NZ TRANSPORT AGENCY
WAKA KOTAHI

Technical Report No 10

Christchurch Southern Motorway Stage 2 and Main South Road Four Laning

Assessment of Air Quality Effects

November 2012

Quality Assurance Statement			
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This Technical Report has been produced in support of the Assessment of Environmental Effects (AEE) for the Main South Road Four Laning and Christchurch Southern Motorway Stage 2 Project. It is one of 20 Technical Reports produced (listed below), which form Volume 3 of the lodgement document. Technical information contained in the AEE is drawn from these Technical Reports, and cross-references to the relevant reports are provided in the AEE where appropriate.

A Construction Environmental Management Plan (CEMP) has been prepared to provide the framework, methods and tools for avoiding, remedying or mitigating environmental effects of the construction phase of the Project. The CEMP is supported by Specialised Environmental Management Plans (SEMPs), which are attached as appendices to the CEMP. These SEMPs are listed against the relevant Technical Reports in the table below. This Technical Report is highlighted in grey in the table below. For a complete understanding of the project all Technical Reports need to be read in full along with the AEE itself; however where certain other Technical Reports are closely linked with this one they are shown in bold.

Schedule of Technical Reports for the AEE

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1	Design philosophy statement	4	
2	Traffic and transportation effects report	11	Construction Traffic Management Plan
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For further information on the structure of the lodgement documentation, refer to the ‘Guide to the lodgement documentation’ document issued with the AEE in Volume 1.

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Executive Summary

The NZ Transport Agency ('the NZTA') is lodging Notices of Requirement (NOR's) and resource consent applications to construct, operate and maintain the second stage of the Christchurch Southern Motorway between Halswell Junction Road and Main South Road ('CSM2') and to widen Main South Road from two to four lanes with a central median barrier between the end of CSM2 and Rolleston ('MSRFL'). CSM2 and MSRFL are collectively referred to as the Project.

The Project is being progressed as part of Christchurch's Southern Corridor Roads of National Significance (RoNS) package, aimed at providing more efficient and safer access to Lyttelton Port and the Christchurch City Centre for people and freight from south of Christchurch.

This report, prepared by Beca Infrastructure Limited (Beca), considers the effects of discharges to air associated with the construction and operation of the Project.

The scope and purpose of this report is to provide:

- an overview of the Project itself and of the receiving environment;
- a description of the types and sources of discharges to air from motor vehicles;
- an assessment of the effects of discharges to air from motor vehicles; and
- a description of the types and sources of discharges to air from construction activities (including dust, odour and hazardous air pollutants);
- to outline a range of mitigation measures that will be employed as required.

The Project is outside the Christchurch Clean Air Zone 1 which is a gazetted airshed under the Resource Management (National Environmental Standards for Air Quality) Regulations 2004 (AQNES). With the exception of the southernmost end of Main South Road, there are only a limited number of sensitive receptors in the vicinity of either CSM2 or MSRFL. All the identified sensitive receptors are residential dwellings.

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). The Project is identified as being "medium risk" under the NZTA air pollution risk assessment criteria.

Dispersion modelling has been used as the primary tool to quantitatively assess pollutant concentrations associated with the CSM2, MSRFL and changes in the existing road 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 Vehicle Emissions Prediction Model v3 (VEPM) emission factors. Potential effects have been assessed by comparing predictions against relevant health-based AQNES, New Zealand Ambient Air Quality Guidelines and Environment Canterbury Regional Air Quality Targets. These air quality criteria are designed to protect the health of the most vulnerable individuals in the community.

The potential air quality impacts have been predicted for the projected year of opening (2016) and 10 years after opening (2026). For each of these years, the emission scenarios have considered "Do nothing" (i.e. neither CSM2 nor MSRFL being undertaken) and the "With Project" scenario (CSM2 and MSRFL). The assessment has focused on the relative impacts that the "With Project" emission scenario will have on air quality, when compared to the "Do nothing" emission scenario for the same year.

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 NO2 have been derived using ambient air quality data collected at locations in the Canterbury Plains that are similar to the Project area.

Dust will also be generated during the construction phase of the Project. An assessment has been made of potential sources of dust discharges, control and mitigation methods and monitoring. This can be used to inform the preparation of a Construction Air Quality Management Plan, which will form part of a Construction Environmental Management Plan for the Project.

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

- There are no existing sensitive receptors (i.e. schools, preschools or residential healthcare facilities) within 200m of the proposed alignments of either CSM2 or Main South Road four-laning. However, there are a number of houses within 200m of the proposed alignments, particularly along Main South Road.

- The maximum cumulative PM_{10} concentration predicted to occur anywhere 25m from the centreline of either CSM2 or MSRFL is 32.9 µg/m^3 including background concentration. The contribution from the Project is 2.9 µg/m^3. The maximum increase in PM_{10} concentrations predicted to occur at an existing sensitive receptor is 1.4 µg/m^3, which is lower than the MfE Tier 2 significance criterion. For this reason, a Tier 3 assessment was not considered necessary for this Project.

- People living close to the proposed CSM2 alignment or the existing Main South Road corridor, which is proposed to be widened, will have a slightly increased exposure to vehicle related contaminants as a result of the Project, than would occur without the Project.

- Concentrations of CO, PM_{10}, $PM_{2.5}$, NO_2 and benzene are unlikely to exceed the relevant health-based assessment criteria (AQNES, ambient air quality guidelines and regional air quality targets) as a result of discharges to air associated with vehicles using either CSM2 or MSRFL in 2016 or 2026.

- Overall, it can be concluded that there are unlikely to be significant effects on air quality arising from the operation of the Project. In consequence, neither mitigation measures nor monitoring of air quality effects will be required.

- The main adverse effects arising from discharges to air associated with the construction of the Project are associated with discharges of construction dust. This report identifies key dust control methods that should be applied (via a Construction Air Quality Management Plan) to mitigate the effects of those emissions.

Glossary of Terms

AADT	Annual average daily traffic (vehicles per day)
AEE	Assessment of Environmental Effects
AQNES	Resource Management (National Environmental Standards for Air Quality) Regulations 2004
AUSROADS	Atmospheric dispersion model for road sources developed for the Victorian Environmental Protection Agency
CO	Carbon monoxide
CEMP	Construction Environmental Management Plan
CSM2	Stage 2 of the Christchurch Southern Motorway, between Halswell Junction Road and Main South Road
MSRFL	Four-laning of Main South Road between CSM2 and Rolleston
HAPs	Hazardous air pollutants
HCV	Commercial vehicles with a gross laden weight of over 3.5 tonnes
FIDOL	Factors used in the assessment dust or odour discharges: the frequency of dust nuisance events the intensity of events, as indicated by dust quantity and the degree of nuisance the duration of each dust nuisance event the offensiveness of the discharge, having regard to the nature of the dust the location of the dust nuisance, having regard to the sensitivity of the receiving environment
Hazardous air pollutants	Include fine particles (PM_{10} and $PM_{2.5}$) and a wide range of chemicals that may cause adverse effects on human health
Highly sensitive air pollution land use / highly sensitive land use	A location where people or surroundings may be particularly sensitive to the effects of air pollution. Examples include residential dwellings, hospitals, schools, early childhood education centres, childcare facilities, rest homes, marae, other cultural facilities and sensitive ecosystems.
LTMA	Land Transport Management Act 2003
$\mu g/m^3$	Micrograms per cubic metre

mg/m^3	Milligrams per cubic metre
MfE	Ministry for the Environment
MfE Dust GPG	Ministry for the Environment Good Practice Guide for the Assessment of Effects of Dust
MfE Transport GPG	Ministry for the Environment Good Practice Guide for Assessing Discharges to Air from Land Transport
NRRP	Natural Resources Regional Plan
NoR	Notice of Requirement
NZAAQG	New Zealand ambient air quality guidelines
NZTA	The New Zealand Transport Agency
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
PM_{10}	Fine particulate matter with an aerodynamic diameter of less than 10 micrometres
$PM_{2.5}$	Fine particulate matter with an aerodynamic diameter of less than 2.5 micrometres
RAQT	Regional Air Quality Target
RMA	Resource Management Act 1991
Sensitive receptor	Highly sensitive air pollution land use
TSP	Total suspended particulate matter, typically with an aerodynamic diameter of less than 30 micrometres
VEPM	Vehicle Emissions Prediction Model v3, developed for the Auckland Regional Council

1. Introduction

1.1 Project Backgound

The New Zealand Transport Agency (NZTA) is improving access to and from the south of Christchurch via State Highway 1 (SH1) to the Christchurch City centre and Lyttelton Port, by improving the capacity, safety and alignment of routes through the Christchurch Southern Corridor.

