year)
Carbon monoxide	10 mg/m^3	Rolling 8-hour	1
Fine particles (PM_{10})	50 µg/m^3	24-hour	1
Nitrogen dioxide	200 µg/m^3	1-hour	9
Sulphur dioxide	350 µg/m^3 570 µg/m^3	1-hour 1-hour	9 Nil
Ozone	150 µg/m^3	1-hour	Nil
Notes: mg/m^3 milligrammes per cubic metre µg/m^3 microgrammes per cubic metre			

The whole of the WRR: Waterview Connection lies within the Auckland Urban airshed. Because ambient concentrations of PM_{10} in the Auckland Urban airshed currently exceed the relevant air quality standard, the Auckland Regional Council has developed a Straight Line implementation Path (SLiP) towards achieving compliance with the PM_{10} air quality standard by 2013 and is developing an emissions reduction strategy for the same purpose.

Emissions of PM_{10} from land transport are estimated to contribute 51% of the total annual PM_{10} emissions within the airshed (27% in winter, 75% in summer).

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[1] In the absence of these criteria, relevant overseas guidelines have been considered. These include the World Health Organisation Ambient Air Quality Guidelines.

[2] Threshold concentrations under the AQNES apply in the open air, in places that people may be present, for the averaging period of the standard.

3.4.2 Ambient Air Quality Guidelines and Regional Air Quality Targets

The Ministry for the Environment has published a set of NZAAQG, which were most recently updated in 2002 (MfE, 2002). The Auckland Regional Council (ARC) has adopted those guideline values (to the extent that they have not been superseded by the AQNES) as Auckland Regional Air Quality Targets (ARAQT), which are set out in the Proposed Auckland Regional Plan: Air, Land and Water (PARP: ALW) (ARC, 2009a). The NZAAQG and ARAQT that are relevant to this assessment are summarised in Table 3.3.

Table 3.3 – New Zealand Ambient Air Quality Guidelines and Auckland Regional Air Quality Targets

Pollutant	Threshold Concentration	Averaging period
Carbon Monoxide	30 mg/m^3	1-hour
Fine Particles (as PM_{10})	20 µg/m^3	Annual
Fine Particles (as $PM_{2.5}$) *	25 µg/m^3	24-hour
Nitrogen dioxide	100 µg/m^3	24-hour
Sulphur dioxide	120 µg/m^3	Annual
Ozone	100 µg/m^3	8-hour
Benzene	3.6 µg/m^3	Annual
* NOTE: the $PM_{2.5}$ NZAAQG is a monitoring level only – that is, there is no specific requirement to achieve it (MfE, 2002).		

In addition, there are a number of relevant international guidelines, particularly those promulgated by the World Health Organisation (WHO) (WHO, 2006) that should be considered. Table 3.4 summarises the relevant WHO Air Quality Guidelines that are different from the AQNES, NZAAQG and ARAQT.

Table 3.4 – WHO Air Quality Guidelines

Pollutant	Threshold concentration (µg/m³)	Averaging period
Fine particles (as $PM_{2.5}$)	10 µg/m³	Annual
Nitrogen dioxide	40 µg/m³	Annual
Sulphur dioxide	500 µg/m³ 20 µg/m³	10-minuute 24-hour

Most of the New Zealand guidelines are based on the same guideline concentrations and averaging periods as the WHO air quality guidelines. The main exceptions to this are:

- the WHO annual average for $PM_{2.5}$ (which has no equivalent in New Zealand), and
- the 'not to be exceeded' 1-hour average AQNES for SO_2 of 570 µg/m³.

The 24-hour average NZAAQG and ARAQT for SO_2 of 120 µg/m³ is based on the previous WHO air quality guideline (WHO, 2000).

3.4.3 Trigger Levels for Dust

Dust refers to larger airborne particles, typically more than 50µm in diameter, that have the potential to settle on surfaces. These larger particulates are not generally associated with adverse health effects, although may have the potential to cause nuisance effects from dust settling if emissions are not appropriately managed and controlled.

There are no AQNES, NZAAQG or ARAQT for dust. A number of 'trigger levels' are contained in the "Good Practice Guide for Assessing and Managing the Environmental Effects of Dust Emissions" (MfE Dust GPG, MfE, 2001), which are summarised in Table 3.5. Table 3.5 presents three different trigger levels for total suspended particulate (TSP), depending on the sensitivity of the receiving environment.

Table 3.5 – Recommended Trigger Levels for Deposited and Suspended Particulate (MfE, 2001)

Pollutant	Trigger Level	Averaging period	Applicability
Deposited dust	4 g/m^2	30 days	All Areas
Total Suspended Particulate	80 $\mu g/m^3$ 100 $\mu g/m^3$ 120 $\mu g/m^3$	24-hour 24-hour 24-hour	Highly sensitive areas Moderately sensitive areas Insensitive areas

The ARC also includes a narrative standard for dust in the PARP: ALW and in "*Technical Publication 152 – Assessing Discharges of Contaminants into Air – Draft*" (TP152) (ARC, 2002), as follows:

> *"That beyond the boundary of the premise where the activity is being undertaken there shall be no noxious, dangerous, offensive or objectionable dust, particulate, smoke or ash" (ARC, 2002)*

The trigger levels presented in Table 3.5 have not been used as assessment criteria in this document as no dust dispersion modelling has been carried out. This is because the MfE Dust GPG recommends focusing on effective dust control procedures for assessment of effects from fugitive dust emissions, rather than estimating dust emissions and dispersion modelling which carries a high degree of uncertainty for such emissions. As discussed in Section 12.6 of this report, the trigger values for TSP are appropriate for managing the effects of dust once construction of the Project has commenced.

3.4.4 Relevant Air Quality Assessment Criteria

Table 3.6 summarises the relevant assessment criteria that have been used in the dispersion modelling.

Table 3.6 – Relevant Assessment Criteria

Pollutant	Threshold concentration	Averaging period	Rationale
Fine particles (as PM_{10})	50 $\mu g/m^3$ 20 $\mu g/m^3$	24-hour Annual	AQNES NZAAQG, ARAQT
Fine particles (as $PM_{2.5}$)	25 $\mu g/m^3$ 10 $\mu g/m^3$	24-hour Annual	ARAQT WHO
Carbon monoxide	30 mg/m^3 10 mg/m^3	1-hour Rolling 8-hour	NZAAQG, ARAQT AQNES

Pollutant	Threshold concentration	Averaging period	Rationale
Nitrogen dioxide	200 μg/m^3 100 μg/m^3 40 μg/m^3	1-hour 24-hour Annual	AQNES NZAAQG, ARAQT WHO
Benzene	3.6 μg/m^3	Annual	NZAAQG, ARAQT

Due to the reductions in the permissible sulphur content of vehicle fuels over recent years, vehicle exhaust emissions are no longer regarded as a significant source of SO_2 in ambient air in New Zealand. Therefore, assessment criteria for SO_2 have not been used in this report.

3.4.5 Application of Criteria to Receptors

The MfE Transport GPG (p30) indicates that the ambient air quality standards should apply where people would reasonably be exposed for the standard's averaging period. Specific guidance on the applicability of the AQNES is provided in the MfE Transport GPG, as follows:

Averaging period	Locations where assessment against the Standards should apply
1 hour	This includes any outdoor areas where the public might reasonably be expected to spend one hour or longer, including pavements in shopping streets, as well as facades of any building where the public might reasonably be expected to spend one hour or longer.
24 hours and 8 hours	This includes all outdoor locations where members of the public might be regularly exposed for longer than one-hour durations (e.g., residential gardens) as well as facades of residential properties, schools, hospitals, libraries, etc.

4. Assessment Matters

The NZTA uses designations for its State Highway network. In applying for a designation, the requiring authority (in this case the NZTA) submits a notice of requirement to the relevant territorial local authority (in this case Auckland and Waitakere City Councils). The notice of requirement is accompanied by an assessment of environmental effects (AEE) including an assessment of potential effects on air quality.

Several pieces of legislation guide land transport planning. The statutory framework for land use planning is largely contained within the RMA. The purpose of the RMA is to promote the sustainable management of natural and physical resources. The Land Transport Management Act 2003 (LTMA) sets out requirements for the operation, development and funding of the land transport system.

In addition to the notice of requirement, consent will be required from the Auckland Regional Council for the discharge of contaminants into air from concrete batching and rock crushing, associated with the construction of the Project. In an abundance of caution, consent is also sought for discharges to air from construction generally.

The following sections of this report outline the key statutory and non-statutory documents that must be considered in relation to the assessment of effects of discharges into air. A complete description of the statutory framework can be found in Section 6 of the AEE.

4.1 Resource Management Act 1991

The purpose and principles of the RMA are set out in Sections 5 to 8 of that Act. Of particular relevance to the assessment of effects of discharges into air from land transport activities are Sections 5(1) and 5(2)(c), which state:

> *"(1) The purpose of this Act is to promote the sustainable management of natural and physical resources*
>
> *(2) In this Act, sustainable management means managing the use, development and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural wellbeing and for their health and safety while – …*
>
> *(c) Avoiding, remedying or mitigating any adverse effects of activities on the environment."*

Air is one such natural resource. Section 7 of the RMA requires consent authorities to give particular regard to those matters listed in the section. In the case of discharges into air from this particular Project, the following matters are considered relevant: maintenance and enhancement of amenity values (Section 7(c)) and maintenance and enhancement of the quality of the environment (Section 7(f)).

In the context of this assessment, amenity values may be affected by discharges of construction dust, while the quality of the environment is described in the context of effects on human health. Effects on the environment that are not associated with the direct effects of vehicle exhaust emissions on human health or with discharges of dust are considered to be outside the scope of this report. Amenity values are addressed in Section 8.4 of this report, while other effects on human health are considered in Section 8.

Discharges of contaminants into air are specifically addressed in section 15 of the RMA. Sections 15(2) and (2A) state:

> *(2) No person may discharge a contaminant into the air, or into or onto land, from a place or any other source, whether moveable or not, in a manner that contravenes a national environmental standard unless the discharge—*
>
> *(a) is expressly allowed by other regulations; or*
>
> *(b) is expressly allowed by a resource consent; or*
>
> *(c) is an activity allowed by section 20A.*
>
> *(2A) No person may discharge a contaminant into the air, or into or onto land, from a place or any other source, whether moveable or not, in a manner that contravenes a regional rule unless the discharge—*
>
> *(a) is expressly allowed by a national environmental standard or other regulations; or*
>
> *(b) is expressly allowed by a resource consent; or*
>
> *(c) is an activity allowed by section 20A.*

The relevant regional plan requirements as they relate to air discharges are described in more detail below.

4.2 Transitional Auckland Regional Plan

There are no rules relating to discharges into air from land transport within the Transitional Auckland Regional Plan (TARP). There are rules that relate to the discharges of contaminants into air from concrete batching plant within the Waitakere City (through the incorporation of (through the inclusion of Waitakere City Council Bylaw Nº 4), but none that apply within Auckland City.

4.3 Proposed Auckland Regional Plan: Air, Land and Water

The PARP: ALW was first notified in October 2001. Following consideration of submissions, Decision Notices were issued on 8 October 2004 and the PARP: ALW was updated to include the decisions on submissions. The text of the 2004 Decision Notices version has been revised several times since then to incorporate the ongoing settlement of relevant appeals, most recently in November 2009. It is the text of the November 2009 version that is referenced in this document.

The PARP: ALW contains objectives, policies and rules relating to air quality impacts from mobile sources.

Regional Objectives and Policies

Objective 4.3.6 is:

"To minimise the discharge of contaminants into air from mobile sources while enabling sustainable development and protecting the health and social well being of the people of the Auckland region"

Policy 4.4.15 states:

"Any land use proposals with transportation effects, and any new transport projects or proposals for redeveloping transport infrastructure which have the potential to adversely affect air quality, should be assessed at a level considered appropriate for the size and scale of the project or proposal, and shall consider the following:

(a) Effects on human health;

(b) Effects on regional and local air quality; and

(c) Any alternatives or methods to mitigate effects on air quality or minimise the discharge of contaminants into air."

The management approach to protect human health in the Auckland region from ambient air pollution has been to select key pollutants as indicators, by utilising the AQNES and setting additional complementary ARAQT. The primary methods for implementing these policies will be through land use planning procedures and transport strategies.

Regional Rules

Rule 4.5.1, the general permitted activity rule, states:

> *"Unless provided for otherwise in this plan, activities that discharge contaminants into air are Permitted Activities, subject to the following conditions:*
>
> *(a) That beyond the boundary of the premises where the activity is being undertaken there shall be no noxious, dangerous, offensive or objectionable odour, dust, particulate, smoke or ash; and*
>
> *(b) That there shall be no noxious, dangerous, offensive or objectionable visible emissions; and*
>
> *(c) That beyond the boundary of the premises where the activity is being undertaken there shall be no discharge into air of hazardous air pollutants that does, or is likely to, cause adverse effects on human health, ecosystems or property; and . . ."*

'Premises' is defined in the PARP: ALW as including land, buildings, mobile sources and any other location where an activity that discharges contaminants into air takes place.

Vehicle exhaust emissions, whether directly from vehicles on surface roads or discharged via tunnel ventilation stacks or portals, are specifically provided for in Rule 4.5.3, which states:

> *"The discharge of contaminants into air from motor vehicle, aircraft, train, vessel and lawnmower engines including those located on industrial or trade premises is a Permitted Activity."*

Therefore, resource consent is not required for the discharge of contaminants into air from the proposed tunnel portals, ventilation stacks or new surface sections of road.

The discharge of contaminants into air (i.e. dust) from road construction activities is addressed under Rules 4.5.G and 4.5.H of the PARP: ALW, which state:

4.5.G The discharge of contaminants into air from earthworks or from the construction, maintenance or repair of roads (road works) is a Permitted Activity, subject to conditions (a) to (c) of Rule 4.5.1.

4.5.H The discharge of contaminants into air from earthworks or from the construction, maintenance and repair of roads (road works) that does not comply with Rule 4.5.G is a Restricted Discretionary Activity.

The explanation to Rule 4.5.G notes that the ARC's preference is to enforce compliance with this Rule, rather than to require an air discharge consent to be obtained, largely because dust management issues will normally be addressed in the conditions of land use consents (including designations). Notwithstanding this commentary, the NZTA is applying for resource consent for the Project under Rule 4.5.H out of an abundance of caution. The construction of the Project will be a major project extending across a wide area over a number of years, with the potential to cause significant impacts on the immediate environment, particularly through the discharge of dust. An assessment of the effects of discharges of dust, odour and vehicle related emissions from the construction of the Project is given in Section 12 of this report, together with proposed monitoring and mitigation measures.

In addition to this general provision for construction activities, resource consents will be required for any concrete batching or rock crushing plant used on site as part of the Project. These are classified as Restricted Discretionary Activities in accordance with Rules 4.5.54(b) and 4.5.55, as follows:

4.5.54 The discharge of contaminants into air, through a bag filter system, from

> *(b) The mixing of cement powder with other materials to manufacture concrete or concrete products at a rate exceeding a total production capacity of 110 tonnes per day is a Restricted Discretionary Activity.*

4.5.55 The discharge of contaminants into air from the temporary crushing of concrete, masonry products, minerals, ores and/or aggregates with a mobile crusher at a rate not exceeding a total on-site capacity of 60 tonnes per hour that does not comply with Rule 4.5.48 or at a rate exceeding a total on-site capacity of 60 tonnes per hour is a Restricted Discretionary Activity.

An assessment of the effects of discharges of dust from concrete batching and rock crushing activities associated with the construction of the Project is given in Section 13 of this report.

4.4 Land Transport Management Act

The Land Transport Management Act 2003 (LTMA) sets out requirements for the operation, development and funding of the land transport system. Section 94 of the LTMA states that the objective of the NZTA is to "*undertake its functions in a way that contributes to an affordable, integrated, safe, responsive, and sustainable land transport system.*" The functions of the NZTA in the context of this proposal are set out in Section 95(1) of the LTMA, while Section 96 sets out the operating principles of the NZTA. The specific principle that applies to this assessment is set out in Section 96(1)(a)(i), as follows:

> *"(1) In meeting its objective and undertaking its functions, the* [NZTA] *must—*
>
> *(a) exhibit a sense of social and environmental responsibility, which includes—*
>
> *(i) avoiding, to the extent reasonable in the circumstances, adverse effects on the environment; and ..."*

4.5 New Zealand Transport Strategy 2008 (NZTS)

The NZTS has established targets that support the delivery of the government's transport objectives and provide a focus for many of the government's actions over the life of the Strategy. The NZTS guides New Zealand transport policy at all levels to create a sustainable, affordable, integrated, safe and responsive transport system. The vision of the NZTS is that by "*2010 New Zealand will have an affordable, integrated, safe, responsive and sustainable transport system*".

The NZTS includes a target to *'reduce the number of people exposed to health-endangering concentrations of air pollution in locations where the impact of transport emissions is significant'*.

4.6 Auckland Regional Land Transport Strategy (RLTS)

The 2010 Auckland Regional Land Transport Strategy (the RLTS) is a statutory document prepared under the LTMA. The RLTS sets the direction for the region's transport system for the next 30 years. One of the seven objectives of the RLTS that relates to air quality is: *Objective 4: Protecting and Promoting Public Health.*

The Auckland region as a whole experiences a significant impact from transport emissions as indentified in the ARC's Emissions Inventory (2004) which concludes that "*the largest single contributors to annual emissions of PM_{10} are motor vehicles (41%) and domestic heating (38%). For NO_x emissions, the principal source is motor vehicles (71%). Consequently, emissions management strategies that target these sources will have the greatest impact on improving air quality in Auckland*."

Objective 4 looks to improve community health by promoting active modes of transport, and to protect public health by reducing exposure to health-impacting pollutants from the transport system. Reducing the levels of congestion, the amount of travel by motor vehicles and improving fuel quality can improve public health by reducing air pollution, water pollution and noise.

The approach to assessing how the Project meets this objective, as well as Policy 4.4.15 of the PARP: ALW (refer Section 4.2), is described below in Section 4.6.

4.7 The NZTA [Transit] Environmental Plan

Where the NZTA (formerly Transit New Zealand) seeks a new or altered designation, it must take into account any air quality effects and the requirements of the AQNES.

In 2004, Transit New Zealand (the predecessor of the NZTA) issued an Environmental Plan, which set out how its obligations under the LTMA would be exercised in practice. This Environmental Plan was reissued as Version 2 in 2008. Section 2.2 of the Environmental Plan addresses air quality issues and sets out the following objectives:

"A1 Understand the contribution of vehicle traffic to air quality.

A2 Ensure new State highway projects do not directly cause national environmental standards for ambient air quality to be exceeded.

A3 Contribute to reducing emissions where the State highway network is a significant source of exceedances of national ambient air quality standards."

A number of methods are specified to give effect to these objectives, for example:

Route Selection	*Investigate, consider and prioritise route options for new or upgraded sections of State highways that avoid increasing the exposure of sensitive receivers to poor air quality.*
Assessment of Effects	*Assess the effects on local air quality of new or improved sections of State highways in accordance with appropriate New Zealand and overseas guidance*
Design Approach	*In situations where vehicles are likely to be a significant source of emissions and cause of poor air quality, design new or upgraded State highways in order to remedy and/or mitigate adverse effects. Consider design measures to reduce vehicle emissions and avoid exposure to poor air quality, for example, by: … ensuring that vehicle emissions from road tunnels are appropriately controlled, dispersed and diluted.*
Construction Dust and	*Ensure Construction Management Plans, or equivalent, include an air quality management component. These should detail consultant and contractor obligations*

Air Pollution	*during the construction phase in relation to:* *· monitoring and reporting requirements including results of risk assessments and any air pollution measurements, for example in relation to dust and/or odour;* *· identifying appropriate dust and air pollution mitigation measures to be implemented; and* *· procedures for maintaining contact with stakeholders and managing dust and air pollution complaints.*

This assessment of effects considers the requirements of these objectives, in particular objective A2, in the context of the proposed Project. In support of this assessment (and related to objective A1), an extensive air quality monitoring programme has been undertaken in the Project area over the past three years, including two continuous air quality monitoring stations (monitoring oxides of nitrogen, carbon monoxide, fine particulate matter and meteorology) and a network of passive nitrogen dioxide samplers.

4.8 Approach to the Assessment of Health Effects

The Project will be assessed against the relevant AQNES, guidelines and, where relevant, permitted activity performance measures / levels. The assessment of impacts has been considered within the parameters of these existing standards (rather than determining whether these levels themselves are appropriate).

A regional Health Impact Assessment (HIA) (ARC, 2009c) was undertaken in the preparation of the RLTS for Auckland. This assessment is considered to provide sufficient health assessment to confirm the regional impacts associated with the WRR and this Project. More specific local impacts are being considered for the Project (e.g. air, noise, pedestrian and cycle linkages and local social impacts) and will be drawn together in consideration of 'wellbeing' elements in the Social Impact Assessment (SIA) (which includes perceptions of health). The conclusions of the SIA are that while the Project reduces congestion and therefore has positive impacts on the projected vehicle emissions to air, overall it is considered that transportation projects and the transportation network continue to have moderate negative social impacts taking into account the health consequences across the region. It is considered the matters covered in the SIA are sufficiently comprehensive to cover the issues of a HIA.

5. Existing Environment

The potential impacts of the Project on air quality must be considered in light of the local topography and meteorology, the sensitivity of the receiving environment and existing air quality. These aspects are summarised in the following sections of this report:

- Section 5.1: Description of current and future land use in relation to potential air quality impacts
- Section 5.2: Description of local topography
- Section 5.3: The areas being assessed and the regional scale of the assessment
- Section 5.4: Assessment of the sensitivity of the receiving environment and locations of sensitive receptors
- Sections 5.5 and 5.6: Assessment of existing (baseline) air quality and meteorology
- Section 5.7: Baseline concentration scenarios

5.1 Land Use

Consideration of land use for the purposes of air quality assessment focuses on the sensitivity of those land uses to adverse effects of air emissions on human health or amenity values. An assessment of the sensitive sites in the Project domain is detailed in Section 5.4. When considering effects of a future project, such as the Waterview Connection, it is necessary to consider both current and potential future land use, to the extent that future land use is defined through resource consents or designations.

Refer to Figure 2.1: Sector Diagram (page 5), for sector locations and key local land use features.

5.1.1 SH16

Sector 1 crosses the ridge of the Te Atatu peninsular in a northwest-southeast alignment. Jack Colvin Park is located adjacent to the northern side, home to the Te Atatu Rugby League club clubrooms and playing fields. Residential areas lie to the south/southwest, the closest houses being within 10m of the edge of SH16, while a mix of residential areas, reserves and schools sites are located to the north/northeast. The residential areas and school sites are zoned Living Environment under the Operative Waitakere City District Plan.

Sector 2 is the length of SH16 which crosses the Whau River. There are no residential properties or other sensitive activities in Sector 2.

Sector 3 covers the section of SH16 which passes through a narrow section of industrial land to the north of the Rosebank Peninsula. This land is occupied by manufacturing and commercial operators including a car wrecking facility. Adjacent land uses (to the southwest) are entirely industrial, zoned Business 6 under the

Operative Auckland City District Plan Isthmus Section. Residential premises and educational or healthcare facilities are not permitted in this zone. Rosebank Park Domain is located to the south of SH16, which is a large area used for recreational activities such as BMX racing and go-karting. The Domain is primarily a dirt track with grandstand seating, and is leased exclusively to the Auckland Kart Club Inc and Auckland Speedway Riders Club.

Sector 4 is the length of SH16 causeway between Rosebank peninsula and Point Chevalier. There are no residential areas within Sector 4. Pollen Island and Traherne Island are zoned as Open Space 1 in the Auckland City District Plan. There is no access available to either island off SH16. All access for recreational purpose is via boat across the harbour.

Sector 5 includes the Great North Road Interchange between SH16 and Great North Road. The land rises gently to the south, east and north, but does not exceed 50m above sea level anywhere within 2km of the site. Sector 5 covers the residential areas of northern Waterview and south-west Point Chevalier. Waterview Park is accessed off Cowley St and facilities include a soccer field (prone to flooding), tennis courts and a basketball court.

Surrounding land use zones under the Auckland City District Plan are predominately Residential 6a or 6b, although the Waterview School, St Francis School and Unitec sites are Special Purpose Zone 2. The Unitec site has developed a concept plan for future development of the site which is part of the Auckland City District Plan. This concept may include future on-site residential accommodation. There is an existing petrol filling station located across Great North Road which is zoned Residential 6a.

Sector 6 is the length of SH16 between the Waterview and St Lukes interchanges, which runs through a mixture of residential areas and open space (Western Springs Park and Chamberlain Park Golf Course). Land to the east of Point Chevalier Road including properties fronting Great North Road which are occupied by a range of sub-urban retail and food outlets. The closest houses to SH16 are located within 30m of the edge of the road.

5.1.2 SH20

Sector 7 forms part of the cut and tunnel section of the Project and is within the suburb of Waterview. Waterview School, Waterview Kindergarten and the Mason Clinic are located in close proximity to the SH20 alignment within Sector 7.

Sector 8 is within the residential areas in Mt Albert, Avondale Heights and Springleigh. Phyllis Reserve is the largest and most frequented reserve in the study area, and is home to the Metro Sports Club. The Club and grounds represent a significant recreation resource in the area. Alan Wood Reserve is also located between the neighbourhoods of New Windsor and Owairaka, and is bisected by land designated for the Avondale - Southdown rail corridor.

A railway designation generally parallels the existing alignment of SH20 through Alan Wood reserve. The residential areas to the north are zoned Residential 6a under the Auckland City District Plan, while those to the south are zoned Residential 5.

Surrounding land use zones under the Operative Auckland City District Plan include Open Space 2 and 3 to the east of the proposed SH20 alignment, with Residential 5 to the south and Residential 6a to the north. Land immediately to the west is zoned Business 8, with Business 2 and Mixed Use zones beyond Richardson Road, approximately 180m to the east.

Sector 9 runs northwest/southeast through the Oakley Creek valley. Sector 9 generally covers those residential areas of Owairaka, New Windsor and Walmsley. Sector 9 runs through Alan Wood Reserve and Hendon Park, while the southeastern part of Sector 9 is adjoined by commercial activities along Stoddard Road to the northeast (zoned Mixed Use and Business 4 under the Auckland City District Plan) and residential activities to the southwest (Residential 6a). The Avondale Motor Park is located on Bollard Avenue (adjacent to Alan Wood Reserve) also appears to provide a home to a number of unofficial 'long-term' residents. Christ the King primary school is located on Richardson Rd, close to the Maioro St interchange.

In addition to existing residential areas, resource consent has been granted for the development of a site close to the proposed alignment of SH20 at 25 Valonia Rd for 83 residential units (Gold Star Insurance Company Limited).

5.2 Topography

Local topography can have several influences on the transport and diffusion of air pollutants. For example, hills or rough terrain can change wind speeds, directions and turbulence characteristics, and nearby water bodies can considerably dampen turbulence levels. Significant valleys can restrict horizontal movement and dispersion and encourage the development and persistence of drainage flows.

The main topographical features in the Project vicinity are:

- The topography of the area around the "Oakley Creek valley" which is formed by two volcanic ridges (corresponding, roughly, to Mt Albert Rd and Richardson Rd/Avondale Heights).

- Mount Albert, approximately 1100m to the north, rises to above 120m above sea level.

The remainder of the land within 2km of the project does not exceed 70m above sea level.

5.3 Area Being Assessed

The principal scope of this assessment is to consider the effects of emissions from the traffic operating on the new sections of SH20 (tunnelled and surface) and those sections of SH16 to be upgraded, that together form the Waterview Connection Project as described in Section 2. As the Project forms the final link in the WRR, the existing length of SH20, in particular the SH20 Mt Roskill Extension, will become fully utilised and consequently see substantial increases in traffic as a result of the Project. Completion of the WRR is also likely to give rise to re-distribution of traffic on district and arterial roads in the Project vicinity, including potential offsets (improvements in air quality) along roads experiencing a reduction in total or heavy goods traffic, or congestion. For both the direct Project scope of work and these areas within the Project vicinity, a detailed analysis of air quality impacts was considered appropriate.

The completion of the WRR will also provide an alternative route to SH1 between Manukau and Albany. It is recognised that this will redistribute traffic beyond the Project vicinity as described above. The scope of this assessment has included assessment of the total changes in vehicle emissions along all the routes in the Auckland regional model, in order to infer the likely wider regional impacts of the Project on air quality (refer Section 8.3 for further detail).

5.4 Sensitive Receptors

5.4.1 What is a Sensitive Receptor?

The MfE Transport GPG recommends assessing the air quality effects of a proposed road on identified sensitive receptors. In this context, sensitive individuals include children and those whose health is already compromised, such as elderly persons.

Sensitive receptors, therefore, include residential areas, childcare and early learning facilities, schools, hospitals and residential care homes.

These people are generally regarded as likely to be more sensitive than the general population to the effects of vehicle exhaust emissions. The identification of specific sensitive receptors is based on both the presence of vulnerable individuals and their exposure time (the period when people might reasonably be expected to be exposed to pollutants at a specific site). The frequency and duration of exposure is related to the averaging periods used for the various assessment standards and guidelines (see Table 3.6).

5.4.2 Selection of Sensitive Receptors

Concentrations of air pollutants from vehicles on surface roads tend to decrease fairly rapidly with increasing distance from the road. For example, in 2006 the ARC undertook passive monitoring of NO_2 at a number of sites at varying distances from SH20 in Mangere and SH1 in Penrose (ARC, 2008). The results of this monitoring indicated that elevated concentrations of NO_2 arising from motor vehicle emissions could be detected only up to 300m from the motorway.

The discharges via tunnel ventilation stacks will tend to be dispersed over a much wider area, the extent of which depends on a number of factors, including ventilation stack height, the temperature and velocity of the discharge and local meteorology. An assessment domain was identified including all areas within 2km of each tunnel portal, 300m of the centreline of the surface alignment, and 400m of the Te Atatu Road, St Luke's Road and the proposed Maioro St interchanges. For the purposes of this assessment, therefore, sensitive receptors have only been identified if they are located within 2km of either tunnel ventilation stack or within 300m of a major surface road.

Childcare and early learning facilities, schools, hospitals and residential care homes have been considered in this assessment.

Ten other residential receptors (nine houses plus the Avondale Motor Park) have also been included, selected on the basis of their proximity to SH16 and the proposed surface alignment of SH20. Six of the residential receptors are the same as monitoring locations selected for the noise assessment carried out for the Project.

In addition to receptors within the area likely to be directly affected by the Project, six schools and preschools located close to the SH20 extension through Mount Roskill have also been included.

In addition, areas of open space or parks used for recreational activities are classified in the MfE Transport GPG as being receiving environments of high sensitivity. Sports fields have therefore also been identified as sensitive receptors. This assessment does not include any possible effects of vehicle exhaust emissions on vehicle occupants (which are excluded from consideration under the AQNES) or on users of the cycleway that runs alongside SH16 within the existing designation.

The identified discrete receptors are listed in APPENDIX A and also shown in APPENDIX B. Grid references (New Zealand Transverse Mercator) for each receptor have been included. The method for gathering information and the data sources are also described in APPENDIX A.

5.4.3 Key Sensitive Receptors for this Assessment

Sensitive receptors of note in this assessment due to their proximity to the Project include the following (receptor ID numbers can be cross referenced with the map in Appendix B):

- Sensitive activities in close proximity to SH16 include a preschool, Te Puna Reo O Manawanui (TPR Manawanui) (C3) located on Titoki Street north of SH16.
- St Francis School (E7)) is located less than 100m north of the existing alignment of SH16, east of the Great North Road interchange.
- Collectively Kids Childcare centre (C7) is located 50 m from SH16.
- 1102G Great North Road (R5) is the closest residential receptor to SH16 between Great North Road interchange and St Lukes.
- The closest residential properties (R4) to the northern tunnel portal and ventilation stack are 150m to the west, behind the Waterview Primary school playing fields.
- Waterview Kindergarten (C8) is located approximately 50m west of the proposed ventilation stack. The nearest buildings of Waterview School (E8) are located 100m southwest of the proposed ventilation stack (although the nearest part of the school grounds is within 30m of the proposed ventilation stack).
- The closest residential properties (R7 and R8) to the southern tunnel portal and ventilation stack and the SH20 surface alignment lie along Hendon Avenue and are 30 -50m from the edge of the alignment.

- Avondale Motor Park (R6) is located approximately 150m from the southern tunnel portal and ventilation stack.
- Christ the King School (E23) is located less than 100m to the west of the proposed Maioro Interchange.
- Edukids (C36), a child care centre, is located approximately 50m southwest of the existing alignment of SH20 at Mt Roskill.

5.5 Ambient Air Quality

5.5.1 Introduction

In order to assess the impacts of the Project on future air quality, an estimate needs to be made of the state of current air quality. This section provides an assessment of the current state and trends in Auckland's air quality, based on air quality data collected by the ARC's network as well as project specific sites across the Project domain.

Section 5.6 describes the effects of meteorology in Auckland on air quality in general and describes the micro-climate of the Oakley Creek valley which runs through the project domain.

Section 5.7 describes the development of a baseline scenario against which the future impact of the Project can be compared. This baseline is developed from the analysis of the existing air quality monitoring data described in this Section 5.5 and is summed with the impact of the Project to predict a cumulative effect. In a simple case the baseline can consist solely of a single number – the maximum expected 24 hour average PM_{10}. However, this is inadequate for such a large project, which spans several kilometres and encompasses a wide range of land-uses and topography. In this case, hourly baseline concentrations for a single year have been derived for the baseline.

5.5.2 Sources of Data

Air quality is continuously monitored at various sites across Auckland by the ARC. A summary of the results is provided in this section. The ARC network has generally expanded over time, although some sites have been decommissioned or re-located on occasion. Project-specific monitoring has also been conducted by the NZTA for the Project. The spatial and temporal coverage of these monitoring data varies between pollutants. This implies that the degree of detail in the knowledge about ambient air quality varies between pollutants.

The analysis in Sections 5.5 - 5.7 is derived from data collected at the sites listed in Table 5.1. ARC's sites at Khyber Pass Road and Queen Street have not been included. This is because these sites have particular local characteristics (on a busy road intersection and in a Central Business District (CBD) street canyon, respectively) which mean that they are not generally representative of the Waterview Connection Project vicinity. Data from ARC sites outside of the core urban area of Auckland (i.e. Kumeu, Warkworth, Whangaparaoa, Pukekohe, Orewa) have also not been incorporated as they are unlikely to be representative or informative of the Project vicinity.

Table 5.1 – Relevant Datasets used for Determining Baseline and Trends in Air Quality for the Project.

Site name	Location	Site type[3]	Distance to nearest major roads[4]	Vehicle counts on nearest roads (average per day)[5]	Dates[6]	Source	Approx. distance from Project
Alan Wood Reserve	Nr 5 Barrymore Rd 1752793 E 5914879 N	Suburban background	70 m, Hendon Ave	7 000	2006 - 2009	NZTA	0
Cowley Street	2 Cowley St 1751890 E 5917660 N	Suburban background/roadside	40 m, Great North Road 260 m, N-West' Motorway	50 200 104 000	2007 - 2009	NZTA	0
Kingsland	Kowhai Int. School 1755961E 5917772N	Inner-urban background/roadside	50 m, Sandringham Rd	23 958	2004 – 2007	ARC	4 km
Glen Eden	Ceramco Park 1747144 E 5912490 N	Suburban background	20 m, Meadowvale Rise	n/a	2005 - 2008	ARC	6 km
Henderson	70 Lincoln Rd 1745140E 5918533N	Suburban roadside	10 m, Lincoln Rd	13 300	2003 - 2008	ARC	7 km
Penrose II (B)	Gavin St Substation 1761751 E 5914176 N	Suburban/Industrial near-motorway	106 m, Southern Motorway	140 380	2003 - 2008	ARC	10 km

[3] Intended as a description of the likely factors affecting observations, this is provided by NIWA. ARC classes all of the sites listed as "Urban", except for Paturnahoe which ARC describes as "rural".

[4] ARC, 2006b.

[5] ARC, 2006b, except for Alan Wood Reserve and Cowley Street, for which data is derived from Waterview Project traffic modelling report (rev 3) (section 6) for 2006.

[6] Dates indicate availability of PM_{10} data from beta attenuation monitors, rather than the existence of the site.

Site name	Location	Site type[3]	Distance to nearest major roads[4]	Vehicle counts on nearest roads (average per day)[5]	Dates[6]	Source	Approx. distance from Project
Takapuna	Westlake Girls High School 1756059E 5928077N	Suburban near-motorway	30 m, Wairau Road 60 m. Northern Motorway	24 000 109 680	2004 - 2008	ARC	12 km
Botany Downs	Our Lady Star of the Sea School 1771363E 5912351N	Urban edge background	50 m Crescent Hills Court	n/a	2005 - 2008	ARC	20 km
Patumahoe	Cronin Rd 1765441E 5880820N	Rural background	100 m, Cronin Road	n/a	2005 - 2008	ARC	35 km

5.5.3 Particulate Matter (PM_{10})

Table 5.2 shows the annual mean PM_{10}[7] from key sites listed in Table 5.1 for the years 2005 to 2008 inclusive[8]. It shows that all sites have been compliant with the annual average NZAAQG of 20 µg/m³ over all four years.

Table 5.2 – Annual Mean PM_{10} (µg/m³) at Urban Auckland Sites*

Site	2005	2006	2007	2008
Alan Wood Reserve	n/a	n/a	13	13
Cowley Street	n/a	n/a	n/a	15
Kingsland	15	15	n/a	n/a
Glen Eden	n/a	13	13	14
Henderson	16	17	17	15
Penrose II	16	18	18	18
Takapuna	17	18	18	17

Note: * Only sites for which a complete year of data was available were selected, for comparison with Ambient Air Quality Guideline of 20 µg/m³.

A review of the ARC database[9] for the years 2004 to 2008 inclusive reveals no consistent trends in long-term average concentrations of PM_{10} across the Auckland region for this period (Figure 5.1). Most monitoring sites within more urbanised areas for which three or more years of data are available have reported weak falling trends of < 0.7 µg/m³ per year. However, inter-annual variation is clearly evident with most sites reporting higher annual means in 2004, 2006 and 2007 and lower values in 2005 and 2008. However, data from rural and peri-urban sites appear suggestive of a rising trend, as illustrated by Glen Eden, Botany Downs and Patumahoe (Figure 5.1). In conclusion, in the absence of highly abnormal meteorological conditions, it is not possible to generalise or extrapolate trends of this small magnitude with any confidence, particularly to the timeframes of the assessed project.

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[7] Only data observed using Beta Attenuation Monitors is reported, to ensure consistency and fair intercomparison.

[8] Data for 2009 is not available at time of writing.

[9] Data from the NZTA sites were not used as there have been only two complete years of monitoring at Alan Wood Reserve, and one at Cowley Street – insufficient to detect trends.

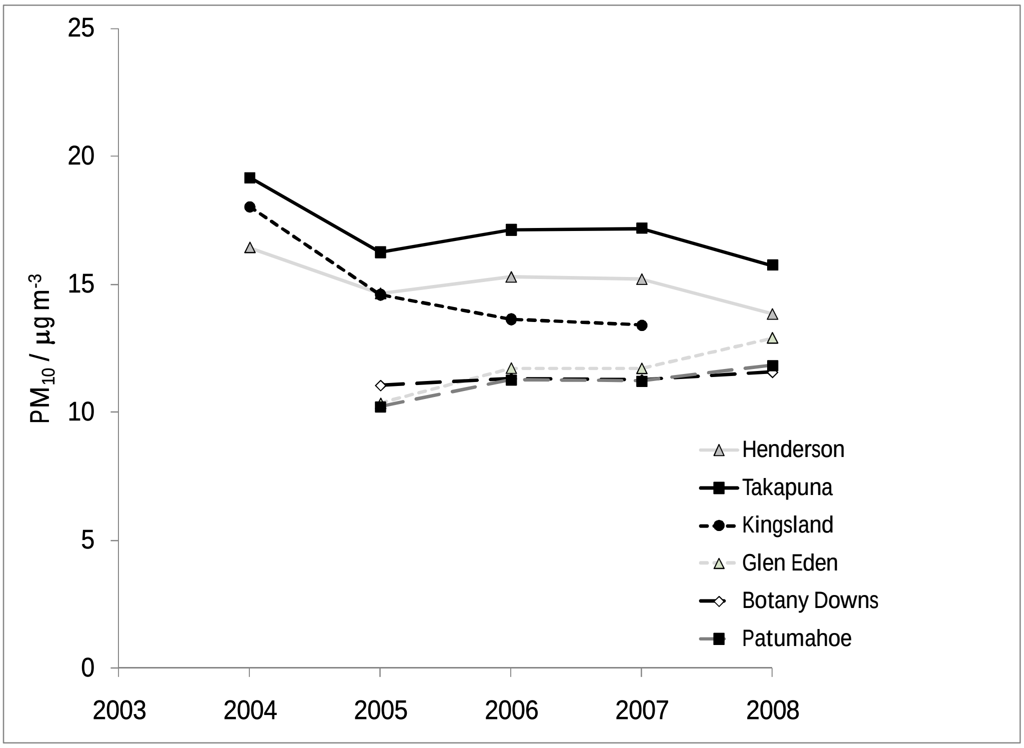

Figure 5.1 - Annual mean PM_{10} (BAM data only) for 2004 – 2008 at 6 ARC monitoring sites

The AQNES for PM_{10} relates to the maximum 24-hour average per year. In Auckland, maxima are most likely[10] to occur in the winter months (May to August inclusive) when domestic wood smoke emissions coincide with calm winds. Other atypical influences (local burning near monitors, sea spray events, bonfires and fireworks) can lead to peak concentrations at other times. Table 5.3 reports the maximum 24-hr average PM_{10} for the same range of sites as Table 5.1 above. The value for Henderson in 2007 is actually the 2nd highest value. The maximum concentration was 125 µg/m³. This was due to a short-lived, large elevation in concentrations in the middle of the day. The cause is unknown but is almost certainly a highly localised emission source such that the data is not considered representative of the site or locality in general. Similarly the true maximum value for Glen Eden in 2006 (57 µg/m³) has been removed as it was recorded on bonfire night, was substantially elevated compared to other sites and therefore not considered representative of normal conditions.

Once the removal of these non-representative peaks is made it can be seen that these sites are currently reporting compliance with the AQNES (50 µg/m³) by a margin of the order of 10 µg/m³.

When considering peaks there is a slightly stronger downward trend than for the annual mean at many, but not all, urban sites. For instance, Figure 5.2 and Figure 5.3 show the 2nd highest 24-hour concentration recorded[11] per year at a selection of sites. Figure 5.2 shows sites considered relevant and representative of the Project vicinity, while Figure 5.3 shows other ARC sites). These figures seem to indicate a downward trend at the more urbanised sites. However, the trend at rural and peri-urban sites is less clear.

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[10] Based on all ARC monitoring sites (2004- 2008) the probability of a PM_{10} exceedance anywhere in Auckland is 2.5% in winter, 0.5% outside winter.

[11] As measured using Beta Attenuation Monitors.

Table 5.3 – Annual Maximum 24-Hour Mean PM_{10} (µg/m³) at Urban Auckland Sites*

Site	2004	2005	2006	2007	2008
Alan Wood Reserve	n/a	n/a	n/a	33	35
Cowley Street	n/a	n/a	n/a	n/a	38
Kingsland	n/a	49	40	n/a	n/a
Glen Eden	n/a	n/a	41**	33	33
Henderson	45	36	40	39**	33
Penrose II	45	44	45	46	41
Takapuna	n/a	51	46	41	35

Note: * Only sites for which a complete year of data was available were selected, for comparison with Ambient Air Quality National Environmental Standard of 50 µg/m³.
** Henderson 2007 and Glen Eden 2006 represent the 2nd highest PM_{10} concentrations recorded as discussed in Section 5.5.3.

In conclusion, these trends are sufficiently weak and subject to variability that it is not recommended to make predictions of continuing downward trends into the future based on this analysis. This report therefore assumes background air quality (in terms of particulate matter) remains unchanged between the Project Assessment Years of 2006, 2016 and 2026. This assumption is conservative as over a longer period of time it is expected there will be reductions due to the ARC's emissions reduction strategy aimed at achieving compliance with the AQNES, as well as the trend for lower vehicle emissions from new vehicles.

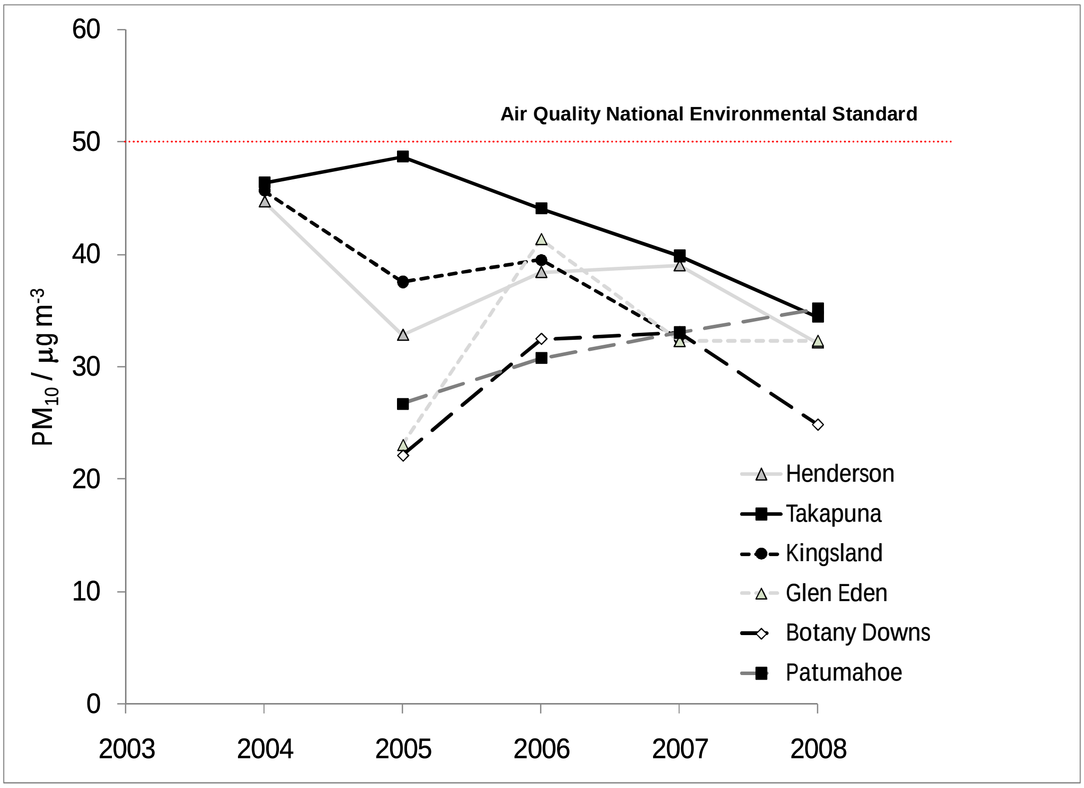

Figure 5.2 - 2nd highest 24-hour average PM_{10} concentration per year (2004 – 2008) from 6 ARC monitoring sites.