The proposal is made up of two sections – Main South Road Four Laning (MSRFL) involves the widening and upgrading of Main South Road (SH1) to provide for a four-lane median separated expressway along the existing arterial route; and the construction, operation and maintenance of the Christchurch Southern Motorway Stage 2 (CSM2) as a four-lane median separated motorway. CSM2 will link into Christchurch Southern Motorway Stage 1 (CSM1), which is currently under construction. CSM1 connects Brougham Street (SH73) in the east with Halswell Junction Road and is due to be completed in early 2013.

The government has identified MSRFL, CSM2 and CSM1 as roads of national significance (RoNS). These roads are critical for supporting economic growth, reducing congestion and improving safety in the region.

The NZTA is seeking all necessary Resource Management Act approvals to construct, operate and maintain the State Highway and local road works required for the CSM2 and MSRFL Project. This includes Notices of Requirement for new and altered designations within the Christchurch City and Selwyn District Plans. The NZTA has engaged GHD Ltd (GHD) and its sub-consultant, Beca Infrastructure Ltd (Beca) to investigate CSM2 and MSRFL. This report details the assessment of air quality effects for the Project.

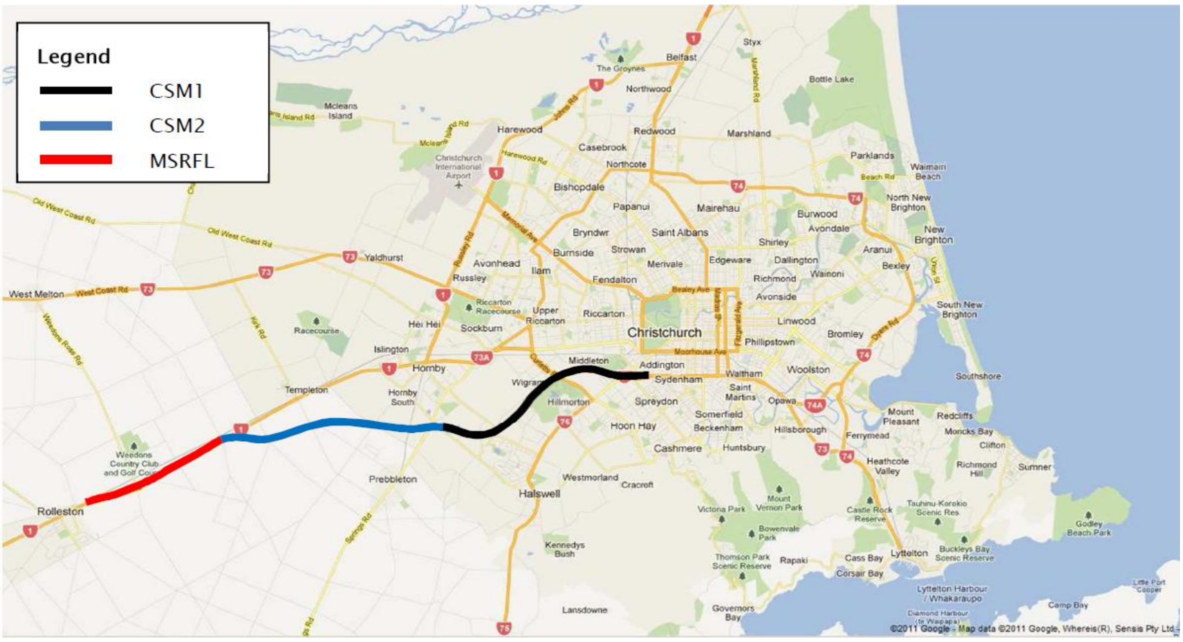

Figure 1: Location Map

1.2 Tier 1 Assessment of Air Quality Effects

In accordance with Ministry for the Environment (MfE) Good Practice Guide for Assessing Discharges to Air from Land Transport (MfE, 2008)[1](MfE Transport GPG), a Tier 1 preliminary assessment of air quality effects was carried out in February 2011. The Tier 1 Assessment is a qualitative assessment to be undertaken at the beginning of a project to identify key issues, identify the likely air quality risk and therefore the appropriate level of assessment. This assessment identified the following:

- CSM2 is a new road.
- Traffic volumes (AADT) on CSM2 are predicted to be greater than 7,000 vehicles per day.
- Traffic volumes on Main South Road are predicted to increase by more than 7,000 vehicles per day.
- There are likely to be more than 500 HCV using both CSM2 and MSRFL each day.
- Sensitive receptors are located within 200m of CSM2 and MSRFL.

The following recommendations arose from the preliminary assessment:

- Further assessment of the air quality in the vicinity of the Project should be undertaken to confirm the likelihood of air quality assessment criteria being exceeded at nearby sensitive receptors.
- Given the proximity of sensitive receptors to several sections of the Project, further assessment should be undertaken of the potential impact of discharges of construction dust.

This report has been prepared in response to those recommendations.

1.3 Report Structure

This assessment of air quality effects has been prepared to identify any potential adverse effects on air quality arising from the construction or operation of the Project.

The assessment of air quality effects for the Project is based on a modified Tier 2 assessment in the draft NZTA Standard for Producing Air Quality Assessments for State Highway Projects (NZTA, 2010), hereafter referred to as the NZTA Guide, and the MfE Transport GPG. The purpose of this assessment is to determine whether the Project is likely to result in ambient air quality criteria being exceeded; in particular the national ambient air quality standards.

The following sections of this report present:

[1] The assessment also referenced a pre-consultation draft of the 2012 draft NZTA Guide for Producing Air Quality Assessments for State Highway Projects which will replace this standard.

- A description of the receiving environment (section 2), including:
  - topography
  - existing land uses (including sensitive receptors)
  - existing air quality
  - current airshed designation.
- A brief description of the Project, including projected traffic flows both on new or upgraded road links and on the existing road network in the immediate area (section 3).
- Methods used for determining pollutant emissions and assessing the impacts, and the relevant air quality standards and guidelines (section 4).
- A summary of the relevant provisions of regional and district plans and other relevant policy documents (section 4.5).
- Vehicle emissions modelling and dispersion modelling to predict future vehicle related emissions and to predict exposure levels to vehicle related contaminants (sections 6 and 7).
- Interpretation and analysis of predicted air quality impacts from vehicles (section 8).
- A discussion of the need for post-project monitoring and mitigation measures (section 8.11).
- A generic assessment of the potential effects arising from the construction of the Project, including a range of suitable mitigation and monitoring methods (section 9).
- A discussion of assumptions made and limitations of statistical models used (section 10).
- Conclusions (section 11)

2. Receiving Environment

2.1 Project Location and Land Use Zoning

The Project alignment runs through land that is currently rural or semi-rural. The CSM2 alignment also passes between two consented residential subdivisions. The Aberdeen subdivision is located between Prebbleton and Shands Road immediately south of the proposed alignment, and the Claremont subdivision is located between Main South Road and Hamptons Road immediately north of the proposed alignment. In addition, there are a number of individual residential dwellings scattered along the route.

Most of the land through which the Project runs through is within the Inner Plains Zone under the Selwyn District Plan. Land between Springs Road and Halswell Junction Road, at the eastern end of CSM2, is within the Rural 2 Zone under the Christchurch City Plan, while the southern end of MSRFL (on the eastern edge of Rolleston) lies adjacent to a Living 1B Zone under the Selwyn District Plan.

The Aberdeen subdivision is zoned Living 2, while an area of land to the northeast of Selwyn, immediately south of MSRFL (extending 600m northeast from Park Lane), is zoned Living Z under the Selwyn District Plan.

2.2 Topography

The Project area lies in the Canterbury Plain, southwest of Christchurch. The land across the Project area rises gently to the northeast, from approximately 20m above sea level near Prebbleton to 60m above sea level north of Rolleston. The nearest areas of elevated terrain are the Port Hills, which rise from the plain approximately 5.5 km southeast of the eastern end of the Project.

2.3 Sensitive Receptors

A sensitive receptor is a location where people or surroundings may be particularly sensitive to the effects of air pollution, also defined as: “highly sensitive air pollution land use” in the NZTA Guide. These include schools, preschools, residential healthcare facilities and residential dwellings.

There are no schools, preschools or healthcare facilities within 200m of any part of the proposed alignments of either CSM2 or MSRFL. Prebbleton School is located over 450m south of CSM2. However, as noted above, there are a number of residential dwellings within 200m of the proposed alignments, as shown in Figure 2 and **Appendix A**[2]. Part of the Aberdeen subdivision (approximately 1.6 hectares) is also within 200m of the alignment of the southbound off-ramp from CSM2 at the Shands Road intersection.

[2] As noted in section 4.2.1 of this report, beyond 200m from the kerbside, the contribution from vehicle-related emissions to concentrations of ambient air pollutants is expected to be minimal. Air dispersion models for road sources do not predict pollutant concentrations beyond 200m from the roadside.

The Outline Development Plan for the Living Z zones[3] to the northeast of Rolleston limits housing density to 10 houses/hectare, with a 40m wide setback along the existing alignment of Main South Road. This gives the potential for up to 100 houses to be constructed within 200m of MSRFL in this area, about 40 of which could be within 100m of the alignment.

Almost all of the Claremont subdivision is more than 200m from any part of the alignment.

[3] Outline development plans for Living Z zones form part of the Operative Selwyn District Plan.

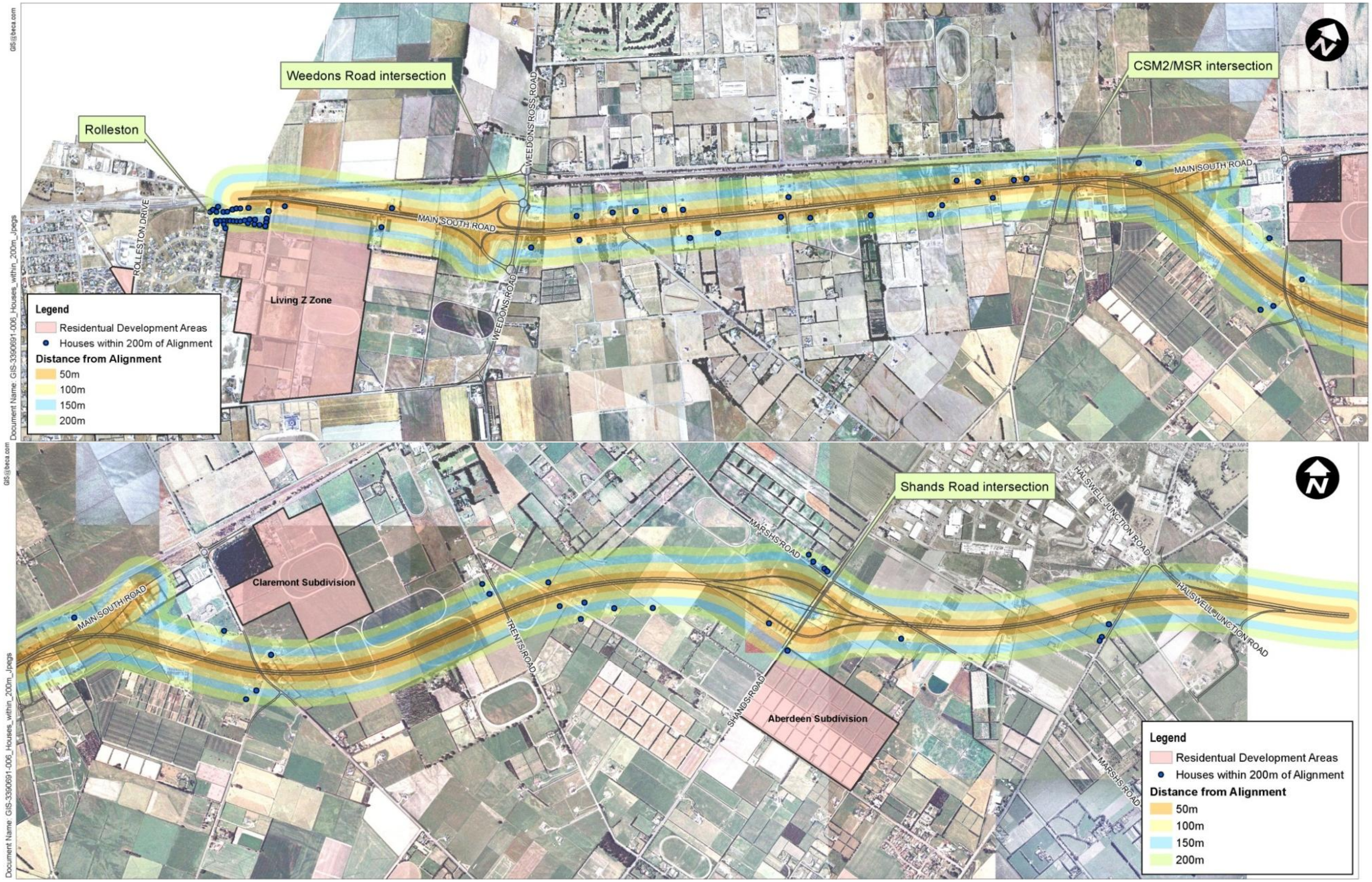

Figure 2: Residential Premises in the Vicinity of the Project

2.4 Meteorology

Wind directions in the Project area are highly variable, with the predominant wind direction being from the northeast. Figure 3 shows a summary of wind speed and direction recorded at Christchurch International Airport in between 2006 and 2009.

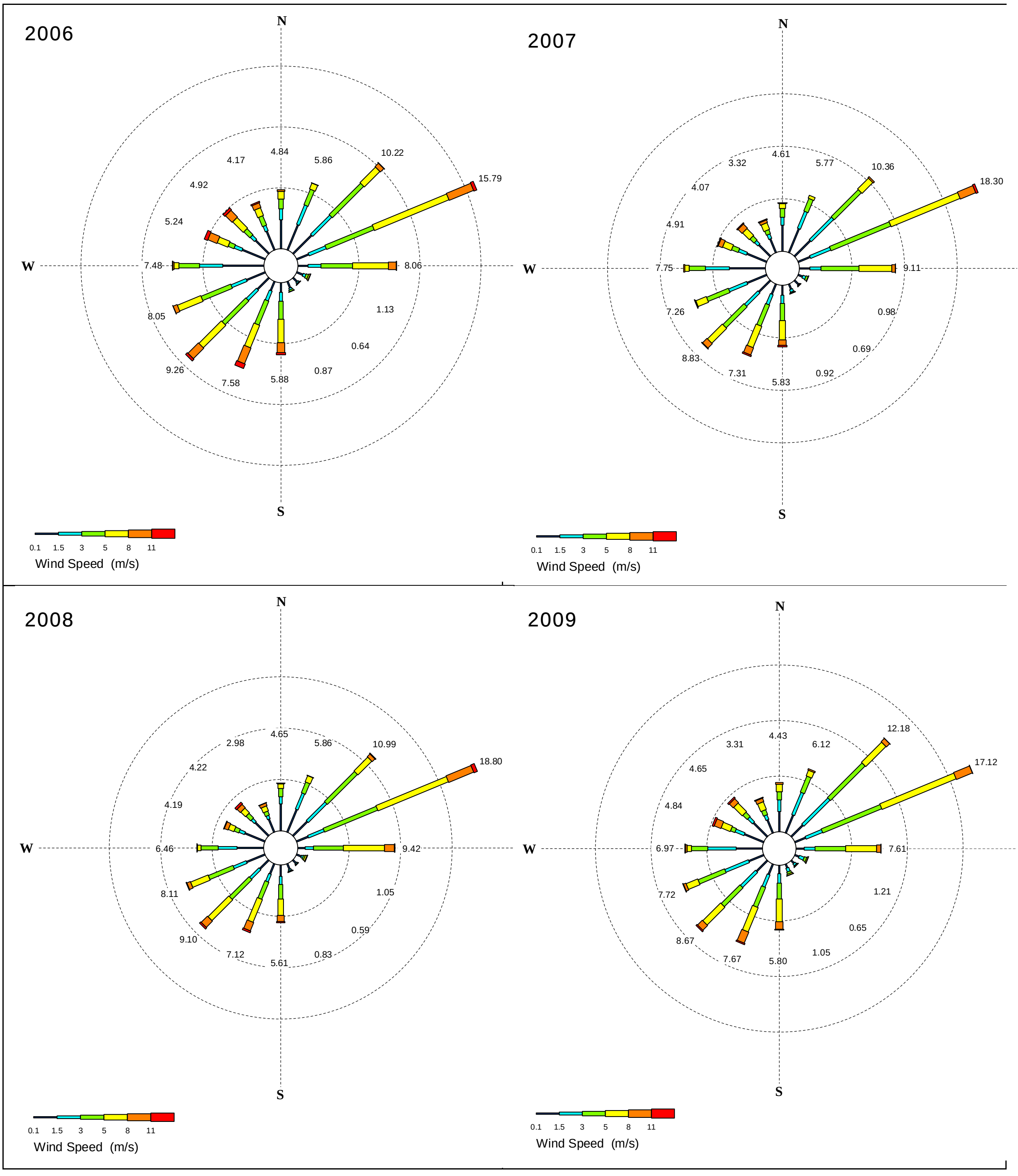

Figure 3: Wind speed and wind direction distribution at Christchurch International Airport, 2006-2009