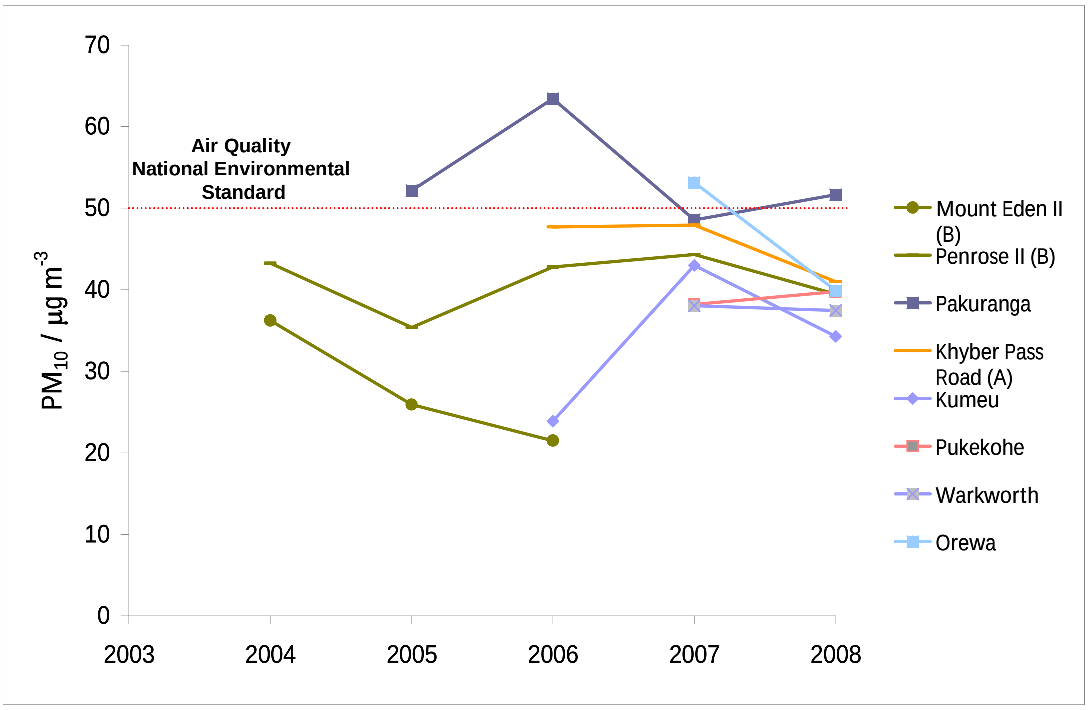

Figure 5.3 - 2nd highest 24-hour average PM_{10} concentration per year (2004 – 2008) from other ARC monitoring sites.

5.5.4 Particulate Matter ($PM_{2.5}$)

Much fewer data are available for $PM_{2.5}$ compared to PM_{10}. ARC have conducted long-term monitoring of $PM_{2.5}$ at their motorway-influenced sites (Takapuna and Penrose II), and at the inner-urban site of Kingsland. However, no monitoring has yet been conducted anywhere west of Kingsland. Table 5.4 below summarises some features of measured 24-hour $PM_{2.5}$ at the three sites over the last 3 years.

Table 5.4 – Annual Maximum 24-hour Mean $PM_{2.5}$ (μg/m³) and Number of ARAQT Exceedances at Urban Auckland Sites

Site	2005		2006		2007		2008	
	Max 24 – hr $PM_{2.5}$	*ARAQT exceedances*	Max 24 – hr $PM_{2.5}$	*ARAQT exceedances*	Max 24 – hr $PM_{2.5}$	*ARAQT exceedances*	Max 24 – hr $PM_{2.5}$	*ARAQT exceedances*
Kingsland (Partisol)[12]	22	*0*	36	*4*	24	*0*	n/a	
Kingsland (BAM)[13]	n/a		26	*1*	20	*0*	n/a	
Penrose II (BAM)	n/a		24	*0*	28	*3*	31	*2*
Takapuna (BAM)	n/a		n/a		24	*0*	29	*3*

Table 5.4 shows that exceedances of the Regional Target (25 μg/m³) have occurred at all three monitoring sites, but not every year. It is believed that the dataset is not yet sufficiently long to identify long-term trends. It is concluded that compliance with the $PM_{2.5}$ Regional Target is currently highly marginal.

5.5.5 Nitrogen Dioxide

Concentrations of NO_2 tend to be more spatially heterogeneous than for particulate matter. Monitored concentrations are more sensitive to the precise location of the monitoring site, in particular its proximity to significant traffic sources. This makes it harder to draw general and spatially representative conclusions about NO_2 from monitoring data.

[12] Partisol: Thermo Scientific Partisol 2000-FRM Air Sampler, which is a US EPA Reference Method ambient manual sampler for both $PM_{2.5}$ and PM_{10}.

[13] BAM: Thermo FH62M Beta Attenuation Monitor, which is a US EPA Equivalent Method continuous ambient sampler for both $PM_{2.5}$ and PM_{10}.

To address this stronger local variation, both the ARC and the NZTA have deployed dense networks of passive monitoring devices (passive diffusion tubes) across Auckland. These devices report monthly average concentrations. ARC's monitors have been deployed on limited campaigns, whereas NZTA maintains a National NO_2 Network with a clear bias towards the State Highway network and road-influenced locations.

Prediction of ambient urban NO_2, especially at road-affected locations, is inherently much more difficult and uncertain than for other pollutants. Assessment of NO_2 effects has to take into account concentrations of NO_x (total oxides of nitrogen) and the effect of ambient ozone availability. This is because, in urban areas, vehicle exhaust is the dominant source of NO_2 through both direct emission and secondary formation. The high temperatures of the internal combustion engine combine nitrogen and oxygen from the air into nitric oxide (NO) and a much smaller amount of nitrogen dioxide (NO_2). Together these compounds are referred to as oxides of nitrogen (NO_x), and vehicle emission rates are specified in terms of NO_x. Once released from the tailpipe, a series of chemical reactions will readily begin, the net effect of which is to start rapidly converting the NO into NO_2. Several factors influence the rate of this conversion, which is why vehicle emission models cannot specify the highly dynamic split in NO_x between NO and NO_2. At roadside and urban locations most of the ambient NO_2 will have formed from NO in this way (with a smaller amount arising from direct emission and background sources). However, the rate at which NO is converted to NO_2 is highly dynamic as it depends very sensitively on meteorological factors and the concentrations of other compounds in the air, especially ozone. Ozone is the main "driver" of NO to NO_2 conversion, and depletion of available ozone in the surface layer of the atmosphere is a key process limiting the formation of urban NO_2.

By combining information from both continuous monitoring and passive monitoring some general conclusions can be drawn about NO_2 in Auckland. The general determinants and levels of NO_2 in New Zealand were reviewed by Longley et al. (2008), and further analysis conducted for the purposes of this Project does not change these basic findings:

1. Annual mean NO_2 concentrations are relatively low at most locations in Auckland compared to the WHO guideline of 40 μg/m^3,

2. Peak 1-hour NO_2 concentrations are relatively low compared to the AQNES at most locations in Auckland,

3. High concentrations, and exceedances of the AQNES, have only been observed at CBD locations very close to high levels of traffic (e.g. Khyber Pass Road) or in deep street canyons (e.g. Queen Street).

Of the continuous monitoring sites for which data is available, Khyber Pass Road and Queen Street are not representative of the Project vicinity. Alan Wood Reserve is representative of urban background locations in the project vicinity, while Cowley Street is representative of sites close to major roads. ARC's Takapuna site is more representative of the upper-bound of locations near busy motorways in Auckland. Table 5.5, Figure 5.4 and Figure 5.5 present summary NO_2 statistics for these three representative sites.

Table 5.5 – Annual Mean and Peak 1-hr Average NO_2 Concentrations at Three Continuous Auckland Monitoring Sites (2007-2008).

Site	Distance from		Annual mean NO_2 (µg/m³)		99.9th percentile 1-hr NO_2 (µg/m³)		Maximum 1-hr NO_2 (µg/m³)	
	Motorway	Nearest major road	2007	2008	2007	2008	2007	2008
Alan Wood Reserve	1 km +	70 m	11	10	55	54	61	66
Cowley Street	230 m	40 m	n/a	18	n/a	71	n/a	130
Takapuna	60 m	30 m	24	21	86	86	102	110

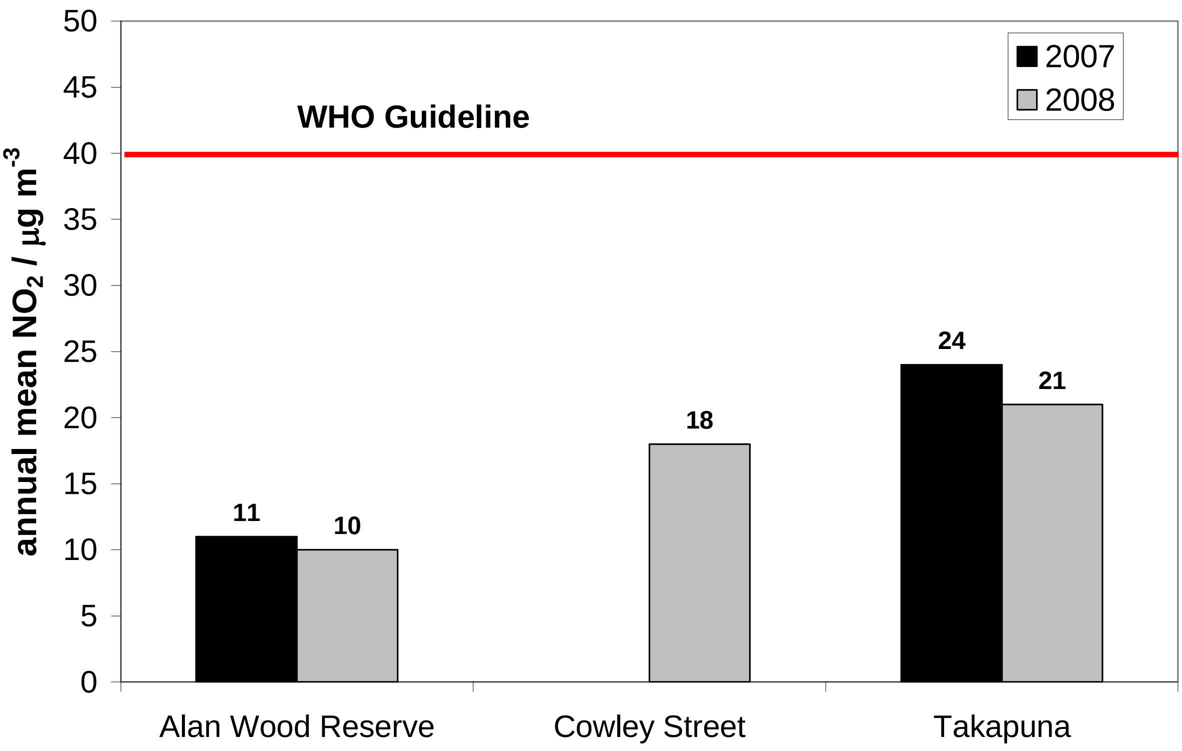

Figure 5.4 - Annual Mean NO_2 Concentrations at Three Continuous Auckland Monitoring Sites (2007-2008).

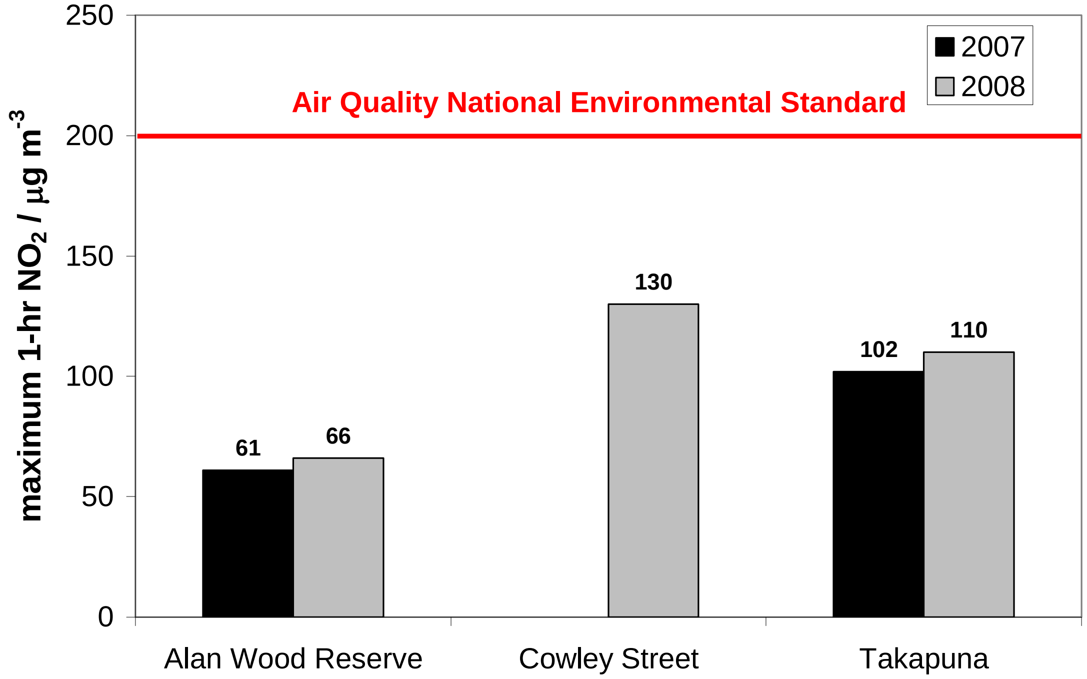

Figure 5.5 - Annual Maximum 1-hr average NO_2 concentrations at three Continuous Auckland Monitoring Sites (2007-2008).

To investigate long-term trends in NO_2, data from the ARC monitoring network over the five years 2004 – 2008[14] have been analysed. Five sites were identified which are representative of the Project vicinity, shown in Figure 5.6 and Figure 5.7[15]. These figures show no evidence of strong or consistent trends in peak NO_2 concentrations. Figure 5.8 focuses on the Takapuna site, which typically reports the highest concentrations of the five selected sites. Again, no clear trend is discernible. However, it can be seen that all sites comply with both the WHO annual AQG of 40 µg/m³ as an annual mean, the AQNES (maximum 1-hr value of 200 µg/m³) and the ARAQT/NZAAQG (maximum 24-hour average of 100 µg/m³).

A review of the determinants of NO_2 in Auckland by NIWA (Longley et al., 2008) has shown that ozone availability is low compared to many comparable northern hemisphere cities. This, along with low urban densities, keeps NO_2 levels in Auckland (outside of the CBD) compliant with the AQNES and WHO guidelines by a significant margin. It is also why NO_2 concentrations have generally not responded to falls in NO_x emissions (particularly from road vehicles) over the same period. There is no significant current trend in ozone levels in Auckland (Longley et al., 2008) and there is no strong evidence to suggest typical NO_2 levels or compliance with the standards will change at relevant receptors in the next two decades.

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[14] Data from 2009 were not available at the time of writing. There were insufficient representative monitoring sites prior to 2004.

[15] Sites not included are Khyber Pass Road (very close to a major intersection), Queen Street II (CBD street canyon), Patumahoe, Pukekohe, Warkworth, Musick Point II (not representative of urban Auckland) and Mt Eden II(B) (only two years of data in this period).

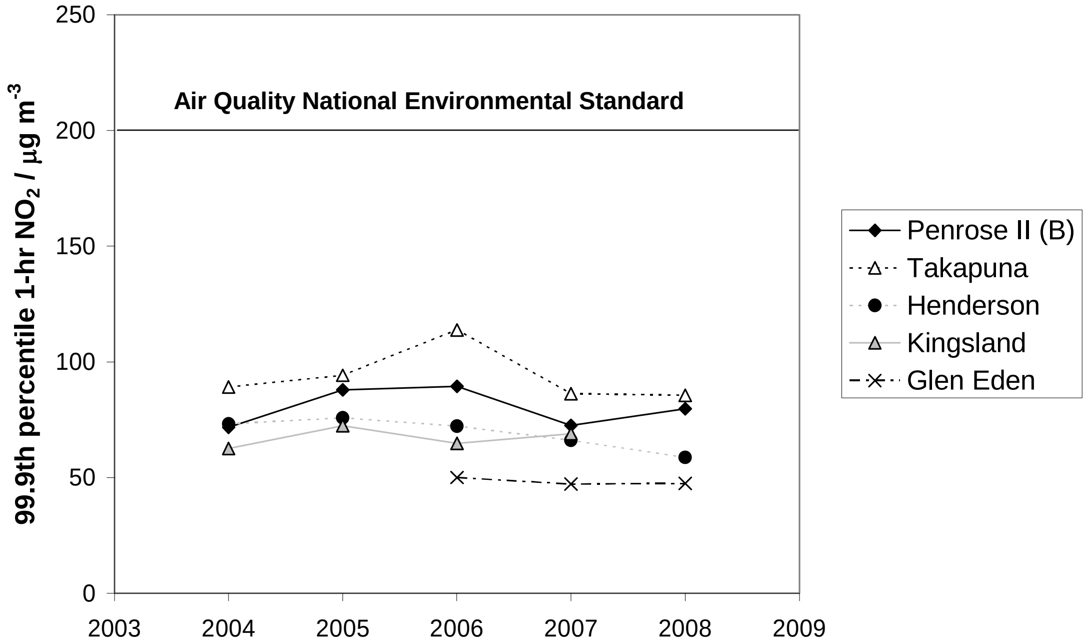

Figure 5.6 – Yearly 99.9th Percentile of 1-Hour Average NO_2 Concentrations from 5 Relevant ARC Monitoring Sites (2004-2008).

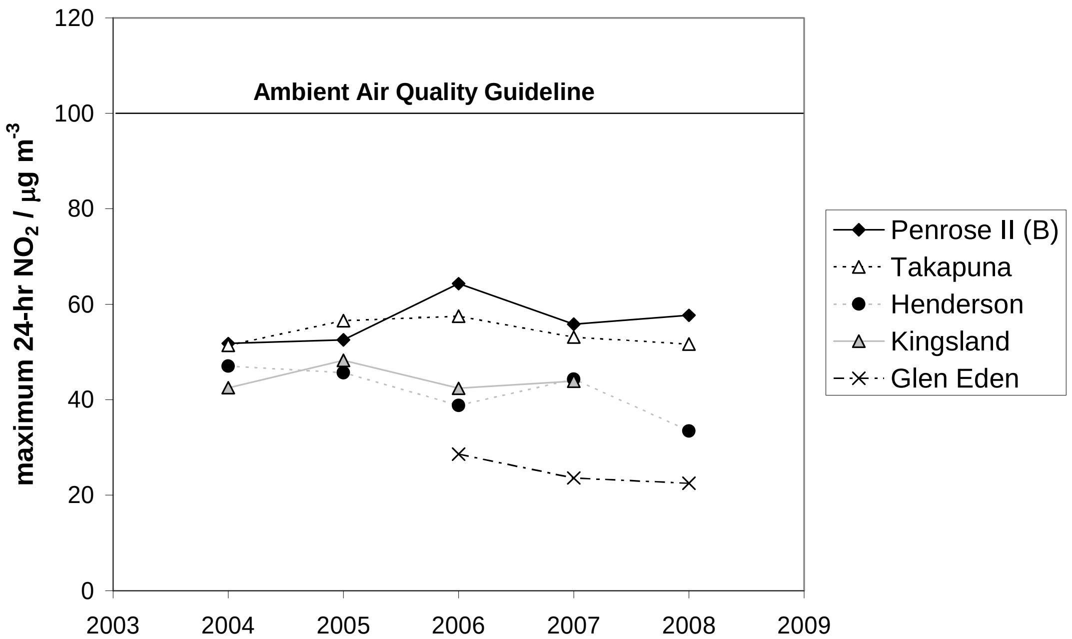

Figure 5.7 – Yearly Maximum 24-hour Average NO_2 Concentration from 5 Relevant ARC Monitoring Sites (2004-2008).

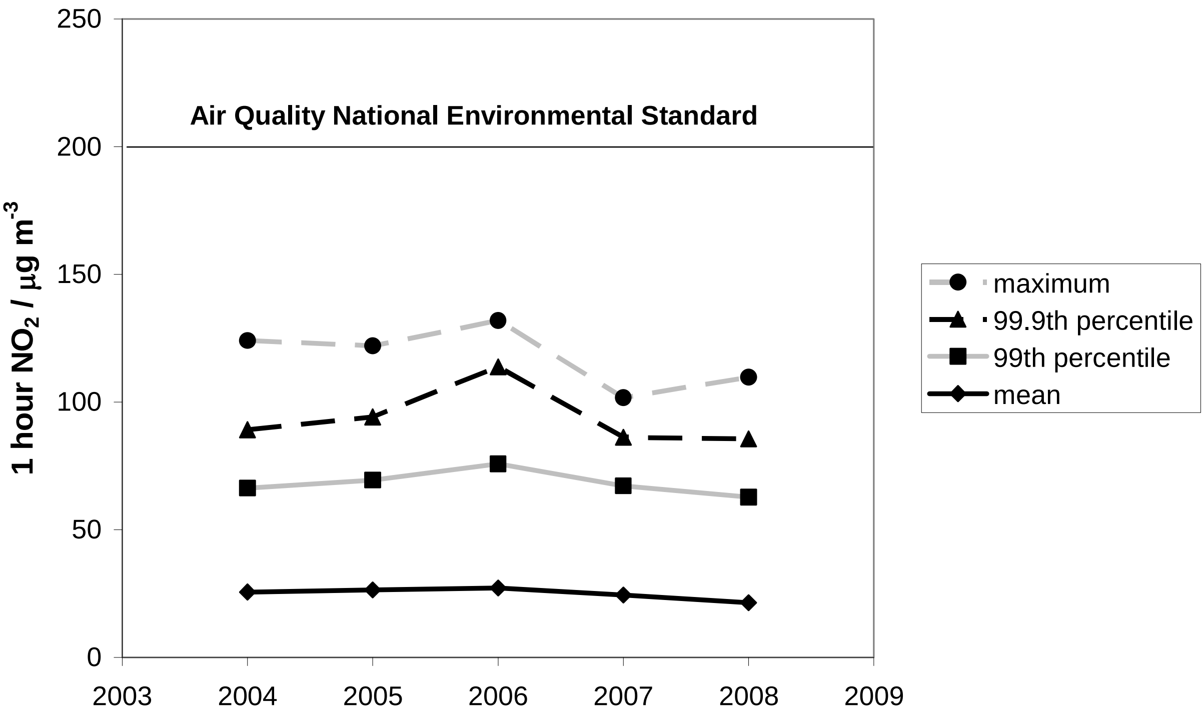

Figure 5.8 - 5 Year Trend in 1-hour Average NO_2 Concentrations at the ARC Takapuna Monitoring Site.

5.5.6 Carbon Monoxide

Ambient concentrations of carbon monoxide in Auckland are low, relative to the AQNES of 10 mg/m^3 (as an 8-hour rolling average), and have been continually falling since monitoring began. The dominant source of urban CO is petrol vehicle emissions. This falling trend is consistent with expectations arising from recent technological developments in vehicle emission control leading to rapid falls in emission factors, and the penetration of these new technology vehicles into the Auckland vehicle fleet (e.g. Bluett & Fisher, 2005). Figure 5.9 shows the maximum 8-hour concentration per year for the last five years at four ARC monitoring sites. These sites describe suburban locations with varying degrees of local traffic influence, as summarised in Table 5.1. They are considered to be broadly representative of the range of receptors likely to be encountered in the Project vicinity. It can be seen that a concentration of 5 mg/m^3 may be considered to represent the highest probable 8-hour rolling-average concentration at such sites in 2008. A similarly representative maximum 1-hour concentration would be 8 mg/m^3.

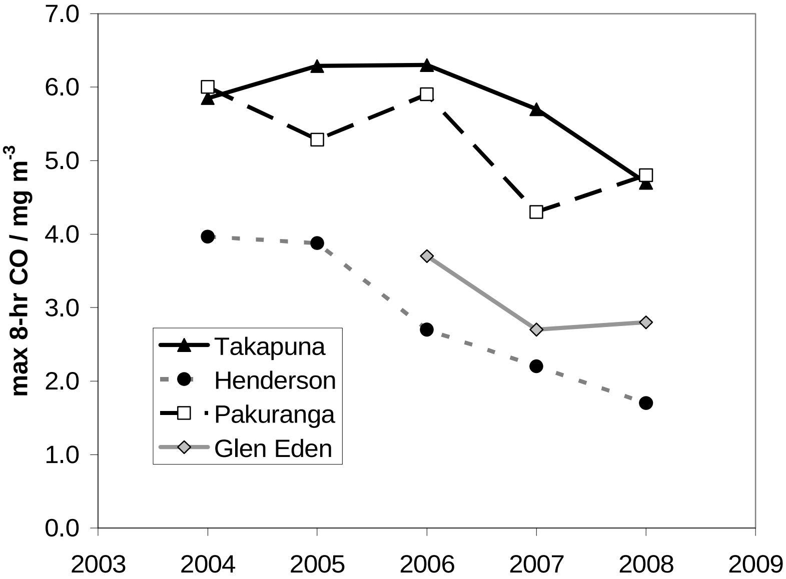

Figure 5.9 – Yearly Maximum 8-Hour Average CO Concentration from 4 ARC Monitoring Sites (2004-2008).

5.5.7 Benzene

Compared to the pollutants discussed above, monitoring data for benzene is much scarcer. Long-term semi-continuous monitoring has been conducted by the ARC at Khyber Pass Road (ARC, 2009b). This monitoring has revealed major reductions in concentrations over the last decade. Similarly to carbon monoxide, this is consistent with expectations of rapidly reduced emissions from vehicle tailpipes following technological changes and new fuel standards (ARC, 2009b).

Limited passive monitoring has been conducted by the NZTA at selected sites around the Project. Data from July to November 2009 has been made available for this assessment. These data have been extrapolated to annual means using adjustment factors derived by NIWA. This has revealed concentrations which lie far below the NZAAQG of 3.6 µg/m^3, as shown in Figure 5.10.

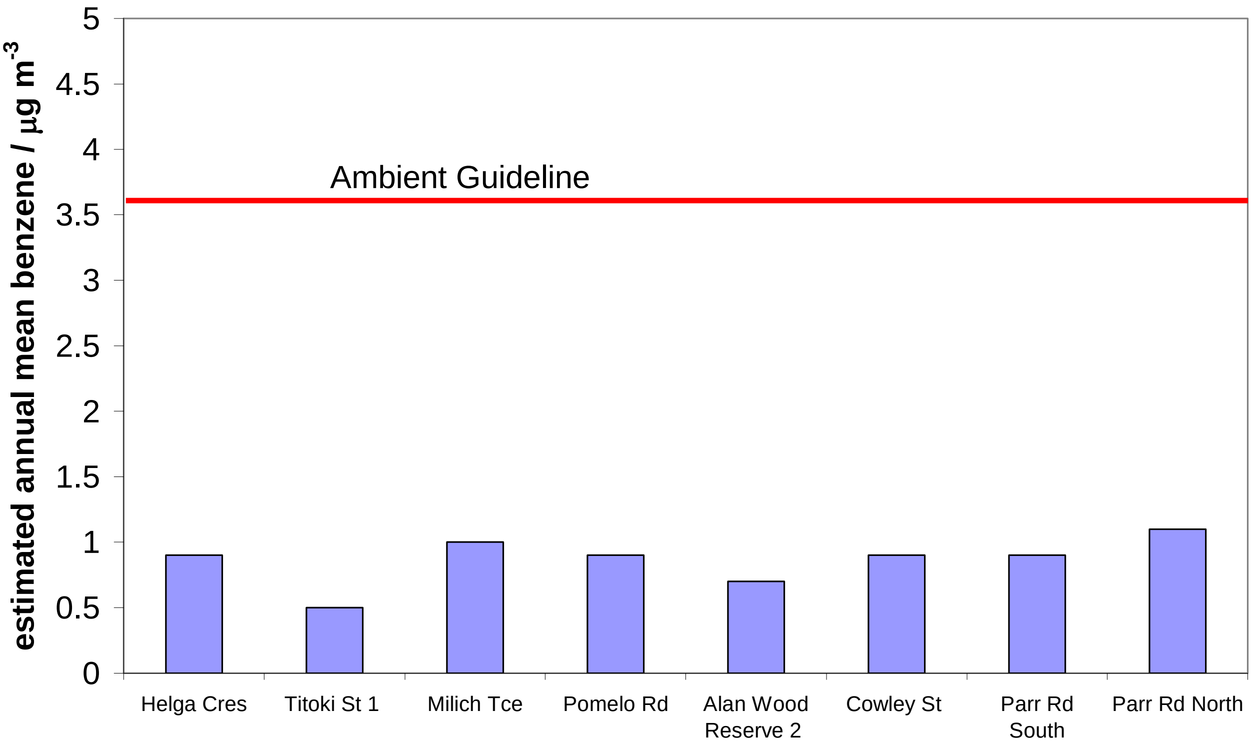

Figure 5.10 - Estimated Annual Mean Benzene Concentrations, Based on NZTA Monitoring Data from July – November 2009.

5.5.8 Trends in Background Concentrations

It has been noted throughout Section 5.5 above that there is insufficient evidence to confidently predict long-term future trends in air quality (independently of the Project) for any of the relevant pollutants. There is circumstantial evidence that concentrations of most traffic pollutants have been on a downward trend due to technological improvements in combustion efficiency, emission control and fuel quality. However, there is insufficient evidence to confidently predict that such trends are general, consistent, or will continue into the future (see Figure 5.3 and Figure 5.6, for example). For this reason, a conservative position has been taken which assumes that there is no change in background air quality (i.e. arising from emissions external to the Project) in 2016 and 2026 compared to 2006. Thus, all predicted net changes in air quality in this assessment arise from the changes in traffic flow as described by the Project traffic modelling, and due to changes in emission factors (arising from changes in fleet composition, fleet turnover, and/or traffic speeds), but not due to non-traffic influences (such as changes in domestic heating emissions, changes in climate, changes in industrial emissions) which are assumed to be zero.

5.6 The Impact of Meteorology on Air Quality in Auckland

Auckland's meteorology is dominated primarily by south-westerly winds and secondarily by north-easterly winds for a significant portion of the year. In terms of air quality, light winds and calm conditions are the most critical conditions. Light winds lead to reduced dispersion of traffic emissions. This also applies to other local emissions (such as domestic wood smoke), which compound poor air quality. Analysis of meteorological data from several Auckland weather stations reveals that light winds (< 1 m/s) are:

a. more common at night and a few hours after dawn,

b. very rare in the afternoon,

c. more common in the winter and less common in summer, especially in the evening, and

d. more likely than average to be south-westerly.

Compared to more continental cities, periods of calm winds in Auckland are of relatively short duration, and very rarely persist for a day or more. In summer, land-sea breeze systems maintain air circulation and partly account for the low occurrence of calm winds. In winter, the regular passage of low-pressure systems prevents the establishment of anti-cyclones which would lead to extended periods of light winds. The result in terms of air quality is that pollutants are typically dispersed from the Auckland urban airshed in under 24 hours and there is very little evidence of accumulation of pollutants over several days.

Meteorological data has been collected on behalf of the NZTA at two locations in the Project area (Oakley Creek and Alan Wood Reserve). NIWA has analysed these datasets with particular emphasis on identifying differences in wind flow to that observed at other Auckland sites.

In general, it was found that during "normal" (i.e. non-calm) periods, winds around the Project are not substantially different from elsewhere in Auckland. However, during calm conditions, a local-scale climate can form which is relatively isolated from what is happening elsewhere. This micro-climate is interpreted as being a result of the well-known physical effect of valley-drainage-flow in the "Oakley Creek valley" formed by two volcanic ridges (corresponding, roughly, to Mt Albert Rd and Richardson Rd/Avondale Heights). On some calm winter nights associated with south-westerly winds in central and west Auckland, winds in the valley become aligned with the valley's axis (i.e. roughly parallel to the Waterview Connection). Winds predominantly flow down the valley (as a result of cold air sinking), although at the southern (Alan Wood Reserve) end of the valley, winds can be extremely light and variable, suggesting meandering or pooling of air on the sheltered valley floor. The effect disappears as soon as external winds increase.

The effect of this local valley flow and sheltering on air quality is clearly seen in the PM_{10} data observed at Alan Wood Reserve. In winter, calm winds usually coincide with low temperatures and a (presumed) high emission rate of domestic wood smoke. The Alan Wood Reserve site is on the valley floor and is surrounded by residential properties. On nights when valley flow is observed, hourly PM_{10} concentrations are elevated compared to normal. This elevation persists for several hours post-midnight, when (it is presumed) wood smoke emission is greatly reduced, and can be interpreted as due to a reduced rate of dispersion.

5.7 Baseline Concentration Scenarios

5.7.1 Overview of Approach

The baseline concentration scenarios quantify the existing air quality at the assessment receptors in the 2006 Base Year. They provide a reference for comparing the impact of the Project on air quality. They also permit all five scenarios to be compared with the relevant air quality standards, guidelines and targets.

Baseline air quality inevitably contains spatial variation and gradients due to variations in emission densities, differences in land-use, and topography, which affect dispersion. For all pollutants **except** NO_2 there is insufficient data available to describe that variation in the vicinity of the Project. For this reason the conservative assumption is made that the highest concentrations recorded in the Project vicinity are applicable for all assessment receptors. Thus all receptors have been assumed to have the same baseline concentrations of PM_{10}, $PM_{2.5}$, CO and benzene (with the exception of PM_{10} at receptors in Te Atatu, see below).

For NO_2 **only,** there is sufficient local data (from the network of passive monitoring mentioned in Section 5.5) to describe this spatial variation, so that every receptor could have its own specific baseline concentration. The derivation of baseline concentrations of NO_2 is outlined in Section 5.7.6 below and APPENDIX L.

Baseline scenarios have been constructed from local monitoring data from the year 2007 where available. This is principally due to 2007 being used as the dispersion modelling year for all scenarios (see Section 6.6 below). The year 2007 also presents a larger source of data than 2006 (the traffic modelling year) due to the commencement of monitoring at Alan Wood Reserve in mid 2006 and Cowley Street in mid 2007.

For particulate matter and carbon monoxide, the baseline scenario consists of an hourly time series designed to be representative of the assessment receptors. For nitrogen dioxide, spatial gradients are much more significant, concentrations more unpredictable, and monitoring data is more biased towards long-term mean concentrations. For these reasons a different approach has been taken, with a single annual mean and 99.9th percentile[16] 1-hour concentration being predicted for each receptor. For benzene (for which there are no short-term guidelines) only an annual mean baseline concentration has been predicted.

The following sections discuss the baseline scenarios used for each pollutant in further detail.

5.7.2 Particulate Matter (PM_{10})

Research conducted by NIWA (with funding from FRST[17]) has indicated that a PM_{10} time series can be derived that is broadly representative of the western side of Auckland (roughly from Henderson to Kingsland). This time series is derived for each hour of 2007 from the mean of 1-hour average concentrations from ARC's sites at Henderson, Kingsland and Penrose II, and NZTA's sites at Alan Wood Reserve and Cowley Street. This is

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[16] It is the convention to report 99.9th percentile concentrations rather than maxima, in the case of 1-hr average NO_2, as per the MfE Transport GPG (2008).

[17] FSRT – Foundation for Research, Science and Technology.

labelled the West Auckland Baseline[18]. The West Auckland Baseline time series is representative of sites with moderate traffic influence, but not heavily-trafficked locations (such as < 10 m from a motorway or major intersection).

It was noted in Section 5.6 above that peak concentrations of PM_{10} are associated with light winds in winter, during which time local topographically-related air flows are observed. During such periods small shallow valleys, such as the Oakley Creek valley, can become relatively isolated and experience different rates of dilution, and hence pollutant concentrations, compared to other locations. This is borne out in the observational data from Alan Wood Reserve and Cowley Street. During such periods the West Auckland Baseline represents an under-estimate of PM_{10} levels inside the Oakley Creek valley. For this reason, a second baseline time series for the Oakley Creek valley has been derived. NIWA's research has developed an approach to identifying the meteorological conditions that lead to peak PM_{10} events. Those hours during 2007 in which these conditions existed have also been identified and the anticipated effect on PM_{10} corroborated with monitoring data. The Oakley Creek Baseline is the same as the West Auckland Baseline except during these pre-defined poor dispersion events when the PM_{10} value is derived from the mean of data reported at Cowley Street and Alan Wood Reserve only.

In Figure 5.11 and Figure 5.12, 24-hour PM_{10} concentrations have been calculated for the two PM_{10} baseline time series. It can be seen how the baselines are the same except on a few key days (27th, 28th, 29th and 30th May, 1st, 19th and 20th June) when concentrations in Oakley Creek are higher. Figure 5.13 compares the two baselines with the relevant guideline and standard for PM_{10}.

One of these two baselines applies to each assessment receptor. The West Auckland Baseline will apply to all receptors on the Te Atatu Peninsula. The Oakley Creek Baseline will apply to all receptors in Hillsborough, Mt Roskill, Owairaka, Waterview and Pt Chevalier. A number of receptors are to the west of the Oakley Creek valley (i.e. in Avondale) or to the east (i.e. in Mt Albert). There is no PM_{10} data from these areas to verify whether the West Auckland or Oakley Creek Baseline is more representative. However, both could be considered to occupy valley locations and, to maintain a degree of conservatism, the Oakley Creek Baseline is applied at these receptors also. This is summarised in Table 5.6.

[18] Although not located in west Auckland itself, the Penrose II site reports levels of PM_{10} that are little different from other sites in urban Auckland and its inclusion improves the statistical robustness of the derived baseline.

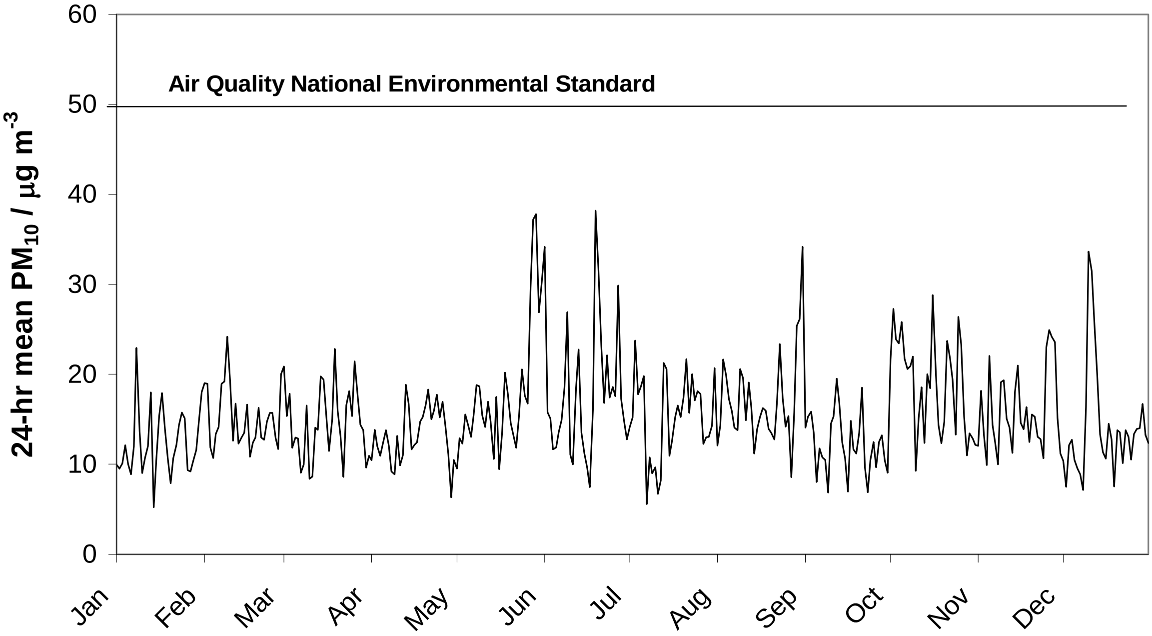

Figure 5.11 - Complete Time Series of the Oakley Creek Baseline 24-hr Average PM_{10}.

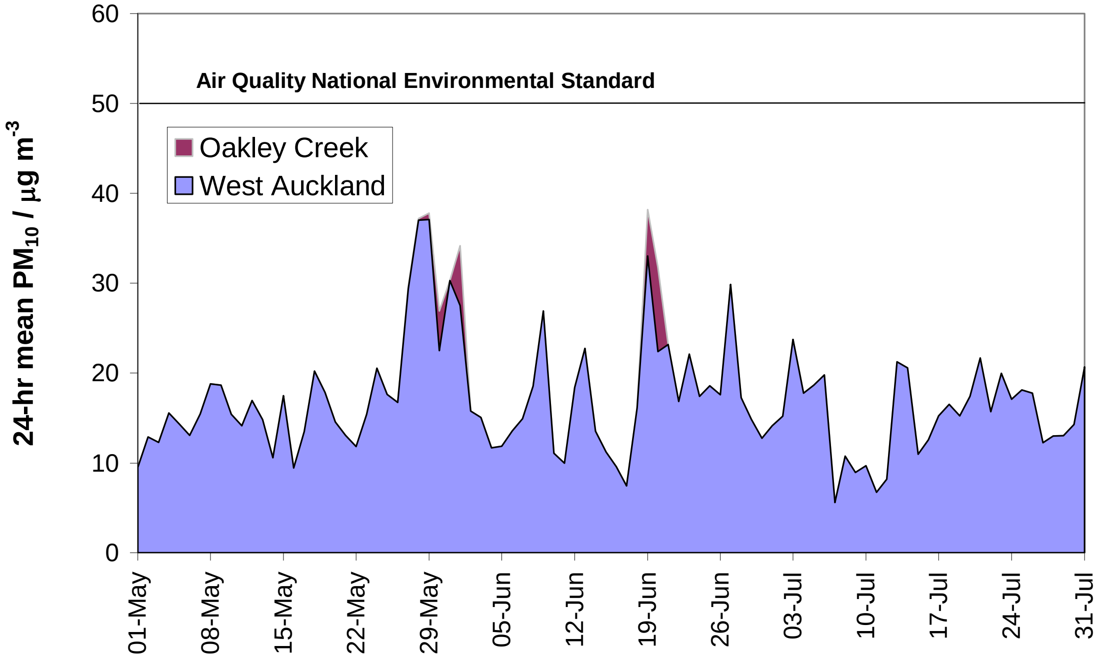

Figure 5.12 - Detail of the Time Series of Baseline 24-hr Average PM_{10} During May to July Inclusive
(showing occasions when the Oakley Creek Baseline is elevated compared to the West Auckland Baseline.)

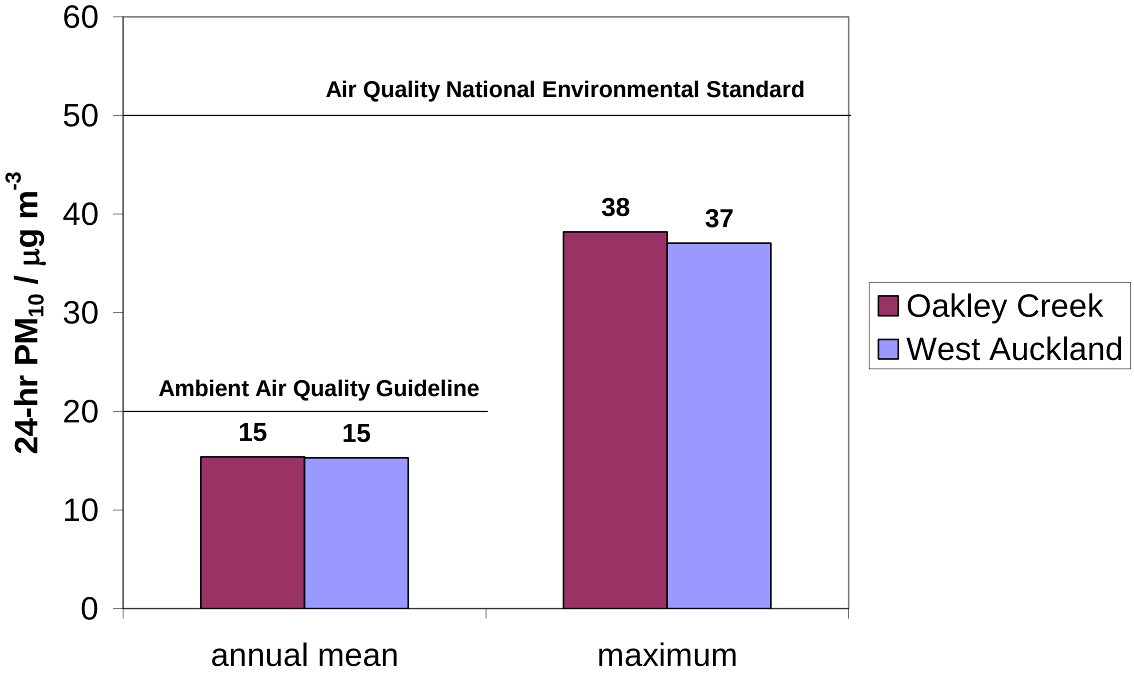

Figure 5.13 - Annual Mean and Maximum 24-hr Average PM_{10} in the Two PM_{10} Baseline Scenarios.