2.5 Current Air Quality

2.5.1 Air Quality Zoning

The easternmost end of CSM2, between Halswell Junction Road and Springs Road, is within Christchurch Clean Air Zone 2 under Chapter 3 of the Canterbury Natural Resources Regional Plan (NRRP). Although not explicitly stated in the NRRP, the main purpose of Christchurch Clean Air Zone 2 is to provide for management tools to assist in reducing typical winter concentrations of PM_{10} in Christchurch Clean Air Zone 1 to below 50 µg/m^3. Christchurch Clean Air Zone 1 (the boundary of which follows Halswell Junction Road, which is the eastern edge of the Project area (refer Figure 4) has been gazetted as an airshed under the AQNES, because ambient concentrations of PM_{10} frequently exceed the AQNES threshold concentration of 50 µg/m^3 within this zone. The majority of the Project is not within any clean air zone area.

No part of the Project is in any airshed that has been gazetted as an airshed under the AQNES.

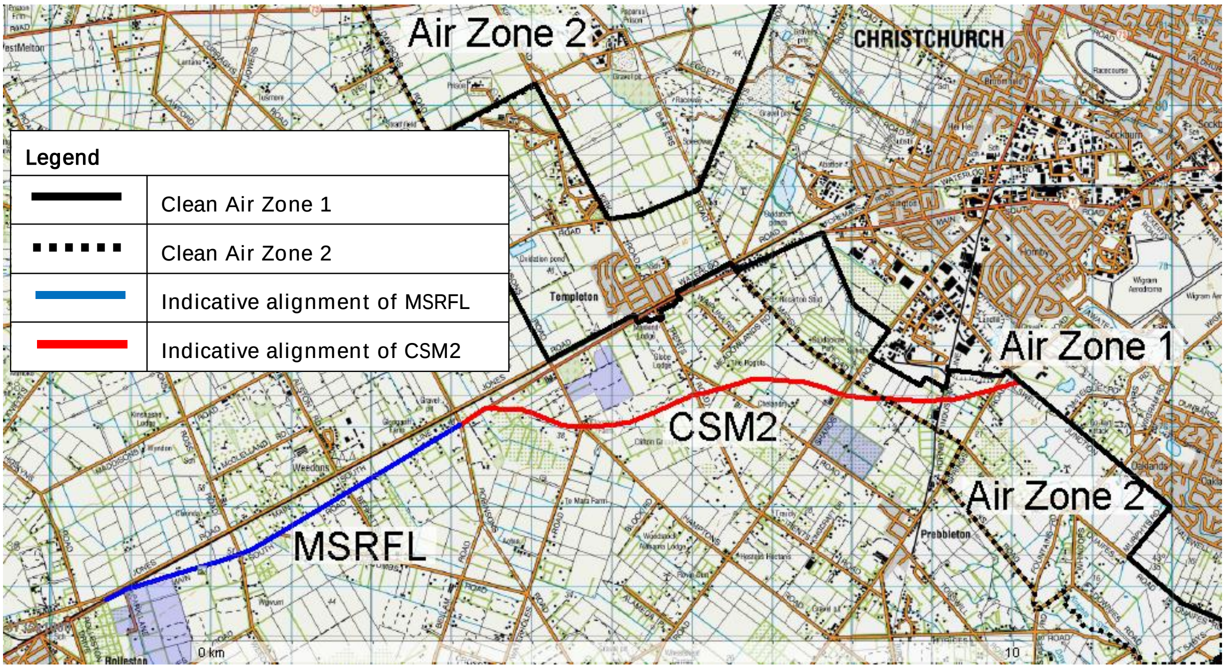

Figure 4: Christchurch Clean Air Zones – Map AQL17

2.5.2 Air Quality Monitoring

Although Environment Canterbury operates a number of continuous ambient air quality monitoring sites across the region, these are all located within urban areas. The closest of these sites is located on Riccarton Road, Christchurch, approximately 6.5km northeast of the Project area. The MfE also operates a continuous ambient air quality monitoring site in Burnside, Christchurch, approximately 8km northeast of the Project area. Given the location of each of these sites in urban areas and their distance from the Project area, it is considered that they are unlikely to be representative of air quality within the Project area.

Environment Canterbury has previously undertaken continuous air quality monitoring at sites in Hornby, Hoon Hay and Lincoln that are somewhat closer to the Project area. A continuous ambient air quality monitoring site has been operated in Papanui on behalf of the NZTA, in conjunction with the Christchurch Northern Arterial Project. Although this site is not in the vicinity of the Project, it is located in an urban fringe environment, which is likely to be more representative of air quality in the Project area than would sites located in urban environments. A brief description of each of these sites is given below, while the results of PM_{10}, NO_x and CO monitoring at each site are summarised in Table 1, while the locations of the sites relative to the Project are indicated in Figure 5.

Table 1: Summary of continuous ambient monitoring of PM_{10}, NO_2 and CO

Parameter	Site	Monitoring Period	Maximum Recorded Concentrations			
			1-Hour Average	Running 8-Hour Average	24-Hour Average	Annual Average *
PM_{10}	Hoon Hay	2002-2004	-	-	164 µg/m³	23 µg/m³
	Hornby	1995-1998	-	-	120 µg/m³	27 µg/m³
	Lincoln	2010-2011	-	-	30 µg/m³	13 µg/m³
	Papanui	2010 (part)	-	-	63 µg/m³	#
NO_2	Papanui	2010 (part)	63.5 µg/m³	-	29.3 µg/m³	#
CO	Hoon Hay	2002-2004	11.0 mg/m³	8.5 mg/m³	-	-
	Hornby	1995-1998	29.3 mg/m³	12.0 mg/m³	-	-
	Papanui	2010 (part)	8.2 mg/m³	5.4 mg/m³	-	-

Notes: * – The annual average PM_{10} concentration for the Lincoln monitoring site is calculated from the hourly average concentrations for the entire monitoring period (July 2010 to May 2011).
- There is insufficient data to calculate annual average concentrations at the Papanui monitoring sites

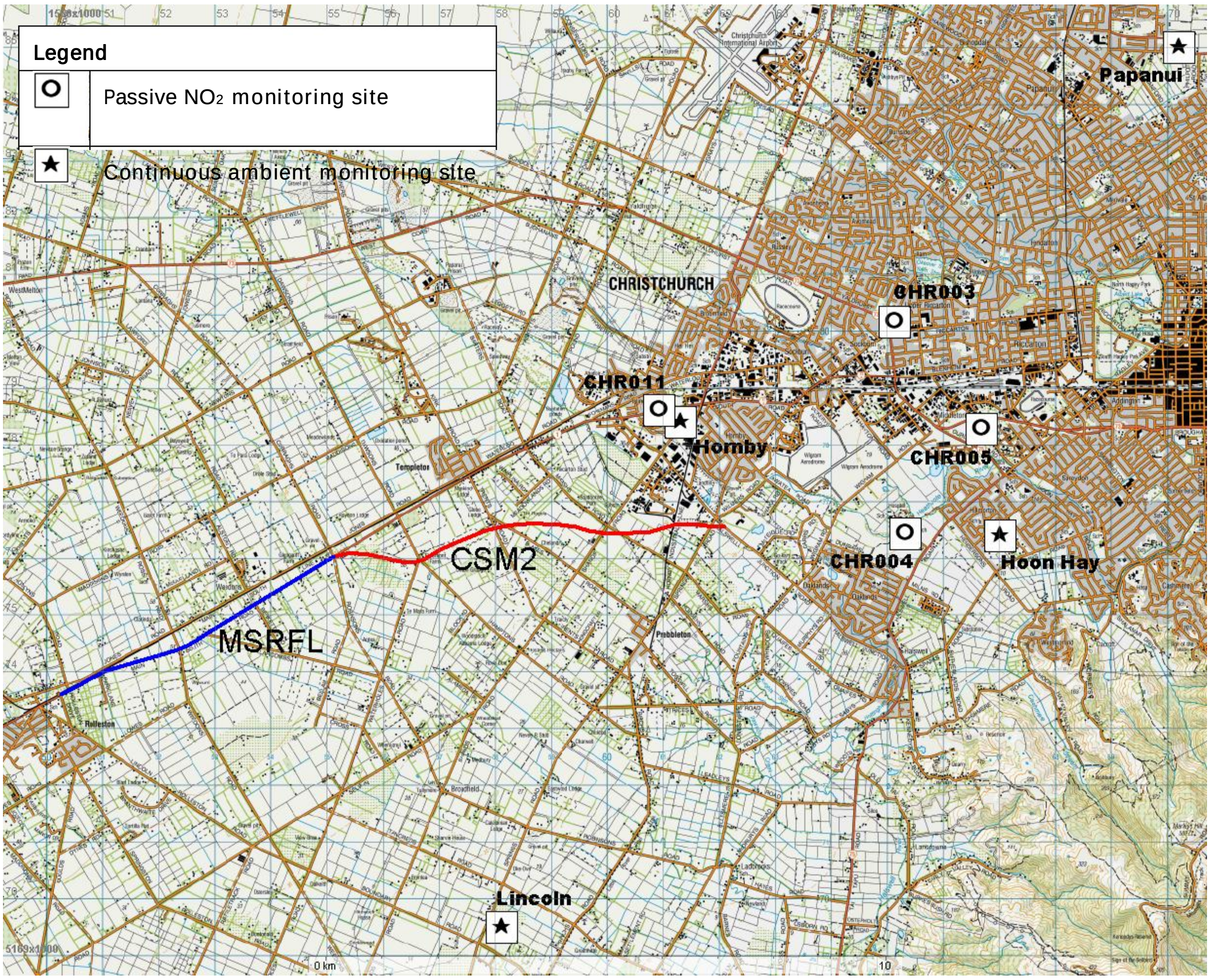

Figure 5: Ambient air quality monitoring sites

Hornby Monitoring Site

The Hornby site was located in the grounds of South Hornby Primary School (grid reference NZTM 15613 51784), approximately 1.2km north of the Project area. PM_{10} monitoring results are available for the Hornby site for 1995 to 1998 inclusive, while CO monitoring results are available for 1995 to 2000 inclusive. Five exceedances of the AQNES threshold concentration for CO (10 mg/m^3 as a running 8-hour average) were recorded in 1999, all occurring on the same day.

Up to 30 exceedences per year of the AQNES threshold for PM_{10} were recorded at the site between 1995 and 1998, with a maximum 24-hour average PM_{10} concentration of 120 µg/m^3 (recorded in 1997).

Hoon Hay Monitoring Site

The Hoon Hay site was located in Hoon Hay Park, between the Christchurch suburbs of Hilmorton and Hoon Hay (grid reference NZTM 15670 51764), approximately 5.2km east of the Project area. PM_{10} monitoring results are available for the Hoon Hay site for 2002, 2003 and part of 2004, while CO monitoring results are available for 2003 and 2003. 18 exceedences of the AQNES threshold for PM_{10} were recorded at the site in 2002 and 13 in 2003, with a maximum 24-hour average PM_{10} concentration of 164 µg/m^3 (recorded in 2002). Air quality monitoring at the site ceased in March 2004.

Lincoln Monitoring Site

The Lincoln monitoring site was located at the Crop & Food Research station 1km north of Lincoln (grid reference NZTM 1558114 5169504), approximately 5.5km south of the Project area. This site is periodically used for the monitoring of ozone, but a continuous PM_{10} monitor (TEOM_FDMS) was located at the site from July 2010 to May 2011, with the aim of identifying a 'background' level of PM_{10} with minimal interference from combustion activities. A copy of the monitoring results for this site has been provided to Beca, although these have not yet been validated by Environment Canterbury. The highest PM_{10} concentration recorded at the Lincoln site over this period was 30.0 mg/m^3 as a 24-hour average; both the highest and second highest PM_{10} concentrations at this site were recorded during the summer.

Papanui Monitoring Site (Northern Arterial Road)

The Papanui monitoring site was located close to Queen Elizabeth Drive, approximately 350m southeast of Redwood on the northern outskirts of Christchurch (grid reference NZTM 15702 51850). The site was operated by Watercare Services Limited between June and August 2010 on behalf of the NZTA, in support of an air discharge assessment for the proposed Christchurch Northern Arterial Road by the National Institute for Water and Atmospheric Research.

Three exceedences of the AQNES threshold for PM_{10} were recorded at the site during the monitoring period, with a maximum 24-hour average PM_{10} concentration of 63 µg/m^3. The highest recorded NO_2 concentrations were 63.5 µg/m^3 and 29.3 µg/m^3 as 1-hour and 24-hour averages respectively.

Passive NO_2 Monitoring

The NZTA operates a network of passive diffusion samplers to monitor NO_2 in the vicinity of state highways across the country.[4] Three of these are located in the vicinity of the Project area – SH75 Halswell, SH1 Hornby and SH76/SH75 intersection, while a fourth is located in Riccarton, approximately 4.5km to the northeast of the Project area.

Diffusion samplers are typically exposed to ambient air for periods of up to a month at a time, so cannot be used to measure short term concentrations of air pollutants. Instead, the results of such monitoring are typically expressed as annual average concentrations, which can be used to compare overall air quality at a number of locations. Annual average concentrations can also be used to estimate the 'risk' or likelihood of 1-hour average concentrations of NO_2 exceeding the AQNES[5].

The results of passive NO_2 monitoring at each site are summarised in Table 2. These results can be compared with the World Health Organisation (WHO) annual NO_2 guideline of 40 µg/m^3.

[4] Although most of the NZTA's passive NO_2 monitoring sites are adjacent to state highways, the network also includes local road and background sites.

[5] Longley et al, 2008.

Table 2: Annual average concentrations of NO_2 at passive NO_2 monitoring sites

Site ID	Location	Distance from Major Road (metres)	Annual Average NO2 Concentration (µg/ m³)		
			2009	2010	2011
CHR003	20 Rimutaka St, Riccarton	20	24.8	26.9	30.0
CHR004	Cnr Nash Rd & Aidanfield Dr, Hilmorton	470	11.3	15.0	16.3
CHR005	68 Annex Rd, Middleton	200	17.0	19.1 #	-
CHR011	2 Parker St, Hornby	20	-	27.6	26.2 *

* There are no results for monthly average NO_2 concentrations from CHR011 for July to December 2011. The annual average NO_2 concentration for CHR011 in 2011 have been estimated from the monthly average results for the period January – June, using a scale factor based on the relationship between monthly and annual average concentrations across the sites. This is based on an approach developed by NIWA for the assessment of the Western Ring Route: Waterview Connection Project in Auckland (Beca, 2010)

Passive NO_2 monitoring at the Annex Rd, Middleton site ceased at the end of March 2010.

3. Overview of Project

The NZ Transport Agency (NZTA) seeks to improve access for people and freight to and from the south of Christchurch via State highway 1 (SH1) to the Christchurch City centre and Lyttelton Port by constructing, operating and maintaining the Christchurch Southern Corridor. The Government has identified the Christchurch motorway projects, including the Christchurch Southern Corridor, as a road of national significance (RoNS).

The proposal forms part of the Christchurch Southern Corridor and is made up of two sections: Main South Road Four Laning (MSRFL) involves the widening and upgrading of Main South Road (MSR), also referred to as SH1, to provide for a four-lane median separated expressway; and the construction of the Christchurch Southern Motorway Stage 2 (CSM2) as a four-lane median separated motorway. The proposed construction, operation and maintenance of MSRFL and CSM2, together with ancillary local road improvements, are referred to hereafter as 'the Project'.

3.1 Main South Road Four-Laning

Main South Road will be increased in width to four lanes from its intersection with Park Lane north of Rolleston, for approximately 4.5 km to the connection with CSM2 at Robinsons Road. MSRFL will be an expressway consisting of two lanes in each direction, a median with barrier separating oncoming traffic, and sealed shoulders. An interchange at Weedons Road will provide full access on and off the expressway. MSFRL will connect with CSM2 via an interchange near Robinsons Road, and SH1 will continue on its current alignment towards Templeton.

Rear access for properties fronting the western side of MSRFL will be provided via a new road running parallel to the immediate east of the Main Trunk rail corridor from Weedons Ross Road to just north of Curraghs Road. For properties fronting the eastern side of MSRFL, rear access is to be provided via an extension of Berketts Drive and private rights of way.