Table 5.6 – Application of the Two PM_{10} Baselines to Receptors

Receptor location	PM_{10} baseline applied
Te Atatu	West Auckland
All other receptors	Oakley Creek

5.7.3 Particulate Matter ($PM_{2.5}$)

The baseline scenario for $PM_{2.5}$ is necessarily simpler than that for PM_{10}, due to the relative paucity of data. During 2007, $PM_{2.5}$ data was available from the ARC's sites at Penrose II, Kingsland and Takapuna. Therefore a baseline is derived for each hour of 2007 from the mean of 1-hr average concentrations from these three sites. With no data available from within the Oakley Creek valley, there is no evidence on which to base an alternative baseline for the valley. However, the inclusion of Takapuna, and the absence of Henderson in the baseline (relative to PM_{10}) makes the $PM_{2.5}$ baseline potentially slightly more biased towards roadside sites and therefore marginally more conservative than the PM_{10} baseline.

The resulting time series of 24-hour average $PM_{2.5}$ and comparison with the ARC target are shown in Figure 5.14. The maximum value is 24 µg/m^3.

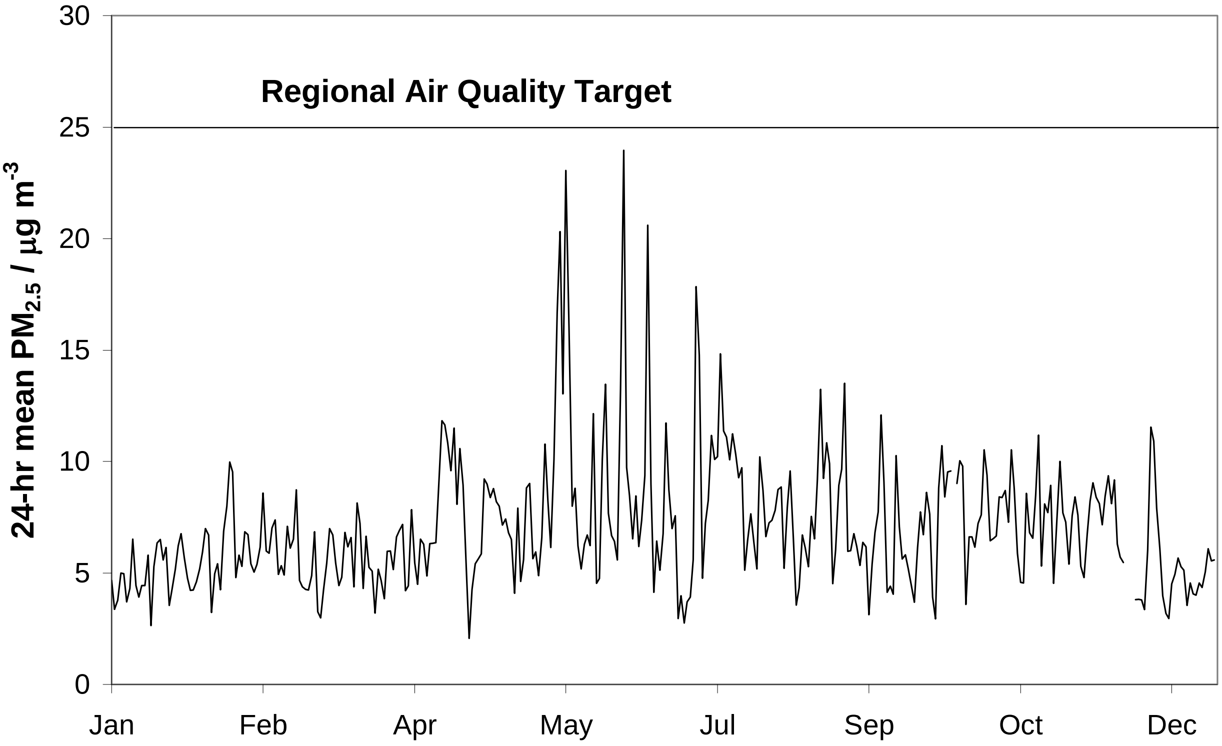

Figure 5.14 - Time Series of Baseline 24-hr Average $PM_{2.5}$.

5.7.4 Carbon Monoxide

Petrol vehicle emissions are the dominant source of CO in the urban atmosphere. This means that ambient concentrations are generally very low except very close (tens of metres) to roads. Consequently, CO data from a monitoring site is representative of locations at a similar distance to similar roads, rather than a broader neighbourhood or suburb. CO monitoring is likewise mostly concentrated at, and biased towards, roadside sites. This makes a baseline derived from a range of monitoring sites inherently conservative when applied to a wide urban area such as the Project vicinity.

The CO baseline time series is constructed for each hour of 2007 from the mean of 1-hr average data from the following ARC monitoring sites:

- Takapuna
- Khyber Pass Road
- Henderson
- Pakuranga
- Queen Street II
- Glen Eden

The resulting time series of 8-hr rolling-average CO is shown in Figure 5.15. The peak concentration is 3.7 mg/m^3. This baseline time series is applied to all receptors, although this is likely to be conservative for non-roadside receptors.

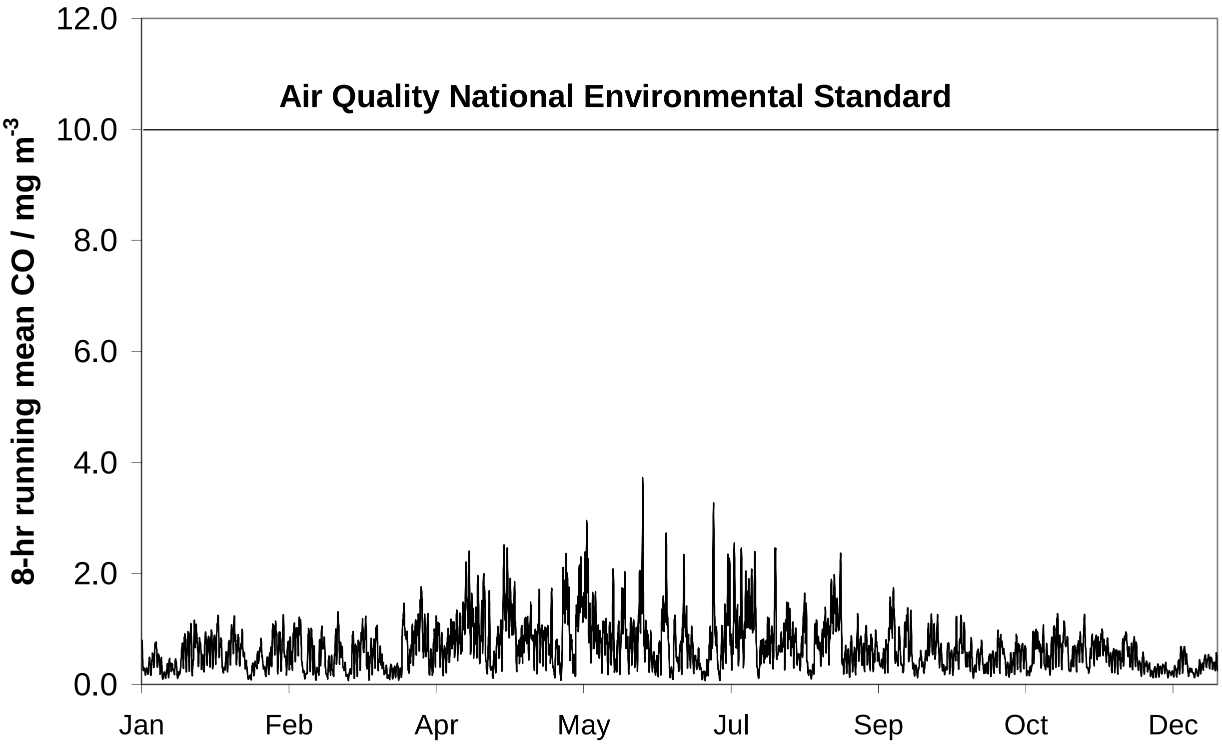

Figure 5.15 - Time Series of Baseline 8-hr Rolling Average CO.

5.7.5 Benzene

The benzene baseline is derived from passive monitoring conducted for the Project, described in section 5.5.7 above. Estimated annual mean benzene was below 1 µg/m^3 at all monitoring locations. These locations encompassed some of the highest observed levels of NO_2 in the Project vicinity. As road traffic emissions are the common dominant source of both NO_2 and benzene, there is no evidence to suggest that benzene levels will be higher at any location in the Project vicinity other than where monitoring was conducted. Therefore a value is applied of 1 µg/m^3 as an annual mean for all assessment receptors.

5.7.6 Nitrogen Dioxide

Short-term (e.g. 1-hour average) concentrations of NO_2 are much more unpredictable than PM and CO concentrations. This is due to the added influence of atmospheric oxidants and photochemical reactions, described briefly in section 5.5. Consequently, the NO_2 baseline that has been derived for this assessment does not take the form of a time series. Instead, the annual mean and annual 99.9th percentile 1-hour average and maximum 24-hour average have been predicted. The method predicts values for a "typical" year rather than any specific year. The annual maximum 1-hour concentration has not been predicted, as this is too subject to random and often highly localised factors and is effectively unpredictable and unrepresentative. The method is summarised in APPENDIX L. Using this approach, the following 'urban background' concentrations have been derived for NO_2:

- 16 µg/m^3 as an annual average
- 44 µg/m^3 as the maximum 24-hour average
- 65 µg/m^3 as the 99.9th percentile of 1-hour averages.

These urban background values apply across all receptors and all modelling scenarios (refer also to Section 5.5).

6. Traffic and Emissions Modelling

This section of the report provides information relating to the estimation of pollutant emissions from vehicles travelling on roads within the Project area, based on traffic volumes predicted through the use of traffic modelling. Sources of vehicle emission rates are discussed as well as the traffic information used in the study. Traffic emissions and speeds and emissions rates for vehicle related emissions are key inputs into the dispersion modelling described in Section 7. These aspects are summarised in the following sections of this report:

- Sections 6.1 and 6.2 summarise the traffic modelling undertaken for this Project (Beca, 2010a)
- Section 6.3 outlines the approach taken to modelling vehicle related emissions
- Section 6.4 describes key characteristic of the New Zealand vehicle fleet
- Section 6.5 discusses the results of the vehicle emissions modelling
- Section 6.6 summarises the stack emissions parameters sourced from the tunnel ventilation design (URS, 2010).

6.1 Traffic Modelling

Traffic volumes through the proposed new sections of SH20, the widened sections of SH16 and on surrounding roads in 2016 and 2026 have been derived using the traffic modelling program EMME/3. This incorporates the ART3 Demand Model and the Project Assignment Model. Traffic modelling is described in detail in the Western Ring Route - Assessment of Transport Effects (Beca, 2010a).

The ART3 model is operated by the ARC and is implemented in the EMME/3 software. The ART3 Demand Model is a multi-modal transport model that predicts overall regional traffic patterns based on inputs and forecasts of population and employment growth, the level of road and public transport infrastructure and other policy assumptions (such fuel price and traffic demand management).

The Project Assignment Model uses data from the ART3 Demand Model and 'assigns' it to network roads, which, although covering the whole Auckland region, has significantly greater detail in the study area than the ART3 Model.

Two forecast years have been assumed, 2016 (to represent opening year for the project) and 2026 (to represent 10 years post opening) for both the "With Project" and "Do Nothing" scenarios.

Table 6.1 details the roading, rail and bus network assumptions in the traffic modelling for the Do Nothing scenarios for 2016 and 2026, sourced from the traffic modelling report for this Project (Beca, 2010a). The '**ü**' indicates the modelled years(s) in which the scheme was included. Some of these projects have already been completed (e.g. SH18 Greenhithe, SH20 Mt Roskill and the Northern Busway); they are included in this table of assumptions because they may not have been completed for the 'base year' of 2006.

Table 6.1 – Traffic Modelling Assumptions (Do Nothing and With Project)

Project	2016	2026
Roading Projects		
Regional Arterial Road Plan (RARP)	ü	ü
SH1 Wainui Interchange	ü	ü
SH1 Alpurt	ü	ü
Central Motorway Junction Stage 2	ü	ü
SH18 Greenhithe	ü	ü
SH18 Hobsonville	ü	ü
SH1 Esmonde Interchange	ü	ü
SH1 Onewa Interchange	ü	ü
SH1 Victoria Park Tunnel	ü	ü
SH1 Newmarket Viaduct	ü	ü
SH1 Highbrook Interchange	ü	ü
SH1 Papakura Interchange	ü	ü
SH20 Mt Roskill	ü	ü
SH20 Manukau Harbour Crossing	ü	ü
SH20 – SH1 Manukau	ü	ü
SH20A	ü	ü
SH1 Widening (various)	ü	ü
AMETI stage 1	ü	ü
PENLINK	ü	ü
Tiverton/Wolverton	ü	ü
South West to East Tamaki Stage 1	ü	ü
Redoubt Road	ü	ü
Glenfield Road		ü
Massey North		ü
SH16 Grafton Gully Stage 3		ü
AMETI Stage 2		ü

Project	2016	2026
South West to East Tamaki Stage 2		ü
SH20 B		ü
Mill Road Corridor Stage 1		ü
Pukekohe Eastern Corridor		ü
Rail Projects		
Electrification	ü	ü
Onehunga Branch	ü	ü
Manukau Spur	ü	ü
CBD Rail Loop		ü
Bus Projects		
Central Transit Corridor	ü	ü
Northern Busway	ü	ü
Bus Lanes (various)	ü	ü
Northern Busway extension to Silverdale		ü

The effect of traffic flows on both the wider State highway network and also the local road network are summarised briefly below.

6.1.1 Effects on SH16

Even without the Project (i.e. in the "Do Nothing" scenarios), there is a predicted increase in flows on all sections of SH16 (apart from St Lukes to Great North Road) between 2006 and 2016 due to growth in the corridor, and between 2016 and 2026. This growth is minor on the eastern Sections of SH16 (Sector 6), but is predicted to be more than 20% on the western Sections of SH16 (Sectors 1 to 4).

A further increase in flow can be observed with the proposed widening of SH16 (up to 22% in Sector 6, between the St Lukes and Great North Road Interchanges). In 2016, the greatest increase is seen in the sections to the east of the intersection of Lincoln Road and SH16, as widening beyond Lincoln Road will not have been completed. In 2026, there is a large increase in traffic along the whole length of SH16 as the whole motorway is widened, thereby attracting more traffic (up to 20% in the section between Te Atatu and Lincoln Road Interchanges). [It is noted that the effects of vehicle emissions from sections of SH16 to the west of the Te Atatu Interchange is outside the scope of this report; however, comments on traffic flow in these sections are included for completeness.]

6.1.2 Impacts on the Wider State Highway Network

With the Project in place, there is an increase (6% – 7%) in flow expected on SH20 Manukau Harbour Crossing. This is because completion of the WRR provides an alternative to SH1 for traffic to the north and west and attracts traffic from the local road network. The increase in flow on SH20 Mt Roskill is predicted to be 71% in 2016 and 92% in 2026 with the Project in place.

Between 2016 and 2026, 1% growth is forecast on Auckland Harbour Bridge and SH1, with a further 17% growth being forecast for SH18. With the Project in place, in both 2016 and 2026 a marginal increase in flows on both SH1 and SH18 is forecast compared to the 'Do Nothing' scenarios.

6.1.3 Impacts on District and Arterial Roads

The improvements to SH16 between St Lukes and Te Atatu are predicted to have only a minimal impact on traffic on Great North Road, New North Road and Rosebank Road. However, for those roads that parallel the route of SH20 (Carrington Road and Mt Albert Road), substantial decreases in traffic are predicted (30-40% on Mt Albert Road and 20-30% on Carrington Road).

Te Atatu Road is a four-lane arterial road, which is already congested, in large part due to the SH16 interchange. As the modelling has assumed that the Te Atatu Interchange would be upgraded as part of the SH16 widening project, this road would be better able than the current configuration to accommodate the increase in traffic created by the Project.

6.1.4 Impact on Heavy Commercial Vehicle Traffic

The traffic assessment showed that when the WRR: Waterview Connection is in place, reductions in the number of HCVs are observed on the regional/arterial roads, especially:

- Sandringham Road;
- Dominion Road;
- Manukau Road;
- Carrington Road;
- Rosebank Road;
- Great North Road;
- Blockhouse Bay Road; and
- Mt Albert Road.

6.2 Traffic Volumes and Speeds

Average weekday traffic flow rates have been used to predict traffic emissions and are summarised in Table 6.2.

Table 6.2 – Daily Traffic Volumes 'With Project' (Average Weekday)

Motorway Section	AADT[19] (Vehicles/day)	
	2016	2026
SH16 Sectors 1-4	120,000	135,100
SH16 Sector 6	139,200	147,300
SH20 Sectors 7-9	69,900	82,200

Detailed traffic flows for SH20 including the tunnel portion (Sectors 7 and 8) have been extracted from the traffic model for 2016 and 2026, as summarised in Table 6.3. The model output provides morning and evening peak flows and weekday inter-peak flows.

Table 6.3 – Two-Hourly Traffic Flow Predictions – SH20 Including the Tunnel (Sectors 7 and 8) (Average Weekday)

	2016		2026	
Period	**Northbound**	**Southbound**	**Northbound**	**Southbound**
AM Peak 07:00-09:00	4704	5520	4996	6506
Inter-Peak (IP)	4572	4467	5383	5450
PM Peak 16:00-18:00	5827	3801	6902	4144

The two-hour flows were converted into a 24-hour weekday flow profile. To do this, hourly traffic volumes outside the modelled peak flow periods (AM and PM) were calculated from the IP hourly flow using factors shown in Table 6.4 (provided by the traffic modellers and based on actual traffic count data), while hourly traffic volumes for the AM and PM peak periods were calculated by halving the predicted two-hourly flows for those periods.

[19] AADT – Annual Average Daily Traffic.

Table 6.4 – 24 Hourly Traffic Flow Factors

Hour	Weekday	Weekend		Hour	Weekday	Weekend
00:00-01:00	0.088	0.237		12:00-13:00	0.864	1.028
01:00- 02:00	0.041	0.155		13:00- 14:00	0.847	0.998
02:00-03:00	0.027	0.106		14:00-15:00	0.922	0.998
03:00-04:00	0.030	0.079		15:00- 16:00	1.125	0.938
04:00-05:00	0.054	0.071		16:00- 17:00	PM Peak	0.958
05:00-06:00	0.125	0.094		17:00- 18:00	PM Peak	0.949
06:00-07:00	0.451	0.184		18:00- 19:00	0.723	0.827
07:00-08:00	AM Peak	0.283		19:00- 20:00	0.752	0.632
08:00-09:00	AM Peak	0.490		20:00- 21:00	0.551	0.497
09:00-10:00	0.843	0.786		21:00- 22:00	0.454	0.398
10:00-11:00	0.800	0.938		22:00- 23:00	0.343	0.320
11:00-12:00	0.813	0.982		23:00- 24:00	0.206	0.296

6.3 Vehicle Emission Modelling Methodology

The volume and relative concentrations of vehicle emissions depend on a variety of factors including:

- Vehicle fleet profile;
- Vehicle age and condition;
- Fleet composition, including the proportion of HCVs;
- Engine and exhaust design, including the use of catalytic converters;
- Fuel type;
- Emission control regulations and enforcement;
- Vehicle speed and traffic congestion;
- Distance travelled, both cumulatively and within the span of a single trip; and
- Road surface type and gradient.

The effects of the vehicle fleet profile, vehicle speeds, traffic congestion, journey lengths, cumulative vehicle mileage, road surface type and gradient are discussed in Section 6.4 of this report. These factors are incorporated into VEPM, a model developed on behalf of the ARC and approved by the ARC. VEPM is described in more detail in Section 6.5 of this report.

6.4 NZ Vehicle Fleet Characteristics

This section details the considerable analysis that has been carried out on the vehicle fleet characteristics, as these are important inputs to the assessment. Much of this analysis has been carried out on the NZ fleet (rather than specifically on the fleet in west Auckland). This has been done since good data are available for the NZ fleet, but very little on the local fleet. In general this is acceptable, and an appropriately conservative assumption, since the Auckland fleet tends to be newer and emits less air pollution that the average NZ fleet vehicle. Where specific local features are important – such as the proportion of heavy duty vehicles – this is specifically assessed for the local situation.

6.4.1 Vehicle Numbers

The numbers of vehicles of all types registered in New Zealand increased from 2001 to 2008, with a slight decline in 2009. Figure 6.1 summarises the total numbers of motor vehicles of all types registered in New Zealand in each of the years 2001-2009. This information is derived from vehicle registration statistics and Warrant of Fitness data (MoT, 2010).

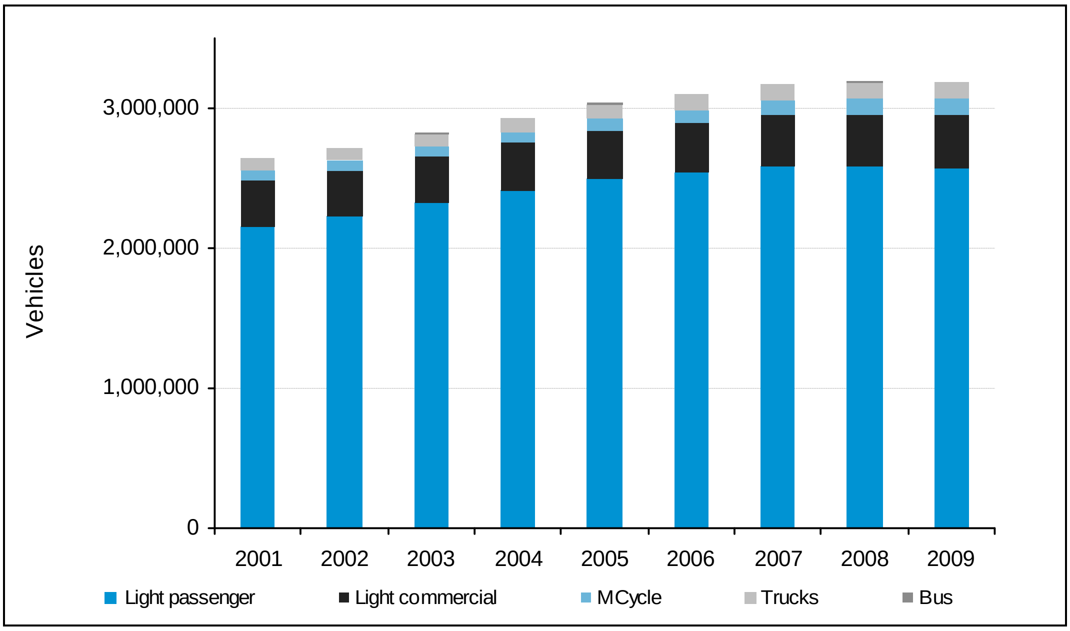

Figure 6.1 – New Zealand Vehicle Fleet Composition (MoT, 2010)

However, the total distance travelled by all vehicles in New Zealand was increasing in the years prior to 2004, but appears to have remained relatively constant since then. Figure 6.2 summarises the total distance travelled in each year for the different vehicles of different types.

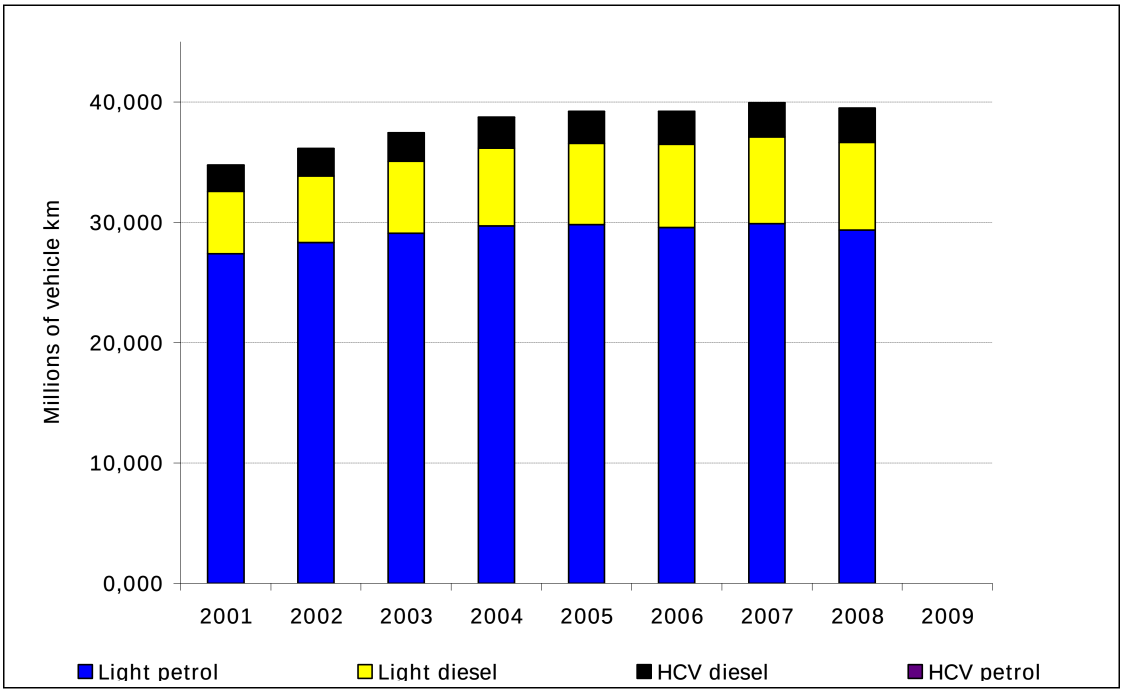

Figure 6.2 – New Zealand Vehicle Fleet Travel (MoT, 2010)

6.4.2 Vehicle Age

The New Zealand vehicle fleet is old in comparison with other countries where car ownership is high. Figure 6.3 summarises the total distance travelled in each year for vehicles of different ages. This shows that the vast majority of mileage is driven by cars manufactured between 1990 and 1999. The average age of New Zealand cars is 12.6 years, with the current majority having been used overseas prior to importation to New Zealand (MoT, 2010). The average fleet age of trucks is 14.3 years, whereas the average for buses is marginally older at 15.5 years. Older vehicles tend to have higher emission levels for both CO and NO_x, as vehicle emissions increase with age.

In 2003 the ARC carried out remote sensing of emissions from over 40,000 vehicles in the Auckland region (ARC, 2003).This report identified “gross emitters” in the fleet, which are older or poorly tuned vehicles. This study showed that “gross emitters” (defined as the most polluting 10% of vehicles) were responsible for approximately half the total emissions of PM_{10}.

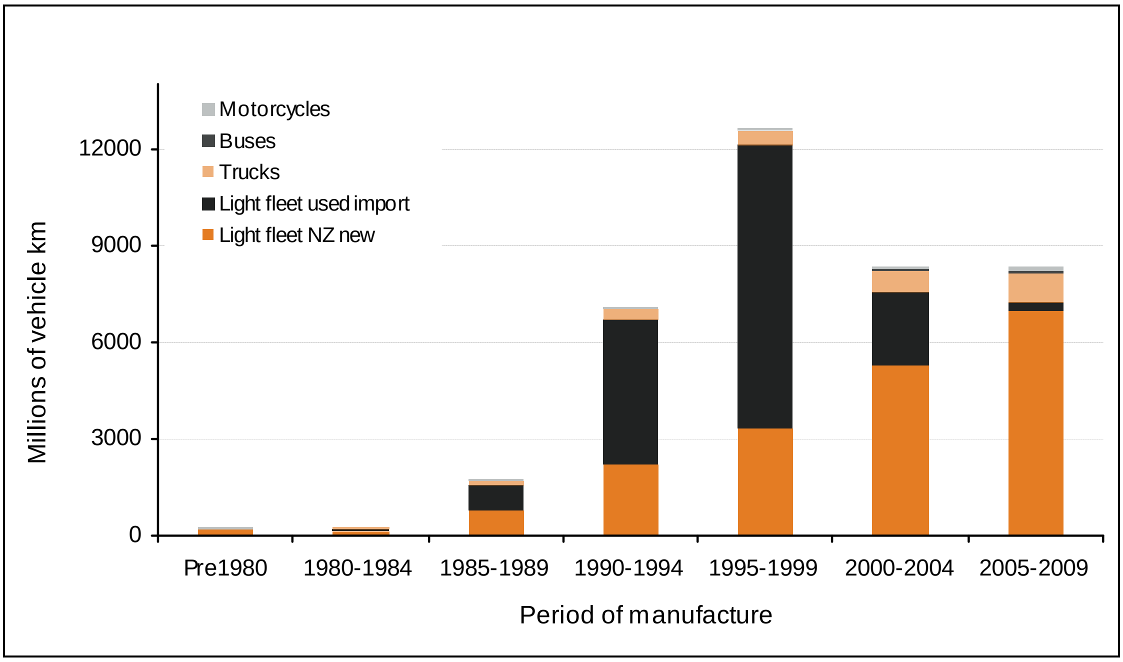

Figure 6.3 – New Zealand Vehicle Fleet Travel by Year of Manufacture (MoT, 2010)

6.4.3 Catalytic Converters

Emissions of CO, VOC and NO_x from a catalytic converter equipped petrol vehicle are approximately ten times lower than an equivalent non catalyst equipped vehicle. Catalytic converters do not reduce the level of PM_{10} discharged from vehicles.

The Land Transport Rule: Vehicle Exhaust Emissions 2007 was introduced in NZ in 2008 and updated the minimum standards for new and used vehicles imported into New Zealand. More than 95% of vehicles imported to New Zealand are from Japan. Under this Rule, all used vehicles are now tested before entering New Zealand to ensure their emissions control equipment is working. It is also illegal to modify vehicle emissions control equipment including catalytic converters.

Due to the high average fleet age, the New Zealand fleet has a higher proportion of vehicles operating without catalytic converters compared to Australia and Europe. About one quarter of the New Zealand fleet have catalytic converters, although this situation is expected to improve as the New Zealand fleet is almost entirely composed of vehicles manufactured overseas to international standards. The majority of newer cars (e.g. petrol vehicles manufactured since 2000) are assumed to have catalytic converters installed.

6.4.4 Vehicle Speed

Maintaining a steady flow of traffic will produce fewer pollutants than the stop start traffic often experienced at peak times. In general:

- Reducing traffic speed reduces emissions of CO and PM_{10}.
- NO_x emissions increase slightly as speed increases.

These trends can be observed in the graphs of emission factors with varying vehicle speed, in APPENDIX D (Trends in Vehicle Exhaust Emissions).

APPENDIX D also includes a limited sensitivity analysis on the potential effect of severe congestion in the tunnels, using an absolute conceivable worst case situation where the numbers of vehicles attempting to use the tunnels is in excess of the design capacity, with consequent hourly average speeds reduced to 10 km/h. This could result in emission rates for the various pollutants up to 10 times those from normal peak hour traffic. However, as can be seen from the results of dispersion modelling presented in APPENDIX H, even a 10-fold increase in the contribution via the tunnel ventilation stacks to ground level concentrations of (for example) CO will have a minimal impact on the overall concentrations of pollutants at any sensitive receptor.

6.4.5 Fuel

The bulk of the NZ car fleet is fuelled by petrol; however the number of diesel cars and commercial vehicles is forecast to continue to increase. The removal of lead from petrol in 1996 and the lowering of sulphur in diesel from 2002 have resulted in a significant improvement in the emission of these contaminants.

Diesel vehicles produce emissions with different concentrations of pollutants than those produced by petrol vehicles. Particulate emissions are significantly higher for diesel vehicles and can impact on visibility in tunnels, human health and the wider environment.

6.4.6 Proportion of Heavy Vehicles

The proportion of heavy vehicles (usually diesel fuelled) using a road is significant due to their relatively higher emissions of particulate matter per kilometre travelled compared to light vehicles. In terms of relative emissions, a large (e.g. 16-32 tonne) diesel heavy vehicle emits around fifty times more particulate matter than a petrol passenger car.

The proportion of heavy vehicles predicted to travel on SH20 and through the tunnel in 2016 is 8% of all vehicle trips. This figure comes from the traffic modelling (refer Section 6.1). The impacts of the Project in reducing heavy vehicle numbers on district and arterial roads are discussed in Section 6.1.4.

Based on current projections (as used in VEPM), the proportion of diesel vehicles modelled in VEPM for 2006 is 26%, rising slightly to 30% by 2026. This is somewhat higher than the actual proportion of diesel vehicles in the New Zealand fleet (18% based on registrations statistics) (MoT, 2010), because VEPM takes account of relative vehicle kilometre travelled rather than just the numbers of vehicles. However, for use in the estimation of emissions rates for the Project, the default proportions of diesel vehicles in VEPM were replaced with predicted proportions based on the results of traffic modelling.

6.4.7 Trip Length and Cold Starts

Vehicle exhaust emissions tend to be highest when the engine is cold (‘cold start’); once the engine has warmed up, exhaust emissions decrease substantially. This is especially true of vehicles fitted with catalytic converters – these tend to be ineffective until they have reached operating temperature. Therefore, average emissions will decrease as the individual trip length increases. For this assessment, an average trip length of 25km was assumed for SH20, based on traffic modelling predictions.

6.4.8 Road Gradient

Road gradients can increase or decrease vehicle fuel consumption depending on whether vehicles are travelling uphill or downhill.

Within each of the northbound and southbound tunnels, gradients vary between -5% and +3.3%. A sensitivity analysis has been conducted to test the potential impacts of these gradients on vehicle travelling inside the tunnels. Graphs showing the change in vehicle emissions with speed for CO and NO_x (assuming a gradient of 4% as a conservative maximum) are presented in APPENDIX D. This data applies to the 2016 scenario, while the gradient factors are sourced from PIARC (PIARC, 2004). No data was available for particulate matter. On this basis, the maximum impact is predicted to increase CO emissions by a factor of 5 for petrol cars and LCVs at the tunnel design speed of 80 km/hr. The maximum impact on NO_x emissions is for HCVs, and equates to a factor of 3.5 at 80 km/hr. As will be shown in Section 8, the predicted impacts of concentrations from the ventilation stacks are sufficiently low that even an absolute worst case assumption of increasing the emission rates by a factor of 5 would not change the conclusions of the assessment.

Within the Project area, the terrain is relatively level, without any major hills that would significantly affect vehicle exhaust emissions. Therefore, road gradients have been ignored in this assessment.

6.5 Vehicle Emission Rates

6.5.1 Vehicle Emissions Prediction Model

Detailed emissions factors have been derived from VEPM. This emissions model has been developed by the ARC after considerable research and validation since 2004. The VEPM database calculates emissions factors for European origin vehicles and also draws on emissions data from New Zealand, the Japan Clean Air Programme, the European Environment Agency (COPERT III), and the European Programme on Emissions, Fuels and Engine Technologies (EPEFE). The model provides a comprehensive emissions database covering the range of vehicle types available in the New Zealand fleet.

Two sets of emissions rates were modelled:

- tunnel emissions (i.e. via the tunnel ventilation stacks and/or tunnel portals)
- surface roads emissions.

With the gradual introduction of newer vehicles into the New Zealand vehicle fleet and the availability of cleaner fuels (such as the removal of lead from petrol and substantial reductions in levels of sulphur in both petrol and diesel), average exhaust pollutant emission rates (grams per vehicle-kilometre) have declined over recent years and are predicted to decline in the future. This is illustrated for PM_{10} exhaust emissions in Figure 6.4. Similar figures for NO_x, CO and VOCs are presented in APPENDIX D.

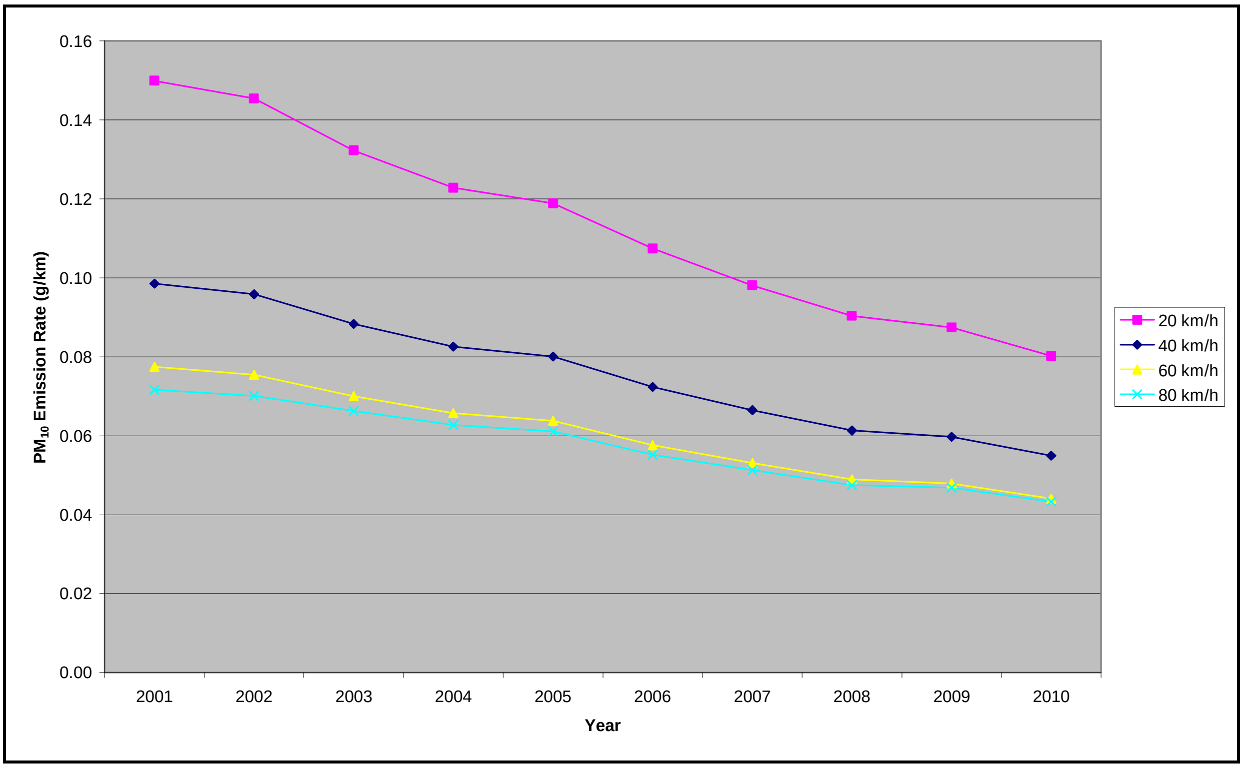

Figure 6.4 – Average PM_{10} Emissions Rates (from VEPM)

6.5.2 Non exhaust emission factors

The MfE Transport GPG recommends that brake and tyre wear emissions be considered, since for busy roads these can be a significant source of PM_{10}. Due to the high level of uncertainty associated with these emission factors, it is also recommended that a sensitivity analysis be undertaken. This has not been carried out at this stage. However, the brake and tyre wear emission calculated by VEPM increase the PM_{10} emissions by 20-50% depending on the average speed; this has been included in the modelling.

VEPM provides the option to calculate brake and tyre wear particulate emissions based on the average number of wheels for each vehicle class. In this case the model default settings were used for the purposes of the assessment.

6.5.3 PM_{10} and $PM_{2.5}$ Emission Rates

Vehicle exhaust emissions are concentrated in the finer fractions of PM (generally less than 1µm) while road tyre and break wear correspond generally to particles larger than 2 µm (Olivares et al., 2008 and references therein). Therefore, PM_{10} concentrations were obtained from the **total** emissions reported by VEPM while the $PM_{2.5}$ concentrations were obtained by using only the exhaust fraction of the emissions.

6.5.4 Comparison of VEPM with NZTER

Until recently, only the Ministry of Transport's NZTER model was recommended in the MfE Transport GPG for use in the assessment of vehicle emissions from roading projects. NZTER has now been superseded by the publication of the VEPM model. For this assessment the VEPM model (v. 3.0) was used rather than NZTER. The benefits of using VEPM over NZTER are that VEPM has been developed much more recently (2008 vs. 1996), contains much more detailed breakdown of fleet components (especially HCV) and was specifically developed and used by the ARC in their regional emissions inventory.

6.5.5 Catalytic Converters in VEPM

VEPM assumes a percentage of cars with non-functioning catalytic converters for vehicles aged between 1980 and 1997. This is a percentage of the total number of cars manufactured with catalytic converters. The default value is 15% for older cars and 0% for newer cars. A sensitivity analysis of this variable was conducted and indicated that emission rates could increase by up to 20% for CO and VOC and up to 5% for NO_x, while the impact on PM_{10} emissions is negligible. This is based on a scenario of 25% of installed catalytic converters not functioning.

As this assumption is constant across all modelled scenarios, comparisons of predicted ground level concentrations between the various scenarios remain valid.

6.5.6 Tunnel Emissions Modelling

Key assumptions in the determination of vehicle emissions from the tunnel were:

- The tunnel length is 2.46 km.
- A typical 24 hour hourly emission profile was created for the years 2016 and 2026 on the basis of 24 hour traffic flow profile, developed from actual traffic counts provided by the Beca transportation team.
- The vehicle emission factors are a fleet average "composite" factor. The average "composite" factor is generated using a vehicle fleet profile and represents the average emission rate for all vehicles in the fleet.
- Based on the results of the traffic modelling, the proportion of heavy vehicles predicted to travel through the Waterview tunnel in 2016 is 8% of all vehicle trips during weekdays and 4% of the fleet during the weekends (Table 6.5)[20]. The breakdown of the different HCV categories was reached by increasing or decreasing the four categories of HCV in the default VEPM 2016 and 2026 proportionally. The other categories were then adjusted proportionally so that the total fleet composition remained as 100%.

[20] The default values for the proportion of HCVs in VEPM are 7.5% and 8.2% in 2016 and 2026 respectively, while the equivalent values derived from the traffic modelling (for weekdays) are 6% and 7%.

Table 6.5 – Vehicle Fleet Profile as Percentage of Total Fleet -VEPM v3.0

	Cars		LCV		HCV 3.5-7.5t	HCV 7.5 -16t	HCV 16-30t	HCV >30t	Buses	M/cycle
Year	Petrol	Diesel	Petrol	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Petrol
2016 Weekday	69.5%	8.7%	2.7%	11.8%	0.5%	1.5%	1.1%	3.0%	1.3%	neg *
2016 Weekend	70.4%	9.6%	2.6%	12.6%	0.3%	0.8%	0.6%	1.8%	0.9%	neg
VEPM 2016 default	69.3%	8.7%	2.7%	11.7%	0.5%	1.5%	1.1%	3.0%	1.4%	neg
2026 Weekday	69.5%	8.7%	2.7%	11.8%	0.5%	1.5%	1.1%	3.0%	1.3%	neg
2026 Weekend	70.4%	9.6%	2.6%	12.6%	0.3%	0.8%	0.6%	1.8%	0.9%	neg
VEPM 2026 default	67.8%	9.3%	2.5%	12.1%	0.5%	1.5%	1.2%	3.4%	1.6%	neg

* Note: “neg” = negligible.

- It was assumed that 15% of “old vehicles” built between 1980 and 1997 and 0% of new vehicles do not have catalytic converters. These are the default values assumed by VEPM, based upon the Auckland Air Emissions Inventory 2004 - Auckland Regional Council TP292, (2006).

- Non tail pipe (brake and tyre wear) particulate emission factors have been included. VEPM provides the option to calculate brake and tyre wear particulate emissions based on the average number of wheels for each vehicle class. In this case the model default settings were used.

- The VEPM cold start option was used. When a vehicle is started from cold, emissions are substantially higher, until the engine and catalyst warm up. Cold start emissions were estimated in the model for each vehicle class except HCVs. Cold start emissions are affected by the user defined ambient temperature and average trip length.

- The VEPM model allows average trip lengths. A shorter average trip length will result in higher average emissions because the proportion of the trip in cold start conditions is higher. The average trip lengths setting was set to 25km (which is the maximum value able to be selected in VEPM) because the actual average trip length for the Waterview tunnel users will be 30km. Therefore the assumptions used are conservative.

- The VEPM degradation option was used. This raises the emissions from both exhaust and non-exhaust sources with the age of vehicle modelled.

- An average speed of 80 km/h (the proposed speed limit in the tunnels) has been assumed for those periods when traffic in the tunnels is operating under free-flow conditions, as the tunnel will have maximum speed restrictions for safety reasons.

A copy of a composite spreadsheet containing the hourly traffic flow profiles for the tunnel and VEPM outputs for each of those hours is attached at APPENDIX C:

6.5.7 Surface Road Vehicle Emissions Modelling

Key assumptions in the determination of vehicle emissions from surface roads in the vicinity of the Project (including the surface sections of the Project) were:

- Surface roads emissions were modelled using the results of the traffic modelling (% HCV, total vehicles and speeds) for each link in the EMME/3 model.

- The proportion of heavy vehicles predicted to travel on surface roads in the study area in 2016 is predicted to range from 1% to 25%; these values have been used in VEPM. As with tunnel emissions modelling, the breakdown of the different HCV categories was reached by increasing or decreasing the 4 categories of HCV in the default VEPM 2016 and 2026 proportionally, while maintaining the proportion of buses on surface roads at 0.5% (the VEPM default value). The other categories were then adjusted proportionally so that the total fleet composition remained as 100%.

- In total, 15 scenarios were run as follows:

    - 2006 AM, IP and PM (3 scenarios),

    - 2016 AM, IP, PM Do Nothing and With Project (6 scenarios) and

    - 2026 AM, IP, PM Do Nothing and With Project (6 scenarios).

- The vehicle emission factors are a fleet average “composite” factor. The average “composite” factor is generated using a vehicle fleet profile.