The full length of MSRFL is located within the Selwyn District.

3.2 Christchurch Southern Motorway Stage 2

CSM2 will extend from its link with SH1 / MSRFL at Robinsons Road for approximately 8.4 km to link with Christchurch Southern Motorway Stage 1(CSM1, currently under construction) at Halswell Junction Road. The road will be constructed to a motorway standard comprising four lanes, with two lanes in each direction, with a median and barrier to separate oncoming traffic and provide for safety.[6] Access to CSM2 will be limited to an interchange at Shands Road, and a half-interchange with eastward facing ramps at Halswell Junction Road. At four places along the motorway, underpasses (local road over the motorway) will be used to enable connectivity for local roads, and at Robinsons / Curraghs Roads, an overpass (local road under the motorway) will be provided. CSM2 will largely be constructed at grade,

6 CSM2 will not become a motorway until the Governor-General declares it to be a motorway upon request from the NZTA under section 71 of the Government Roading Powers Act 1989 (GRPA). However, for the purposes of this report, the term "motorway" may be used to describe the CSM2 section of the Project.

with a number of underpasses where elevated structures provide for intersecting roads to pass above the proposed alignment.

CSM2 crosses the Selwyn District and Christchurch City Council boundary at Marshs Road, with approximately 6 km of the CSM2 section within the Selwyn District and the remaining 2.4 km within the Christchurch City limits.

3.3 Key design features

The key design features and changes to the existing road network (from south to north) proposed are:

- a new full grade separated partial cloverleaf interchange at Weedons Road;
- a new roundabout at Weedons Ross / Jones Road;
- a realignment and intersection upgrade at Weedons / Levi Road;
- a new local road running to the immediate east of the rail corridor, to the west of Main South Road, between Weedons Ross Road and Curraghs Road;
- alterations and partial closure of Larcombs Road intersection with Main South Road to left in only;
- alterations to Berketts Road intersection with Main South Road to left in and left out only;
- a new accessway running to the east of Main South Road, between Berketts Road and Robinsons Road;
- an overpass at Robinsons and Curraghs Roads (the local roads will link under the motorway);
- construction of a grade separated y-junction (interchange) with Main South Road near Robinsons Road;
- a link road connecting SH1 with Robinsons Road;
- a short new access road north of Curraghs Road, adjacent to the rail line;
- a new roundabout at SH1 / Dawsons Road / Waterholes Road;
- an underpass at Waterholes Road (the local road will pass over the motorway);
- an underpass at Trents Road (the local road will pass over the motorway);
- the closure of Blakes Road and conversion to two cul-de-sacs where it is severed by CSM2;
- a new full grade separated diamond interchange at Shands Road;
- an underpass at Marshs Road (the local road will pass over the motorway);
- providing a new walking and cycling path linking the Little River Rail Trail at Marshs Road to the shared use path being constructed as part of CSM1;
- an underpass at Springs Road (the local road will pass over the motorway);
- a new grade separated half interchange at Halswell Junction Road with east facing on and off ramps linking Halswell Junction Road to CSM1; and
- closure of John Paterson Drive at Springs Road and eastern extension of John Paterson Drive to connect with the CSM1 off-ramp via Halswell Junction Road roundabout (east of CSM2).

The proposed alignment is illustrated in Figure 6 and encompasses the MSRFL and CSM2 alignments between Rolleston and Halswell Junction Road.

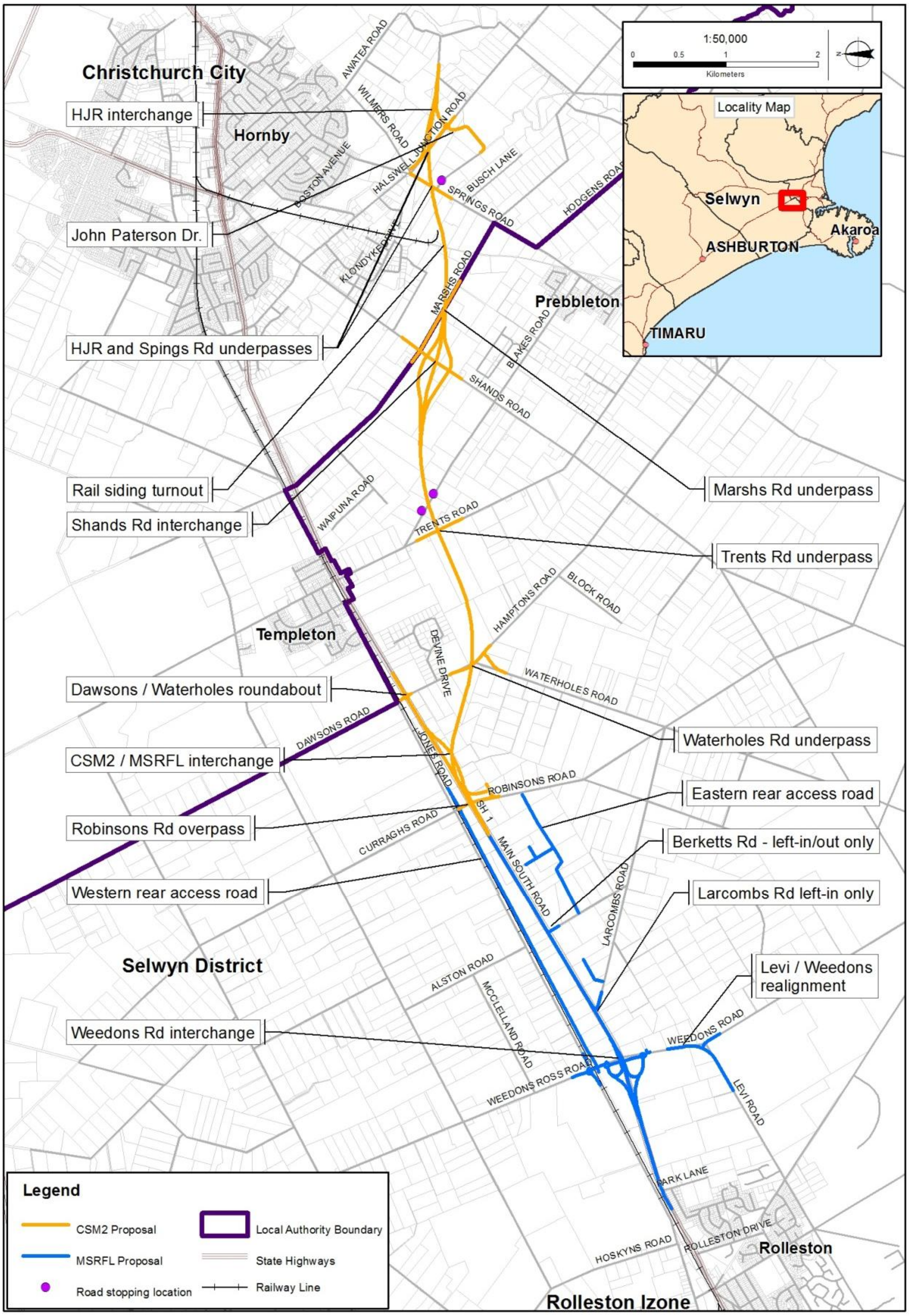

Figure 6 - Proposal Location Map

3.4 Traffic Volumes

Predicted traffic flows for each road link in the Project area, required as key input data for this assessment, have been prepared by Beca using a project specific model, CSM2 CUBE Voyager, based on the Christchurch Transportation Model (CTM_v2). Traffic flows have been provided for the projected year of opening (2016) and a future year (2026) for 'Do Minimum' and 'With Project' (CSM2 + MSRFL). Table 3 provides a high level summary of the predicted traffic volumes for each scenario.

Table 3: Average Daily Traffic Volumes [7]

Road and Location	With Project		Do Minimum	
	2016	2026	2016	2026
CSM2: Between Halswell Jn Rd & Shands Rd	19,750	27,250	N/A*	N/A
CSM2: Between Shands Rd & MSR	16,000	21,750	N/A	N/A
MSR: South of Halswell Jn Rd	16,250	20,000	30,250	35,750
MSR: South of Marshs Rd/ Barters Rd	17,000	20,750	28,000	33,250
MSR: South of Robinsons Rd/ Curraghs Rd	26,750	36,250	25,000	31,000
MSR: South of Weedons Rd/ Weedons Ross Rd	27,000	34,000	24,750	30,500

A summary of Annual Average Daily Traffic (AADT) for each link used in this assessment is presented in **Appendix B**. **Appendix B** also includes data for some of the minor roads in the vicinity of the Project, although the effects of vehicle emissions from traffic on these roads have only been considered for Shands Road and Marsh Road close to the Shands Road intersection. Traffic volumes on these two roads are predicted to increase significantly (i.e. by more than 10%) following the opening of CSM2 and there are a number of residential receptors close to that interchange.