- It has been assumed that hourly vehicle flows on nearby surface roads considered in the assessment vary proportionally with the in-tunnel traffic flows. That is, the intermediate traffic flows have been factored to estimate hourly emissions for the roadside modelling (Table 6.4).

- For the purpose of modelling, all surface roads have been assumed to be “at grade” – i.e. level with the surrounding land surface. This is a reasonable assumption for the majority of roads in the area.

6.6 Tunnel Ventilation Stack Parameters

Hourly average traffic volumes, the required extraction volumes and the discharge velocities used in dispersion modelling are summarised in Table 6.6. It should be noted that the hourly traffic volumes for each hour of the day and consequent ventilation parameters shown in Table 6.6 are based on the higher of predicted hourly traffic volumes for weekdays and weekends.

Table 6.6 – Tunnel Ventilation Stack Parameters

	Northbound Tunnel			Southbound Tunnel		
Hour	Traffic Volume (vehicles/hr)	Required Flow Rate (m^3/s)	Exit Velocity (m/s)	Traffic Volume (vehicles/hr)	Required Flow Rate (m^3/s)	Exit Velocity (m/s)
1	543	56	1.9	477	54	1.8
2	354	32	1.1	311	36	1.2
3	242	24	0.8	212	27	0.9
4	180	16	0.5	158	18	0.6
5	166	16	0.5	146	18	0.6
6	287	32	1.1	252	27	0.9
7	1032	104	3.5	908	99	3.3
8	2493	247	8.2	2926	334	11.1
9	2493	247	8.2	2926	334	11.1
10	1927	191	6.4	1695	190	6.3
11	2203	223	7.4	1938	217	7.2
12	2304	231	7.7	2026	226	7.5
13	2414	239	8.0	2123	244	8.1
14	2344	231	7.7	2061	235	7.8
15	2359	231	7.7	2074	235	7.8
16	2573	255	8.5	2262	253	8.4
17	3204	319	10.6	2509	280	9.3
18	3204	319	10.6	2509	280	9.3
19	2318	231	7.7	1814	208	6.9
20	1721	175	5.8	1513	172	5.7
21	1259	127	4.2	1107	126	4.2
22	1039	104	3.5	913	99	3.3
23	784	80	2.7	689	81	2.7
24	687	72	2.4	604	72	2.4

7. Dispersion Modelling

7.1 Dispersion Modelling Methods

7.1.1 Modelling Stages

Several stages of modelling were necessary in order to assess the impacts of the Project on the air quality in its surroundings.

1. **Traffic modelling.** Described in detail in Section 6, this is the first layer of modelling that translates the geography of the road network into vehicle activity for the different scenarios.

2. **Emission modelling.** As described in Section 6, the traffic modelling results provided input for the emission modelling to obtain fleet averaged emission factors for all the roads in the area.

3. **Meteorological modelling.** Described below in Section 7.1.2, the meteorological modelling generates the necessary meteorological information needed as input to the dispersion modelling.

4. **Dispersion modelling.** Described below in Sections 7.2 to 7.4, dispersion modelling translates the vehicle emissions information into a contribution to ambient concentrations. Contributions from other sources (such as domestic wood burning emissions) are not modelled, as their contribution is assessed as part of the baseline (Section 5.6). As the Project includes both surface roads and ventilation stacks, two different modelling layers are required:

    a. **Surface roads.** Surface road network (including surface sections of the Project), emissions and local meteorology were inputs to a roadside modelling tool in order to estimate the impact of the changes in traffic emissions on the ambient air quality. Full details are given in the following sections.

    b. **Tunnel ventilation stacks.** As stack emissions require a different approach to surface roads, a second modelling tool was necessary, driven by the tunnel ventilation stack emissions and the local meteorology. Full details are given in the following sections.

7.1.2 Dispersion Modelling Meteorology

Accurate atmospheric dispersion modelling requires good meteorological information that is representative of the dispersion conditions near the emission source, and in a format that can be used by the dispersion model.

The ARC and NZTA have recently released a suite of CALMET meteorological datasets intended for use in regulatory assessments (Golders Associates, 2009). The ARC/NZTA suite includes nine high resolution data sets for selected urban areas and a single low resolution data set covering all of Auckland's urban area. A full year high resolution CALMET dataset was developed for this assessment using the same meteorological inputs that were used to develop the ARC/NZTA CALMET datasets. The same grid density was used in the Project CALMET dataset as was used in the high resolution urban ARC/NZTA CALMET files, whereby meteorological grid points were defined every 100m in the northerly and easterly direction in the CALMET modelling domain. The modelling domain is the geographic area of interest selected, and across which the modelling assessment will be carried out. Predicted meteorological parameters are expected to be virtually identical for both the ARC/NZTA and Project data sets. The data set was developed for the 2007 meteorological year. A detailed description of the CALMET data set inputs is described in APPENDIX G.

Dispersion parameters (temperature, wind speed, wind direction, atmospheric stability class, and mixing height) were then extracted from eight CALMET grid points (representing “subdomain” locations; i.e. smaller geographic areas selected within the overall domain) for the AUSROADS surface roads modelling (refer Section 7.3). The meteorological parameters at each subdomain location are expected to be representative of typical dispersion conditions in the immediately surrounding area.

7.2 Ventilation Stack Emissions Modelling

The dispersion model chosen to estimate the impact of the stack emissions was CALPUFF. CALPUFF is a multi-layer, multi-species, non-steady-state Lagrangian Gaussian puff model that contains modules for complex terrain effects, overwater transport, coastal effects and building downwash (Scire, 2000). Puff models simulate pollutant releases by a series of puffs of material which are transported by the modelled winds. Each puff represents a discrete amount of pollution, whose volume increases due to turbulent mixing.

CALPUFF is recognised by the USEPA and the Ministry for the Environment (MfE, 2004) as an appropriate model in instances where pollutant dispersion will be influenced by complex terrain features and meteorological conditions. Several factors influenced the choice of CALPUFF as the modelling tool:

- **Topography**. The Auckland area is considered a complex terrain because of the coastline and the presence of volcanic cones. Therefore it is necessary that the model chosen is able to capture the impacts of these features. CALPUFF, coupled to a CALMET meteorological dataset, is suited for complex terrain and coastal areas (Scire, 2000).

- **Horizontal scale**. The highly variable terrain and coastline, together with the relatively close distance that separates the stacks from the receptors requires a high spatial resolution (less than 500m). The generated CALMET dataset has a horizontal resolution of 100m and allows the use of CALPUFF with the same high resolution.

- **Atmospheric inversion**. Auckland is often affected by atmospheric inversion conditions during winter that trap pollutants near the surface. CALPUFF is able to capture, with input from CALMET, inversion conditions and it is able to describe the behaviour of a plume of pollutants in stable, low wind conditions.

The set up of the model followed the recommendations contained in the ARC’s user guide for the meteorological datasets (Golder, 2009). Figure 7.1 shows the extent of the modelling domain and the location of the stacks as used by the model. Table 7.1 describes the general parameters used in this simulation. CALPUFF chemistry modules (sulphur, nitrogen and photochemistry modules) were not used because of the lack of detailed information to set all the required parameters. This meant that all species were treated as inert for modelling purposes; therefore direct output of NO_2 concentrations from the model is not possible and must be obtained from the estimated NO_x concentrations (see Section 7.6).

Table 7.1 – Stack Modelling Parameters

Parameter	Value	Comments
Stack height	25 m	Refer stack height discussion in Section 11.3
Stack Diameter	6.2 m	Defined by the tunnel design
Surrounding buildings (for downwash effect estimates)	15m	This height was chosen in order to obtain conservative estimates of the impact of the stacks in their immediate surroundings
Emission profile	24 hour cycle	See **APPENDIX E**
Emission temperature	25˚ C	The expected range of emission temperature is between 10˚ C and 30˚ C
Emission vertical velocity	24 hour cycle	See Section 6.6 of this report

In order to reduce the computational time required to run this large domain, the baseline analysis informed the choice of the worst case meteorology to run the dispersion model in order to obtain 1-hr, 8-hr and 24-hr maximum expected concentrations due to the stacks. This worst case (in terms of maximum PM_{10} concentrations over several sites in 2007) was identified as the days between the 27 May and 03 June 2007. To estimate the annual average of the impact of the stacks (necessary for NO_2 and $PM_{2.5}$ estimates) the maximum 24 hour averages from that period was used as a conservative estimate.

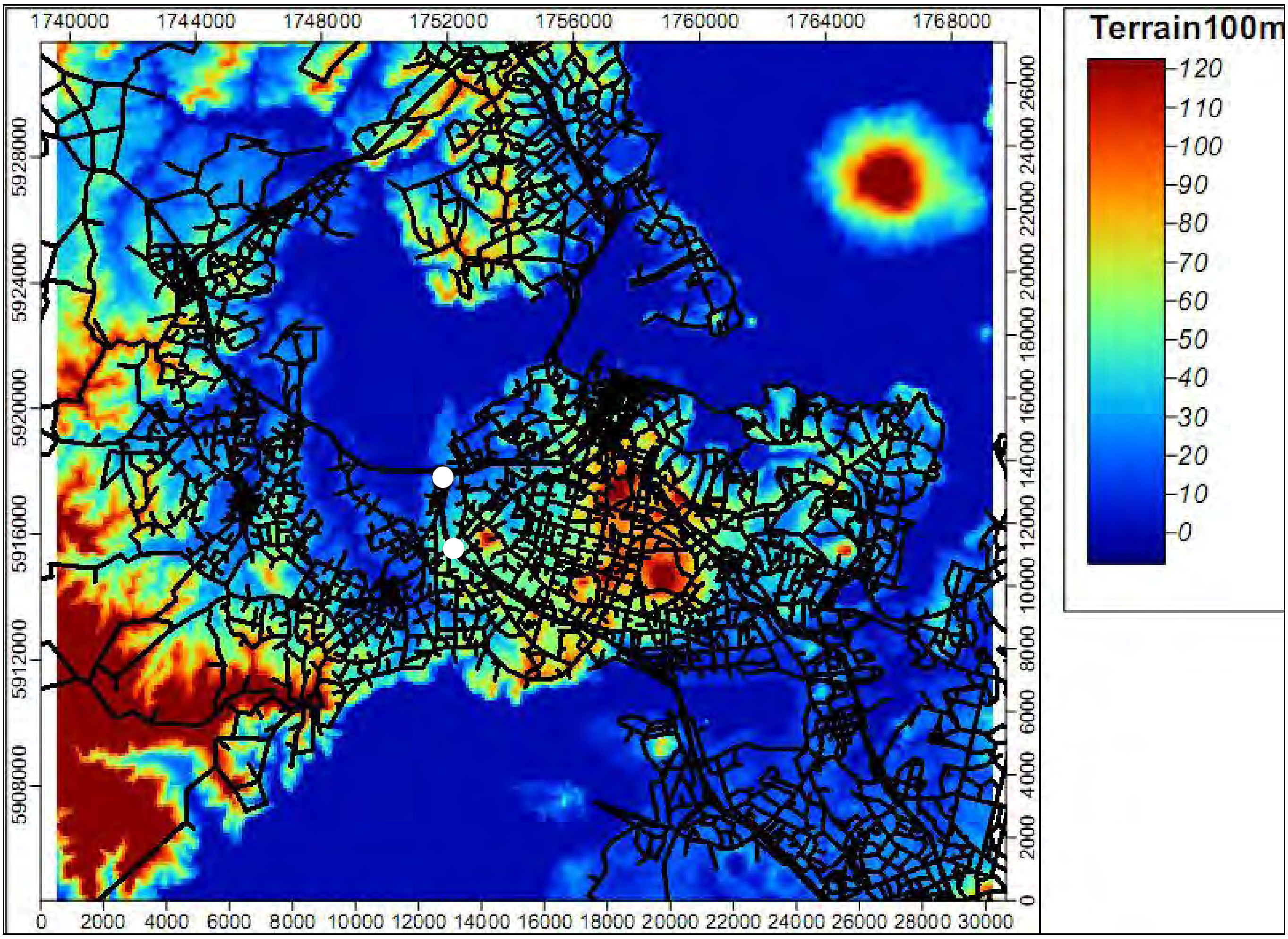

Figure 7.1 - Meteorological Model Domain.

(The white circles represent the locations of the ventilation stacks for the Waterview Connection tunnel and terrain contours. Horizontal and vertical scales correspond to the map projection system in NZTM metres).

7.3 Surface Roads Modelling

For the existing surface roads included in the modelling domain and the new surface sections of the Project, the roadside model AUSROADS (v1.0) was used. AUSROADS is a steady-state Gaussian-plume dispersion model, based on the CALINE4 model recommended by the MfE (MfE, 2008), but offering several practical advantages over CALINE4, including:

- An increased number of links and receptor locations that can be modelled
- A full year of local meteorological information can be read into the program from an external file
- Road geometry, traffic density and emission factors and receptor location information can now be entered either directly from the graphical user interface or read from external files.

Both AUSROADS and CALINE4 are affected by the same limitations as other steady-state Gaussian-plume models (MfE, 2004). With respect to the handling of calm or light winds, AUSROADS performs better than CALINE4 due to the minimum allowable wind speed being set at 0.5 m/s rather than 1 m/s. However, there are no other dispersion models currently recommended in New Zealand for modelling of emissions from roads.

AUSROADS requires less detailed meteorological information than CALPUFF. Also, as AUSROADS is a *roadside* model, it is only suited to applications no more than a few hundred metres from the roads, mainly constrained by the representativeness of the meteorology for the chosen area. Because the modelling domain for this assessment extends for more than 10km, it was necessary to divide the modelling domain in several areas and obtain representative meteorological information for those subdomains.

Ten subdomains were chosen that cover all the sensitive receptors and the roads approximately within 1km of them. Figure 7.2 illustrates the extent of the combined ten subdomains. Eight time series of meteorological data were extracted from the larger CALMET run (see Section 7.1.2) in order to represent the different subdomains illustrated in Figure 7.2.

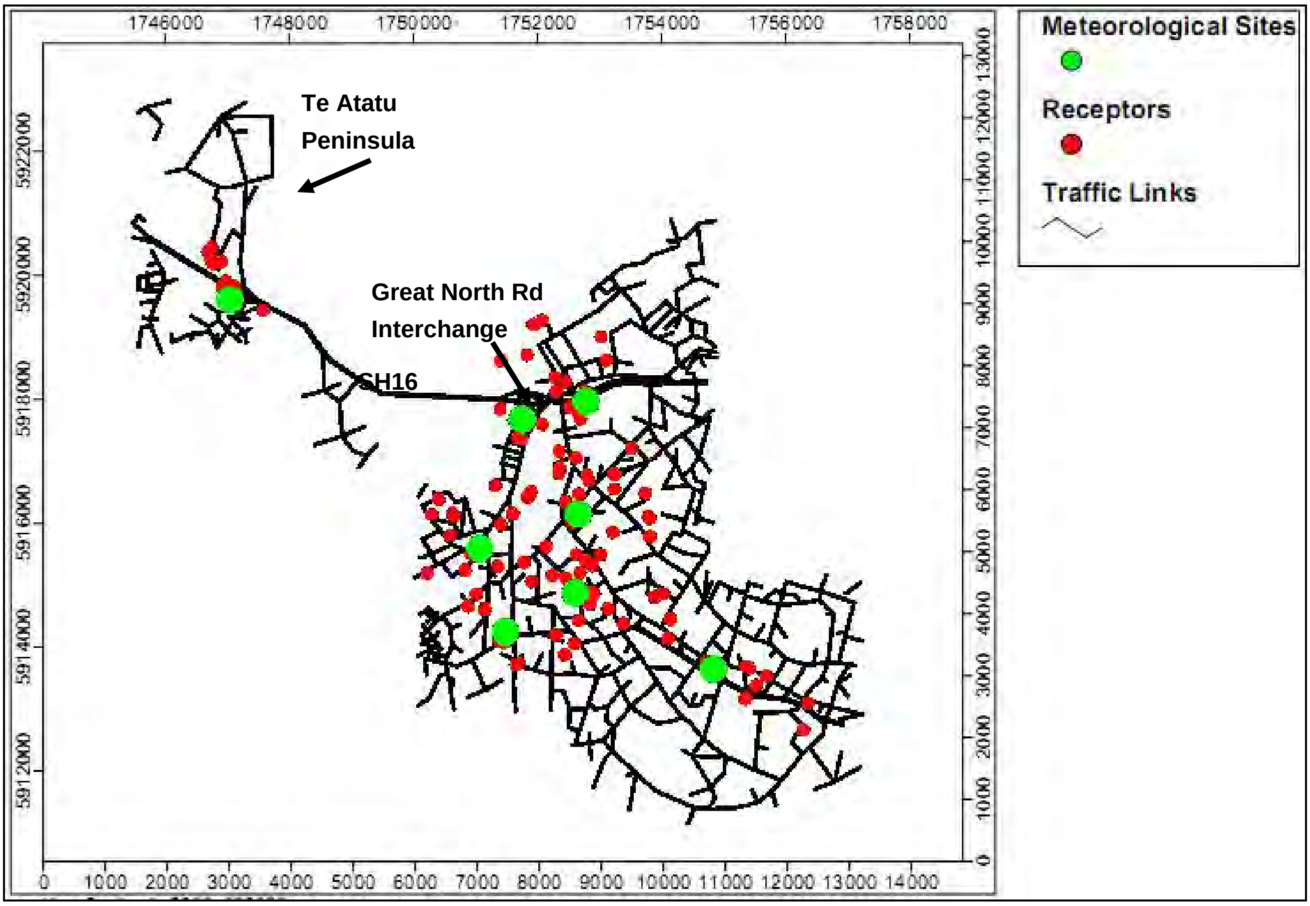

Figure 7.2 - Detail of Surface Roads Domains.

(The lines represent the modelled traffic links in the area. The green circles indicate the locations used to extract meteorological information from the CALMET runs and the red circles show the sensitive receptors identified in the area. Horizontal and vertical scales correspond to NZTM metres.)

To accommodate the limitation (within AUSROADS) of 100 links per AUSROADS modelling project, some of the subdomains were further divided so that in total 14 modelling domains were used for the surface roads in the area and one additional subdomain was set up for the surface section of the project (between the Maioro intersection and the southern portal of the tunnels).

Emissions were estimated from the traffic modelling output for all the links in the regional domain using VEPM, as described in Section 6 of this report. For the purposes of the dispersion modelling, the full set of emissions information was input into the same GIS project where the receptors and the traffic links information were handled. This allowed the large emissions tables to be translated for all the links into a form ready to be used by AUSROADS, with diurnal cycles for every one of the 1000+ links within the modelling domains.

7.4 Modelling Assumptions

The following assumptions have been made in undertaking this assessment:

- Baseline air quality assessments were not an input to sensitive receptor selection. The selection of receptors was based upon potential response to a given air quality rather than the potential existence of a change in air quality.

- For modelling purposes, results are predicted at the approximate centre of the sensitive receptor, not the kerbside, fenceline or property boundary.

- All pollutants disperse in exactly the same way (i.e. coarse and fine particles both disperse at the same rate as trace gases).

- There are no sources or sinks of pollutants other than that described by the emission modelling. There is no particle deposition.

- For the surface roads modelling, it is assumed there is no accumulation of traffic pollutants from one hour to the next.

- PM (tailpipe) emission rates are used to predict $PM_{2.5}$ concentration. PM_{10} concentrations are derived from the sum of PM (tailpipe) and PM (brake & tyre wear) emissions.

- Meteorological data from 2007 is representative of typical and repeatable conditions (Section 5.5.3 shows that 2007 led to slightly higher PM_{10} concentrations than the alternative available year of the ARC meteorological dataset of 2005).

- There is no significant change in Auckland's climate between 2006 and 2026, i.e. the meteorological data from 2007 is equally representative of 2006, 2016 and 2026.

- Discharges from the tunnel ventilation system have been assumed to be at ambient temperature (25 °C) via 25m high vents located above the northern and southern ventilation stations.

- For all scenarios (except worst case congested), the assessment has assumed emissions from typical weekday traffic flows.

- For the purpose of modelling, all surface roads have been assumed to be "at grade" – i.e. level with the surrounding land surface. This is considered a reasonable assumption for the majority of roads in the area.

7.5 Reporting of modelling results

Dispersion modelling results for surface roads were generated as hourly average concentrations of CO, NO_x, PM_{10}, $PM_{2.5}$ and VOCs for every hour of 2007, at every sensitive receptor (as identified in Section 5.3 and listed in APPENDIX A).

Results were independently generated arising from stack emissions only and surface roads (as shown in Figure 7.2 only). The complete results are contained in APPENDIX H.

It is necessary to note a few issues with specific pollutants:

- **PM_{10} and $PM_{2.5}$**. As indicated in the emissions modelling section (Section 6.5), information was made available as *exhaust* and *TOTAL* particulate matter emissions. Therefore, PM_{10} concentrations were obtained by running the models with the total emissions reported by VEPM while the $PM_{2.5}$ concentrations were obtained by using only the exhaust fraction of the emissions.

- **Benzene**. The emission information obtained from VEPM gives total VOC emissions. Benzene usually corresponds to between 6% and 8% of the total VOC. MfE recommends a value of 5.9% to be used for vehicles beyond 2006 and around 8% for older vehicles (MfE, 2008). In this assessment, a conservative value of 7% of VOC emissions as Benzene was used for all the scenario years.

7.6 Reporting of Cumulative Effects

The results of the dispersion modelling cannot be directly compared to the assessment criteria for ambient air quality, because they neglect the contribution of other (non-traffic and unmodelled) sources. The assessment can only be performed on predicted cumulative effects, which combine dispersion modelling results with baseline air quality assessment (described in Section 5.7).

As detailed in Section 5.7, different approaches were taken to construct baseline estimates for different pollutants, due to the availability of data for each pollutant. This also translates into different methods to construct the cumulative effects.

For PM_{10}, $PM_{2.5}$, CO and benzene there is insufficient data to decompose the baseline concentration into its constituent “background” and “local traffic” contributions. In the case of these pollutants, the approach adopted was to develop baseline scenarios which incorporate the current local impact of traffic. This means that the modelling results for these pollutants cannot be directly added to the estimated baseline because that would mean “double counting” the impact of the 2006 local traffic. To overcome this issue, it is the difference in the modelling results (between the 2016 or 2026 scenario and the 2006 Base Year) which is added to the estimated baseline (see Equation 7.1):

$$[\text{Cumulative impact}]_{\text{scenario}} = [\text{Baseline}] + [\text{Change in Modelled (Traffic) impacts}]$$

$$[\text{Change in Modelled (Traffic) impacts}] = [\text{modelled traffic impact}]_{\text{scenario}} - [\text{modelled traffic impact}]_{2006}$$

Equation 7.1. Calculation of Cumulative Concentrations

For PM_{10}, $PM_{2.5}$, and CO, the baseline (in common with the dispersion modelling output) is provided as an hourly time series for a whole year. Thus, Equation 7.1 was applied for every hour. Following this, running 8-hour (for CO), fixed 24-hour midnight-to-midnight and annual (for PM_{10} and $PM_{2.5}$) averages were constructed for the complete time series. For benzene, the hourly predicted concentrations were averaged before being added to the baseline, which is provided as an annual average only.

In the case of NO_2, a totally different approach has been taken. Firstly, the results of dispersion modelling are expressed in terms of NO_x rather than NO_2, since the emission rates used in the model (from VEPM) are expressed as total NO_x. Secondly, NO and NO_2 (the principal components of NO_x) are both reactive species, so it is not appropriate to directly add concentrations of NO_2 derived from different sources. Finally, urban background concentrations of NO_2 have been estimated as annual and 24-hour averages and the 99.9th percentile of 1-hour averages, rather than as an hourly time series. Therefore, the basic approach for NO_2 has been to add ground level concentrations of NO_x predicted by dispersion modelling to urban background concentrations of NO_x derived from urban background NO_2, and then convert the result to cumulative concentrations of NO_2. A more detailed summary of this is provided in APPENDIX L.

The process used to estimate ground level concentrations of vehicle related pollutants at each receptor involves the following steps:

- 2006 Baseline concentrations (1) are estimated from ambient monitoring data

- The surface roads contributions for the 2006 Base Year (calculated by dispersion modelling based on the 2006 Base Year vehicle emissions rates) are subtracted from the 2006 Baseline (1) to produce an ambient background contribution (2)

- For all 2016 and 2026 scenarios, surface roads contributions (calculated by dispersion modelling based on the relevant vehicle emissions rates) are added to the ambient background contribution to produce cumulative ground level concentrations (3)

- For 2016 and 2026 With Project scenarios, the contribution from emission via tunnel ventilation stacks (calculated by dispersion modelling based on the relevant vehicle emissions rates) are added to the cumulative ground level concentrations (3) to produce total cumulative ground level concentrations (4).

This is illustrated schematically in Figure 7.3.

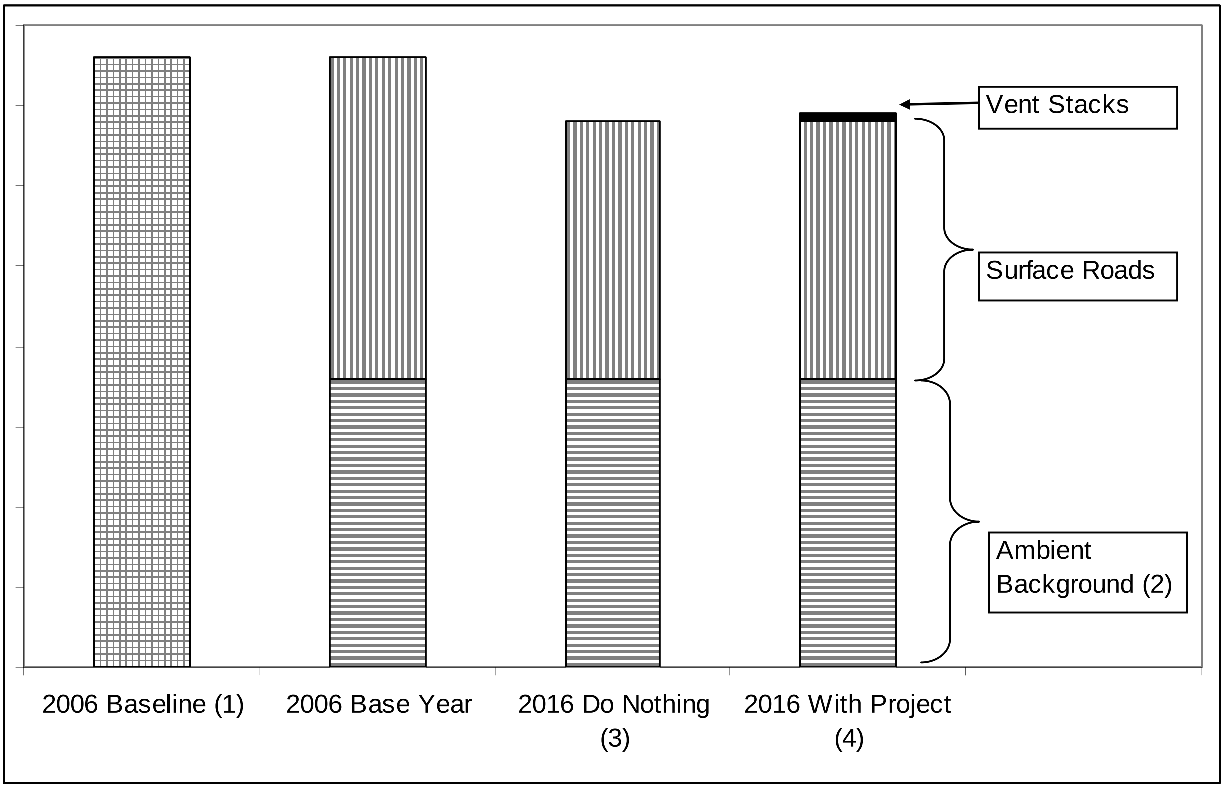

Figure 7.3 – Schematic Illustration of Calculation of Ground Level Concentrations

8. Effects Assessment: Operation of Project

This section provides an assessment of the air quality impacts associated with the opening of the Project in 2016 and also after ten years of operation (2026). Each of the 2016 and 2026 "With Project" scenarios are compared to "Do Nothing" scenarios for the same periods. A summary of the results of the dispersion modelling is presented for each contaminant being assessed. The dispersion modelling results presented indicate the range of impacts estimated for the Project and their relation to the relevant health based assessment criteria for each pollutant. Detailed results for all the identified receptors are given in APPENDIX H. A summary of the potential health effects of these pollutants is attached in APPENDIX J.

This assessment of effects seeks to answer the following questions:

- How is air quality predicted to change as a result of the Project?
- How do the air quality impacts associated with the Project compare to a future case without the Waterview Connection Project ("Do Nothing")?

Dispersion modelling results are also presented overlaid on maps to illustrate the regional variation in effects due to the Project. These figures are attached at the end of this report (Figure 16.1 to Figure 16.14). For ease of reference, Table 8.1 lists the relevant figure numbers.

Table 8.1 – Summary Table of Dispersion Modelling Result Maps

Figure Ref.	Pollutant and averaging time	Title	Page
Figure 16.1	Maximum 24 hour average PM_{10}	Percentage change in maximum predicted concentrations between existing (2006 base year) and 2016	154
Figure 16.2	Maximum 1 hour average NO_2	Percentage change in maximum predicted concentrations between existing (2006 base year) and 2016	155
Figure 16.3	Maximum 24 hour average PM_{10}	Comparison of maximum predicted PM_{10} concentrations for 2016 Do nothing and With Project	156
Figure 16.4	Maximum 1 hour average NO_2	Comparison of maximum predicted NO_2 concentrations for 2016 Do nothing and With Project	157
Figure 16.5	Maximum 24 hour average and maximum annual average PM_{10}	Maximum predicted concentrations at sensitive receptors for all scenarios.	158

Figure Ref.	Pollutant and averaging time	Title	Page
Figure 16.6	Maximum 24 hour average and maximum annual average $PM_{2.5}$	Maximum predicted concentrations at sensitive receptors for all scenarios.	159
Figure 16.7	Maximum 1 hour and 8 hr average CO	Maximum predicted concentrations at sensitive receptors for all scenarios.	160
Figure 16.8	Maximum 99.9 percentile 1 hour, 24 hour and annual average NO_2	Maximum predicted concentrations at sensitive receptors for all scenarios.	161
Figure 16.9	Maximum annual average benzene	Maximum predicted concentrations at sensitive receptors for all scenarios.	162
Figure 16.10	Maximum 24 hour average PM_{10} from Stack contributions only	Maximum predicted concentrations at sensitive receptors for all scenarios.	163
Figure 16.11	Maximum 1 hour average NO_x from Stack contributions only	Maximum predicted concentrations at sensitive receptors for all scenarios.	164

8.1 Summary of Effects

This assessment of effects considers the cumulative impact of emissions from vehicles on surface sections of the Project (SH16 and SH20 south of the tunnel portal), the other roads within the Project domain and impacts of the ventilation stacks. The method for calculation of the cummulative impact of emissions is described above in Section 7.6. Contributions from the ventilation stacks alone are summarised in Section 8.2.

The net effects on future air quality, in both the "With Project" and without the Project ("Do Nothing") scenarios are summarised below:

2006 Baseline compared to 2016 With Project

- Over the full range of receptors across the Project domain, concentrations of all pollutants are predicted to decrease on average between the 2006 base year and the 2016 "With Project" scenario.
- Figure 16.1 shows the percentage decrease in maximum PM_{10} concentrations across the Project domain between the existing case (2006 base year) and 2016 With Project. Figure 16.2 shows the percentage decrease in maximum 1 hour average NO_2 concentrations between the existing case (2006 base year) and 2016. The largest predicted air quality improvements are in locations currently strongly affected by the busy existing arterial roads in the Project domain.

2006 Base year compared to 2026 With Project

- In 2026, despite an increase in vehicle volumes due to growth, concentrations of all pollutants are expected to decrease in comparison to 2016. This is due to assumptions in VEPM regarding the relative age of the future vehicle fleet and consequent improvements in fuel efficiency and emission control.

2016 With Project compared to 2016 Do Nothing

- Approximately one quarter of receptors experience a net increase in PM_{10} and NO_2 concentrations (one sixth for $PM_{2.5}$) in the 2016 "With Project" scenario compared to the 2016 "Do Nothing" scenario. Figure 16.3 compares the maximum 24 hour average PM_{10} concentrations across the Project domain for the 2016 "With Project" case with the 2016 "Do Nothing" scenario. Figure 16.4 presents the same comparison for maximum 1 hour average NO_2 concentrations.

- When comparing the 2016 "With Project" and "Do Nothing" scenarios, the biggest increases due the Project are in PM_{10} concentrations (1 – 4 μg/m^3) and $PM_{2.5}$ concentrations (1 – 3 μg/m^3). These increases occur around the surface section of SH20, between the southern tunnel portal and the Maioro Street/Sandringham Rd interchange. This is because this area currently has relatively minor roads with low traffic volumes in the "Do Nothing" scenario. Smaller increases are predicted at receptors close to the SH20 Mt Roskill Extension, which is consistent with the increases in traffic volumes predicted between the "Do Nothing" and "With Project" scenarios (refer Figure 16.3).

- When comparing the 2016 "With Project" and "Do Nothing" scenarios, approximately one quarter of receptors are predicted to experience small (< 0.4 μg/m^3) reductions in PM_{10} concentrations as a result of the Project (refer Figure 16.3). Fewer receptors experience decreases in NO_2 (refer Figure 16.4). This may be related to a general increase in traffic speed in the "With Project" scenario compared to the "Do Nothing" scenario.

- In the 2016 "With Project" scenario, 11 receptors exceed the ARC Regional Air Quality Target for $PM_{2.5}$ (three by more than 5%) in contrast to 1 in the "Do Nothing" scenario) (refer Figure 16.6). Those receptors experiencing the greatest increase in air quality impacts are close to the surface section of the Project south of the tunnel portal in Owairaka (Sector 9). A smaller deterioration in air quality is predicted around the Mt Roskill Extension. A conservative $PM_{2.5}$ baseline was applied to this assessment, due to a lack of available ambient monitoring data. No further exceedances of Standards, Guidelines or Targets are predicted to occur in 2016 as a result of the Project.

- Even without the Project, the 2016 "Do Nothing" scenario shows that six receptors in the Mt Roskill area are predicted to experience an increase in $PM_{2.5}$ and NO_2 concentrations, and nine will experience an increase in PM_{10} between 2006 and 2016. All of these receptors are in the Mt Roskill area close to the SH20 Mt Roskill Extension. It is predicted that one receptor (Keith Hay Park) will be marginally in exceedance of the Regional $PM_{2.5}$ Target whilst the others will be within 5% of the Target. These results are consistent with the opening of the SH20 Extension between 2006 and 2016, and not related to the Project.

2026 With Project compared to 2026 Do Nothing

- When comparing the 2026 "With Project" and "Do Nothing" scenarios, the predictions described above for the 2016 scenarios are unchanged. Overall, despite an increase in vehicle volumes due to growth, 2026 "With Project" and "Do Nothing" concentrations of all pollutants are expected to decrease in comparison to 2016. Therefore the effects in 2016 represent the worst case.

The following sections (8.1.1-8.1.5) summarise the predicted maximum cumulative concentrations anywhere in the Project domain, as well as at key sensitive receptors, for all relevant pollutants and averaging periods compared to health based assessment criteria. Concentrations of PM_{10} and NO_2 are also summarised for key sensitive receptors in Figure 16.12, Figure 16.13, and Figure 16.14. Key sensitive receptors (refer Section 5.4.3) are of note in this assessment due to their proximity to the Project.

8.1.1 Predicted PM_{10} Concentrations

Table 8.2 and Table 8.3 present estimated baseline and predicted maximum cumulative concentrations of PM_{10} as 24-hour and annual averages respectively for the five scenarios. The locations of these predicted highest and lowest PM_{10} concentrations are shown in Figure 16.5. The results indicate that the maximum 24 hour average and annual PM_{10} concentrations associated with the Project are predicted to increase in 2016 relative to the baseline 2006 scenario in locations close to the southern surface section of SH20 through Alan Wood Reserve.

Concentrations in 2026 are predicted to be similar to 2016 or slightly less than 2016 for both "With Project" and "Do Nothing Scenarios". The results of the modelling indicate that emissions from the Project are unlikely to exceed the AQNES assessment criteria of 50 ug/m³ for any of the modelled emission scenarios.

Table 8.2 – PM_{10}: Estimated 24-Hour Cumulative Impacts [μg/m³]

Receptor		Baseline 2006	Do Nothing 2016	With Project 2016	Do Nothing 2026	With Project 2026	Assessment Criteria
Highest estimated cumulative concentration							
S6	Alan Wood Reserve	38	38	42	38	42	50
R8	5 Barrymore St	38	38	42	38	41	50
Lowest estimated cumulative concentration							
R2	20 Titoki St	37	35	35	34	35	50
C3	TPR Manawanui	37	35	35	34	34	50
Estimated cumulative concentration at key sensitive receptors							
C3	TPR Manawanui	37	35	35	34	34	50

Receptor		Baseline 2006	Do Nothing 2016	With Project 2016	Do Nothing 2026	With Project 2026	Assessment Criteria
E7	St Francis School	38	35	36	36	37	50
C7	Collectively Kids	38	37	38	37	38	50
C8	Waterview Kindergarten	38	37	37	36	37	50
E8	Waterview Primary	38	37	38	37	37	50
E23	Christ the King School	38	38	40	38	40	50
C37	Edukids Stoddard Rd	38	39	40	39	40	50

Table 8.3 – PM_{10}: Estimated Annual Cumulative Impacts [μg/m^3]

Receptor		Baseline 2006	Do Nothing 2016	With Project 2016	Do Nothing 2026	With Project 2026	Assessment Criteria
Highest estimated cumulative concentration							
S6	Alan Wood Reserve	15	16	17	15	17	20
R8	5 Barrymore St	15	16	17	15	17	20
Lowest estimated cumulative concentration							
R2	20 Titoki St	15	14	14	13	14	20
H9	Avon Rest Home	15	14	14	14	14	20
Estimated cumulative concentration at key sensitive receptors							
C3	TPR Manawanui	15	14	14	14	14	20
E7	St Francis School	15	14	14	14	14	20
C7	Collectively Kids	15	14	14	14	14	20
C8	Waterview Kindergarten	15	15	15	14	15	20
E8	Waterview Primary	15	15	15	15	15	20

Receptor		Baseline 2006	Do Nothing 2016	With Project 2016	Do Nothing 2026	With Project 2026	Assessment Criteria
E23	Christ the King School	15	15	16	15	16	20
C37	Edukids Stoddard Rd	15	16	16	15	16	20

8.1.2 Predicted $PM_{2.5}$ Concentrations

Table 8.4 and Table 8.5 present estimated baseline and cumulative concentrations of $PM_{2.5}$ as 24-hour and annual averages respectively. The locations of these predicted highest and lowest maximum PM_{10} concentrations are shown in Figure 16.6.

The results indicate that the maximum 24 hour average and annual $PM_{2.5}$ concentrations associated with the Project are predicted to increase in 2016 relative to the baseline 2006 scenario in locations close to the existing section of SH20 Mt Roskill extension and surface sections of the Project south of the southern tunnel portal (Sector 9). Concentrations in 2026 are predicted to be similar to 2016 or slightly less than 2016 for both "With Project" and "Do Nothing Scenarios". The results of the modelling indicate that emissions from both the existing (Mt Roskill extension) and proposed ("With Project") surface sections of SH20 may exceed the assessment criteria for 24 hour $PM_{2.5}$ assuming the conservative baseline assumptions are correct (as described in Section 5.7.3). In these locations, the $PM_{2.5}$ ARAQT would be also be exceeded under the "Do Nothing" scenario.

Table 8.4 – $PM_{2.5}$: Estimated 24-Hour Cumulative Impacts [μg/m^3]

Receptor		Baseline 2006	Do Nothing 2016	With Project 2016	Do Nothing 2026	With Project 2026	Assessment Criteria
Highest estimated cumulative concentration							
D3	Keith Hay Park	24	27	28	27	28	25
D6	Mt Roskill Grammar	24	25	26	24	25	25
Lowest estimated cumulative concentration							
H9	Avon Rest Home	24	20	20	19	20	25
E7	St Francis School	24	20	20	20	20	25
Estimated cumulative concentration at key sensitive receptors							
C3	TPR Manawanui	24	21	21	20	21	25

Receptor		Baseline 2006	Do Nothing 2016	With Project 2016	Do Nothing 2026	With Project 2026	Assessment Criteria
E7	St Francis School	24	20	20	20	20	25
C7	Collectively Kids	24	22	23	24	24	25
C8	Waterview Kindergarten	24	23	23	22	22	25
E8	Waterview Primary	24	23	23	23	23	25
E23	Christ the King School	24	24	26	26	26	25
C37	Edukids Stoddard Rd	24	25	26	24	26	25

Table 8.5 – $PM_{2.5}$: Estimated Annual Cumulative Impacts [μg/m^3]

Receptor		Baseline 2006	Do Nothing 2016	With Project 2016	Do Nothing 2026	With Project 2026	Assessment Criteria
Highest estimated cumulative concentration							
D3	Keith Hay Park	7	8	8	8	8	10
D6	Mt Roskill Grammar	7	8	8	7	8	10
Lowest estimated cumulative concentration							
H9	Avon Rest Home	7	6	6	6	5	10
E7	St Francis School	7	6	6	6	6	10
Estimated cumulative concentration at key sensitive receptors							
C3	TPR Manawanui	7	6	6	6	6	10
E7	St Francis School	7	6	6	6	6	10
C7	Collectively Kids	7	6	6	6	6	10
C8	Waterview Kindergarten	7	6	6	6	6	10
E8	Waterview Primary	7	6	6	6	6	10

Receptor		Baseline 2006	Do Nothing 2016	With Project 2016	Do Nothing 2026	With Project 2026	Assessment Criteria
E23	Christ the King School	7	7	7	7	7	10
C37	Christ the King School		7	8	7	8	10

8.1.3 Predicted CO Concentrations

Table 8.6 and Table 8.7 present estimated baseline and cumulative concentrations of CO as 1-hour and running 8-hour averages respectively. The locations of these predicted highest and lowest CO concentrations are shown in Figure 16.7.

The results indicate that the maximum 1 hour average CO concentrations are predicted to be constant between 2016 "With Project" and 2026 "With Project" relative to the baseline 2006 scenario. The modelling results indicate maximum 8 hour average CO concentrations increase slightly in 2016 "With Project" and then reduce by 2026 "With Project". This is due to the predicted improvements in engine technology and fuel efficiency. The 2026 "With Project" scenario for maximum 8 hour average CO concentrations is predicted to be less than 2026 "Do Nothing". This is likely to be due to congestion being more severe by 2026 in the "Do Nothing" scenario compared to "With Project".

9 Valonia St is within the designation footprint for the Project and it is therefore unlikely to be residential property once the Project is complete.

The results of the modelling indicate that emissions from the Project are predicted to be comparatively low compared to the AQNES of 10 mg/m³ and the NZAAQG of 30 mg/m³.

Table 8.6 – CO: Estimated 1-Hour Cumulative Impacts [mg/m³]

Receptor		Baseline 2006	Do Nothing 2016	With Project 2016	Do Nothing 2026	With Project 2026	Assessment Criteria
Highest estimated cumulative concentration							
R10	9 Valonia St	5.4	5.4	5.5	5.4	5.4	30
R9	204 Methuen	5.4	5.4	5.5	5.4	5.4	30
Lowest estimated cumulative concentration							
C7	Collectively Kids	5.4	5.0	5.0	4.9	5.0	30
R1	17 Milich Terrace	5.4	4.7	4.7	4.6	4.6	30

Receptor		Baseline 2006	Do Nothing 2016	With Project 2016	Do Nothing 2026	With Project 2026	Assessment Criteria
Estimated cumulative concentration at key sensitive receptors							
C3	TPR Manawanui	5.4	5.4	5.4	5.4	5.4	30
E7	St Francis School	5.4	5.4	5.4	5.4	5.4	30
C7	Collectively Kids	5.4	5.0	5.0	4.9	5.0	30
C8	Waterview Kindergarten	5.4	5.3	5.3	5.3	5.3	30
E8	Waterview Primary	5.4	5.3	5.3	5.3	5.3	30
E23	Christ the King School	5.4	5.3	5.4	5.3	5.3	30
C37	Edukids Stoddard Rd	5.4	5.4	5.5	5.4	5.4	30

Table 8.7 – CO: Estimated 8-Hour Running Average Cumulative Impacts [mg/m³]

Receptor		Baseline 2006	Do Nothing 2016	With Project 2016	Do Nothing 2026	With Project 2026	Assessment Criteria
Highest estimated cumulative concentration							
D3	Keith Hay Park	3.7	3.8	3.9	3.7	3.5	10
C37	Edukids Stoddard Rd	3.7	3.7	3.8	3.6	3.4	10
Lowest estimated cumulative concentration							
C5	Stylee Kids Ahead ELC	3.7	3.2	3.2	3.1	3.0	10
E7	St Francis School	3.7	3.1	3.1	3.0	3.0	10
Estimated cumulative concentration at key sensitive receptors							
C3	TPR Manawanui	3.7	3.2	3.2	3.1	3.1	10
E7	St Francis School	3.7	3.1	3.1	3.0	3.0	10
C7	Collectively Kids	3.7	3.6	3.6	3.6	3.4	10

Receptor		Baseline 2006	Do Nothing 2016	With Project 2016	Do Nothing 2026	With Project 2026	Assessment Criteria
C8	Waterview Kindergarten	3.7	3.6	3.6	3.5	3.3	10
E8	Waterview Primary	3.7	3.6	3.6	3.6	3.4	10
E23	Christ the King School	3.7	3.7	3.7	3.6	3.5	10
C37	Edukids Stoddard Rd	3.7	3.7	3.8	3.6	3.4	10

8.1.4 Predicted NO_2 Concentrations

Table 8.8, Table 8.9 and Table 8.10 present estimated baseline and cumulative concentrations of NO_2 as 1-hour, 24-hour and annual averages respectively. The locations of these predicted highest and lowest NO_2 concentrations are shown on a Sector map in Figure 16.8.

The results indicate that the maximum 1 hour, 24 hour and annual average NO_2 concentrations associated with the Project are predicted to decrease in 2016 relative to the baseline 2006 scenario.

Receptors in locations close to the existing SH20 Mt Roskill extension and proposed (With Project) SH20 surface section are predicted to experience the largest net increase in NO_2 concentrations in 2016 "With Project" compared to 2016 Do Nothing. There are also smaller net increases for receptors close to SH16 and the Te Atatu interchange.

Overall the results indicate that the maximum cumulative concentrations in 2016 "With Project" are predicted to occur in locations close to the SH16 Te Atatu interchange. This is due to the high traffic volumes predicted along SH16.

In 2026, the "With Project" maximum predicted concentrations decrease further compared to 2006.

The estimates presented here include the impact of the stacks. Because of the chemically active nature of NO_2 it is not meaningful to present the concentrations of NO_2 arising from the surface roads and the stacks separately.

Table 8.8 – NO_2: Estimated 99.9th Percentile 1-Hr Cumulative Impacts [µg/m³]

Receptor		Baseline 2006	Do Nothing 2016	With Project 2016	Do Nothing 2026	With Project 2026	Assessment Criteria
Highest estimated cumulative concentration							
R1	17 Milich Terrace	109	91	93	86	88	200
R2	20 Titoki St	103	88	90	83	86	200
Lowest estimated cumulative concentration							
E15	TKKM o Nga Maungarongo	74	70	71	69	70	200
C19	Rosebank ECE	75	71	71	69	69	200
Estimated cumulative concentration at key sensitive receptors							
C3	TPR Manawanui	100	85	88	82	84	200
E7	St Francis School	94	82	83	80	83	200
C7	Collectively Kids	107	88	87	85	87	200
C8	Waterview Kindergarten	84	75	76	73	73	200
E8	Waterview Primary	81	74	76	71	73	200
E23	Christ the King School	74	76	79	73	77	200
C37	Edukids Stoddard Rd	73	75	81	73	78	200

Table 8.9 – NO_2: Estimated Maximum 24hr Cumulative Impacts [μg/m^3]

Receptor		Baseline 2006	Do Nothing 2016	With Project 2016	Do Nothing 2026	With Project 2026	Assessment Criteria
Highest estimated cumulative concentration							
R1	17 Milich Terrace	73	61	62	57	58	100
R2	20 Titoki St	69	59	60	55	57	100
Lowest estimated cumulative concentration							
E15	TKKM o Nga Maungarongo	49	46	47	46	46	100
C19	Rosebank ECE	50	47	46	46	46	100
Estimated cumulative concentration at key sensitive receptors							
C3	TPR Manawanui	67	57	59	54	56	100
E7	St Francis School	63	54	55	53	55	100
C7	Collectively Kids	72	58	58	56	58	100
C8	Waterview Kindergarten	49	47	48	46	47	100
E8	Waterview Primary	51	48	48	47	48	100
E23	Christ the King School	49	50	52	48	51	100
C37	Edukids Stoddard Rd	48	50	54	48	52	100

Table 8.10 – NO_2: Estimated Annual Cumulative Impacts [$\mu g/m^3$]

Receptor		Baseline 2006	Do Nothing 2016	With Project 2016	Do Nothing 2026	With Project 2026	Assessment Criteria
Highest estimated cumulative concentration							
R1	17 Milich Terrace	35	27	28	25	26	40
R2	20 Titoki St	32	26	27	24	25	40
Lowest estimated cumulative concentration							
E15	TKKM o Nga Maungarongo	20	18	19	18	18	40
C19	Rosebank ECE	20	18	18	18	18	40
Estimated cumulative concentration at key sensitive receptors							
C3	TPR Manawanui	31	25	26	23	24	40
E7	St Francis School	29	23	24	22	24	40
C7	Collectively Kids	34	26	26	24	25	40
C8	Waterview Kindergarten	24	20	21	19	20	40
E8	Waterview Primary	23	20	21	19	19	40
E23	Christ the King School	20	21	22	20	21	40
C37	Edukids Stoddard Rd	20	20	23	19	22	40

8.1.5 Predicted Benzene Concentrations

Table 8.11 presents estimated baseline and cumulative concentrations of benzene as annual averages. The locations of these predicted highest and lowest benzene concentrations are shown on the Sector map in Figure 16.9. The modelling results indicate that the maximum benzene concentrations are predicted to increase slightly in the 2016 “With Project” scenario compared to 2006 and the 2016 “Do Nothing” scenario. Between 2016 and 2026 benzene concentrations reduce slightly both with and without the Project.

Predicted concentration for all the modelled emission scenarios are significantly less than the assessment NZAAQG criteria of 3.6 μg/m³.

Table 8.11 – Benzene: Estimated Annual Cumulative Impacts [μg/m³]

Receptor		Baseline 2006	Do Nothing 2016	With Project 2016	Do Nothing 2026	With Project 2026	Assessment Criteria
Highest estimated cumulative concentration							
S6	Alan Wood Reserve	1.0	0.9	1.2	0.9	1.1	3.6
R8	5 Barrymore St	1.0	0.9	1.1	0.9	1.1	3.6
Lowest estimated cumulative concentration							
H9	Avon Rest Home	1.0	0.6	0.6	0.4	0.4	3.6
C23	Treasure Hunt Preschool	1.0	0.6	0.6	0.5	0.5	3.6
Estimated cumulative concentration at key sensitive receptors							
C3	TPR Manawanui	1.0	0.7	0.6	0.6	0.6	3.6
E7	St Francis School	1.0	0.6	0.6	0.6	0.5	3.6
C7	Collectively Kids	1.0	0.7	0.7	0.7	0.7	3.6
C8	Waterview Kindergarten	1.0	0.8	0.8	0.7	0.7	3.6
E8	Waterview Primary	1.0	0.8	0.8	0.8	0.8	3.6
E23	Christ the King School	1.0	0.9	1.0	0.9	0.9	3.6
C37	Edukids Stoddard Rd	1.0	1.0	1.1	1.0	1.0	3.6

8.2 Tunnel Ventilation Stacks

The purpose of this section is to examine pollutant concentrations due only to the impact of vehicle exhaust emissions via the tunnel ventilation stacks. Table 8.12 shows the highest ground-level pollutant concentrations that are predicted to occur at a sensitive receptor due only to the emissions from the two tunnel ventilation stacks for the 2016 and 2026 With Project scenarios respectively. These results exclude baseline concentrations and contributions from vehicles on surface roads. Modelling results at each individual receptor are reported in APPENDIX H. Figure 16.10 and Figure 16.11 show the dispersion contours for the maximum PM_{10} concentrations and maximum NO_2 concentrations respectively. The pattern of dispersion is the same for all contaminants.

Table 8.12 – Estimated Maximum Ventilation Stack Impacts

Pollutant and average time	2016	2026	Assessment Criteria
24 hour average PM_{10} (µg/m^3)	0.29	0.29	50
Annual average PM_{10} (µg/m^3)	0.06	0.06	20
24 hour average $PM_{2.5}$ (µg/m^3)	0.20	0.17	25
1 hour 99.9 Percentile NO_x (µg/m^3)*	29.3	26.6	200
24 hour NO_x (µg/m^3)*	3.5	3.16	100
Annual NO_x (µg/m^3)*	0.68	0.61	40
1 hour average CO (mg/m^3)	0.057	0.037	30
8 hour average CO (mg/m^3)	0.014	0.009	10
Annual Benzene (µg/m^3)	0.01	0.0089	3.6
Note: it is highly conservative to compare NO_x concentrations with assessment criteria for NO_2, since NO_2 only forms a small fraction of the total NO_x discharged in vehicle exhaust emissions			

It can be seen from Table 8.12 that the highest ground-level concentrations predicted to occur at a sensitive receptor due to all ventilation stack emissions are well below all associated air quality criteria. The modelling results for emissions from the tunnel ventilation stacks predict the following:

- Maximum ground level concentrations of PM_{10} (24 hour average) at all sensitive receptors are less than 0.6 % of the AQNES in both 2016 and 2026.
- Maximum concentrations of NO_x (1 hour average) at any receptor in the modelling domain are 14% of the AQNES for NO_2 in 2016 and 13% of the AQNES in 2026. This is highly conservative and actual NO_2 concentrations would be much lower than this.
- For all other contaminants, the maximum ground level concentrations due to emissions via the tunnel vents will be an even lower proportion of the AQNES and NZAAQG than for NO_2.
- Maximum ground level concentrations of all contaminants are expected to be slightly lower in 2026 than in 2016, due to changes in the vehicle fleet composition.
- These predictions suggest that the discharge of vehicle exhaust emissions via ventilation stacks would not cause any exceedances of air quality standards. The relative benefits of discharges via ventilation stacks compared to emission from surface roads are discussed in Section 11 of this report.

- A number of sensitive activities were noted in Section 5.4.3 due to their proximity to either the northern or southern ventilation stacks (50-150 m). These include Waterview Kindergarten and Waterview School at the northern portal, and the Avondale Motor Park and residential properties along Hendon Avenue at the southern portal. The dispersion modelling predicts no adverse impacts on these receptors as a result of the ventilation stack emissions.

8.3 Regional Cumulative Effects

Exhaust emissions from road transport are a major source of PM_{10}, $PM_{2.5}$, NO_x, CO and VOCs in the Auckland region. For example, emissions from transport in 2004 were estimated to contribute 47% of the total annual mass emissions of PM_{10}, 83% of NO_x and 85% of CO in the region (ARC, 2006).

Overall, when comparing the two 2016 scenarios (i.e. the difference between "Do Nothing" and "With Project"), and nearly all receptors in the project domain are predicted to experience small increases in the concentrations of all contaminants, with a mean increase of +1% for peak 24 hr PM_{10} and $PM_{2.5}$, and +4% for annual mean NO_2.

The effects of the Project are known to extend beyond the Project modelling domain. To estimate the total regional impacts of the Project, data from the total traffic modelling network has been analysed. Based on the traffic modelling and vehicle emission modelling undertaken for the Project, the operation of the Project will have a marginal impact on the overall mass emissions of air pollutants from road transport in the region (less than 1.5%). By way of example, Table 8.13 presents total hourly mass emissions rates for all links in the EMME/3 traffic model for the AM Peak period in each 2016 and 2026 scenario.

Table 8.13 - Comparison of Hourly Mass Emission Rates (tonnes/hour)

Scenario	CO	VOC	NO_x	PM_{10}
2016 Do Nothing	3.95	0.37	1.35	0.13
2016 With Project	3.98	0.37	1.37	0.13
2026 Do Nothing	2.15	0.29	1.06	0.11
2026 With Project	2.16	0.29	1.07	0.11

The total emissions of PM_{10} for the Greater Auckland area are predicted to be slightly higher with the Project than without the Project. The differences are considered to be marginal.

8.4 Effects of Tunnel Portal Emissions

As described in Section 2.5, the tunnels will be mechanically ventilated to maintain in-tunnel and outside ambient air quality. However, during periods of low traffic volumes, for example during the early hours of the morning when vehicle exhaust emissions will be minimal, it may be appropriate to cease or reduce mechanical ventilation to conserve energy usage and allow some discharges of contaminants via the portals. The potential impact of allowing such portal emissions during the early morning has been estimated using dispersion modelling techniques (the full report is attached in APPENDIX I).

Near the portals, the most sensitive receptors where the public could likely be exposed during the early morning, when portal emissions may occur, are nearby residential properties. The closest residential property to the northern portal is located approximately 110m to the north-west, and the closest residential property to the southern portal is located approximately 50m to the east.

In this assessment the potential effect of carbon monoxide (CO), fine particles (PM_{10} and $PM_{2.5}$), nitrogen dioxide (NO_2) and benzene have been considered. Ground pollutant concentrations have been predicted for weekday and weekend traffic profiles for the years 2016 and 2026. For the four emission scenarios considered, hourly portal emission rates have been calculated based on the estimated total quantity of pollutants emitted by vehicles travelling along the length of tunnel. Two portal emission periods have been considered in the analysis: 2300 – 0700 and 2400 – 0600.

Table 8.14 shows the maximum cumulative pollutant concentrations predicted at residential receptors located near the northern and southern portals for the modelled 2300 – 0700 and 2400 – 0600 emission periods. The modelling results for emissions from the tunnel portals predict the following:

- Higher concentrations are predicted for the 2300 – 0700 emission period compared to the 2400 – 0600 emission period which can be attributed to the longer portal emission period (8 hours vs. 6 hours) and the higher hourly traffic volumes.
- The results show that the predicted maximum contribution from the portal to ambient pollutant levels are relatively small when compared to the AQNES and ARAQT air quality criteria levels.
- The predicted cumulative concentrations do not exceed any of the air quality criteria.
- Relative to the air quality criteria, the highest cumulative concentrations are those predicted for $PM_{2.5}$. However, the maximum contribution from the portals to 24-hour $PM_{2.5}$ levels at residential properties are predicted to be less than 0.8 $\mu g/m^3$, or 3% of the assumed maximum background concentration of 24 $\mu g/m^3$.
- The results indicate that emissions from the portal are unlikely to results in a significant increase to maximum background pollutant levels.

Table 8.14 - Maximum cumulative concentrations predicted at the residential receptors located near the southern and north portals for 2016 and 2026

Pollutant	Averaging period	Criteria Level	Emission Period	Baseline	Northern Portal	Southern Portal
NO_2 ($\mu g/m^3$)	1-hour (9th highest)	200	11pm - 7am	65	70	72
			12am - 6am	65	65	68
CO (mg/m^3)	1-hour (9th highest)	30	11pm - 7am	7.7	7.9	8.0
			12am - 6am	7.7	7.7	7.8
	8-hour	10	11pm - 7am	3.7	3.7	3.8
			12am - 6am	3.7	3.7	3.8
PM_{10} ($\mu g/m^3$)	24-hour	50	11pm - 7am	38.0	38.5	39.2
			12am - 6am	38.0	38.2	38.8
	Annual	20	11pm - 7am	15.0	15.1	15.4
			12am - 6am	15.0	15.1	15.3
$PM_{2.5}$ ($\mu g/m^3$)	24-hour	25	11pm - 7am	24.0	24.4	24.8
			12am - 6am	24.0	24.2	24.5
Benzene ($\mu g/m^3$)	Annual	3.6	11pm - 7am	1.0	1.02	1.05
			12am - 6am	1.0	1.01	1.03

9. Operational Effects - Post Project Monitoring

This section of the report summarises the monitoring proposed in order to manage the effects on air quality that may be caused through the operation of the Project. The monitoring of effects associated with the construction of the Project is separately addressed in Section 12.6 of this report.

Proposed monitoring conditions for managing the effects of vehicle emissions from the tunnel are given in the Assessment of Environmental Effects. The Project, once constructed, will form part of the Auckland region's motorway network. The motorway network is currently operated and maintained by the Auckland Motorway Alliance (AMA) under contract to the NZTA. The AMA has an operational environmental management plan (AMA EMP) for the existing network. Once the construction of the Project is complete its operations and maintenance will be managed by an Operations and Maintenance Contractor (OMC).

Additional air quality monitoring procedures for the operational phase of the Project that are not already covered by the AMA EMP and are specific only to the Project are summarised in the following sections of the report. Further details of the recommended monitoring are given in APPENDIX O.

9.1 In-tunnel Air Quality Monitoring

The OMC will be required to carry out monitoring of the in-tunnel conditions, including air quality to assist with operation of the ventilation system (as described in the tunnel operation philosophy Section 2.4). Real time in-tunnel air quality should be monitored for visibility, carbon monoxide and nitrogen dioxide through monitoring devices positioned along the tunnel.

The real-time monitoring results should be linked with the automatically operated ventilation system including exhaust fans in the tunnel ceiling and ventilation station to maintain the in-tunnel air quality in accordance with NZTA interim in-tunnel air quality guidelines. This data should be logged and permanently saved in order for it to be available for later analysis of tunnel operating conditions.

9.2 Ambient Air Quality Monitoring

In preparation for the operational phase of the Project, ambient air quality monitoring stations should be established near the northern and southern tunnel portals and ventilation stacks for the tunnel ventilation system prior to commencement of tunnel operations.

The southern monitoring station should be located in the Alan Wood Reserve so as to measure contributions to ambient air quality from the surface section of SH20 close to the location which was used to assess the project baseline air quality. The northern monitoring station should be located at Waterview Primary School, if the school are agreeable to such, as the school is one of the key sensitive receptors at this end of the Project.

Ambient air quality should be continuously monitored and the results of the monitoring reviewed against the relevant ambient air quality criteria (refer Table 3.6). Continuous meteorological monitoring at each of these ambient monitoring sites is also recommended in order to assist with the analysis of the data, and may be used by the OMC to assist with operation of the tunnel ventilation system and portal emissions during periods of low traffic volumes. The OMC should also record numbers of vehicles travelling through the tunnel, as this data could be used in order to calibrate the ambient air quality monitoring results against traffic volumes travelling through the tunnel.

Once monitoring has commenced, it should run continuously for 24 months, in order to account for inter-annual variability in meteorological conditions. For the first 12 months of operation, ambient air quality data should be reported via validated monthly reports issued for information via the Project website.

10. Operational Effects - Mitigation Measures

In accordance with the requirements of LTMA 2003, NZTS and the objectives of the RLTS which include the objective of "*protecting and promoting public health*", this section of the report describes how the Project remedies or mitigates potential adverse effects of vehicle emissions on human health. Whilst the assessment has shown that there are no locations where people will be exposed to air pollution levels that exceed the AQNES, there exists an overall requirement to reduce the effects of vehicle emissions.

Mitigation measures for reducing effects of vehicle emissions are usually centred on either reducing the emissions from the road or reducing the exposure of people close to the road.

The following mitigation measures have been considered for the management of the operational air quality aspects of the tunnels, the new section of SH20 which connects with Maioro St and the widened section of SH16:

- Tunnels compared to surface roads (Section 10.1)
- Environmental management framework (Section 10.2)
- Tunnel ventilation system design and operation (Section 10.3)
- Traffic demand management (Section 10.4)
- Offsets (Section 10.5).

10.1 Tunnels versus Surface Roads

Tunnels afford a greater opportunity to manage vehicle emissions than do surface roads. Ventilation through use of stacks is a very efficient way of dispersing air from the tunnel – studies have shown that removing surface traffic from heavily trafficked roads and discharging the same amount of contaminants from a ventilation stacks (with sufficient height) results in lower concentrations.

Dispersion via mechanical ventilation of a tunnel is also better than emissions from vehicles travelling on congested surface roads (due to dilution).

10.2 Environmental Management Framework

The Project, once constructed, will form part of the Auckland region's motorway network. The motorway network is currently operated and maintained by the Auckland Motorway Alliance (AMA) under contract to the NZTA. The AMA has an operational environmental management plan (AMA EMP) for the existing network. Once the construction of the Project is complete its operations and maintenance will be managed by an Operations and Maintenance Contractor (OMC).

10.3 Tunnel Ventilation System Design and Operation

The purpose of the tunnel ventilation system for the Waterview tunnels is to assist in the management of in-tunnel air quality. Air quality inside tunnels is not required to comply with the AQNES or any other targets or guidelines for ambient air quality. This is similar to buildings and other enclosed spaces where occupational health based exposure standards are applied instead. For completeness, some of the key points covered in the "Concept Design Report: Waterview Tunnel, M&E Service Provisions" (URS, 2010) are repeated here.

The ventilation system has been designed to be operated to minimise the impacts on ambient air quality. A discussion of the alternatives methods for tunnel emissions management considerd during the design are summarised in Section 11.4. Design and operational measures that have been incorporated include:

- Dispersing vitiated air from the tunnel system into the atmosphere via ventilation outlets at least 25 m in height above the ground level or no less than 10 m higher than the highest building within 100 m and existing at commencement of construction, whichever is the higher.

- Making provision in the ventilation system design for the possible future fitting of air treatment devices for the purpose of treating oxides of nitrogen or particulate matter.

The operating philosophy for the tunnel ventilation system is outlined in Section 2.4. Measures that may be used to manage in-tunnel air quality include, for example:

- The operation of exhaust fans

- Controlling the inflow of traffic within the tunnel by engagement of traffic management

- In situations where traffic flows halt, requiring motorists to turn off engines until the incident has been cleared to resume normal traffic operations

- Any combination of the measures above.

In the event that an incident involving a fire or other release of toxic or hazardous gases occurs in the tunnel system, the in-tunnel air quality is managed by activation of the smoke duct and exhaust system and the deluge fire management system as required.

10.4 Traffic Demand Management

There are a range of options for managing vehicle emissions via traffic demand management. Traffic demand management allows vehicle emissions from both tunnels and surface roads to be managed without greatly affecting design. For example, a steady flow of traffic results in a lower emission rate across all vehicles, while travelling at a speed either too slow or too fast will also increase emission rates. However, no specific demand management or traffic management options have been included in the traffic modelling assessment (Beca 2010a).

A number of possible traffic demand management measures utilised by overseas administrations have been considered and some will be implemented for the Project. These measures include:

- **Bus priority, truck priority or high occupancy vehicle lanes.** HCVs contribute proportionately more discharges of air pollutants than light vehicles and this proportion is heavily dependent on speed and traffic interruptions. Measures to improve traffic flow for such vehicles can, therefore, have a significant impact on overall emissions of air pollutants from traffic on particular sections of road. The Project incorporates bus priority lanes on SH16.

- **Lane signalling.** The traffic modelling used in this assessment assumes that on-ramp signalling will be used across the urban motorway network in Auckland to manage the flow of traffic on the motorway. In common with most other State Highways, it is likely that the Project will have lane signalling that could be used to close either tunnel in the event of severe congestion – for example, if an incident beyond one of the tunnels resulted in traffic queuing back into the tunnel.

- **Vehicle Type.** Diesel vehicles emit more particulate than unleaded fuelled vehicles, and the older the vehicle the greater the level of pollution is produced. As a result, for example, the Tokyo local government banned diesel vehicles unless fitted with an appropriate particle filter (PIARC, 2008). Currently, vehicle emission standards are controlled by the Ministry of Transport (MoT) and it is not proposed to limit vehicle types that can use the Waterview Connection.

- **Speed Restrictions.** Maintaining a steady flow of traffic will produce fewer pollutants than the stop start traffic often experienced at peak times. The United Kingdom, Australia and the Netherlands all operate road networks to variable speed limits depending on the amount of traffic and time of the day. Driver behaviour can be significantly improved by restricting traffic speeds to lower levels during rush hour periods (PIARC, 2008).

- **Lane closures.** Lane closures are used as a mechanism to avoid placing additional pressure on an already polluted area. In overseas examples, a number of tunnels are permitted to close lanes during poor air quality conditions; this reduces capacity resulting in less net tunnel emissions (PIARC, 2008). It is not anticipated that such measures will be required to mitigate effects of emissions from the Waterview Connection tunnels, as the ventilation system and stacks are designed to minimise the effects of the vehicle emissions from the tunnels.

10.5 Offsets

Measures to offset any overall increase in emissions are suggested by the MfE Transport GPG for when emissions from a project are sufficient to cause unacceptable localised impacts when added to (relatively high) background levels. In the case of the Project, no such unacceptable localised impacts have been identified and therefore no offsets are proposed. Although 24-hour average concentrations of $PM_{2.5}$ are predicted to exceed the ARAQT at receptors in the vicinity of Sector 9 and of SH20 through Mt Roskill, this is not regarded as unacceptable *per se*, since these predicted exceedances are largely due to the very high baseline (ambient background) value assumed for the assessment. At most of these receptors, the assessment predicts that the ARAQT would be exceeded even without the Project.

11. Consideration of Alternatives

Section 171(1)(b) of the RMA requires that consideration be given to alternative sites, routes, or methods of undertaking the work for which a designation is being sought. Although the assessment undertaken for this report indicates that significant effects of air quality as a result of the Project are unlikely, for completeness, discussion on a number of alternatives are included in this section. This section of the report addresses:

- Air quality considerations in alternative route selection (Section 11.1);
- Alternative location and height of ventilation stacks (Sections 11.2 and 11.3); and
- Alternative methods for managing emissions from tunnels (Section 11.4).

11.1 Route Selection

A comprehensive process was undertaken between 2000 and 2006 inorder to identify the preferred route of the tunnel alignment. This is described in detail in Chapter 11 of the AEE, and involved an initial route analysis of 12 route options to produce a short list of options. The short list of options was further evaluated and the preferred route was identified in 2006. In identifying the preferred route, a range of factors were considered including traffic performance, potential physical environmental impacts, potential human environmental impacts, constructability and the cost/benefit ratio.

11.2 Alternative Ventilation Stack Locations

The dispersion modelling assessment is based on concept locations for the northern and southern ventilation stacks. The proposed stack locations underwent a number of iterations as the project detailed design developed. However, it was determined that the dispersion modelling results were relatively insensitive to small shifts in the location of the ventilation stacks (within several hundred metres) as the ground level concentrations predicted by the modelling are minor, and tend to be well away from the vent locations.

The proposed ventilation stack locations were selected by representatives of the Project team, including tunnel designers, tunnel ventilation system designers, architects, air quality specialists, urban designers and planners. The selection process involved a series of workshops, taking into consideration a wide range of project constraints including:

- Engineering feasibility, constructability, cost and energy efficiency
- Urban design, visual impact and architectural considerations
- Land availability (e.g. within construction footprint/ project designation)
- Avoiding areas of archaeological significance, volcanic sight lines and the coastal protection area.

The proposed locations of the vents are the optimal location for the vents based on the above project constraints. Relocation of the ventilation stacks from the current proposed locations comes with a significant cost, due to the additional tunnelling required.

11.3 Alternative Ventilation Stack Heights

In 2008, in response to requests from the community consultation process in relation to a previous proposal for the Waterview tunnels, the NZTA was asked to consider alternative stack locations and stack heights. A copy of the report assessing alternate stack heights is attached at APPENDIX K. The results of that assessment are summarised in Sections 11.3.1 and 11.3.2 below.

Selection of the ventilation stack height depends on a number of project and site specific factors including:

- local topography
- height of nearby buildings
- tunnel length and traffic volumes
- number of vents.

The height of the tunnel ventilation stacks also has a visual impact on the surrounding area, and these effects need to be considered when designing the optimum height. Dispersion modelling can then be used to confirm that the height achieves sufficient dispersion to meet the air quality standards.

The basic principle of dispersion is that the greater the height of discharge above ground, the more effective the dispersion, i.e. the smaller the impact at ground level. The main factors that affect the atmospheric dispersion and dilution process are wind speed, the height at which the substance is emitted and atmospheric turbulence. Generally speaking, taller vents are more effective at dispersion. This principle is used, for example, in power stations where combustion products are discharged from very tall stacks, which ensures that sufficient mixing and dilution occurs before the pollutants reach the ground. However, there are also factors which can limit the effectiveness of dispersion from such tall stacks, including building downwash and terrain.

The height of 25 m was selected based on consideration of the surrounding topography and land use. The surrounding land use in the area of the northern portal is predominantly residential with building heights typically not taller than 8-10 m. The Unitec Residential Village houses two apartment complexes on Great North Rd, as well as a number of other taller buildings within the campus. At the southern portal the land use is also mostly residential.

District planning requirements generally limit building height to 8-10 m around the northern and southern portals. These height limits may be exceeded at the discretion of the Auckland City Council, through an application for discretionary activity resource consent. It is anticipated that such a consent application would or could be publicly notified (either full or limited notification) and that the NZTA would have scope to be involved in such an application. Additional maximum height restrictions (for volcanic view shaft protection purposes) of between 7-21 m apply in the northern area of the southern portal. These restrictions may not be exceeded without a non-complying resource consent (in other words, it is anticipated such heights would not generally be permitted in the area).

Topography near both portals (e.g. within 300 m) is relatively flat. However, there are locations, particularly at the southern end with variations in elevation of 10-20 m within 400m of the southern portal location.

11.3.1 Modelling of Alternative Stack Height

As noted above, a limited sensitivity analysis using dispersion modelling was carried out in 2008 to determine the potential impacts of these alternatives on the air quality effects of the project (refer APPENDIX K). To test the sensitivity of the modelling to this variable, a reduced alternative stack height of 15 m was modelled. The assessment was limited to predicting the change in effects at the sensitive receptors only. This modelling showed that the difference between the 15 m and 25 m stacks tended to shift the peak effects closer to the stacks, but the actual changes in cumulative effects was predicted to be less than 1%. It was not considered necessary to remodel this sensitivity analysis as the conclusions are expected to be the same.

11.3.2 Summary of Alternative Stack Height Considerations

Whilst previous sensitivity modelling of a 15 m stack did not rule out the suitability of a shorter stack, it was not preferred from an air quality or risk management perspective. To minimise the effects of the discharge from the stacks, it is best for the stacks to be taller than anything else that is (or might be) built close to it in the future (including allowance for such buildings to be built on higher ground than the base of the stacks). Managing land use and building development in the vicinity of the ventilation stacks should therefore be a consideration after the tunnel is constructed.

11.4 Tunnel Emissions Management

Air quality outside tunnels can be managed through any combination of measures including:

- Dispersion methodologies
- Emission treatment technologies.

A separate report on tunnel emissions management options was prepared on behalf of the NZTA in 2008 (Beca, 2008), based on guidance in PIARC, 2008. The purpose of that report was to undertake a review of international practices on the management of vehicle emissions from road-driven tunnels and to benchmark the proposed SH20 Waterview emission management design against international examples. The key findings of that report are summarised below.

11.4.1 Dispersion Methodologies

As outlined in Section of this report, the Waterview tunnels will utilise a longitudinal ventilation system, with the main discharge points being ventilation stacks located close to the tunnel portals. As discussed in Section 8 of this report, discharges of vehicle exhaust emissions via the tunnel ventilation stacks will have minimal impact on concentrations of air pollutants at sensitive receptors.

Dispersion, via ventilation stacks, involves emissions being collected and then discharged at high velocity into the atmosphere from tall vents.

Ventilation through use of stacks is a very efficient way of dispersing air from the tunnel – removing surface traffic from heavily trafficked roads and discharging the same amount of contaminants from a ventilation exhaust (with sufficient height) results in much lower concentrations at ground level where people are most likely to be exposed.

11.4.2 Emission Treatment Technologies

A number of technologies exist which can be used to remove particulate matter and gaseous contaminants from tunnel air.

At present there are two contaminant removal techniques which have been applied for the purpose of tunnel emissions treatment; these technologies include electrostatic precipitators for the treatment of particulates and denitrification for the treatment of NO_2.

a. Electrostatic Precipitators

Electrostatic Precipitators (ESPs) are used to remove dust and particles from tunnel environments. ESPs have been used to control particle emissions from vehicles since 1979 and have been used for many years in industrial applications.

ESPs are effective in removing particles between 1 and 10 microns in diameter (Child et al, 2004). While design efficiencies of ESPs can range up to 99.9%, removal efficiencies of ESPs as reported for road tunnels is more in the order of 70%. These results occur for a number of reasons:

- Air in road tunnels is diluted by drawing fresh air into the tunnel portals
- Variable airspeeds occur in tunnel environments
- Contaminant types and sizes differ with different vehicle profiles
- ESPs are more efficient at removing larger particles than smaller particles.

No data is available to date which demonstrates the actual effect on external air quality with respect to the use of ESPs for external air quality purposes (Dix, 2006).

b. NO_x Removal Technologies

NO_x removal technology is the process by which NO_2 and other oxides of nitrogen are reduced or removed from road tunnel air. Most systems treat contaminants through a chemical absorption or a catalytic process.

The use of NO_2 removal in road tunnels, to date, has been limited. Pilot systems have been successfully demonstrated in some tunnels, and several full scale systems have been installed in Japan, Spain (Madrid) and Norway (Beca, 2010c).

11.4.3 Summary of Tunnel Emissions Management Options

The overall findings of the Tunnel Emissions Management report as they relate to the Project are as follows:

- Contaminant dispersion through use of tall vents (such as is proposed), is considered to be the most efficient way of dispersing vehicle related contaminants from the tunnel.
- Dispersion ensures that vehicle emissions are mixed with a sufficient volume of outside air to meet air quality standards. Dispersion via mechanical ventilation of a tunnel is also better than emissions from vehicles travelling on congested surface roads (due to dilution).
- Almost all tunnel ventilation systems in the world use the principles of dispersion and dilution. Of these, only a small proportion (estimated at <1%) have vertical air dispersion (ventilation stacks) and only <0.01% (as estimated) have contaminant removal technologies to extract pollution from the ventilated tunnel air (ref PIARC 2008).
- At present there are two contaminant removal techniques which have been applied overseas for the purpose of tunnel emissions treatment; these technologies include ESPs for the treatment of particulates and denitrification for the treatment of NO_2.
- There is no known treatment technology for removal of CO or hydrocarbons (e.g. benzene) currently available for use in road tunnels.
- Dispersion via vents is effective for all contaminants.

Dispersion modelling studies (ref: Holmes Air Sciences, 2006) have indicated that, even when high levels of filtration efficiency are assumed, the differences to ambient air quality at ground-level would be very small and unlikely to be detectable by conventional monitoring instrumentation. Ultimately, the most beneficial and cost effective option for the treatment of emissions from motor vehicles lies at the point of emission. Controlling emissions from each individual motor vehicle would ensure that benefits to air quality would be realised on regional and larger scales. One such option is discussed in Section 10.5. Therefore, the installation of filtration or emissions control systems in tunnels to remove contaminants is not justified.

The modelling assessment described in this report has predicted that the effects of vehicle emissions discharged from the Waterview Connection tunnel vents will be minor. On this basis, emission treatment technology has not been proposed. The design of the system could allow for future retrofitting of treatment technology should changing conditions and technologies over the life of the tunnel warrant it.

12. Effects Assessment: Construction Activities

In addition to assessing the effects of vehicle exhaust emissions from roading projects ("operational effects"), the Draft NZTA Standard for Producing Air Quality Assessment s for State Highway Projects (NZTA, 2010a) requires an assessment to be made of the air quality impacts of construction activities associated with such projects, primarily focussed on the effects of dust. The Draft NZTA Standard specifically refers to the MfE Dust GPG (MfE, 2001). This is addressed in the following sections of this report, as follows:

- Section 12.1 outlines the contaminants that may be discharged into air from road construction activities and the approach to the assessment of effects undertaken for this report.
- Sections 12.2 and 12.3 outline the issues related to dust generation during construction.
- Section 12.4 outlines measures that may be taken to mitigate the effects of dust emissions.
- Section 12.5 summarises specific dust generating activities and the receiving environment on a sector by sector basis.
- Section 12.6 outlines the dust monitoring that has been recommended.
- Sections 12.7 and 12.8 summarise the potential effects of discharges of odour and of vehicle exhaust emissions from construction traffic.

Due to the specific issues related to concrete batching and rock crushing, for clarity, discharges of dust from these activities are discussed in a separate section of this report in Section 13.

12.1 Introduction

12.1.1 Dust

The construction of the Project will entail large scale earthworks over a considerable area. The overall Project is expected to take approximately five years to complete, although some parts may be completed more quickly, or will be started later – for example, the driven tunnel section (Sector 8) is expected to take about 2½ years to complete, but cannot be commenced until access is available via the adjacent sectors.

Exposed earthworks can be a significant source of dust. Dust can affect human health and plant life along the edge of the earthworks area, can be a nuisance to the surrounding public, and can contribute to sediment loads by depositing in areas without sediment control measures. Sediments deposited on sealed public roads can also result in a dust nuisance. Rainfall, water evaporation, and wind speed, are meteorological conditions having the greatest effect on dust mobilisation.

Dust discharges from earthworks typically fall into the larger particle sizes, generally referred to as "deposited particulates", although there may also be a significant component in the smaller size ranges. Deposited particulates are particulates having an aerodynamic size range greater than about 20 microns. As a class of material such particulates have minimal physical health impact (particles have only limited penetration into the respiratory tract), but may cause nuisance in sensitive areas due to soiling. Soiling includes excessive dust deposits on houses, cars, and washing and excessive dust within houses.

Construction work associated with the Project will not be the only source of dust in the area. For example, other construction activities may also be occurring at the same time, while re-entrainment of road dust on existing roads (i.e. dust being picked up from surfaces by the wind) will also contribute to overall dust levels.

12.1.2 Odour

Road construction activities in themselves are not usually regarded as a source of odour, however, where the construction involves disturbance of land contaminated with organic wastes (such as closed landfills) discharges of odour may occur.

Sector 8 of the proposed alignment of the Project runs under Phyllis Street Reserve, while Sector 9 runs through Alan Wood Reserve; both of these are closed landfill sites.

12.1.3 Vehicle Exhaust Emissions

There will be discharges of engine exhaust emissions from construction traffic associated with the construction of the Project. These will include fine particles (PM_{10} and $PM_{2.5}$), NO_x, CO and organics such as benzene. Most construction vehicles are diesel powered, and are therefore likely to emit larger quantities of PM_{10}, $PM_{2.5}$, NO_x and organics than the general vehicle fleet (which is mostly petrol driven). As noted in Section 4.2 of this report, vehicle exhaust emissions (including those from construction traffic) are specifically permitted under the Proposed Auckland Regional Plan.

Construction of the Project will temporarily increase truck numbers in the Project vicinity; however the selection of haulage routes includes consideration of air quality and other amenity effects (e.g. noise). Trucks removing spoil from the northern construction site are anticipated to exit the site towards SH16 (with the potential to provide an on-ramp to SH16 prior to other Great North Road Interchange works to allow for easy truck access from the construction site to the motorway) or, from the southern construction site, towards the completed SH20 Mt Roskill section.

Truck movements will typically be below 30 movements per hour during the daytime and less than 10 per hour during the night period. On major roads, such as the motorway and Great North Road, this number of truck movements would result in an imperceptible increase in air quality impacts.

12.1.4 Approach to the Assessment of Effects from Construction Activities

The principal air quality issue in relation to road construction is the discharge of dust. Although certain activities may cause discharges of odour and construction vehicles will discharge exhaust emissions, these are relatively minor issues by comparison to the potential effects of dust. This section of the report, therefore, focuses largely on the assessment, management, mitigation and monitoring of dust discharges from road construction. Discharges of odour and vehicle related emissions are discussed briefly in sections 12.7 and 12.8.

No attempt has been made to undertake a quantitative assessment of dust discharges from construction activities. The MfE Dust GPG recognises that there are severe limitations on the accuracy of dispersion modelling for fugitive sources such as road construction (due to uncertainties in emissions factors and to poor characterisation of localised wind turbulence and flow disturbances due to trees, buildings, or other obstructions). At best, dispersion modelling can be used to highlight the most significant sources on a site, or to identify those receptors most likely to be affected by dust discharges.

In consequence, the MfE Dust GPG states:

The key point to recognise with most fugitive dust sources is that nuisance effects will almost certainly occur if the sources are not adequately controlled. Rather than spending time and money on extensive (and expensive) theoretical predictions of the possible effects, it is likely to be more appropriate to put the effort into the design and development of effective dust control procedures.

It is this approach that has been followed in this assessment. In parallel with this assessment, recommended mitigation and monitoring measures have been detailed in a Draft Construction Air Quality Management Plan (CAQMP), which will form part of a Construction Environmental Plan (CEMP) for the Project. A copy of the draft CAQMP is attached at APPENDIX M.

Out of an abundance of caution, resource consent is being sought for the discharge of contaminants into air (i.e. dust and odour) from construction activities under Rule 4.5.H of the PARP: ALW, which states:

4.5.H *The discharge of contaminants into air from earthworks or from the construction, maintenance and repair of roads (road works) that does not comply with Rule 4.5.G* [which requires conditions in Rule 4.5.1 to be met] *is a Restricted Discretionary Activity.*

The following sections of this report aim to demonstrate how discharges into air arising from the construction of the Project will be managed. The key issues that need to be addressed in terms of Rule 4.5H (i.e Rule 4.5.1 parts (a) to (c)) are as follows:

- **Odour**. Road construction activities in themselves will not generate discharges of odour, other than for the application of bitumen in the final stages of construction. This is a normal activity associated with routine road maintenance, of short duration in any particular locality, which should not be regarded as giving rise to offensive or objectionable impacts. The only other main potential source of odour associated with the Project would be if earthworks in Sector 9 exposed odorous material from the closed Alan Wood landfill. Measures to prevent adverse impacts from this are discussed in Section 12.7.

- **Dust and particulate matter**. This forms the main focus of most of this section of the report. Through the implementation of effective dust management and monitoring, the effects of dust discharges can be controlled to prevent offensive or objectionable impacts. Proposed dust control and mitigation measures that will be used in this Project are outlined in Section 12.4 of this report. More details of the dust control and monitoring to be implemented for the Project are given in the CAQMP.

- **Smoke and ash**. There are no potential sources of smoke or ash associated with the construction of the Project. Rule 4.5.20 of the PARP: ALW prohibits the outdoor burning of waste (including vegetation) within metropolitan Auckland.

- **Visible emissions**. Aside from construction dust and exhaust emissions from construction vehicle, there are no visible discharges into air associated with the construction of the Project. Measures to control dust emissions will also be effective in preventing offensive or objectionable visible discharges.

- **Hazardous air pollutants**. The only source of hazardous air pollutants associated with the construction of the Project is engine exhaust emissions from construction vehicles. These discharges are specifically permitted under Rule 4.5.3 of the PARP: ALW. Notwithstanding that fact, Section 12.8 outlines measures that can be taken to mitigate the effects of such discharges.

As noted above, the key issue in relation to discharges into air from the construction of the Project is the control of dust emissions. It is imperative that discharges of dust from construction activities are sufficiently controlled (mitigated) so that they are not regarded as offensive or objectionable. To this end, effective dust management must be undertaken.

In addition to the use of effective dust control measures to prevent localised impacts, the overall Project can be broken down into a number of distinct (albeit inter-related) construction activities. A summary of the construction timeframe for the Project is shown in Figure 12.1 (taken from Figure 5.1 of the AEE). The two areas of the Project with the longest construction timeframes are the causeway between Te Atatu and Waterview and the Waterview tunnels. There are no sensitive receptors in Sectors 2 to 4 (in the vicinity of the causeway), while most of the construction activities associated with the tunnels will take place underground. Surface activities associated with the construction of the deep tunnels themselves will be focused on contractor's yards near the Great North Road Interchange and in Alan Wood Reserve.

Figure 12.1 - Summary of Work Programme

Construction Area/Activity	Year																							
	1				2				3				4				5				6			
Sector 1 – Te Atatu Interchange		■	■	■	■	■	■	■	■	■	■	■	■	■	■									
Sectors 2-4 – Causeway and Whau Bridge	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Sector 5 – Great North Road Interchange													■	■	■	■	■	■	■	■				
Sector 6 – SH16 Great North Road to St Lukes									■	■	■	■												
Sectors 7 & 8 – Tunnels	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
Sector 9 – SH20 Tunnel to Maioro Street	■	■	■	■	■																			

With respect to dust discharges, the following sections of this report will:

- Summarise the various sources of dust discharges associated with construction activities and the factors that contribute to dust discharges from those sources
- Outline dust control and mitigation measures that may be applied
- Identify specific dust sources on a sector by sector basis, along with receptors that are likely to be sensitive to those discharges
- Outline dust monitoring measures
- Summarise appropriate mitigation, control and monitoring measures.

12.2 Dust Generation during Construction

Potential sources of dust and other air contaminant discharges which are liable to cause nuisance beyond the site boundary during adverse conditions if adequate controls and mitigation measures are not adopted are:

- Dust from roads and access areas generated by trucks and other mobile machinery movements during dry and windy conditions;
- Excavation and disturbance of dry material;
- Loading and unloading of dusty materials to and from trucks;
- Smoke and odour from diesel-engine machinery and truck exhausts; and
- Stockpiling of materials including material placement and removal.

Dust may be generated from dry undisturbed surfaces at wind speeds greater than 5 -10 m/s (10 – 20 knots). Wind can transport dust mobilised from dry surfaces by machinery or truck movements or mechanical disturbance. Transportation of dust is dependent on dust particle size and wind speed. Rainfall, rate of water evaporation, and wind speed, are conditions having the greatest effect on dust mobilisation.

Dust generation by truck and machinery movements in dry conditions is a function of vehicle speed, number of wheels and vehicle size. Judder bars or humps to reduce vehicle speed are not recommended as they can cause spillage of load and may damage loaded vehicles.

Unpaved roads and yards areas can be very dusty during dry weather. This can be aggravated if surfaces are allowed to get muddy during wet weather which eventually dries out and then becomes ground-up by vehicle movements.

Carrying out extensive earthworks during dry conditions exposes large areas to effects of wind while being disturbed by machinery. Excavated areas left exposed during dry windy conditions can be significant dust sources. Stockpiling of topsoil and subsoil, and in particular dry dusty materials, may also be major dust sources during stockpile formation and when exposed to strong winds.

As dust discharges from earthworks typically fall into the larger particle sizes, such particulates have minimal physical health impact (particles have only limited penetration into the respiratory tract), but may cause nuisance in sensitive areas due to soiling. Soiling includes excessive dust deposits on houses, cars, and washing and excessive dust within houses.

12.3 Factors Influencing Dust Generation

There are five primary factors which influence the potential for dust to be generated from the site. These are:

- Wind speed across the exposed surfaces;
- The percentage of fine particles in exposed surface material;
- Moisture content of that material;
- The area of exposed surface; and
- Mechanical disturbance of material including via excavation and filling, loading and unloading of materials and vehicle movements.

Systems for controlling dust emissions should include methods that modify the condition of the materials so that it has a lesser tendency to lift with the wind or disturbances such as vehicle movements and methods that reduce the velocity of the wind at the surface.

Watering of exposed surfaces and materials that may be disturbed is an important method of control. The MfE Dust GPG recommends that, as a general guide, the typical water requirements for dust control in most parts of New Zealand are up to 1 litre per square metre per hour. The dust prevention methods detailed in Section 12.4 are methods that are typically found to be effective. They can be used alone or in combination depending on the circumstances. This list is not exhaustive and other methods may be found to be effective.