Traffic volumes on the other minor roads in the Project area, and the section of Main South Road north of CSM2, are generally predicted to decrease following the opening of the Project or, if not (such as Weedons Road), there are no highly sensitive receptors within 200m of the alignment of either CSM2 or MSRFL in the vicinity of those minor roads.

[7] Predicted traffic volumes shown in Table 3 are taken from the *Assessment of Traffic and Transportation Effects, Technical Report No2*. Traffic volumes used in the remainder of this assessment are taken from an earlier version of the traffic model, generated in August 2011.

4. Methodology

4.1 Overview

The methodology is based on the draft NZTA Air Quality Standard, version 5 (NZTA, 2010), which recommends a tiered approach to the assessment of vehicle exhaust emissions from road projects, as follows:

- Tier 1: preliminary assessment, using the NZTA Screening Tool to identify whether there are likely to be significant air quality effects
- Tier 2: screening assessment, using NZTA Screening Tool for the preferred option
- Tier 3: full assessment, with increased complexity in both traffic emission and dispersion modelling and reliance on site specific data.

The NZTA has subsequently updated the draft standard as a "Guide to Assessing Air Quality Effects for State Highway Asset Improvement Projects" (NZTA Air Quality Guide); this guide is itself still in draft form, the most recent version (version 0.5) having been issued in June 2012. Using the methodology in this guide, a Tier 1 risk assessment for the Project would classify it as having an overall medium air quality risk, for the following reasons:

- There are more than 50 places where sensitive receptors are located within 200m of the alignment.

On this basis, the NZTA Air Quality Guide would require that at least a Tier 2 Screening Assessment was undertaken.

The assessment reported here represents a modified NZTA Tier 2 assessment, based on a Tier 2 screening dispersion modelling study in the MfE Transport GPG (MfE, 2008). The key difference between this assessment and a NZTA Tier 2 assessment is that the AUSROADS dispersion model and site-specific meteorology has been used to predict ground level concentrations of air pollutants, rather than the screening toolkit described in the draft NZTA Air Quality Standard (which was not released at the time this assessment was originally carried out). The aim of this technical assessment is to assess:

- The potential effects of vehicle emissions (including exhaust emissions and tyre and brake wear) on human health and the environment from vehicles using the Project; and
- 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 9 of this report.

The assessment has focused on determining the relative impact the Project will have on the existing air quality at sensitive receptors and areas most impacted by vehicles emissions, as well as comparisons of predicted ground level concentrations to relevant assessment criteria.

4.2 Approach to Assessment of Effects

4.2.1 Assessment of vehicle emissions

The effects of vehicle exhaust emissions are dependent upon a number of factors, including: mass emission rates of various contaminants, meteorology, background concentrations and the sensitivity of the receiving environment. The mass emission rates for different contaminants are in turn dependent on a range of factors, including: traffic volumes, vehicle speed, vehicle type and age and fuel composition.

The assessment of air quality impact has used air dispersion modelling techniques to predict NO_2 PM_{10}, $PM_{2.5}$, CO and benzene air pollutant levels in areas within 200m of CSM2 and MSRFL (see section 7). Beyond 200m, the contribution from the motorway to ambient air pollutants is expected to be minimal. The dispersion model inputs of vehicle emission rates and traffic volumes have been derived using traffic modelling and the Vehicle Emission Prediction Model (VEPM) emission factors (see section 6). To assess potential adverse effects, the predicted ground level concentrations of contaminants are then assessed against relevant health based New Zealand air quality standards, guidelines and targets (see section 8).

Comparisons against the air quality criteria have taken into consideration the sensitivity of the receiving environment (refer to section 2) and existing background pollutant levels (refer to section 5).

A total of four scenarios have been assessed for this report – two different scenarios for each of the years 2016 (the assumed year of opening) and 2026, as follows:

- "**Do Minimum**" assumes that all other road improvement projects in the surrounding area have been completed except for the Project

- "**With Project**" **(CSM2 + MSRFL)** assumes that both CSM2 and MSRFL have been completed along with all other road improvement projects in the surrounding area.

For each of the assessment years, the 'Do Minimum' scenario has been taken to represent the air quality 'baseline' for that year – i.e. ground level concentrations of air pollutants arising from the Project can be compared to predicted ground level concentrations in the absence of the Project, but including the effects of all other roading projects and changes to the vehicle fleet.

4.2.2 Assessment of Construction Dust Emissions

The assessment of construction dust is based on reviewing the proposed construction methodology to identify dust generating activities and assessing the proximity of these activities to residential properties and other sensitive receptors. Having identified these locations, mitigation measures are recommended for managing and minimising the impacts of dust emissions.

Rather than spending considerable time and effort on predicting the possible off site effects of dust discharges, it is considered more appropriate to design adequate and appropriate dust control measures in line with best practicable option (BPO).

4.3 Tier 2 Significance Criteria

The MfE Transport GPG provides a number of criteria to assist in assessing the likelihood of significant air quality effects. These are set out in Table 7.3 of the MfE Transport GPG, which is reproduced in Table 4 below.

The MfE Transport GPG (p. 49) states: "*If these criteria are exceeded, this does not necessarily mean the air quality impacts will be significant; it simply means a more accurate assessment should be undertaken.*"

Table 4: MfE Tier 2 Significance Criteria

Pollutant	Standard/Guideline	Significance Criterion	Time Average
PM_{10}	50 µg/m³	2.5 µg/m³	24 hour
$PM_{2.5}$	25 µg/m³	1.3 µg/m³	24 hour
Nitrogen dioxide (NO_2)	200 µg/m³ 100 µg/m³	20 µg/m³ 5 µg/m³	1 hour 24 hours
Carbon monoxide (CO)	10 mg/m³	1 mg/m³	8 hours

4.4 Air Quality Standards and Guidelines

Air quality standards and guidelines are used to assess the potential for ambient air quality 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
- Regional Air Quality Targets (unless these are more stringent than the equivalent National Environmental Standards, in which case the regional targets take precedence).

For the contaminants being considered within this assessment, relevant assessment criteria are discussed in this section, while the applicability of those criteria to different receptors or land uses is discussed in section 4.4.3.

The 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 that are relevant to this assessment are summarised in Table 5.

Table 5: National Environmental Standards for Ambient Air Quality

Pollutant	Threshold concentration	Averaging period	Permitted exceedances (per year)
Carbon monoxide	10 mg/m³	Rolling 8-hour	1
Fine particles (PM_{10})	50 µg/m³	24-hour	1
Nitrogen dioxide	200 µg/m³	1-hour	9

Notes: mg/m³ - milligrams per cubic metre; µg/m³ - micrograms per cubic metre

The Ministry for the Environment has published a set of NZAAQG, which were most recently updated in 2002 (MfE, 2002). The NZAAQG that are relevant to this assessment are summarised in Table 6.

Table 6: New Zealand Ambient Air Quality Guidelines

Pollutant	Threshold concentration	Averaging period
Carbon monoxide	30 mg/m³	1-hour
Fine particles (PM_{10})	20 µg/m³	Annual
Fine particles ($PM_{2.5}$)	25 µg/m³	24-hour
Nitrogen dioxide	100 µg/m³	24-hour
Benzene	3.6 µg/m³	Annual

Note: the $PM_{2.5}$ NZAAQG is a monitoring level only – that is, there is no specific requirement to achieve it.

The AQNES came into effect in 2005 and are defined for five common 'criteria' air pollutants. The AQNES apply nationally everywhere people may be exposed in the open air, except in areas to which a resource consent applies for the discharge of that contaminant. The standards do not apply inside enclosed spaces such as houses, tunnels or vehicles.

MfE, 2005 provides guidance with respect to the application of the AQNES in relation to land designations, as follows:

*"For **new** designations after 1 September 2005, territorial authorities and/or requiring authorities should consider the ambient air quality standards when weighing up whether new designations, or alterations to existing designations, meet the purposes of the RMA (e.g., safeguarding the life-supporting capacity of air). Territorial authorities will need to take into account the potential impacts of a new designation on air quality in the airshed, and the subsequent impact upon their ability to issue future resource consents within that airshed."*[8]

[8] MfE, 2005, p.31.