In addition to consideration of dust sources and factors that may influence dust generation, any assessment of the effects of dust must consider the distance that any dust may travel from the sources. In general, although construction activities can generate dust with a wide range of particle sizes, it is the larger dust particles that tend to be associated with 'dust nuisance' from construction activities. However, the larger the particle size, the less distance it will travel in light to moderate winds. The MfE Dust GPG states:

"*When dust particles are released into the air they tend to fall back to ground at a rate proportional to their size. This is called the settling velocity. For a particle 10 microns in diameter, the settling velocity is about 0.5 cm/sec, while for a particle 100 microns in diameter it is about 45 cm/sec, in still air. To put this into a practical context, consider the generation of a dust cloud at a height of one metre above the ground. Any particles 100 microns in size will take just over two seconds to fall to the ground, while those 10 microns in size will take more than 200 seconds. In a 10-knot wind (5 m/sec), the 100-micron particles would only be* *blown about 10 metres away from the source while the 10-micron particles have the potential to travel about a kilometre. Fine particles can therefore be widely dispersed, while the larger particles simply settle out in the immediate vicinity of the source.*"

Dust particles generated by construction activities generally fall into the larger size fractions, with an aerodynamic diameter of 100 µm or greater. In steady wind conditions, with average wind speeds of less than 10 m/s (typical of urban areas of Auckland), without vehicle movements, such particles would travel only a few tens of metres from the source. However, this theoretical calculation takes no account of re-entrainment of dust or of the effects of turbulent airflow. There have been a number of studies undertaken using field measurements of suspended particulate at different distances from road sources (e.g. Cowherd and Grelinger, 2003, Cowherd, Grelinger and Gebhart, 2006, Etymezian et al, 2004). Overall, the conclusions from these studies appear to be that dust travels much further under unstable atmospheric conditions than in stable conditions[21]. These conclusions emphasise the need for effective mitigation measures to be applied, especially during hot, dry weather.

Based on the discussion regarding particle size in the MfE Dust GPG and the results of research into dust entrainment, only premises within approximately 100m of significant dust sources have been considered as potentially sensitive receptors for assessing the effects of construction dust. The purpose of the controls outlined in the following sections will be to prevent (if possible) or otherwise minimise the effects of dust emissions on those premises.

12.4 Dust Mitigation and Management

Before considering the effects of dust from those specific activities that will be undertaken as part of the construction of the Project, it is appropriate to outline the dust control and mitigation measures that may be applied. This section of the report presents a range of control and mitigation measures designed to prevent or minimise adverse dust effects on the environment and local community beyond the boundary of the construction site. The following section (Section 12.5) considers, on a sector by sector basis, the specific activities that may generate fugitive dust emissions, the sensitive neighbours that may be affected by such emissions, and the control and monitoring methods that should be applied to each of those activities to avoid dust nuisance. As noted in Section 12.1.4, a separate Construction Air Quality Management Plan includes more detailed recommendations on dust control measures that will be required in specific areas.

Wind Fencing

- Wind break fencing (e.g. shade cloth) of suitable length, height and porosity reduces prevailing wind speed and therefore the impact of dust on surrounding areas. Effectiveness is greatest where fencing is perpendicular to the prevailing wind direction with a porosity of about 50%.

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[21] Atmospheric stability refers to the amount of vertical movement of air, and therefore of dust particles – the more unstable the atmosphere is, the more vertical movement occurs. Atmospheric stability is heavily influenced by temperature and humidity rather than wind speed – stable conditions are typical of cool cloudless winter nights with low wind speeds when surface inversions may form, while unstable conditions are typical of hot cloudless summer days when there is a high level of convective heating.

Vehicles, Machinery and Generators

- Dust discharges from activities can be significantly reduced by using water sprinkler systems during dry conditions. Adequate dust suppression is necessary to provide reasonable working conditions as well as minimising impacts upon sensitive receptors beyond the boundary of the site. Water should be applied to haul roads via water trucks and sprinklers in sufficient quantity to suppress dust but to avoid generating muddy conditions or sediment runoff.

- Semi-permanent working areas and construction site access roads should be constructed with an appropriate base, kept metalled, and kept damp using watering trucks or fixed sprinkler systems.

- Prior agreements should be made with transport operators to ensure that vehicles accessing construction sites that are used on public roads are appropriately maintained to minimise exhaust smoke and odour, and that tailgates are secure and all loads are covered. Material tracked out from the site onto public roads, if significant, should be removed by suction sweeper.

- Vehicles leaving site from unsealed surfaces can be washed down to remove dust and/or coagulated material where necessary. This would occur at selected site exits either manually or automatically via the use of high pressure water hoses, jets or water assisted brushing. Detergents or hydrocarbon based liquids should not be used for vehicle cleaning or dust suppression.

- The imposition of vehicle speed limits is a practical measure to minimise dust emissions caused by construction traffic. This can be done through speed restrictions on site and training of drivers regarding the sensitivity of the local environment. Normal signage will inform drivers of the maximum speed limit. If the control of vehicle speed on site becomes an issue, the implementation of electronic selective speed signs should be considered. The maximum speed limit on site should to be 10 km/h or less.

- Loading and unloading of trucks should be conducted in a manner which minimises the discharge of dust. This includes the minimisation of drop heights during the loading of vehicles to minimise dust generation.

Formation and Maintenance of Roads, Other Accessways, and Parking Areas

- Roads, accessways, and parking areas used by vehicles and mobile machinery that are not hard paved should be kept well metalled.

- All roads, accessways, and parking areas that are liable to dry out and generate excessive dust should be regularly watered by a watering truck or by equivalent means during periods of low rainfall.

- Significant spills of materials that may cause dust when dry should be collected, swept, scraped up or hosed down as soon as practicable.

Earthworks

- The extent of earthworks carried out during dry conditions should be limited as far as practicable to a manageable surface area to minimise dust generation while being disturbed by machinery.

- Excavated areas left exposed during dry windy conditions and liable to be dusty should be watered as necessary, or preferably stabilised e.g. through metalling, grassing or mulching.

- Cleared areas not required for construction, access or for parking, if liable to cause excessive dust during windy conditions, should be stabilised e.g. through metalling, grassing, mulching or the establishment of vegetative cover.

- Haul roads and site laydowns should be metalled to minimise mud during wet conditions and dust during dry and windy conditions.

Stockpiles and Spoil Heaps

- Spoil is proposed to be removed from the driven tunnels via fixed conveyors into enclosed buildings.

- Stockpiles of topsoil, sand, and other materials liable to dry out and generate significant dust during windy conditions, should be monitored and options such as dampening, allowing piles crust over, or covering, will be considered as appropriate.

- Stockpile margins should be defined to minimise spread onto access areas.

- Drop heights should be minimised to the extent practicable during stockpiling activities to minimise dust generation.

- In areas with ongoing dust issues or in close proximity to sensitive receptors, water sprays and/or sprinklers should be considered to suppress and control dust generated from the site.

- Water spraying requires uniform application rates consistent with evaporation rates. Spraying can result in over-watering. Excessive use of water during building-up of stockpiles can saturate their bulk, but the surface will still dry out and become dusty. Excessive wetting (especially during building-up of stockpiles) may cause flow slides and cause slips. Typically, the loss of approximately 5% of moisture from the surface of aggregate may make the material sufficiently dry to result in dust generation during mechanical disturbance, and dust from an undisturbed surface under strong wind conditions. Water application rates, and therefore the capacity of the water spray system, should be carefully evaluated during the design phase.

12.5 Sector by Sector Assessment

The construction methodology for the Project is described in detail in the Western Ring Route Waterview Connection Constructability Report. This section provides an overview of the construction methodology and sensitive receptors in each Sector of the Project.

Activities, which may cause discharges of dust, that are common to all sectors of the Project except Sector 8 (the driven tunnel section), will be open earthworks with frequent vehicle movements and landscaping. In addition, the following activities will be undertaken in specific locations: construction of sediment control ponds, contractor yards, concrete batching, bridge construction, deep excavations and driven tunnel construction.

In general, the same receptors that are sensitive to the effects of vehicle exhaust emissions (residential areas, schools, preschools and healthcare facilities) (previously discussed in Section 5.4) are also likely to be sensitive to the effects of dust emissions from construction works. However, as discussed in Section 12.3, these effects are likely to be even more localised than for vehicle exhaust emissions. Therefore, only sensitive receptors within 100m of surface sections of the proposed construction areas are identified in this section of the report.

12.5.1 Sector 1 – Te Atatu Interchange

Dust Generating Activities

- **Earthworks and construction:** road widening between Te Atatu Interchange and Whau River; bridge widening – demolition of a concrete bridge (Te Atatu Interchange); construction of a sediment control pond (Jack Colvin Park); construction of a contractors' yard (Harbourview Orangihina Park).

- **Vehicle movements:** operation of a contractors' yard (Yard 1 – Harbourview Orangihina Park); vehicles accessing the road and bridge widening.

Sensitive receptors: residential properties along both sides of Alwyn Avenue, on the eastern side of Royal Road (between Te Atatu Road and Milich Terrace), on Milich terrace and McCormick Road and on both sides of the southern end of Titoki Street (refer Figure 12.2).

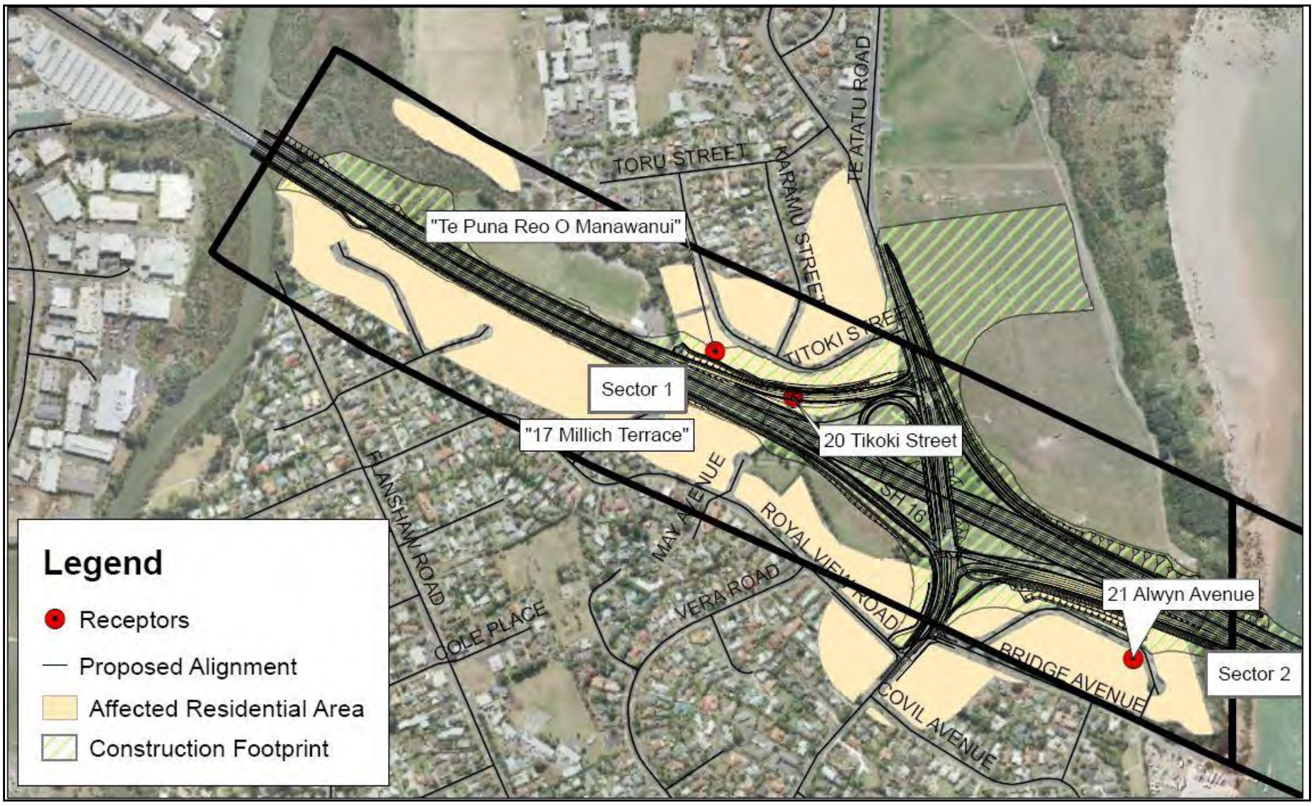

Figure 12.2 - Sensitive Receptors in Sector 1

12.5.2 Sector 2 – Whau River

Dust Generating Activities

- **Earthworks**: bridge widening (Whau River), land reclamation.
- **Vehicle movements**: vehicles accessing the bridge widening and reclamation.

Sensitive receptors: there are no residential properties in this area.

12.5.3 Sector 3 – Rosebank - Terrestrial

Dust Generating Activities

- **Earthworks and construction**: road widening, land reclamation; construction of retaining walls; bridge construction (Patiki Road cycleway).
- **Vehicle movements**: operation of a contractors' yard (Yard 2 – Patiki Road); vehicles accessing the road widening and reclamation.

Sensitive receptors: there are no residential properties in this area.

12.5.4 Sector 4 - Reclamation

Dust Generating Activities

- **Earthworks:** land reclamation.

- **Vehicle movements:** vehicles accessing the reclamation.

Sensitive receptors: there are no residential properties in this area.

12.5.5 Sector 5 – Waterview Interchange

Sector 5 includes the main construction laydown area for the northern extent of the tunnel. This will occupy space within Waterview Park and will be accessed from Cowley Street.

Dust Generating Activities

- **Earthworks and construction:** construction of four new ramps; road construction and widening; bridge construction and widening (Great North Road Interchange); deep excavations (northern portal and ventilation station).

- **Vehicle movements:** operation of three contractors' yards (Yards 3 and 4 – Great North Road interchange and Yard 6 – Waterview Reserve); vehicles accessing the road and bridge widening.

- **Spoil handling and stockpiles;** spoil from inside the tunnel will be handled within a spoil stockpile building located in contractors' yard 6 – Waterview Park.

- **Other:** concrete batching (Yard 6 – Waterview Park).

Sensitive receptors: residential properties within 100m of the current alignment of SH16 (including properties on Maryland Street, Smale Street, Miller Street, Alberta Street and Montrose Street); Mason Clinic and northern parts of the Unitec site; St Francis School, Waterview School and Kindergarten (refer Figure 12.2). The NZTA is acquiring or has acquired those residential properties on Cowley Street, Herdman Street and Waterbank Crescent that may otherwise have been adversely affected by dust from the proposed construction works.

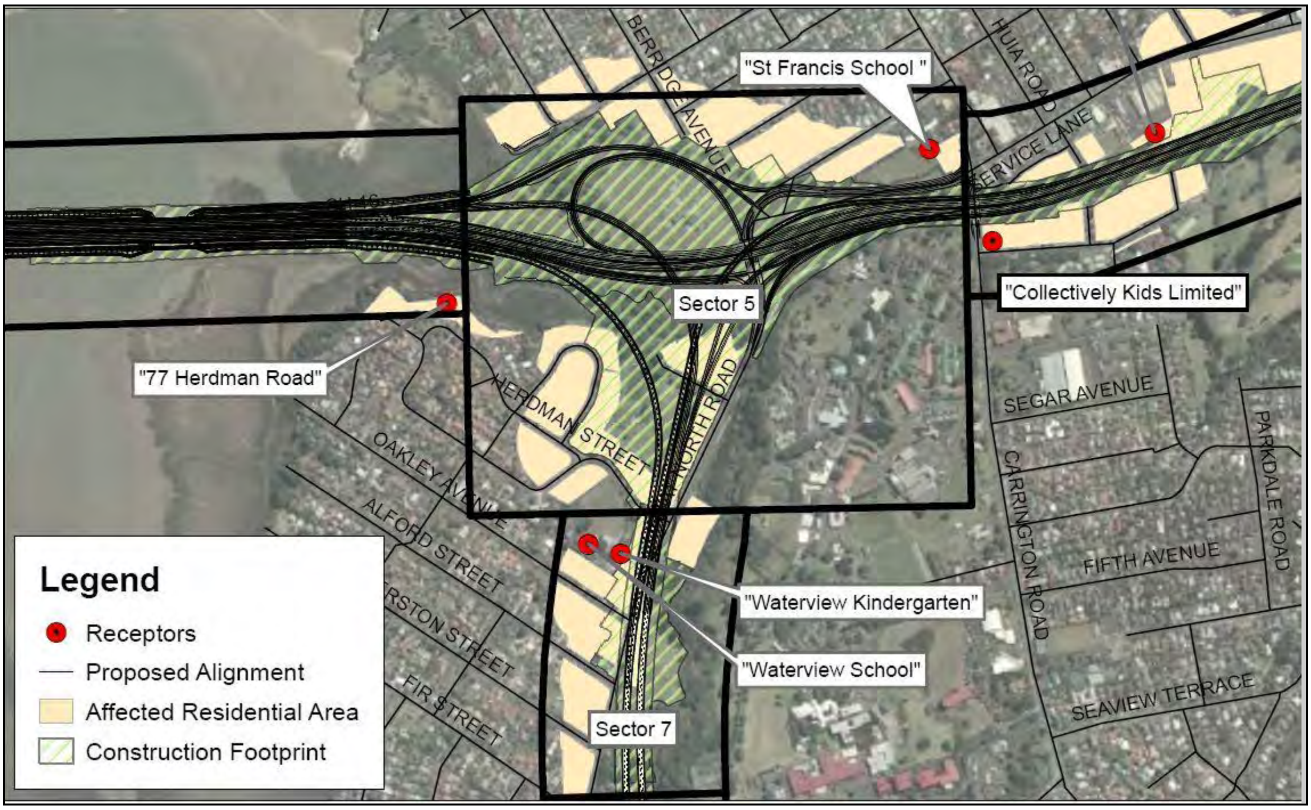

Figure 12.3 - Sensitive Receptors in Sectors 5 and 7

12.5.6 Sector 6 – SH16 to St Lukes

Dust Generating Activities

- **Earthworks and construction:** road widening; bridge construction and widening (Carrington Road construction of contractor's yard and sediment control pond (Meola Creek).
- **Vehicle movements:** operation of contractors' yard (Yard 5 - Meola Creek); construction vehicles accessing road widening.

Sensitive receptors: residential properties along Great North Road, Parr Road North, Parr Road South, Novar Place and Sutherland Road; Collectively Kids (refer Figure 12.4).

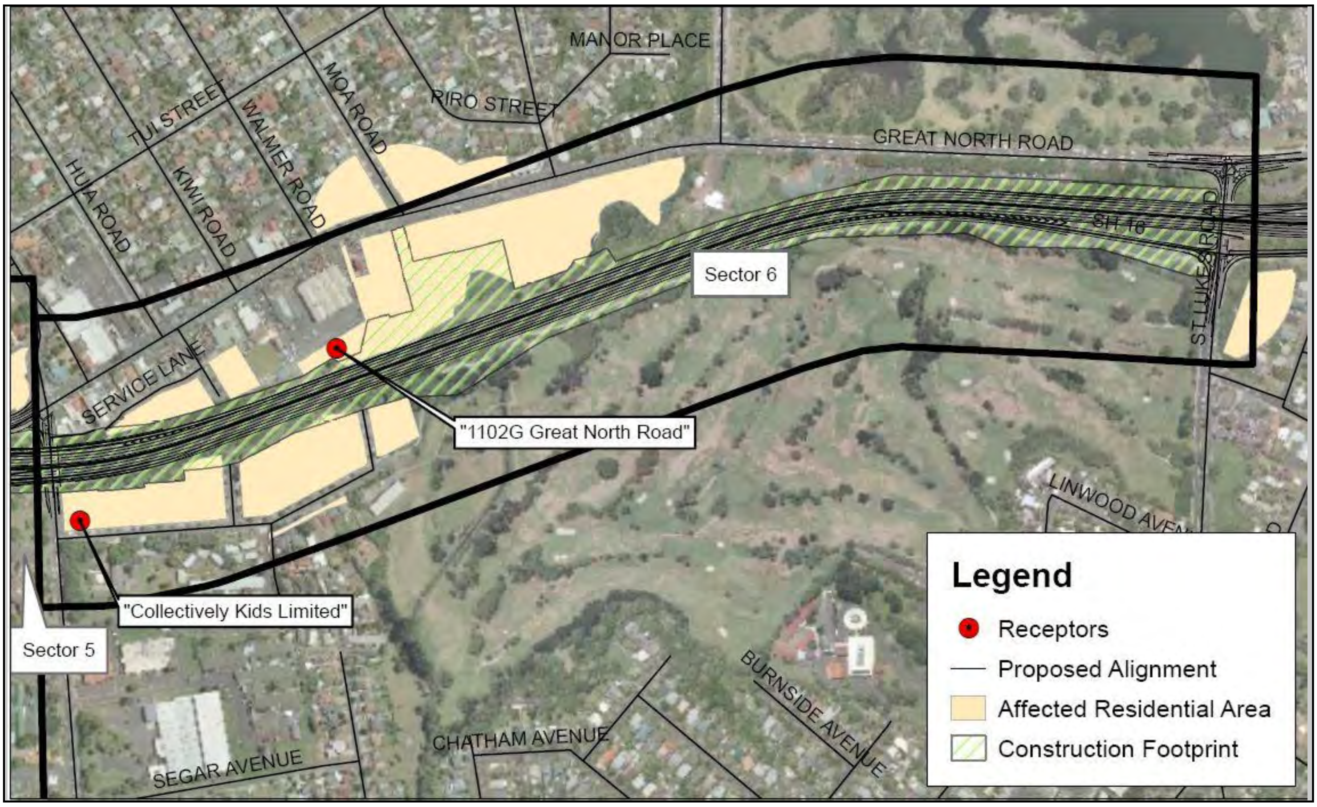

Figure 12.4 - Sensitive Receptors in Sector 6

12.5.7 Sector 7 – Great North Road

Sector 7 covers the Cut and Cover section of tunnel. The cut and cover tunnels will involve the construction of diaphragm walls, excavation of the trench and construction of roof slabs.

Dust Generating Activities

- **Earthworks:** deep excavations (cut and cover tunnel); bridge construction (Oakley Creek).
- **Vehicle movements:** operation of a contractors' yard (Yard 7 – Oakley Creek Reserve); vehicles accessing excavations and removing spoil.
- **Spoil handling;** Spoil from inside the tunnel will be transported either by truck or by enclosed conveyor through this sector to contractors' yard 6.

Sensitive receptors: residential properties along Great North Road between Herdman St and Alverston St; Waterview School and Preschool. Waterview Preschool in particular is located only a few metres from the construction footprint for the cut and cover tunnel (refer Figure 12.2).

12.5.8 Sector 8 – Avondale Heights Deep Tunnel

Sector 8 covers the length of tunnel between the cut and cover tunnel section and the southern portal. Due to the construction methods being employed (tunnel boring), activities within this Sector will not generate dust that could affect sensitive receptors. The driven tunnel excavation will be progressed from both portals and for both tunnels concurrently. Roadheaders and excavators are proposed to be used to excavate the face and spoil will be removed to via enclosed conveyors and/or by trucks.

12.5.9 Sector 9 – Alan Wood Reserve

Sector 9 covers the southern portal and the SH20 carriageway to Maioro interchange. The construction laydown area at the southern end of the tunnel is located within Alan Wood Reserve, and is divided into two separate areas by the diversion of Oakley Creek.

Dust Generating Activities

- **Earthworks and construction:** deep excavations for southern tunnel portals and ventilation building; road construction; construction of contractors' yards (Yards 8, 9 and 10 in Alan Wood Reserve, Yard 11 in Hendon Park and Yard 12 in Valonia Road); bridge construction (Hendon Park pedestrian bridges and Richardson Road bridge); steam diversion (Oakley Creek).

- **Vehicle movements:** operation of four contractors' yards (Yards 8, 9 and 10 in Alan Wood Reserve, Yard 11 in Hendon Park and Yard 12 – Valonia Street); vehicles accessing road construction and removing spoil.

- **Other:** concrete batching (Yard 10 – Alan Wood Reserve) and rock crushing (Yard 11 – Hendon Park)); spoil removal from the driven tunnels.

Sensitive receptors: residential properties along Hendon Avenue, Methuen Road and Valonia Street; Christ the King School; Avondale Motor Park. (refer Figure 12.5).

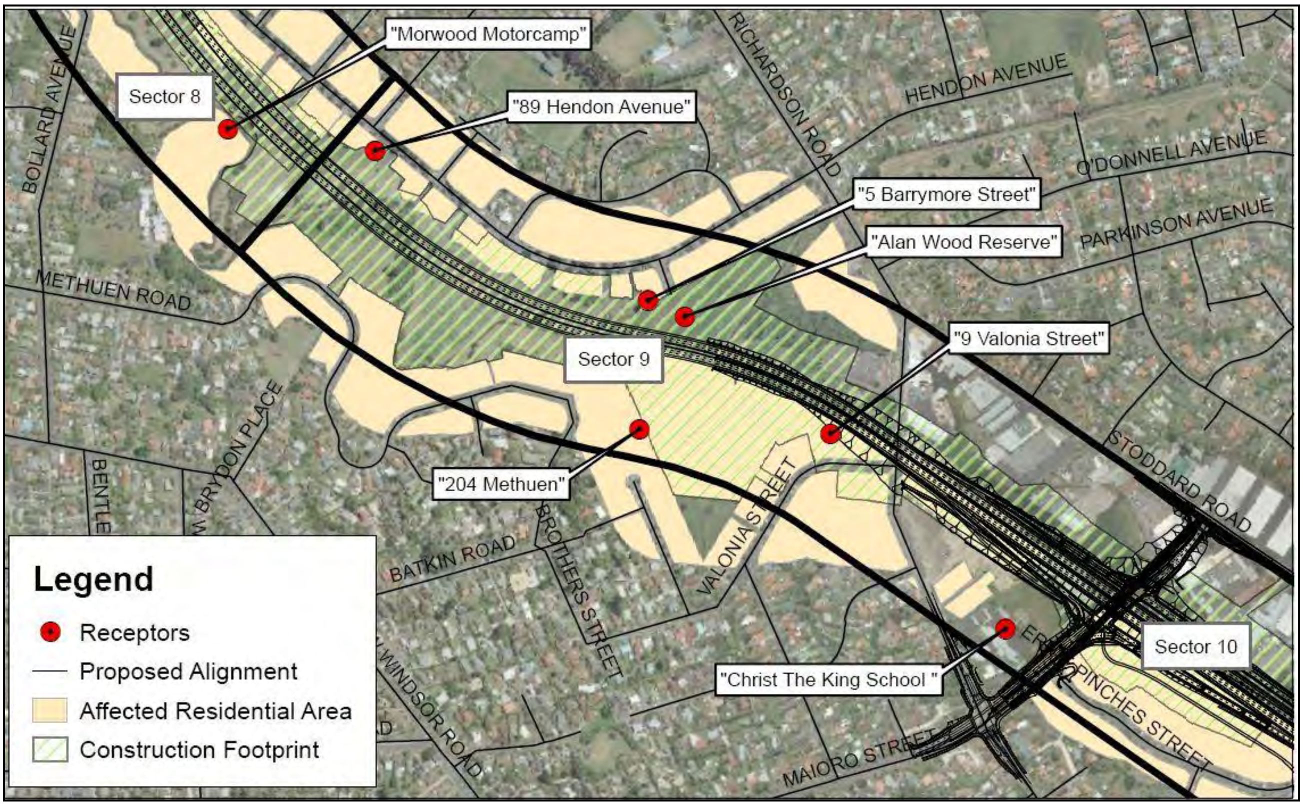

Figure 12.5 - Sensitive Receptors in Sector 9

12.6 Dust Monitoring

A dust monitoring programme should be implemented during the construction and earthworks phases of the development.

The objective of this programme would be to identify conditions where dust nuisance may occur and to assess whether the mitigation and control measures implemented through the CAQMP are effective in minimising dust emissions.

The recommended method for monitoring deposited dust is the use of bucket deposition gauges, while TSP can be monitored by gravimetric samplers or continuous analysers. Although a trigger level for deposited dust is included in both the MfE Dust GPG (MfE, 2004) and TP152 (ARC, 2002), the ARC's guidance given in TP152 does not generally recommend trigger levels except for vegetation monitoring. As any measurements are averaged over 30 days, it is difficult to distinguish the contribution of various sources over the long sampling period (ARC, 2002). Rather than using deposition gauges (and in addition to regular visual, monitoring of potentially dusty activities), it is proposed that dust discharges from operational areas of the site are monitored using continuous particulate monitors (e.g. particulate monitors fitted with a TSP inlet, coupled with continuous wind speed, wind direction and temperature monitors.)

Visual and instrumental monitoring alone will not be sufficient to affectively and adequately mitigate the effects of dust discharges from the construction sites; rather, they should be seen as part of a package, along with good management practices. Visual and instrumental monitoring are tools to inform the management of dust emissions from the construction sites, with site management practices both reacting to observations of increased discharges and being proactively updated to prevent such discharges in the future.

12.6.1 Instrumental Monitoring

The locations of the monitoring sites will depend on the scale of the construction activity in the area, the expected duration of the activity, the sensitivity of the surrounding areas and the availability of suitable monitoring sites. However, given the overall scale and duration of the Project, continuous TSP monitoring will be needed at a number of locations (although it is envisaged that some monitors may be moved as construction progresses). In those areas where the construction activity has a high potential to generate dust and where sensitive locations are nearby, the proposed monitoring locations are as follows:

- Sector 1. McCormick Green and/or the Vector substation at 28A Royal View Road.
- Sectors 2, 3 and 4. None
- Sectors 5 and 7. St Francis School and Waterview School.
- Sectors 6 and 8 None
- Sector 9. Alan Wood Reserve in the vicinity of 108 Methuen Road and Hendon Park between contractors' yards 11 and 12.

A real-time TSP monitor should be located at each of the above (approximate) locations. A meteorological station which measures wind direction, wind speed and temperature is to be located alongside one of the real time TSP monitors in each of Sectors 1, 5 and 9.

The locations selected for the TSP and meteorological monitoring sites should be selected as far as is practicable to comply with the requirements of:

- AS/NZ 3580.1.1:2007 Method for Sampling and Analysis of Ambient Air – Guide to Siting Air Monitoring Equipment; and
- AS 2923:1987 Ambient Air – Guide for the Measurement of Horizontal Wind for Air Quality Applications.

The monitoring system(s) selected must be capable of meeting the following minimum requirements:

- TSP monitors should be able to produce a near continuous measurement of TSP concentrations and be able to calculate 1 hour and 24 hour average concentrations.
- The outputs from the TSP monitors and the meteorological stations must be able to be monitored remotely by the Project Manager and the Environmental Manager for the lead contractor(s), and be set to produce an alarm when trigger values are approached. Alarms should activate a pager or cell phone.
- Outputs from the monitors shall be continuously recorded.

12.6.2 Visual Monitoring

Full details of proposed monitoring methods and frequencies are given in the CAQMP. In addition to the instrumental monitoring referred to above, this will include: visual inspection of operation sites and surrounding areas for evidence of dust discharges; regular inspection of operational areas for dampness and amount of exposed surface area and regular inspection of stockpiles; maintenance and inspection of water spray systems and windbreak fences. In addition to these, procedures will be in place for responding to complaints.

12.7 Discharges of Odour

Sector 8 of the Project's proposed alignment passes underneath Phyllis Street Reserve, while Sector 9 runs through Alan Wood Reserve. Both of these Reserves are closed landfill sites.

One aspect of road construction that is likely to cause discharges of odour is the application of bitumen to form the road surface. However, this is a normal activity that is routinely part of road maintenance undertaken across the Auckland region and will be of relatively short duration in any specific location.

12.7.1 Sector 8

The landfill under Phyllis Street Reserve, although closed in the 1980's, is still actively generating landfill gas (ACC, 2009). This implies that this landfill still contains putrefying organic matter which, if disturbed, can generate highly odorous discharges. However, the proposed vertical alignment of the driven tunnel through this area will take it below the level of the landfill, thus avoiding the risk of disturbance of potentially odorous material in this area.

12.7.2 Sectors 8/9

The closed landfill under Alan Wood Reserve was largely a cleanfill. However, a small area immediately to the northeast of the Avondale Motor Park, in the vicinity of the proposed southern portal, has been identified as containing household waste (MWH, 2009). Because construction activities for the Project will disturb this area of putrescible waste, discharges of odour in this area are possible. However, it is not possible to quantify the level of discharge.

Residential areas lie along both sides of this part of Sectors 8 and 9, with Hendon Avenue to the northeast and Methuen Road to the southwest. The closest receptor that is likely to be sensitive to discharges of odour is the Avondale Motor Park, approximately 50m to the west. Residential properties along the southern side of Hendon Avenue are approximately 80m north of this area, while the Odyssey House School and residential properties on Methuen Road are approximately 150m to the southwest and south respectively.

Because of the likelihood of putrescible material being disturbed in this area, there is a potential for discharges of odour that may affect nearby properties. Measures to mitigate the effects of such discharges would include: temporary cessation of earthworks activities in the event that they disturb odorous material and temporary covering of the exposed material; use of odour suppressant sprays; and management of any excavations in such a way that odorous material is removed from the site as quickly as possible once exposed. Through the use of these mitigation methods, it is considered that any adverse effects from such discharges can be adequately mitigated.

12.8 Vehicle Exhaust Emissions from Construction Traffic

The discharge of engine exhaust emissions from construction vehicle is a permitted activity under Rule 4.5.3 of the PARP: ALW, which states:

> *The discharge of contaminants into air created by motor vehicle, aircraft, train, vessel and lawnmower engines including those located on industrial or trade premises is a Permitted Activity.*

In relation to consideration of applications, Section 104(2) of the RMA states:

> *When forming an opinion for the purposes of subsection (1)(a), a consent authority may disregard an adverse effect of the activity on the environment if a national environmental standard or the plan permits an activity with that effect.*

Therefore, no formal consideration need be given to the effects of vehicle exhaust emissions from construction traffic. The following commentary and recommendations are given for information purposes only.

Excessive smoke and odour from diesel-fuelled trucks, generators and other machinery is primarily caused by poor engine maintenance. Failure to maintain air filters, fuel filters, and fuel injectors to manufacturer's specifications may cause excessive black smoke and objectionable odour.

Excessive smoke and odour discharges from trucks, earth moving machinery and generators, while unlikely, could cause comments from neighbours under adverse meteorological conditions if vehicles and machinery are not well maintained. Contractors should be required, e.g. through contract conditions, to keep trucks and machinery used on-site appropriately maintained. Although it may be desirable to require contractors to only use, machinery that meets specific emissions standards (e.g. Euro 3 or Euro 4), in practice this is likely to be unrealistic given the scale and duration of the Project.

Factors considered in the selection of haulage routes for construction traffic include the minimisation of the effects of truck exhaust emissions and noise on surrounding sensitive areas. Because most of the Project is immediately accessible from the existing motorway network, this will be the preferred route wherever possible. Within Sector 7 (the cut-and-cover section of tunnel), direct access to the motorway is not possible, and traffic will need to travel over a relatively short section of Great North Road (a regional arterial road) to reach SH16.

12.9 Summary

A draft Construction Air Quality Management Plan (CAQMP) has been prepared, which is designed to form the basis for specific management plans to be prepared by contractors. Once finalised, this CAQMP and the specific management plans prepared by contractors will detail methods to be used to mitigate discharges of contaminants into air from the construction of the Project.

Due to the close proximity of sensitive receptors, including residential premises and childcare facilities, to the proposed construction footprint for the Project, a high standard of emissions control and management will be employed to adequately avoid or mitigate the effects of discharges of construction dust.

An extensive dust monitoring programme is proposed, utilising regular visual monitoring in all areas, continuous monitoring of TSP at a number of locations, continuous meteorological monitoring at three locations and prompt responses to complaints from the public and regulatory authorities. The aim of this monitoring programme is to assist the control and management of discharges of construction dust from the Project.

There is the potential for discharges of odour during excavations through the former Alan Wood landfill. It is not possible to predict the timing or extent of discharges of odour from this source; therefore, the CEMP will address measures to be put into effect when odorous material is disturbed.

Contractors will be required to carry out appropriate maintenance on construction machinery to minimise discharges of vehicle exhaust emissions.

Through the use of appropriate emissions control and good on-site management, adverse effects that may otherwise be caused by discharges of contaminants into air from the construction of the Project will be adequately avoided or mitigated.

13. Effects Assessment – Concrete Batching and Rock Crushing

This section of the report specifically considers the potential impacts of discharges of contaminants into air from concrete batching and rock crushing, primarily focussing on methods to mitigate those potential effects.

13.1 Introduction to Concrete Batching and Rock Crushing

The construction of the Project will necessitate the pouring of large quantities of concrete, especially for the tunnel linings. It will also involve excavation through a significant intrusion of basalt at the southern portal. In order to facilitate the overall management of the project, it is proposed to locate two temporary concrete batching plants in contractors' yards, one at each end of the proposed tunnel, and a primary rock crushing plant in the vicinity of the southern portal.

Resource consent is being sought for the discharge of contaminants into air (i.e. dust,) from concrete batching and rock crushing under Rules 4.5.54 and 4.5.55 respectively of the PARP: ALW, which state:

4.5.54 The discharge of contaminants into air, through a bag filter system, from

> *(b) The mixing of cement powder with other materials to manufacture concrete or concrete products at a rate exceeding a total production capacity of 110 tonnes per day is a Restricted Discretionary Activity.*

4.5.55 The discharge of contaminants into air from the temporary crushing of concrete, masonry products, minerals, ores and/or aggregates with a mobile crusher at a rate not exceeding a total on-site capacity of 60 tonnes per hour that does not comply with Rule 4.5.48 or at a rate exceeding a total on-site capacity of 60 tonnes per hour is a Restricted Discretionary Activity.

The following sections of this report aim to demonstrate how discharges of dust from concrete batching and rock crushing associated with the construction of the Project will be managed. In parallel with this assessment, recommended mitigation and monitoring measures have been detailed in a draft Concrete Batching and Rock Crushing Plant Management Plan (CBRCPMP), which will form part of a Construction Environmental Plan (CEMP) for the Project. A copy of the draft CBRCPMP is attached at APPENDIX N.

In line with the general assessment of dust discharges from the construction of the Project, (refer Section 12), no attempt has been made to undertake a quantitative assessment of dust discharges from either concrete batching or rock crushing.

13.2 Activity Description

The following process descriptions are generic, since neither the proposed concrete batching plants nor the proposed rock crusher have yet been specified in any detail.

13.2.1 Concrete Batching

The manufacture of concrete involves mixing, in carefully controlled proportions, Portland cement or a mixture of cementitious materials (cement) in powder form, together with coarse and fine aggregates (gravel, crushed stone and sand), and water. The proportions chosen are determined by the performance or composition necessary to meet the specification or performance requirements. Small amounts of admixtures may be included to modify the properties of the mix.

Aggregates will be transported to the site via truck and trailer and unloaded into ground storage bays. Aggregate from ground storage bays will be transferred into a receiving hopper by front end loader, and then into a weigh hopper by belt conveyors and enclosed gravity feed. Aggregate is then transferred from the weigh hopper to the mixing drum by belt conveyor.

Cement will be delivered to site in bulk tankers, and transferred into fully enclosed silo(s) by compressed air feed. Displaced air from each silo is vented to air via a bagfilter unit mounted on top of the silo. Cement is transferred from silo(s) to an enclosed cement weigh hopper and then to the mixing drum by enclosed gravity feed and enclosed screw conveyor. Displaced air from the cement weigh hopper is vented to atmosphere via a sock filter.

Cement, aggregates and water are loaded together into a mixing drum. Once a slurry has been formed to the correct proportions, this will be emptied either into the drum of a truckmixer unit for use anywhere within the project or possibly into the feed hopper for a concrete pump for transfer directly to the tunnel.

The intention is to use a mobile (truck-mounted) concrete batching plant for the Project, coupled with portable cement storage silos and ground storage bays. Each of the proposed concrete batching plants will be designed to manufacture up to 30 m^3/hr of concrete, with a maximum production rate of 320 m^3/day.

13.2.2 Rock Crushing

A significant intrusion of basalt has been identified close to the southern tunnel portal (Sector 8), which will require drilling and blasting to allow excavation of the route. The intention is to utilise this basalt in other parts of the Project - e.g. widening of the SH16 causeway (Sector 4). For this purpose, primary crushing of rocks from the excavation will be required, using a ‘jaw crusher’, which utilises a stationary steel jaw working with a moving jaw to crush and pulverise material.

Rock will be transferred from the excavation site to the crusher by truck. Crushed rock will be removed from the crusher by belt conveyor and may be screened into different size grades. These may either be loaded directly into truck and trailer units, or temporarily stockpiled prior to removal from the site.

The crushing capacity of the proposed crushing plant has yet to be determined. In general, the higher the capacity, the less time the crusher will be required to operate each day. However, as discussed in Sections 13.4 and 13.5 of this report, due to the planned location of the crusher within a building, its size or crushing capacity will have little bearing on discharges into air.

It is anticipated that the rock crusher will be operated for approximately six months during the early stages of the Project. Once the basalt intrusion near the southern tunnel portal has been removed, there will be no further requirement for rock crushing within the Project footprint.

13.3 Location

The batching plants will be located in contractors' yard 6 (Waterview Park) and 10 (Alan Wood Reserve), close to the northern and southern ends of the tunnel (i.e. in Sectors 5 and 9). The rock crusher will be located in Hendon Park, close to the proposed alignment of the SH20 (Sector 9).

13.3.1 Sector 5

The concrete batching plant for the northern portal will be located toward the northeastern corner of contractor's yard 6, affording the maximum possible separation (at least 80m) from residential and other sensitive receptors. This is illustrated in Figure 13.1.

The Mason Clinic is located approximately 80m to the east of the planned site of the batching plant in Contractors' Yard 6, while the residential activities on Waterbank Crescent are located approximately 80-100m to the west and southwest. Waterview School is located approximately 150m to the south of the site.

Contractors' Yard 6 is within the proposed designation for the Project. Surrounding land uses to the East, South and West are largely residential or educational, while the SH16 lies to the north. The site and all surrounding areas are located within an Urban Air Quality Management Area under the Proposed Auckland Regional Plan: Air, Land and Water (PARP: ALW).

13.3.2 Sector 9

The concrete batching plant for the southern portal will occupy most of contractor's yard 10. This affords approximately 30m separation from residential activities. This is illustrated in Figure 13.2.

The proposed location for the batching plant in contractor's yard 10 is within 30-40m of residential activities on Methuen Road (to the southeast and southwest of the site) and approximately 80m from houses on Hendon Avenue (to the north).

Contractors' Yard 10 is within the proposed designation for the Project. Surrounding land uses are residential. The site and all surrounding areas are located within an Urban Air Quality Management Area under the Proposed Auckland Regional Plan: Air, Land and Water (PARP: ALW).

Operationally, the preferred location for the rock crushing plant would be within the cut for the southern tunnel portal. However, the lack of space in this area and its proximity to residential housing renders this location impracticable. Therefore, the proposed crushing plant will be located toward the eastern end of Hendon Park, within the proposed designation (i.e. in Sector 9), although the precise location has not yet been confirmed.

The proposed location for the crusher is indicated in Figure 13.3, within the proposed alignment of SH20, adjacent to the southern boundary of Contractors' Yard 11. This location provides about 90m separation from residential activities on Hendon Avenue.

Most of Hendon Park is within the proposed designation for the Project. Surrounding land uses are residential. The site and all surrounding areas are located within an Urban Air Quality Management Area under the Proposed Auckland Regional Plan: Air, Land and Water (PARP: ALW).

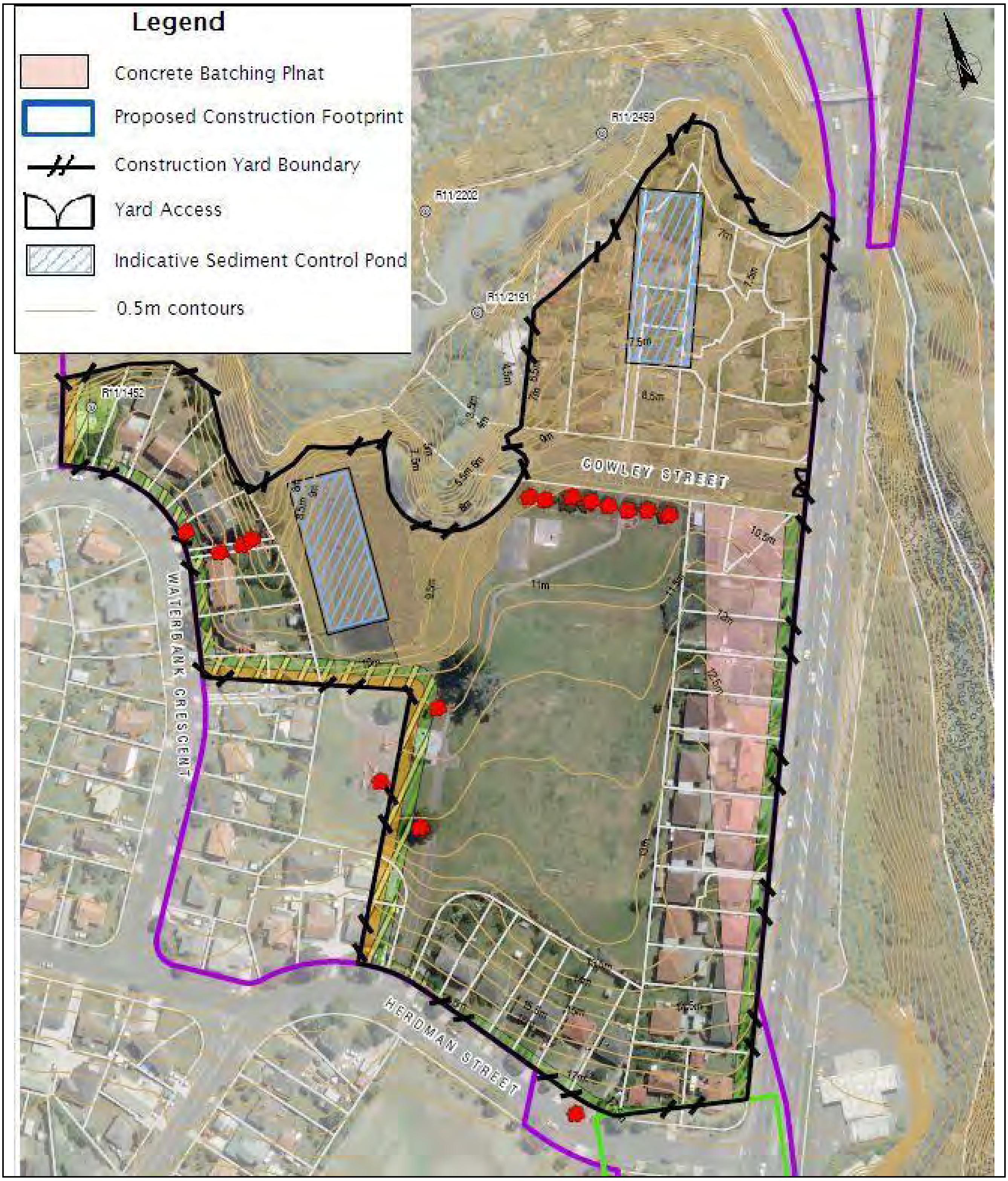

Figure 13.1 - Contractors' Yard 6

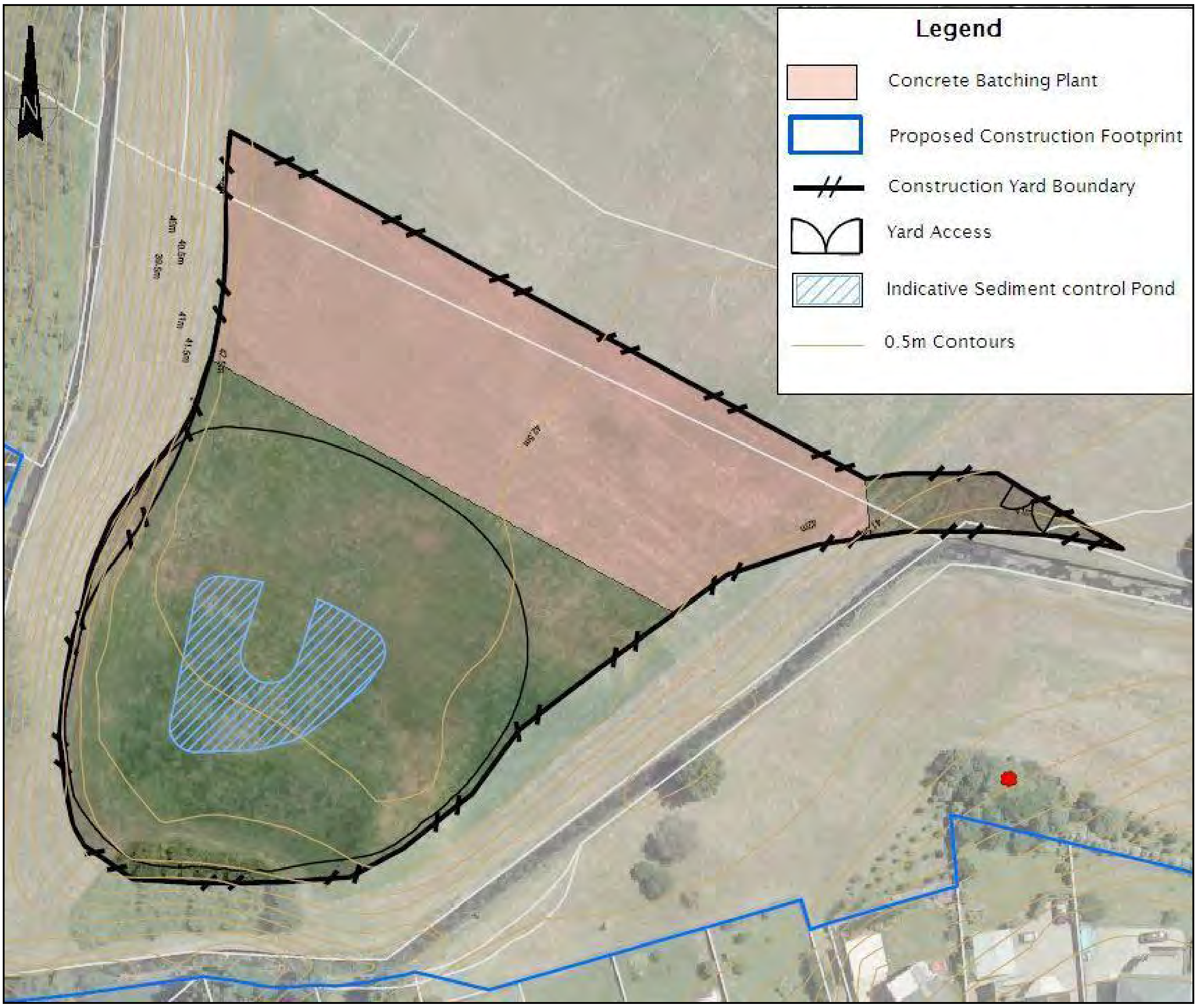

Figure 13.2 - Contractors' Yard 10

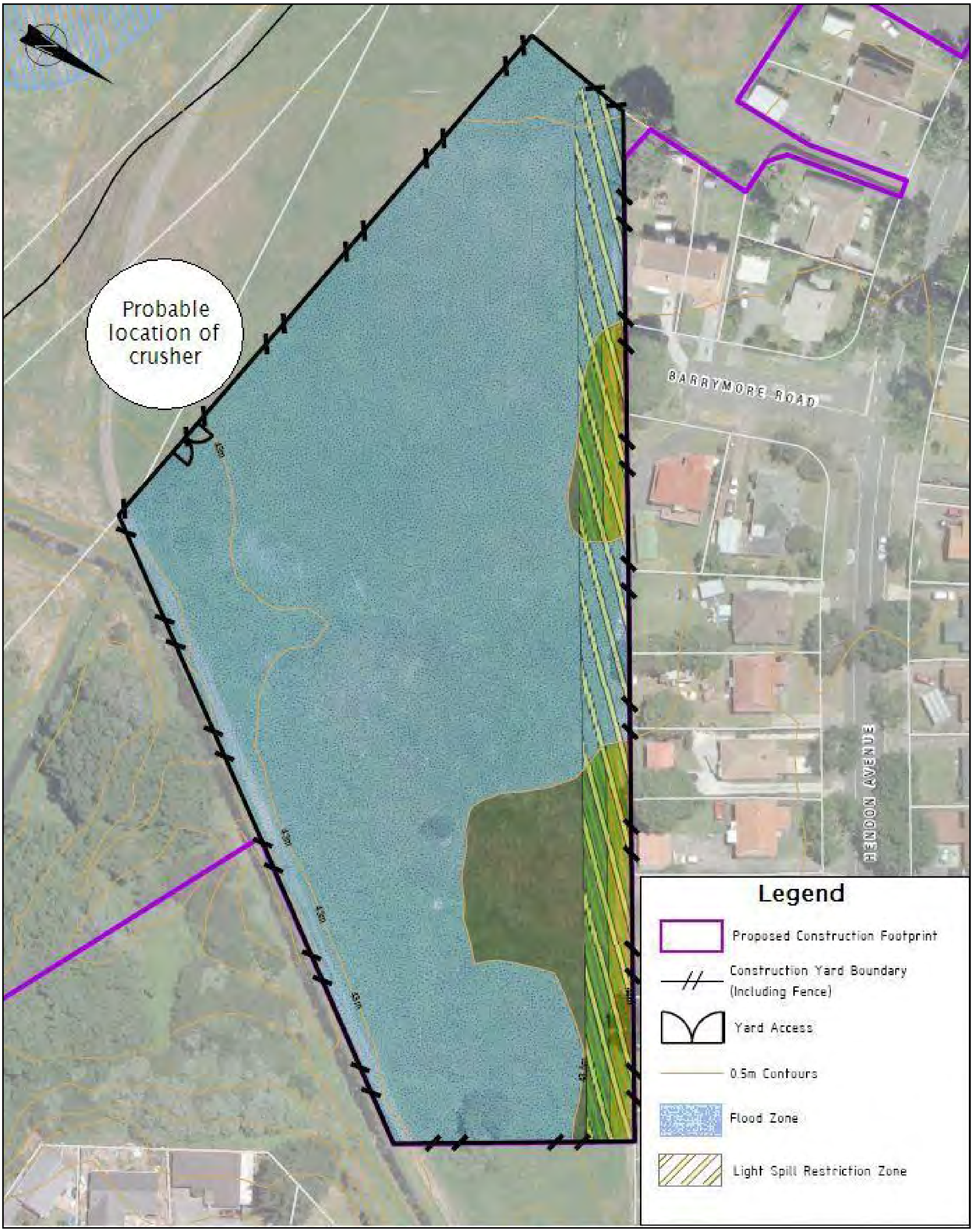

Figure 13.3 - Contractors' Yard 11

13.4 Discharges into Air and Emissions Controls

13.4.1 Concrete Batching

General

Discharges into air from concrete batching include dust from aggregates and cement powder. Almost all of this material falls into larger particle sizes, generally with an aerodynamic diameter greater than 30-50μm.

Aggregate dust is usually inert, only causing nuisance (amenity) effects. However, cement dust is basically calcium oxide (CaO), which is highly alkaline when dissolved in water and can be corrosive to skin.

The main sources of aggregate dust are the storage and handling of dry, fine aggregates (e.g. sand and PAP). Effective emissions control can be achieved by partial enclosure of load hoppers, conveyors and storage bays (to minimise wind entrainment of dusty material), and the use of water sprays and regular sweeping of sealed yard areas.

Discharges of cement dust into air can be avoided through enclosed transport, storage and handling. Good practice for cement handling includes venting of displaced air via filter units.

Dust filter units fitted to cement silos will be designed to comply with the relevant performance requirements of TP152 (ARC, 2002), as summarised in Table 13.1.

Table 13.1 - Standard Design Requirements for Dust Filter Units (from TP152)

Parameter	Filter Application			
	Cement Silo		Weigh Hopper	Mixing Drum
Type	Pulse Jet	Other Types	Sock	Pulse Jet
Design Particulate Discharge Limit	30 mg/m^3	30 mg/m^3	30 mg/m^3	30 mg/m^3
Collection Efficiency	99.9%	99.9%	90%	99.9%
Maximum air to Cloth Ratio	3.0 m^3/m^2/min	1.0 m^3/m^2/min	1.0 m^3/m^2/min	3.0 m^3/m^2/min
Monitoring	Visual	Visual	Visual	Continuous monitoring of pressure drop

Cement silos will also be fitted with pressure relief valves (to avoid over-pressurisation) and high fill alarms. The seating of pressure relief valves and operation of these alarms needs to be checked regularly.

Displaced air from the cement weigh hoppers and from the fill point of mixing drums may either be vented back into the cement silos of discharged into air via filter units. If filters are used on cement weigh hoppers, they will be designed to comply with the relevant performance requirements of TP152 (ARC, 2002), summarised in Table 13.1.

Sector 5 – Contractors' Yard 6

Ground level storage bays will be enclosed on three sides, with the fill level in each bay kept at least 0.5m below the height of the sides and rear of the bays. Windbreak netting should be fitted to a height at least 1m above the rear and outer side walls of the ground storage bays. Water sprays will be used at regular intervals to maintain aggregate stored in these bays in a damp condition.

Hard surfaced areas of the batching plant will be vacuum swept at least twice each week. All areas used for vehicle movement will be maintained visibly damp by the use of water sprays or a water cart.

Belt conveyors will be fitted with water sprays to minimise wind entrainment of dust.

Cement will be delivered to site in enclosed bulk tankers and pumped into silos using compressed air. All handling of cement powder within the batching plant will be fully enclosed, with displaced air being vented via filter units as required.

Displaced air from the silo(s) will be vented via bagfilter unit(s), while that from cement weigh hopper and the mixing drum will either be vented back into the cement silo or to air via bagfilter units as described earlier in this Section.

Sector 9 – Contractors' Yard 10

Due to the proximity of the concrete plant to be located in contractor's yard 10 to residential activities, wet methods of dust suppression will have to be very carefully managed to avoid causing dust nuisance in those residential areas. The preferred method of controlling dust from aggregate storage would be to store aggregate in covered bins, minimising the amount of handling required. However, given the temporary nature of the plant, this may not be practicable. If covered aggregate bins are used, aggregate trucks should be able to unload directly into a receiving hopper, from which material will be transferred directly to the bins and from the bins to the batching plant by belt conveyors. Water sprays around the receiving hopper and on the conveyors will further minimise discharges of dust from this source.

Hard surfaced areas of the batching plant will be vacuum swept at least twice each week. All areas used for vehicle movement will be maintained visibly damp by the use of water sprays or a water cart.

Belt conveyors used to transfer aggregate from a receiving hopper into storage bins and from the bins to the batching plant will be enclosed on one side and above. All other belt conveyors will either be enclosed or will be fitted with water sprays to minimise wind entrainment of dust.

Cement will be delivered to site in enclosed bulk tankers and pumped into silos using compressed air. All handling of cement powder within the batching plant will be fully enclosed, with displaced air being vented via filter units as required.

Displaced air from the silo(s) will be vented via bagfilter unit(s), while that from the cement weigh hopper and air extracted from the mixing drum will either be vented back into the cement silo or to air via bagfilter units as described earlier in this Section.

13.4.2 Rock Crushing

The main discharge into air from rock crushing is dust. Most of this material falls into larger particle sizes, generally with an aerodynamic diameter greater than 30-50μm. Dust from crushing of basalt is usually inert, only causing nuisance (amenity) effects.

In order to mitigate noise from the crusher, it will have to be located within an acoustic enclosure. In this location, effective dust control will be achieved through air extraction to one or more bag filter units. These will be designed to discharge within the building, while the acoustic building enclosure will effectively minimise the discharge of fugitive dust.

Water sprays will be fitted at the end of the conveyor from the crusher, to minimise discharges of dust at the transfer point. If the crushed rock is then screened into different size fractions, water sprays will be fitted to the ends of each screen conveyor.

Fugitive dust

Similar controls on fugitive dust will be applied to concrete batching as to other operating areas of the contractors' yards, including the use of water on stockpiles and areas used for vehicle movement (fixed water sprays or water trucks) and windbreak fencing along site boundaries. Windbreak fencing will in particular be fitted along boundaries with residential areas.

13.5 Assessment of Effects

13.5.1 Overview

Buffer Distance

There is no New Zealand guidance on buffer or separation distances between activities that discharge contaminants into air and potentially sensitive receptors. In lieu of this, reference is often made to guidance published by the Environmental Protection Authorities of Victoria (Vic EPA, 1996) and South Australia (South Aus EPA, 2007).

The South Aus EPA recommends a separation distance of 100m for concrete batching and 500m for the crushing, grinding or milling of rocks, while the Vic EPA recommends a separation distance of 100m for concrete batching. In all cases, these separation distances are designed to minimise the likelihood of complaints regarding dust discharges, and assume a good level of emissions control and site management. Where separation distances are smaller than this, a higher level of emissions control is generally required.

Health Effects

PM_{10} particulate has the potential to cause a range of health effects, including increased morbidity and mortality; there are no apparent threshold concentrations for those health effects.

Both concrete batching and rock crushing have the potential to discharge PM_{10}. In practice, most of the material used on site has a considerably larger particle size – cement dust typically has an aerodynamic diameter of in the range 30µm to 50µm, while sand and aggregates and primary crushed rock are larger still. However, all such materials may include a fraction of PM_{10}, especially where subject to repeated abrasion, such as on roadways.

Due to the difficulty in quantifying releases of PM_{10}, no attempt has been made to assess the potential health effects of PM_{10} discharges from the site. Instead, the focus is on ensuring that effective emissions control is in place to prevent adverse health effects.

Bulk cement will be transported, handled and stored in fully enclosed systems with any displaced air being discharged via bag filter units. All bulk deliveries of cement will be made during operating hours, so that site staff can oversee the delivery.

The bagfilter units to be installed on the cement silos will be designed to current best practice, as set out in TP152 (ARC, 2002). Dust collected in the filter units will discharge by gravity back into the silo. Any spills which do occur will be cleaned up as soon as detected by sweeping or vacuuming.

Amenity Effects

Dust particles larger than about 20-30µm in aerodynamic diameter have the potential to cause localised ‘dust nuisance’ – e.g. soiling of surfaces.

Both concrete batching and rock crushing have the potential to generate fugitive discharges of dust. However, as for PM_{10}, due to the difficulty in quantifying releases of dust, the focus of this assessment is on the effectiveness of measures to control such releases.

As previously stated, all aggregate will either be stored damp or in enclosed bins and conveyors will be partially enclosed. In common with the remainder of the contractors’ yards where the batching plant and crushers will be located, vehicle access areas will be either sealed or metalled and water sprays will be used to minimise dust emissions from vehicle movements.

13.5.2 Sector 5

Potential health effects have been considered in Section 13.5.1 of this report.

The proposed separation distances (80-100m) between the concrete batching plant and sensitive activities, coupled with effective site management and emissions controls, should be sufficient to avoid adverse effects on amenity values in this area.

13.5.3 Sector 9

Potential health effects have been considered in Section 13.5.1 of this memorandum.

The separation distance between residential activities and the proposed location of the concrete batching plant in contractor's yard 10 (approximately 30-40m) is insufficient on its own to avoid effects on amenity values caused by discharges of dust from the plant. However, with the high degree of containment and effective site management that will be put in place, these effects will be appropriately mitigated.

The proposed separation distance (over 100m) between the rock crusher and sensitive activities is considerably smaller than that recommended by the South Aus EPA. However, it is only primary crushing of rock that is proposed on site (i.e. reduction from boulders of several tonnes in weight to rocks of several tens of kilogrammes), with no further grinding or milling. This, coupled with a high degree of emissions control (through wet suppression and enclosure of the crusher), should be sufficient to avoid adverse effects on amenity values in this area.

13.6 Monitoring

Visual monitoring of discharges from cement silos will be undertaken during every delivery of bulk cement to the site that occurs in daylight. High fill monitors fitted to each cement silo will be operating during every delivery of bulk cement, linked to audible and visual alarms. Procedures will be in place requiring tanker drivers to cease unloading into a silo in the event that the high fill alarm for that silo is triggered.

Tanker drivers will be required to monitor hoses and connections between the tanker and silo for leaks during the unloading of bulk cement.

The seating of pressure relief valves will be checked at least once each week and whenever they are operated. The operation of high fill alarms will be checked at least once every six months as part of normal maintenance of the batching plant.

Visual monitoring of discharges from cement batching plant will be undertaken at least once each day.

Filter units fitted to silos, cement weight hoppers and mixer drums will be inspected at least once a month, in accordance with manufacturers' instructions. Filter media will be replaced at least once each year.

The operation of water sprays will be checked at least once each day.

13.7 Alternatives

Section 105 of the RMA requires consideration of alternative means of discharge, including discharge into other media.

13.7.1 Filter Systems

Bag filter systems, in particular pulse-jet bag filters, represent international best practice for the control of emissions from the handling and batching of bulk cement. Therefore, alternatives to bag filter systems need not be considered for discharges of air displaced from cement silos and extracted from mixing drums or load out points.

Volumes of air displaced from cement weigh hoppers tend to be small. The filter also has to readily allow air to enter the weigh hopper (as it is emptied). The repeated filling and emptying provides an effective means of filter cleaning, meaning that the complexity of a mechanical or pulse jet cleaning system is unnecessary.

13.7.2 Wet Suppression

The use of water sprays to minimise dust discharges from the storage, handling and processing of aggregates is recognised as an effective means of control. The only effective alternative would be to fully enclose the concrete batching plant (as is proposed for the crusher).

The use of water sprays and windbreak fencing, in conjunction with good site management, has proven to be effective in controlling fugitive dust from concrete batching plant located in relatively close proximity to sensitive receptors elsewhere in Auckland, notably the Atlas Concrete sites in Takapuna and Panmure. The history of these sites also demonstrates the need for this to be well managed – both sites were the subject of a number of dust complaints before effective wet dust suppression was installed.

Given that the two batching plant will be temporary installations for the purposes of a construction project (albeit a major one) and wet suppression is a proven method of dust control, the cost of constructing temporary buildings to house the entire batching plant in either yard is not justifiable.

13.7.3 Location

Concrete Batching Plant

Consideration has been given to obtaining concrete from existing batching plant elsewhere in Auckland. For example, there are two existing concrete batching plant located in the Rosebank Road industrial area and one on Roscommon Road in Wiri, all of which have ready access to the motorway network. However, an operational requirement of the Project is to have concrete available on demand, 24 hours per day, seven days a week, for construction of the tunnel lining. Realistically, this can only be achieved through having a concrete batching plant on site.

In addition to the operational benefit of locating concrete batching plant in close proximity to the tunnel portals, this also contributes to health and safety on site. Because truck mixers will have to enter the driven tunnel workings to deliver concrete to the working face, it would be preferable that their drivers are under the direct control of the site management.

An additional benefit of locating both batching plant on site is a reduction in vehicle movements, avoiding multiple journeys by truck mixers between either Rosedale or Wiri and the tunnel portals.

Rock Crusher

As stated in Section 13.2.2, the intention is to use rock removed from the basalt intrusion at the southern tunnel portal for widening of the SH16 causeway. The most practicable way of dong this is to crush that rock as close to source as possible. Rocks extracted by blasting from the basalt intrusion will each be over a metre across and weigh several tonnes. Rocks this size are difficult to handle and cannot be loaded efficiently onto trucks, thereby requiring more truck movements than if the rock is first crushed to more manageable proportions.

There are existing quarries in Three Kings and Wiri, with easy access to SH20 south of the Project area. Although these have existing air discharge consents, those consents do not allow them to crush material received from elsewhere. The closest of these quarries (Three Kings) is relatively close to the southern tunnel portal, but is immediately adjacent to residential areas. Given the history of that site, it is unlikely that consent would be granted for basalt to be brought onto site for crushing. Although this same constraint (residential neighbours) does not apply to quarries in Wiri (e.g. Weddings Quarry on McLaughlin's Road), these are located approximately 20km from the southern tunnel portal, considerably increasing the environmental impact from truck movements.

13.8 Summary

The construction programme for the Project requires that concrete batching and rock crushing plant be located very close to the tunnel portals.

Mobile concrete batching plant are to be located in Contractors' Yards 6 (Sector 5) and 10 (Sector 9), close to the northern and southern portals respectively. A primary rock crusher is to be located within Hendon Park, close to the proposed alignment of SH20 in Sector 9.

The crusher will be fully enclosed, with any air extraction ducted to bagfilter units that will discharge within the building. Water sprays will be used to minimise dust discharges from the handling of aggregate and crushed rock. Cement powder will be stored within fully enclosed silos; all transfers of cement into or out of silos will be by pneumatic conveyance, enclosed gravity feed or enclosed screw conveyor. Air displaced during the handling of cement or during concrete batching will be discharged to atmosphere via bagfilter units.

Through the use of appropriate emissions control and good on-site management, adverse effects that may otherwise be caused by discharges of dust from concrete batching or rock crushing will be adequately avoided or mitigated.

Recommended mitigation and monitoring measures have been detailed in a draft Concrete Batching and Rock Crushing Plant Management Plan (CBRCPMP), which will form part of a Construction Environmental Plan (CEMP) for the Project. A copy of the draft CBRCPMP is attached at APPENDIX N.

14. Summary and Conclusions

14.1 Overview

This report has assessed the effects on air quality of the proposed Project. Dispersion modelling has been used as the primary tool to quantitatively assess pollutant concentrations in the study area.

Vehicle-related contaminants are one of the main sources of air pollution – and thus of adverse effects on human health – across metropolitan Auckland generally and also within the area affected by the Project.

This report has assessed the effects of Project on all members of the community; particularly those considered to represent the most vulnerable (e.g. school children and the elderly or infirm).

14.2 Statutory Requirements

This report was prepared in support of the notice of requirement and applications for resource consents for the Project for the designation of the Western Ring Route; Waterview Connection, and is one of a number of technical reports that supplement the overall Assessment of Environmental Effects.

Discharges of contaminants into air from motor vehicles are specifically permitted under the Proposed Auckland Regional Plan: Air Land and Water. However, resource consent is required for the discharge of contaminants into air from the construction of the Project – both from an overall consideration and specifically from the operation of a concrete batching and rock crushing plant.

14.3 Assessment Process

Five different scenarios were considered in this assessment, representing:

- the current situation (2006 Base Year)
- the projected year of opening (2016 "Do Nothing" and "With Project")
- ten years after opening (2016 "Do Nothing" and "With Project").

The "With Project" and "Do Nothing" scenarios respectively represent the situation with or without the completion of the Western Ring Route, although both scenarios assume that all other major roading projects planned for the Auckland region have been completed.

Emission rates for the various pollutants were estimated from the results of the traffic modelling, using the Vehicle Emissions Prediction Model. Atmospheric dispersion modelling was undertaken for vehicle related emissions from surface roads in all five scenarios and via tunnel ventilation stacks for both With Project scenarios. The results of this modelling have been added to estimated background concentrations and then compared to relevant air quality standards and guidelines.

Air quality impacts from construction activities, including the operation of concrete batching and rock crushing have been assessed and the proposed mitigation measures and monitoring are described in the draft Construcion Air Quality Management Plan (CAQMP).

14.4 Discussion

People living, working or spending time (e.g. at school or in reserves) close to most of the existing busy arterial routes through the Project area are predicted to have a reduced exposure to vehicle related contaminants as a result of the Project, than would occur without the Project.

Some locations are predicted to slightly increase the exposure to vehicle related contaminants for people living, working or spending time in the Project area above the “Do Nothing” scenario (i.e. without the Project), due to the southern surface portion of SH20 south of the tunnels and increased flows on the existing section of SH20 at Mt Roskill. However, exposure levels are predicted to comply with the AQNES which are designed to protect the health of the most vulnerable individuals in the community.

In terms of regional air quality, the Project is expected to have an insignificant effect on Auckland’s regional air quality, due to improvements in traffic flow through the Project area.

Due to the close proximity of sensitive receptors, including residential premises and childcare facilities, to the proposed construction footprint for the Project, a high standard of dust emissions control and management will be employed to adequately avoid or mitigate the effects of discharges of construction dust.

The construction programme for the Project requires that concrete batching and rock crushing plant be located very close to the tunnel portals. Through the use of appropriate emissions control and good on-site management, adverse effects that may otherwise be caused by discharges of dust from concrete batching or rock crushing will be adequately avoided or mitigated.

14.5 Conclusions

The key conclusions of this report can be summarised as follows:

- Pollutant concentrations in the study area in future years (2016+) arising from motor vehicles would be expected to be similar or better than existing (2006) concentrations. This is the case both “With Project” and “Do Nothing” scenarios (i.e. without the Project).

- The most significant increases in PM_{10} and $PM_{2.5}$ concentrations as a result of the Project occur around the surface section of SH20, between the southern tunnel portal and the Maioro Street/Sandringham Rd interchange. This is because this area currently has relatively minor roads with low traffic volumes in the “Do Nothing” scenario.

- The “With Project” and “Do Nothing” scenarios are predicted to be very similar. That is, regional air quality with the Project may be expected to be similar to air quality without the Project.

- The highest concentrations due to emissions from ventilation stacks are predicted to be much less than concentrations due to nearby busy surface roads (for instance for PM_{10} the peak concentrations due to discharges via the ventilation stacks are less than 0.5% of the AQNES value).

- An analysis of network traffic flow suggests that total regional emissions in the Auckland area would be slightly higher with the Project than without. The differences in emissions are considered to be marginal.

- Contaminant dispersion through use of tall vents (such as is proposed), is considered to be the most efficient way of dispersing vehicle related contaminants from the tunnels. Tunnel ventilation stacks 25m high are sufficient to provide effective dispersion of vehicle emissions.

- The operation of the tunnels is predicted to improve air quality in many parts of the Project area, due to the emissions being taken off local roads and being vented and dispersed higher in the atmosphere. Moving the traffic through tunnels and venting the emissions means better air quality than the same traffic volumes using local roads.

- Particulate matter concentrations arising from non-motor vehicle sources, such as domestic home heating, may continue to result in elevated levels on occasions.

- Air quality monitoring of the operational effects of the Project will be undertaken in order to demonstrate compliance with the relevant in-tunnel air quality standards and ambient air quality standards. This ambient air quality monitoring will be undertaken at two monitoring stations (i.e. one near to each tunnel ventilation station). Ambient air quality will be monitored in real time and will be run continuously for at least 12 months but preferably 24 months, in order to account for inter-annual variability in meteorological conditions.

- An extensive construction dust monitoring programme is proposed, utilising regular visual monitoring in all areas, continuous monitoring of TSP at a number of locations, continuous meteorological monitoring at three locations and procedures for prompt responses to potential complaints from the public and regulatory authorities.

- It is concluded from the report that there would be no significant adverse air quality impacts as a direct result of the Project.

15. References

ACC, 2009. *Closed Landfills Asset Management Plan 2009/2010*. Auckland City Council, 2009.

ARC, 2003. *On Road Remote Sensing of Vehicle Emissions in the Auckland Region*. Auckland Regional Council Technical Publication TP198.

ARC, 2006a. *Auckland Air Emissions Inventory: 2004*. Auckland Regional Council Technical Publication TP292.

ARC, 2006b. *The Ambient Air Quality Monitoring Network in the Auckland Region*. Auckland Regional Council Technical Publication TP296.

ARC, 2008. *Nitrogen Dioxide in Air in the Auckland Region: Passive Sampling Results*. Auckland Regional Council Technical Publication TP 346.

ARC, 2009a. *Proposed Auckland Regional Plan: Air Land and Water updated to reflect decisions on appeals*. Auckland Regional Council, November 2009

ARC, 2009b. *Benzene, 1,3-butadiene and other volatile organic compounds in Auckland*. Auckland Regional Council Technical Publication TR2009/048.

ARC, 2009c. *RLTS 2010 Health Impact Assessment*, Auckland Regional Council Regional Land Transport Strategy Working Report No 13, October 2009

Beca, 2008. *Management of Vehicle Emissions from Road Tunnels*. Report prepared for the NZTA by Beca Infrastructure Ltd, 2008

Beca, 2010a. *Western Ring Route – Waterview Connection: G.18 Assessment of Transport Effects*, Report prepared for NZTA by Beca Infrastructure Ltd, 2010

Beca, 2010b. *Western Ring Route – Waterview Connection: Project Assignment Traffic Model Validation Report*. Report prepared for the NZTA by Beca Infrastructure Ltd, 2010

Beca, 2010c. *Western Ring Route – Waterview Connection: Greenhouse Gas Assessment*. Report prepared for the NZTA by Beca Infrastructure Ltd, 2010

Bluett, J. and Fisher, G., 2005. *Validation of a Vehicle Emission Model Using On-Road Emission Measurements*. Proceedings of the 17th International Clean Air and Environment Conference, Hobart, 2-5 May 2005. Published by the Clean Air Society of Australia and New Zealand. ISBN 0957850395

Child et al, 2004. *M5 East Freeway: A review of emission treatment technologies, systems & applications*. Castle Hill, Australia. Report prepared for the New South Wales Road Transport Authority.

Cowherd, C. Jr. and Grelinger, M. A., 2003, "*Characterization of Enhanced Dust Deposition on Vegetation Groundcover Bordering Emission Sources*"; Prepared by Midwest Research Institute for U.S. Army Construction Engineering Research Laboratory, June 2003

Cowherd, C. Jr., Grelinger, M. A., and Gebhart, D. L., 2006. "*Development of an Emission Reduction Term for Near Source Depletion. 15th International Emission Inventory Conference "Reinventing Inventories - New Ideas in New Orleans*". US Environmental Protection Agency, May 2006

Dix, A., 2006. *Managing Air Outside of Tunnels:* Contract Nº 6400/3003. Report prepared for the Rijkswaterstaat Department of Road and Hydraulic Engineering, 2006

Etymezian, V., Ahonen, S., Nikolic, D., Gillies, J., Kuhns, H., Gillette, D. and Veranth, J., 2004. "*Deposition and Removal of Fugitive Dust in the Arid Southwestern United States: Measurements and Model Results*." Journal of Air & Waste Management Association 54:1099-1111, 2004

Golder, 2009. *Meteorological Datasets for the Auckland Region – User Guide*. Prepared for Auckland Regional Council and NZ Transport Agency. AUCRCAKL024 – TRANZWLG002. June 2009.

Holmes Air Sciences, 2006. *Air Quality impact Assessment: Brisbane Airport Link Project.*

Longley, I., Olivares, G., Zawar-Reza, P., Khan, B., 2008. *The determinants of levels of secondary particulate pollution and nitrogen dioxide in urban New Zealand Part One*. Prepared for FRST. NIWA Report AKL-2008-053.

MfE, 2002. *New Zealand Ambient Air Quality Guidelines – 2002 Update*. Ministry for the Environment, 2002

MfE, 2004. *Good Practice Guide for Atmospheric Dispersion Modelling*. Ministry for the Environment, 2004.

MfE, 2008. *Good Practice Guide for Assessing Discharges to Air from Land Transport*. Ministry for the Environment, 2008

MoT, 2010. *The New Zealand Vehicle Fleet: Annual Fleet Statistics 2009*. Ministry of Transport, March 2010

MWH, 2009. *Alan Wood Reserve – Phase II Land Investigation*. Report prepared by MWH for Auckland City Council, Draft for Client Review, 2009

NZTA, 2010. *Standard for Producing Air Quality Assessments for State Highway Projects*, Draft version 3, March 2010.

Olivares, G., Ström, J., Johansson, C. and Gidhagen, L., 2008. *Estimates of Black Carbon and Size-Resolved Particle Number Emission Factors from Residential Wood Burning Based on Ambient Monitoring and Model Simulations*. Journal of the Air and Waste Management Association. Vol 58, N 6, pp. 838-848.

PIARC, 2004. *Road Tunnels: Vehicle Emissions and Air Demand for Ventilation*. World Road Association, 2004

PIARC, 2008. *Road tunnels: A guide to Optimising the Air Quality Impact upon the Environment*. World Road Association, 2008

Scire JS, Strimaitis DG, Yamartino BJ, 2000. *A User's Guide for the CALPUFF Dispersion Model (Version 5)*. Earth Tech Inc: Concord.

South Aus EPA, 2007. *Guidelines on Separation Distances*. Environment Protection Authority South Australia, Adelaide, Australia, 2007.

URS, 2010. *Concept Design Report: Waterview Tunnel, M&E Service Provisions*, Report prepared for the NZTA by URS New Zealand Ltd, 2010

Vic EPA, 1996. *Recommended Buffer Distances for Industrial Residual Air Emissions*, AQ2/86. Environmental Protection Authority Victoria, Melbourne, Australia, 1990

WHO, 2006. *Air Quality Guidelines Global Update 2005*. World Health Organisation Regional Office for Europe, 2006

WHO, 2000. *Air Quality Guidelines for Europe, 2nd Edition*, World Health Organisation Regional Office for Europe, 2000.

16. Figures 16.1 to 16.14

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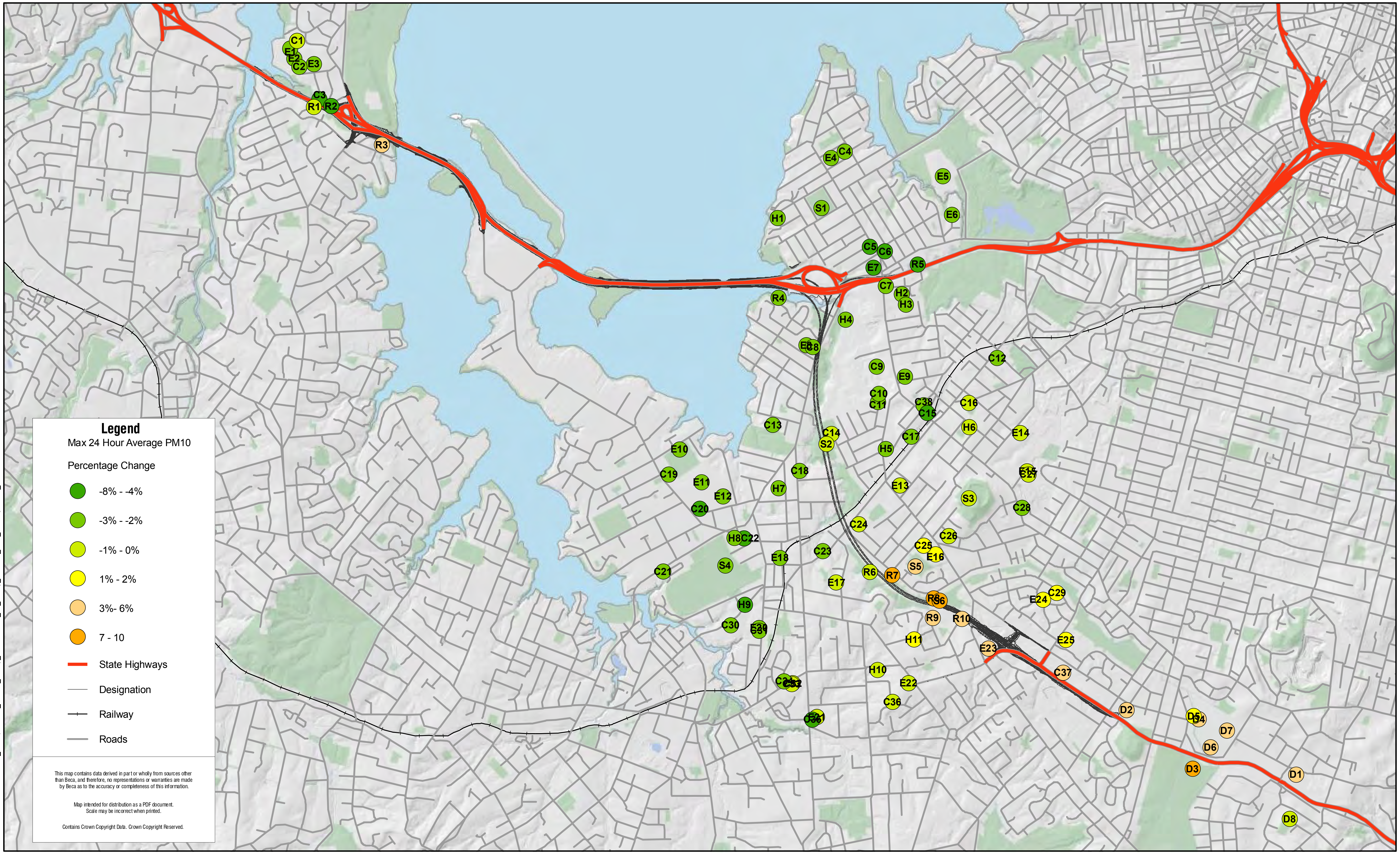

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Kilometers

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Revision	By	Verified	Appd	Date
Rev 1	BAP	AF		29/04/10

Title:
Percentage Change in Maximum 24-Hour Average PM_{10} Concentrations across the Project Domain between the Existing Case (2006 Base Year) and 2016
Figure 16.1

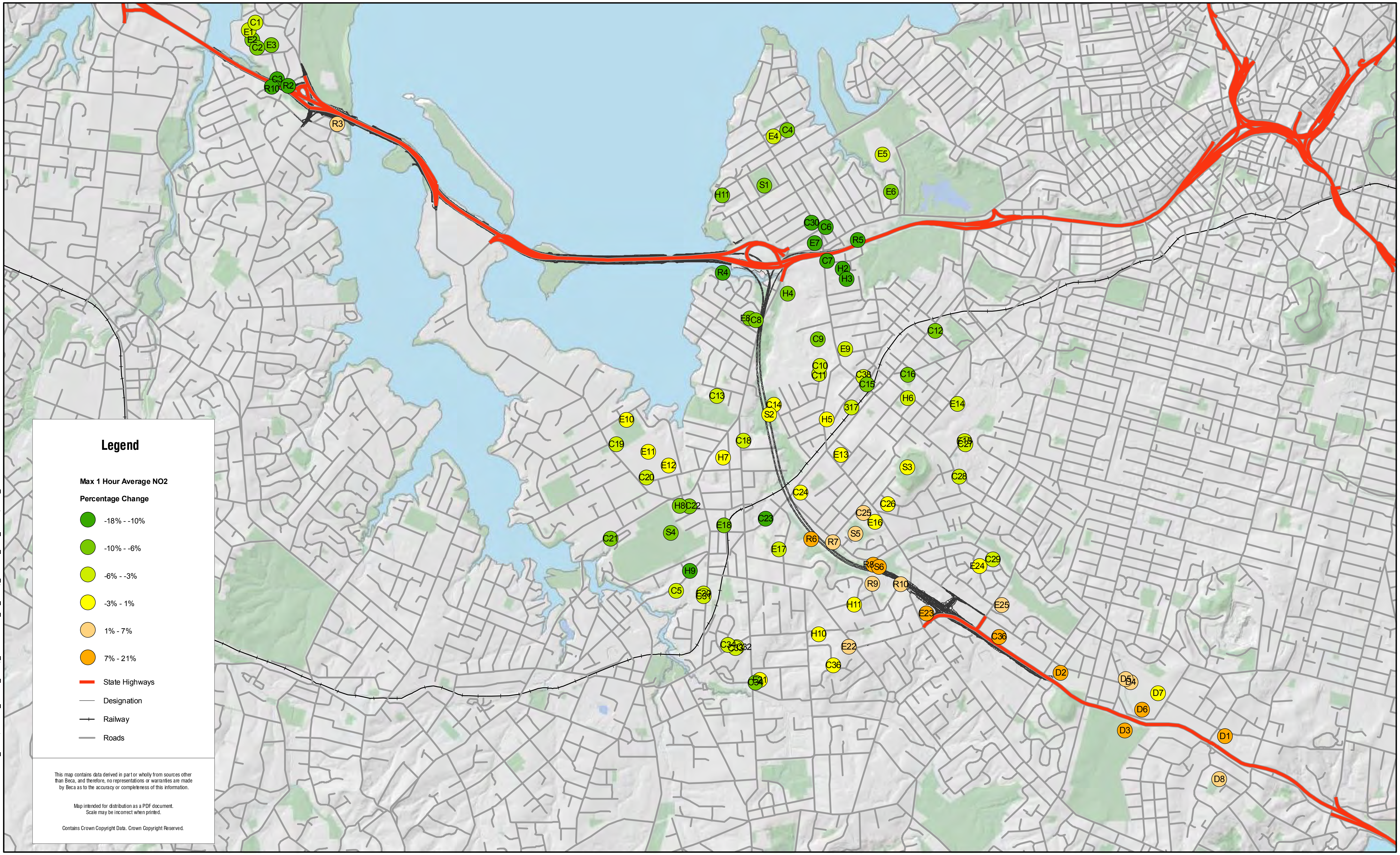
Client: NZ Transport Agency (Auckland)

Project: Waterview Connection Project SH16/SH20

Beca

Discipline: GIS

Drawing No: GIS-3814238-12



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Revision	By	Verified	Appd	Date
Rev 1	BAP	AF		29/04/10

Title:

Percentage Change in Maximum 1-Hour Average NO_2 Concentrations across the Project Domain between the Existing Case (2006 Base Year) and 2016

Figure 16.2

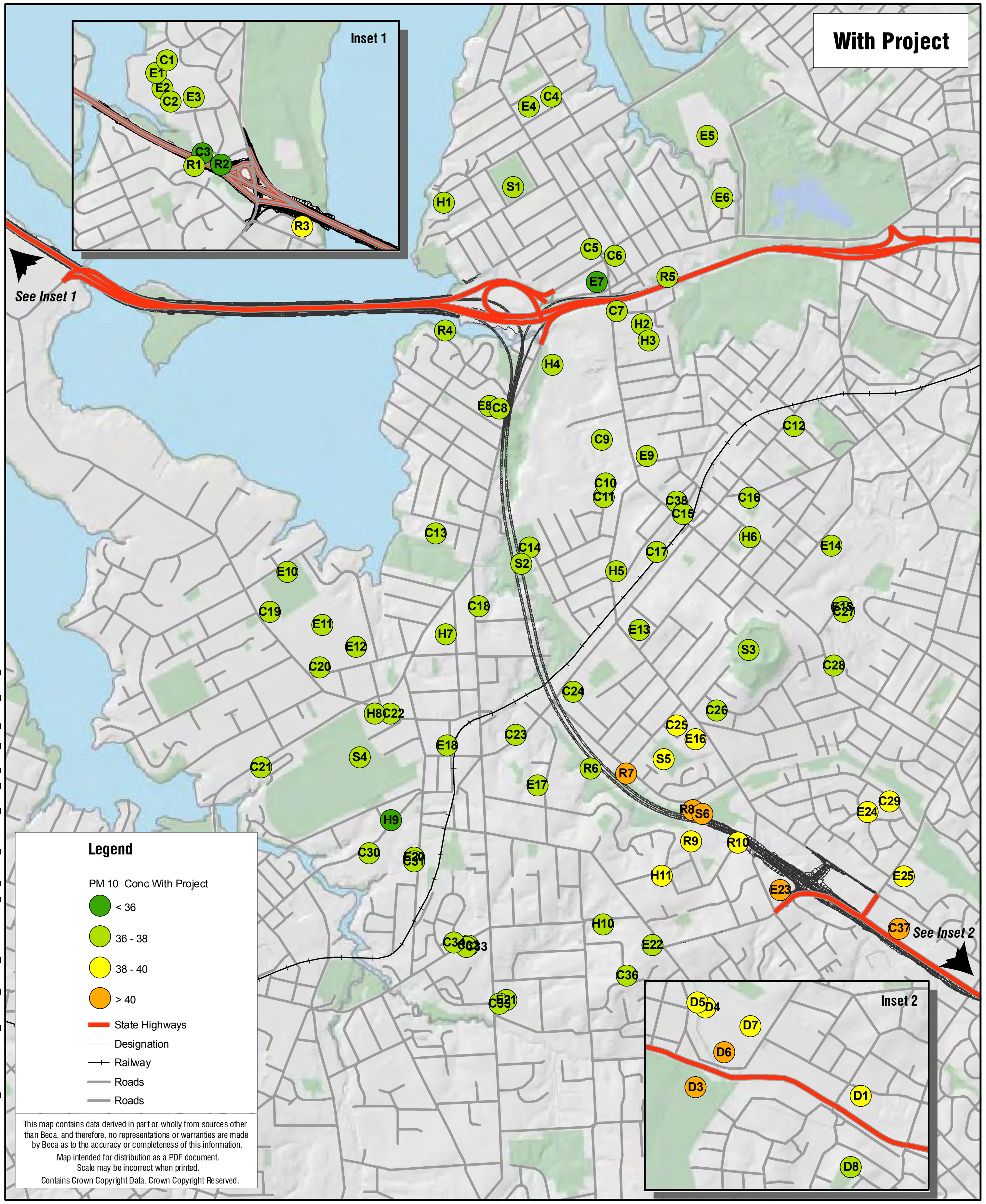
Client: NZ Transport Agency (Auckland)

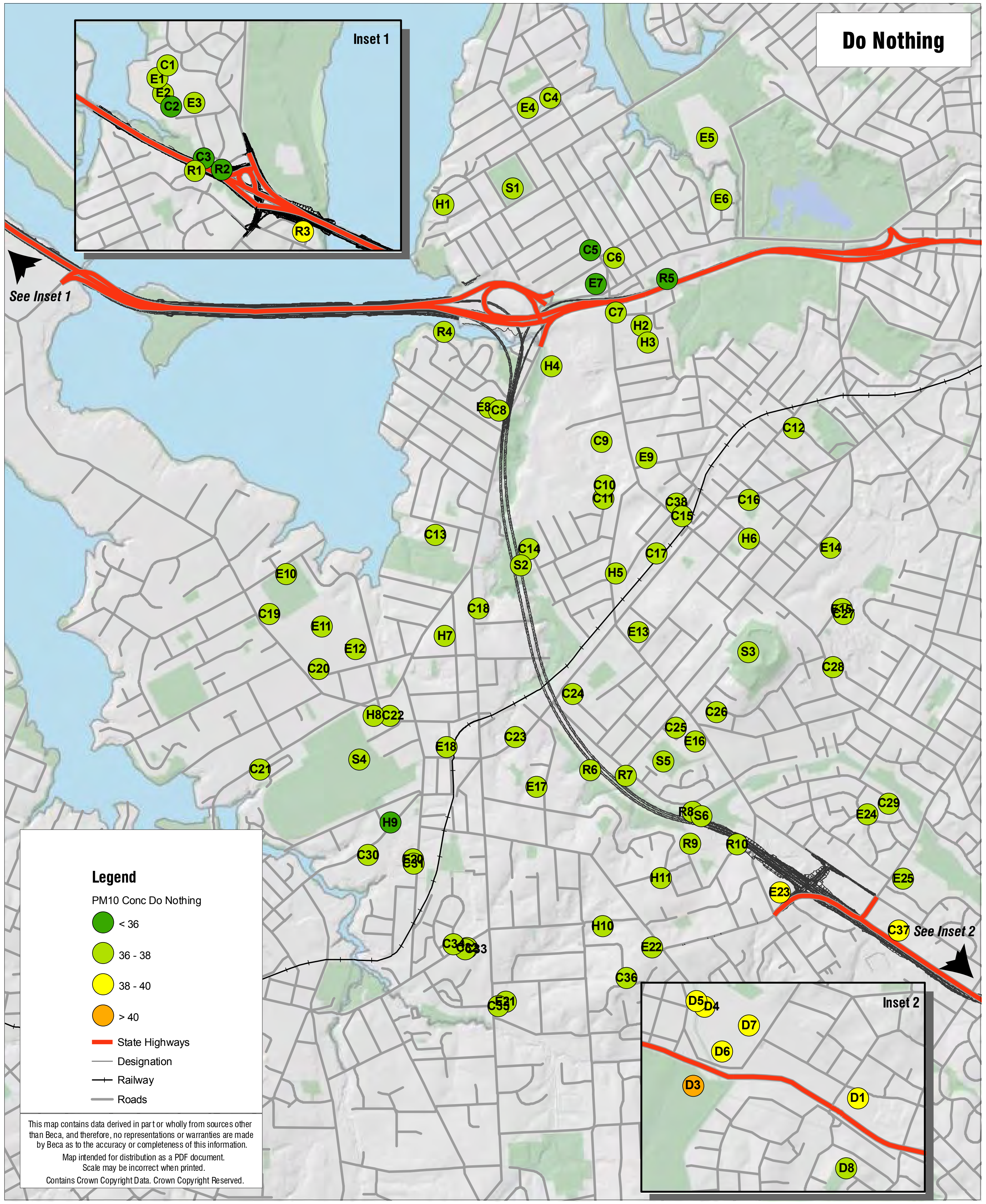
Project: Waterview Connection Project SH16/SH20

Beca

Discipline: GIS

Drawing No: GIS-3814238-12





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Kilometres

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Revision	By	Verified	Appd	Date
Rev 1	BAP	AF		29/04/10

Title:

Maximum 24-Hour Average PM_{10} Concentrations across the Project Domain (2016 With Project and 2016 Do Nothing)

Figure 16.3

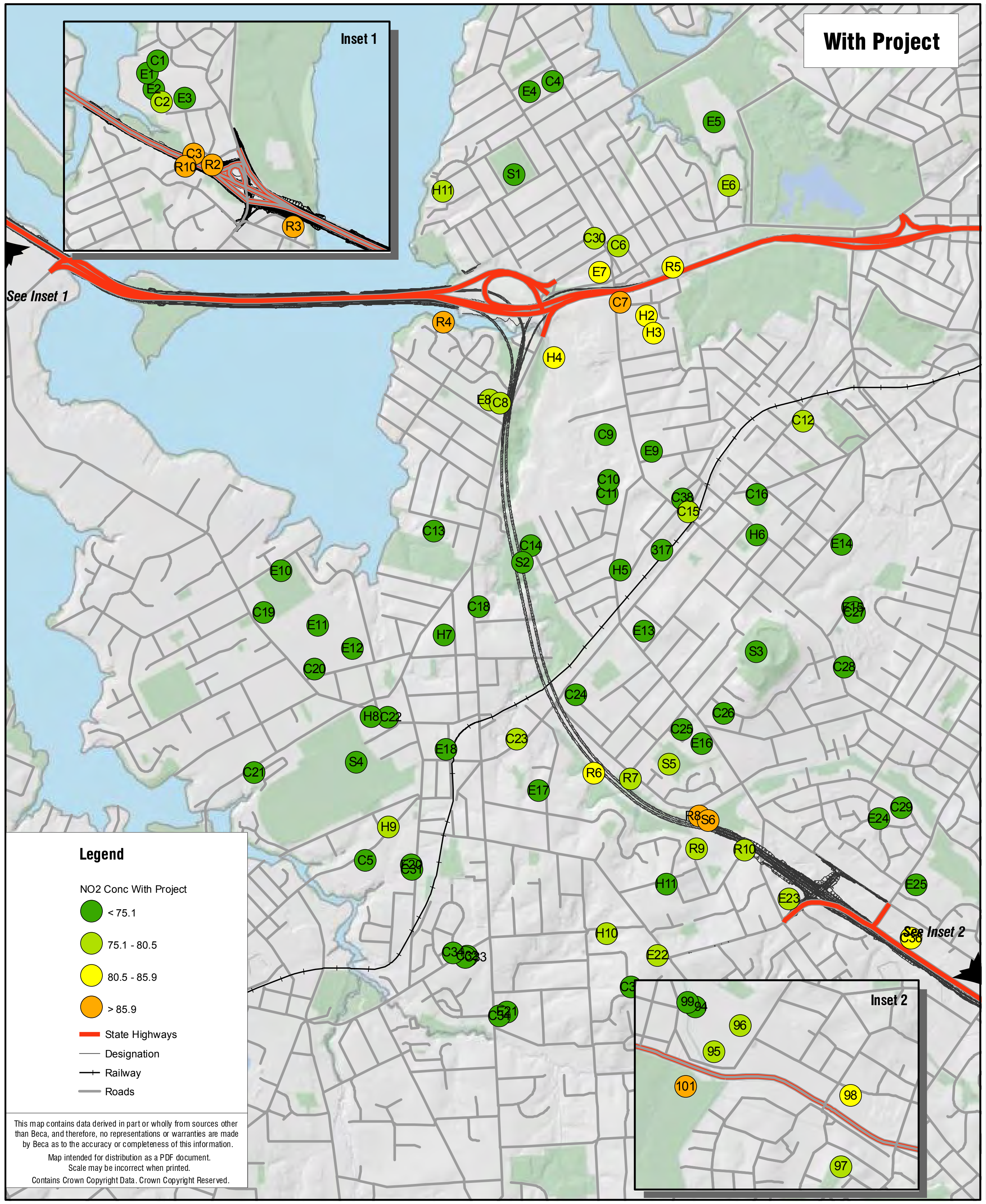
Client: NZ Transport Agency (Auckland)

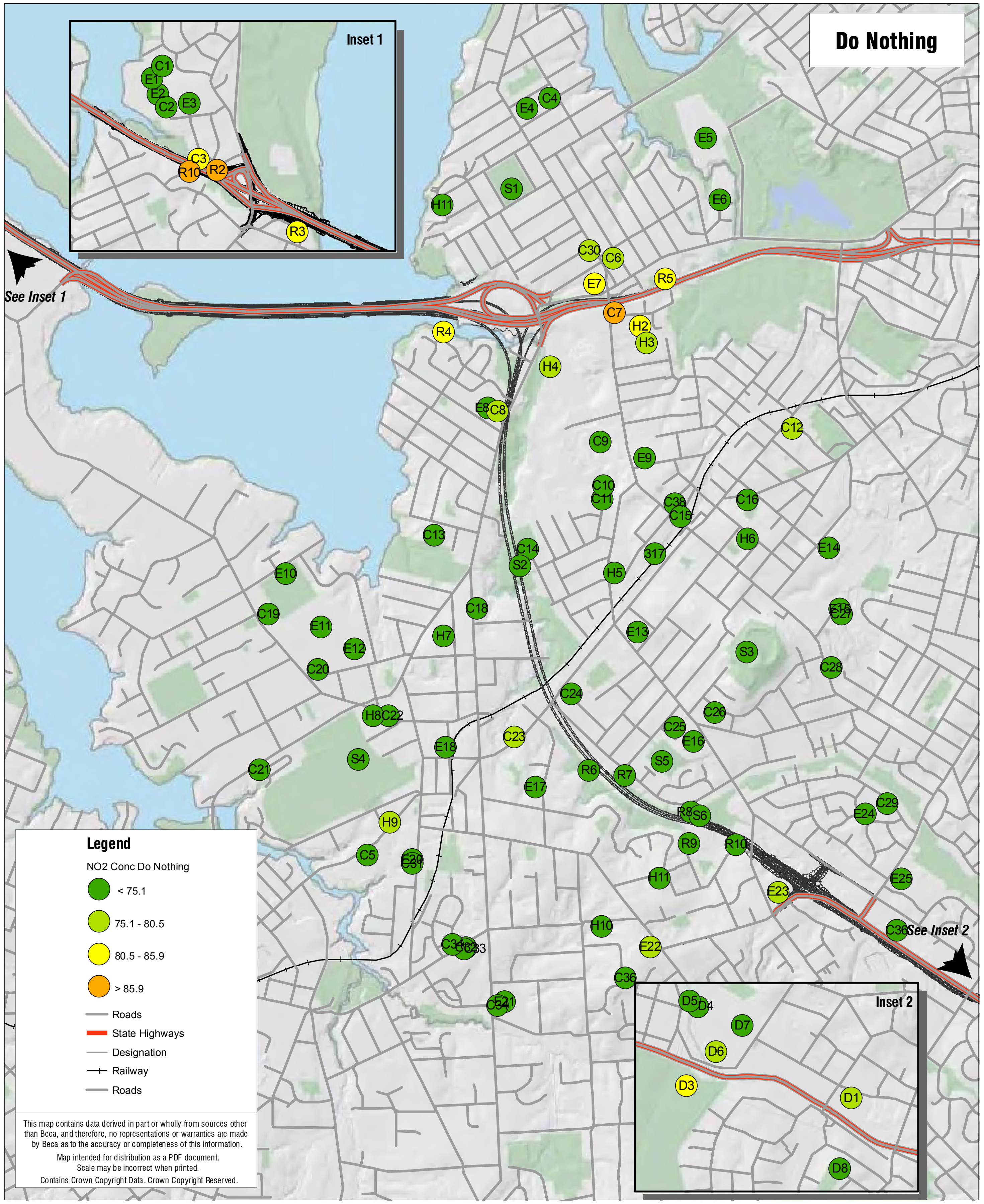
Project: Waterview Connection Project SH16/SH20

Beca

Discipline: GIS

Drawing No: GIS-3814238-12





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Revision	By	Verified	Appd	Date
Rev 1	BAP	AF		29/04/10

Title:

Maximum 1-Hour Average NO_2 Concentrations across the Project Domain (2016 With Project and 2016 Do Nothing)

Figure 16.4

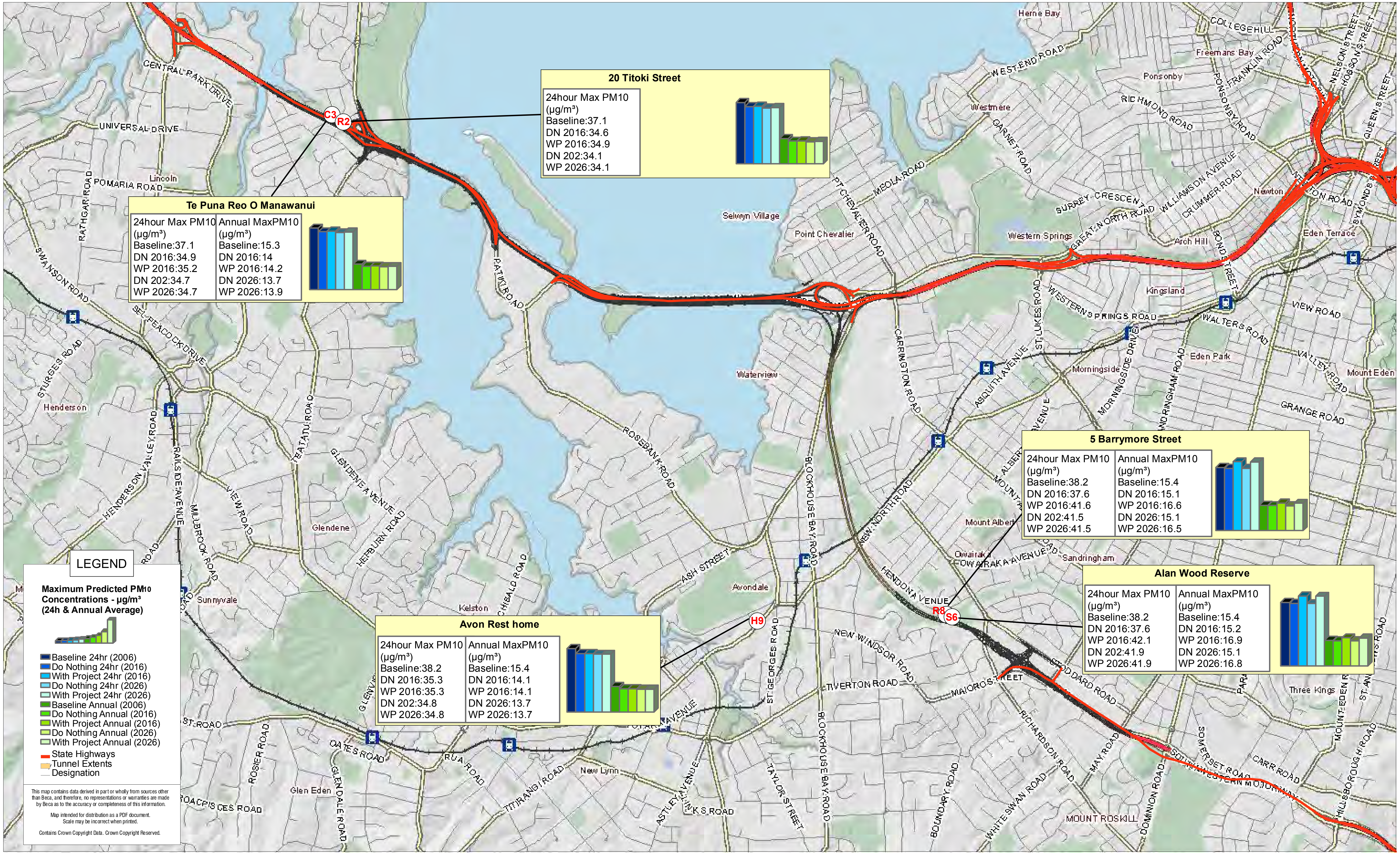
Client: NZ Transport Agency (Auckland)

Project: Waterview Connection Project SH16/SH20

Beca

Discipline: GIS

Drawing No: GIS-3814238-12



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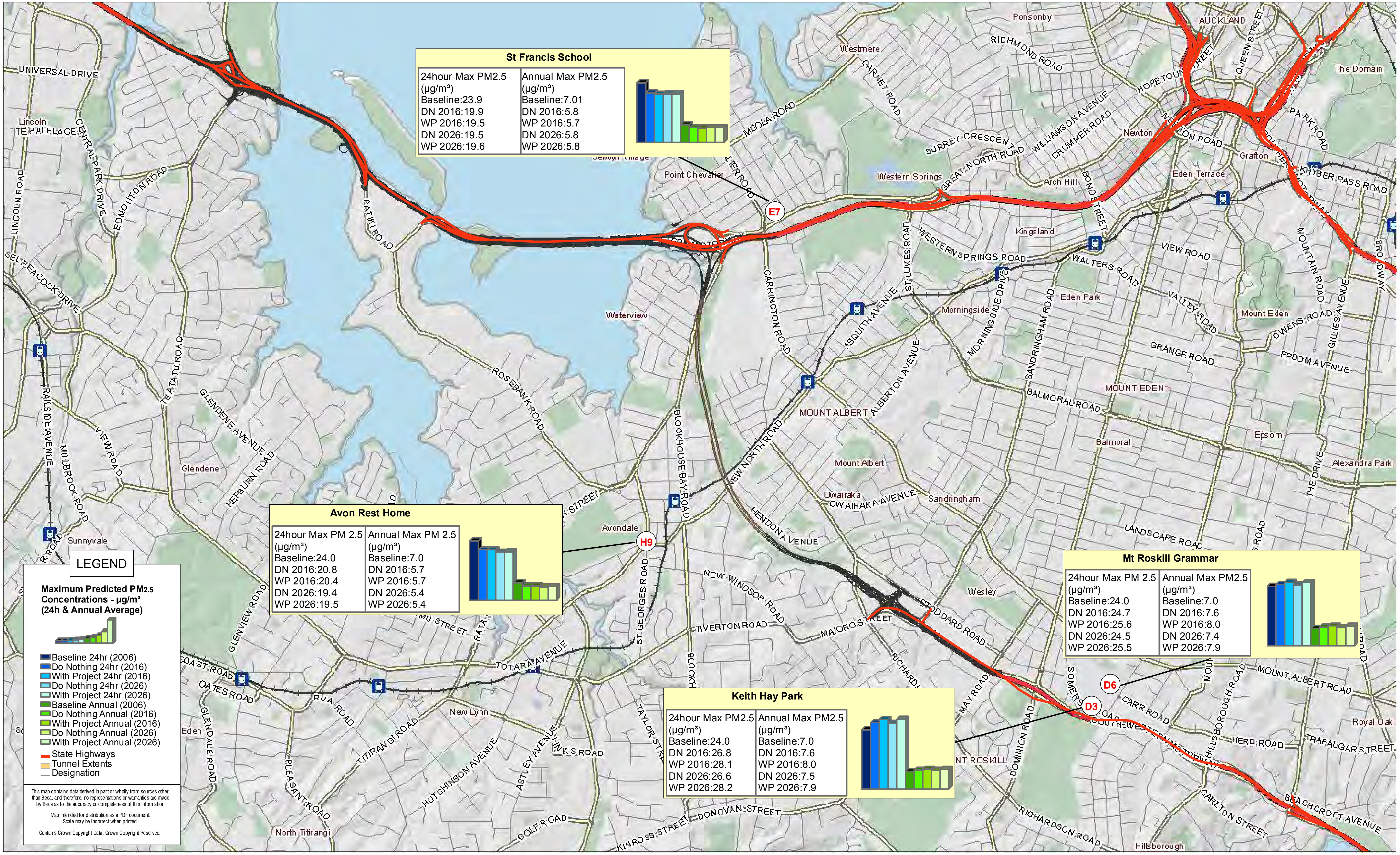

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Revision	By	Verified	Appd	Date
Rev 1	BAP	AF		29/04/10

Title:

Locations of Predicted Highest and Lowest Maximum $PM_{2.5}$ Concentrations

Figure 16.6

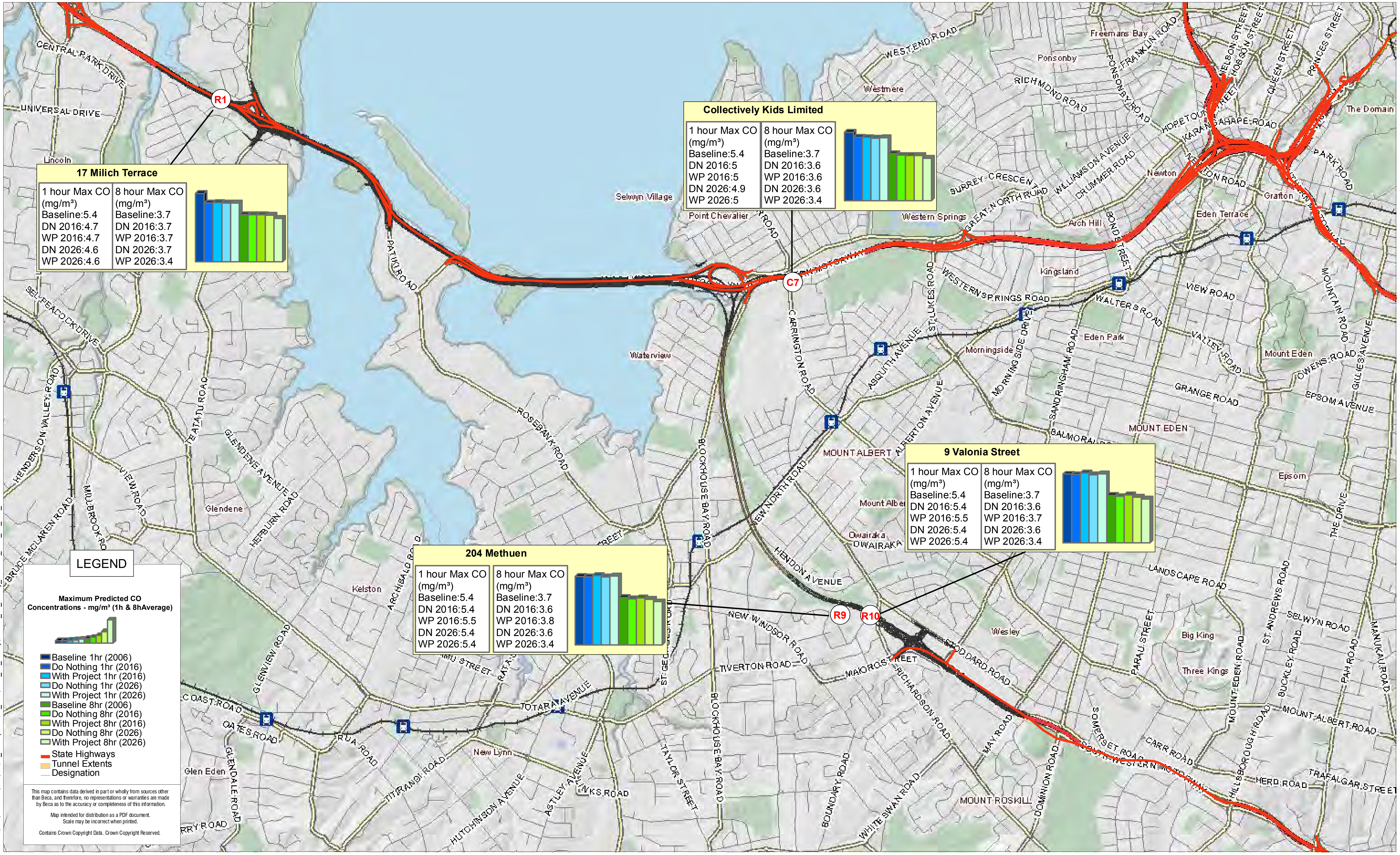
Client: NZ transport Agency (Auckland)

Project: Waterview Connection Project SH16/SH20

Beca

Discipline: GIS

Drawing No: GIS-3814238-12



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Kilometres

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Revision	By	Verified	Appd	Date
Rev 1	BAP	AF		29/04/10

Title:

Locations of Predicted Highest and Lowest Maximum CO Concentrations

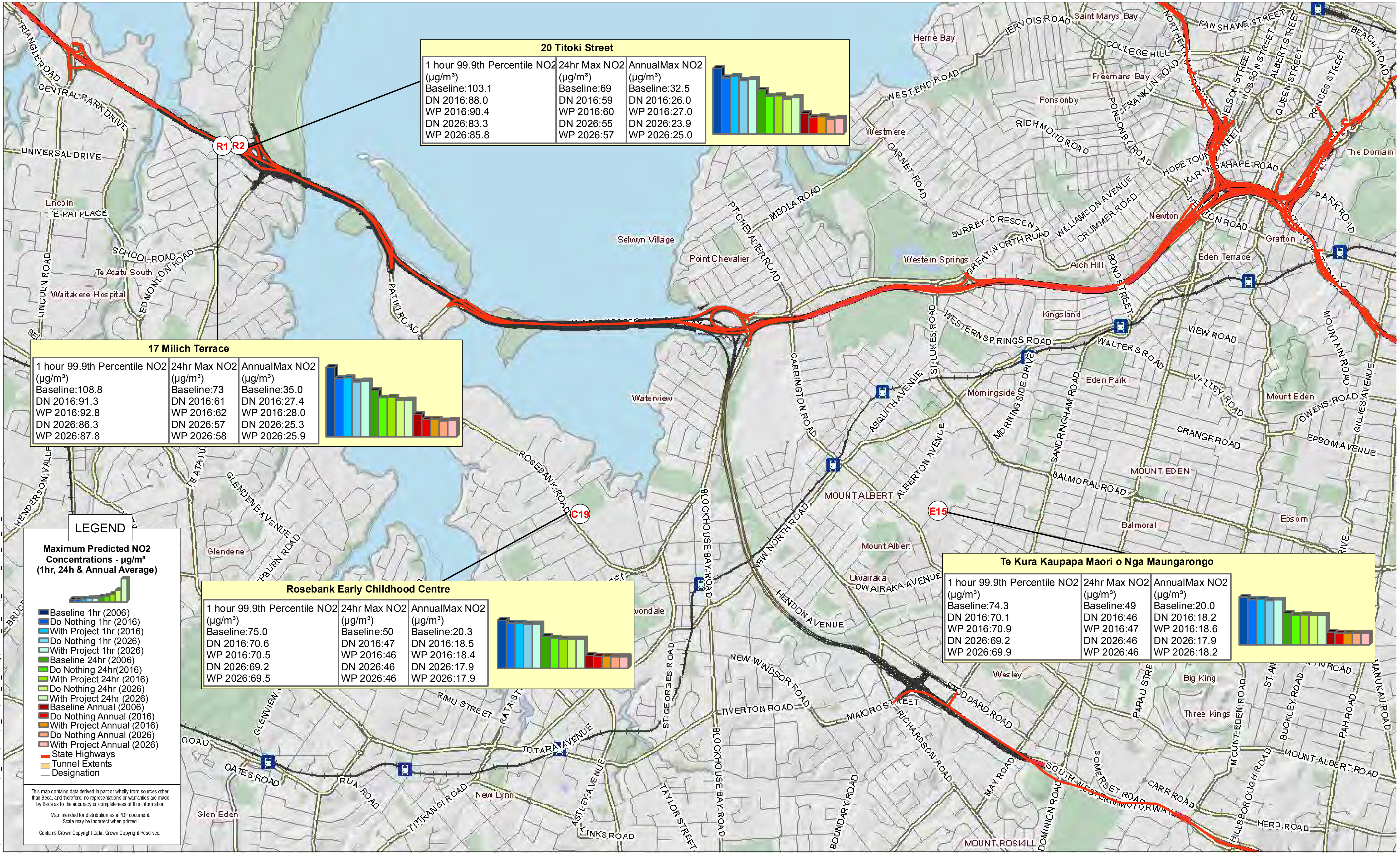
Figure 16.7

Client: NZ Transport Agency (Auckland)

Project: Waterview Connection Project SH16/SH20

Discipline: GIS

Drawing No: GIS-3814238-12



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Revision	By	Verified	Appd	Date
Rev 1	BAP	AF		29/04/10

Title:

Locations of Predicted Highest and Lowest Maximum NO_2 Concentrations

Figure 16.8

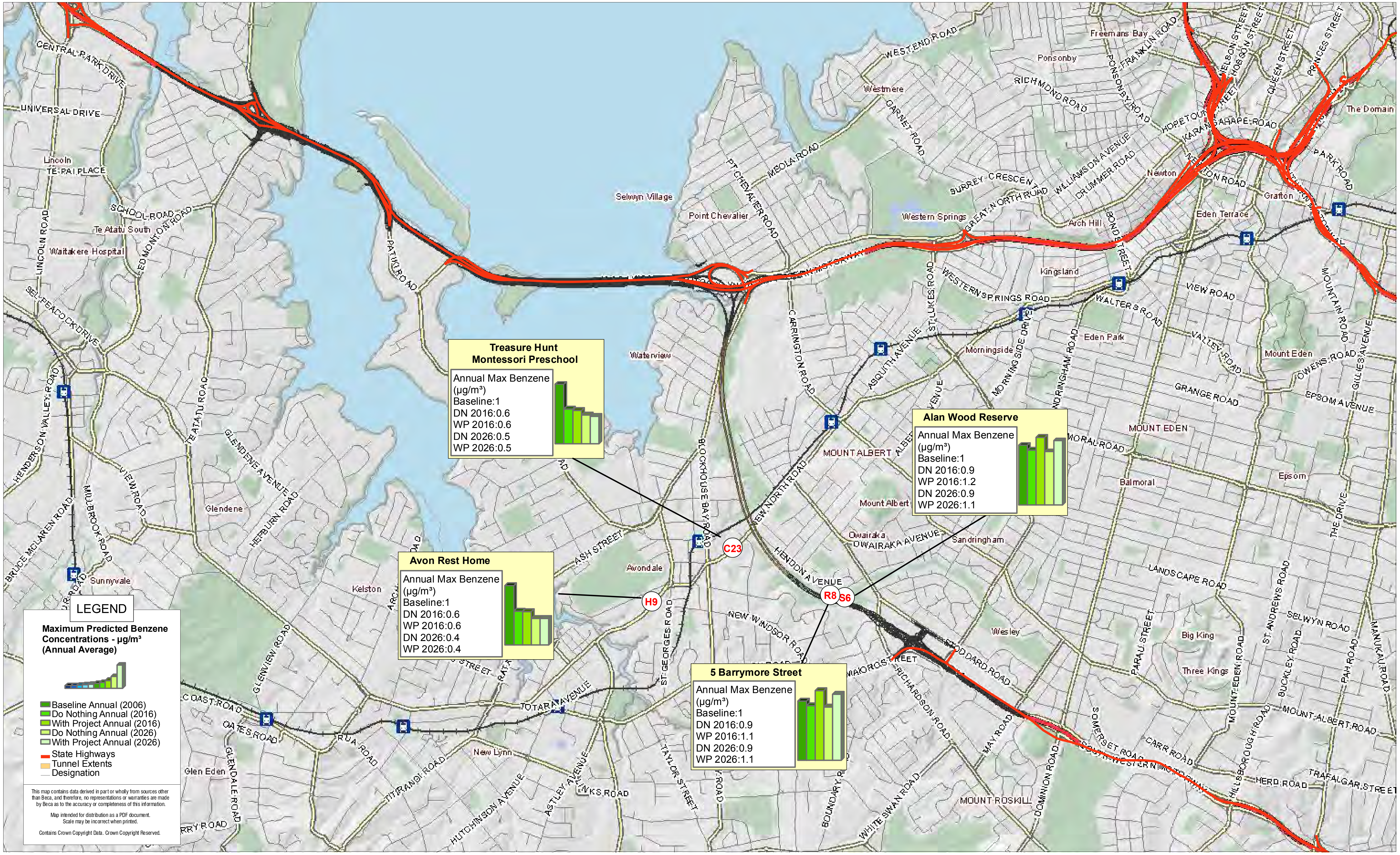
Client: NZ Transport Agency (Auckland)

Project: Waterview Connection Project SH16/SH20

Beca

Discipline: GIS

Drawing No: GIS-3814238-12



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Revision	By	Verified	Appd	Date
Rev 1	BAP	AF		29/04/10

Title:

Locations of Predicted Highest and Lowest Maximum Benzene

Figure 16.9

Client: NZ Transport Agency (Auckland)

Project: Waterview Connection Project SH16/SH20

Beca

Discipline: GIS

Drawing No: GIS-3814238-12

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Metres

Revision	By	Verified	Appd	Date
Rev1	AYF	BAP	AH4	06/05/10

Title:

Maximum PM_{10} Concentrations due to Discharges via the Tunnel Vent Stacks

Figure 16.10

Client: NZ Transport Agency (Auckland)

Project: Waterview Connection Project SH16/SH20

Beca

Discipline: GIS

Drawing No: GIS-3814238-12

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Revision	By	Verified	Appd	Date
Rev1	AYF	BAP	AH4	05/05/10

Title: **Maximum NO_2 Concentrations due to Discharges via the Tunnel Vent Stacks**

Figure 16.11

Client: NZ Tansport Agency (Auckland)

Project: Waterview Connection Project SH16/SH20

Discipline: GIS

Drawing No: GIS-3814238-12

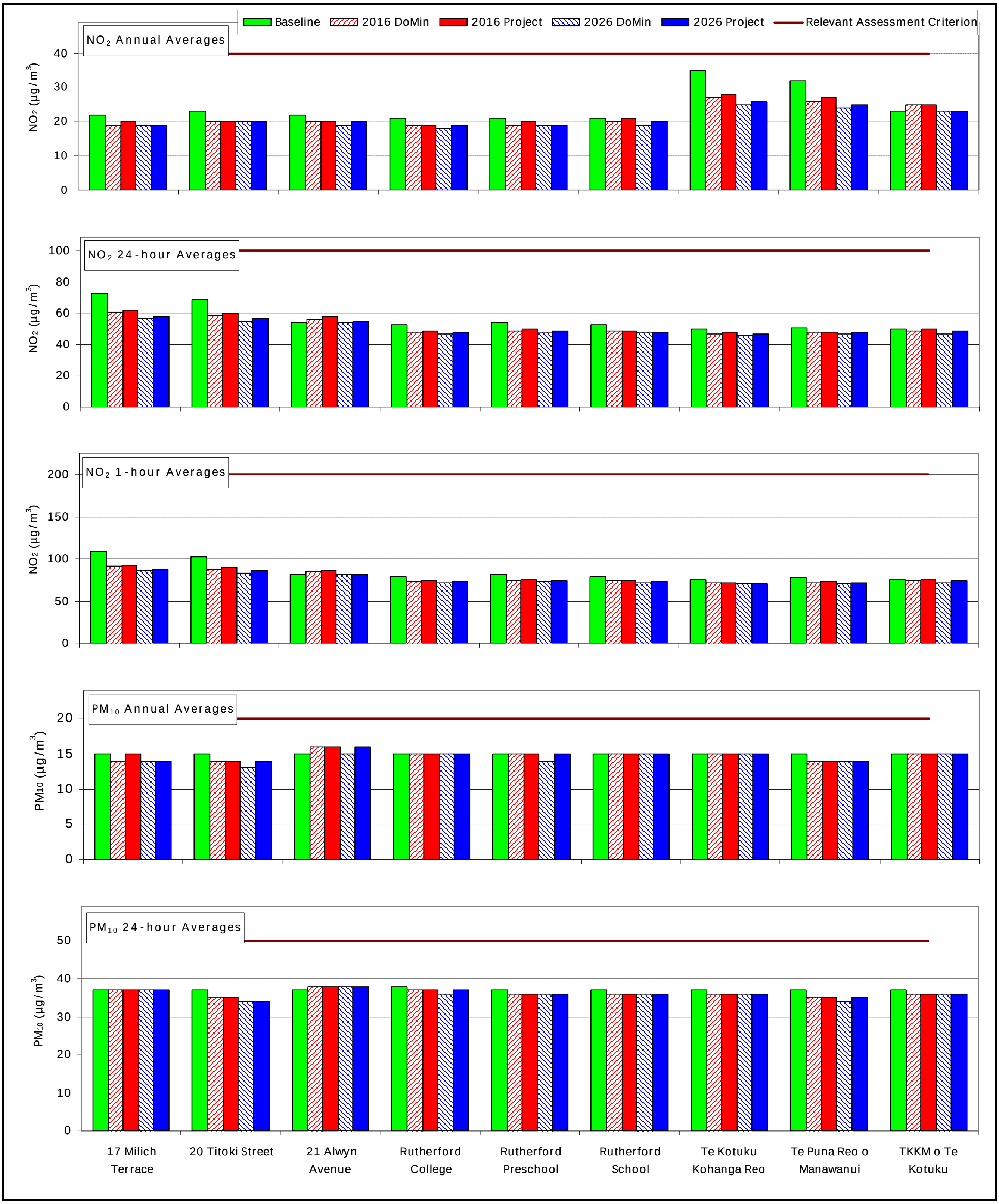

Figure 16.12 - Predicted Ground Level Concentrations of PM_{10} and NO_2 in the Te Atatu Area (Sector 1)

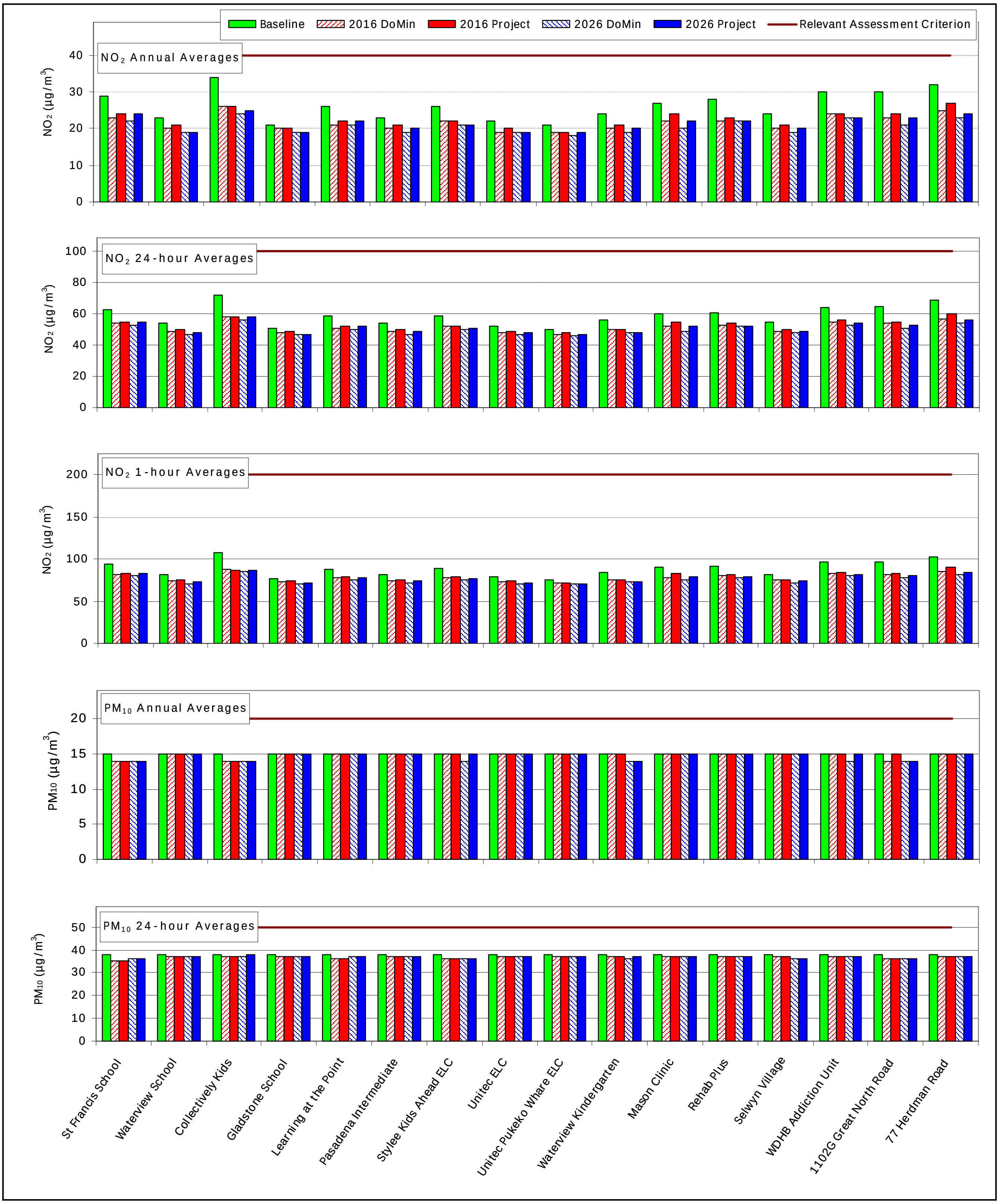

Figure 16.13 - Predicted Ground Level Concentrations of PM_{10} and NO_2 in the St Lukes and Waterview Areas (Sectors 5, 6 and 7)

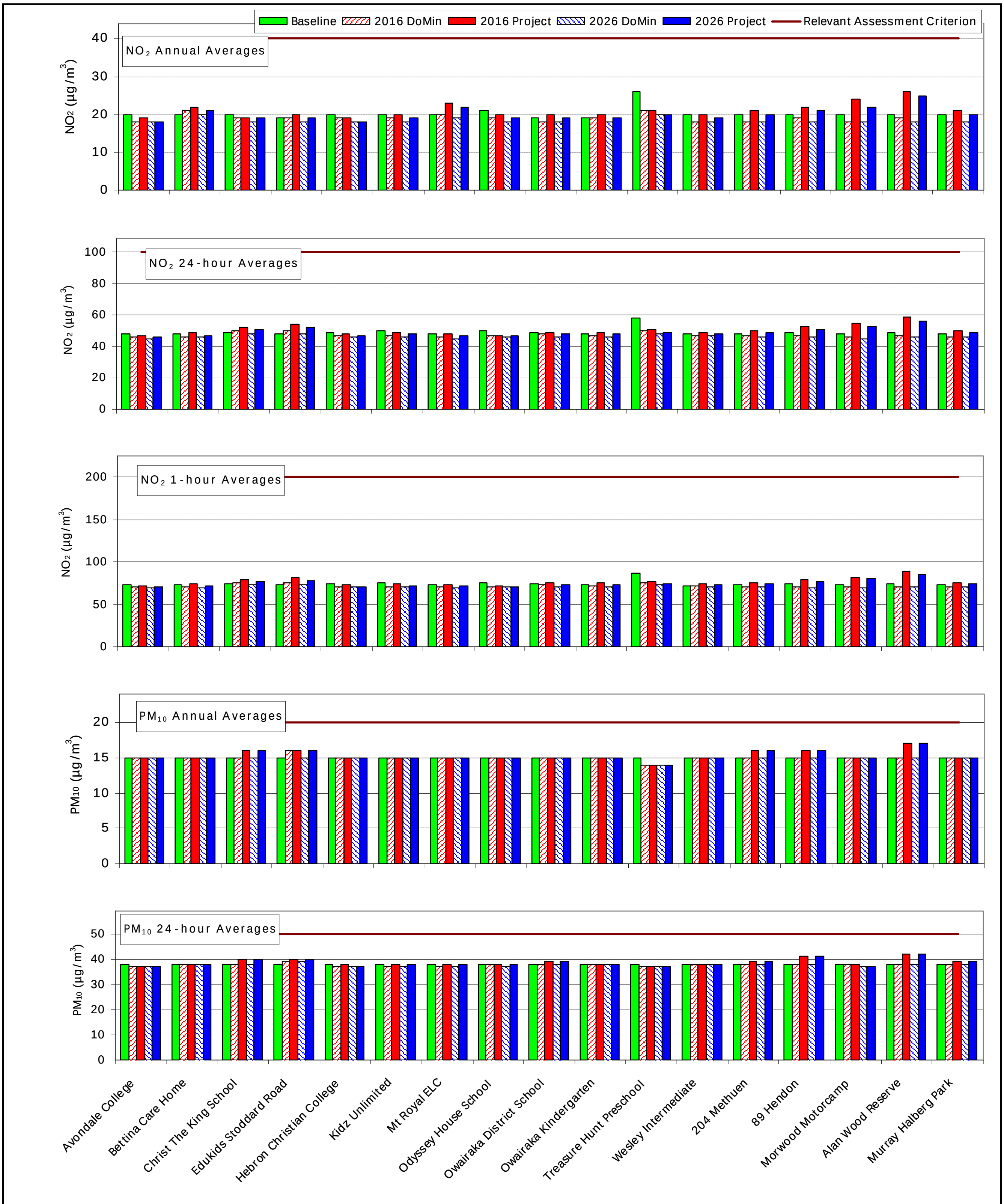

Figure 16.14 - Predicted Ground Level Concentrations of PM_{10} and NO_2 in the Owairaka Area (Sectors 9 and 10)