4.4.1 Regional Air Quality Targets

Schedule AQL1 to the NRRP sets out a number of Regional Air Quality Targets (RAQT) for the Canterbury region, based on the categories of air quality presented in the NZAAQG (i.e. Excellent, Good, Acceptable and Alert). RAQT that are relevant to this assessment are summarised in Table 7.

Table 7: Environment Canterbury Regional Air Quality Targets

Pollutant	Regional Air Quality Targets – Upper Thresholds				Averaging period
	Alert	Acceptable	Good	Excellent	
Carbon monoxide	30 mg/m³ 10 mg/m³	20 mg/m³ 7 mg/m³	10 mg/m³ 5 mg/m³	3 mg/m³ 1 mg/m³	1-hour 8-hour
Fine particles (PM_{10})	50 µg/m³ 20 µg/m³	33 µg/m³ 13.2 µg/m³	17 µg/m³ 5.61 µg/m³	No target set	24-hour Annual
Nitrogen dioxide	200 µg/m³ 100 µg/m³	132 µg/m³ 66 µg/m³	66 µg/m³ 33 µg/m³	20 µg/m³ 10 µg/m³	1-hour 24-hour

Comments (from NRRP):
Alert – This is a warning level, which can lead to exceedences if trends are not curbed.
Acceptable – Maximum values might be of concern in some sensitive locations, but are generally at a level that does not warrant dramatic action
Good – Peak measurements in this range are unlikely to affect air quality
Excellent – Peak measurements in this range ore of little concern for air quality

The AQNES are intended to provide for the protection of human health and have an enforceable legal status. The AAQG are intended to promote sustainable management of the air resource. The NRRP states that the aim of the RAAQT is to "*maintain air quality in areas of the Canterbury region where it is already good, and enhance air quality in areas of the Canterbury region where it is degraded or unacceptable.*" The NRRP also states "*The acceptable target is appropriate for protecting air quality for most areas of the Canterbury region where, although there is limited information, the air quality is clean and there are no specific issues. However, in general the rural areas of Canterbury will fit in the "good" category of the RAAQT and in general urban areas, where there are no specific issues or problems, will have "acceptable" air quality in terms of the RAAQT.*"[9]

In addition, there are a number of relevant international guidelines, particularly those promulgated by the World Health Organisation (WHO)[10] that must be considered. The WHO guideline that is applicable to this assessment is summarised in Table 8.

Table 8: WHO Air Quality Guidelines

Pollutant	Threshold concentration	Averaging period
Nitrogen dioxide	40 µg/m³	Annual

[9] NRRP Chapter 3 page 3 - 30

[10] Air Quality Guidelines Global Update 2005, World Health Organisation Regional Office for Europe.

4.4.2 Trigger Levels for Construction Dust

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

There are no air quality standards or guidelines for dust. A number of 'trigger levels' are contained in the MfE Dust GPG, which are summarised in Table 9. This presents three different trigger levels for total suspended particulate matter (TSP), depending on the sensitivity of the receiving environment, as well as one trigger level for deposited particulate.

Table 9: 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 area
Total suspended particulate	80 $\mu g/m^3$ 100 $\mu g/m^3$ 120 $\mu g/m^3$	24-hours 24-hours 24-hours	Highly sensitive areas Moderately sensitive areas Insensitive areas

These TSP trigger levels would be appropriate for managing effects of dust emissions once construction of the Project has commenced.

4.4.3 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.
8 hours and 24 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.

4.5 Statutory and Strategic Context

4.5.1 Overview

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. The RMA requirements are detailed in the Assessment of Environmental Effects for the Project.

There are a number of regional and district plans and certain other statutory and non-statutory documents that must be considered in relation to the assessment of effects of discharges into air, including:

- The Canterbury Regional Policy Statement
- The Canterbury Regional Land Transport Strategy
- The Canterbury Natural Resources Regional Plan
- Government Policy Statements on Land Transport Funding
- The NZTA [Transit] Environmental Plan

The following sections identify key matters from these documents, while further commentary on relevant documents is provided in **Appendix C**.

4.5.2 Natural Resources Regional Plan

Chapter 3 of the NRRP addresses air quality issues across the Canterbury region. This Chapter is largely operative, with the exception of provisions related to outdoor burning in residential areas.

Regional Policies

The key relevant policies of the NRRP are Policies AQL3 and AQ6, which state:

Policy AQL3 Promote measures to address motor vehicle exhaust emissions

(a) Promote traffic management that avoids the occurrence of localised air quality problems associated with exhaust emissions from motor vehicles.

(b) Promote initiatives to reduce the occurrence of smoky motor vehicle exhaust emissions.

Policy AQL6 Avoid Dust Nuisance

(a) The discharge to air of dust shall not be corrosive, noxious, dangerous, objectionable, or offensive to the extent that it has or is likely to cause an adverse effect on the environment beyond the boundary of the site where the discharge originates.

Regional Rules

Rule AQL12B defines discharges into air from mobile sources generally as a permitted activity.

Rule AQL12B Discharge to air from mobile sources – permitted activity

The discharge of contaminants into air from a mobile source such as an aircraft, except when it is on an industrial or trade premise for testing, repair, or maintenance, is a permitted activity.

The explanation to Rule AQL12B states:

Moveable sources will include aircraft, cars, and other forms of transport. When such items are being used for transportation, the resulting discharge of contaminants into air should be treated as being from a moveable source, and there should be no requirement that they obtain a resource consent.

Rule AQL38 defines discharges of dust from unconsolidated surfaces as a permitted activity. This rule principally applies to industrial and trade premises/processes. While it does not specifically identify road construction *per se*, the explanation to the rule does make mention of construction sites alongside industrial and trade premises.

Rule AQL38 Fugitive dust emissions from unconsolidated surfaces – permitted activity

Discharge of contaminants into air from unsealed or unconsolidated surfaces on industrial or trade premises and/or from industrial or trade processes, not otherwise addressed by rules in the NRRP, is a permitted activity.

Condition 1: The dispersal or deposition of particles shall not cause an objectionable or offensive effect beyond the boundary of the property where the discharge originates.

The explanation to Rule AQL38 states:

Discharges from unsealed or unconsolidated surfaces on industrial or trade premises and construction sites are common, but mitigation measures can be employed to prevent windblown dust emissions from these sites causing nuisance effects. Condition 1 has been adopted to control potential adverse effects on neighbouring properties. Consideration will be given to the assessment guidelines for dust in assessing the offensive or objectionable nature of any dust discharged beyond the property boundary.

There are no other rules in Chapter 3 of the NRRP that apply to discharges into air from either the construction or operation of roads.

5. Background Concentrations

5.1 Introduction

As noted in section 2.5 of this report, no monitoring of ambient air quality has been undertaken for this Project. Of the three monitoring sites operated by Environment Canterbury that are closest to the Project area, the Lincoln monitoring site is considered to be the most representative of existing ambient air quality. Most of the Project runs through essentially rural areas, with the exception of the southernmost part of MSRFL, which is on the northern edge of Rolleston, immediately adjacent to a residential area. In contrast, both the Hoon Hay and Hornby monitoring sites are located in established residential areas, within Christchurch Air Zone 1, and are likely to be significantly impacted by emissions from solid-fuelled home heating, as is the Papanui monitoring site. However, the Papanui monitoring site is considered to provide useful data for developing background concentrations of CO and NO_2.

5.2 Results of Ambient Air Quality Monitoring

Figure 7 below shows a summary of 24-hour average PM_{10} concentrations recorded at the Papanui and Lincoln monitoring sites, while Figure 8 shows PM_{10} pollution roses for each site based on 1-hour average PM_{10} concentrations and wind directions.

5.2.1 Papanui Monitoring Site

Three exceedences of the AQNES threshold concentration for PM_{10} were recorded at this site, which all occurred when the average daily temperature was less than 6°C and the daily average wind speed less than 1 m/s. As can be seen from Figure 8, the highest concentrations of PM_{10} recorded at the Papanui monitoring site occurred when winds were blowing from the northeastern quarter – i.e. from the Redwood area.

5.2.2 Lincoln Monitoring Site

The highest 24-hour concentrations of PM_{10} recorded at the Lincoln monitoring site occurred during the summer, although the highest 1-hour concentrations of PM_{10} were recorded during the winter. The highest concentrations of PM_{10} were recorded to occur when winds are blowing from the northeast – i.e. from the rural areas (refer Figure 8).

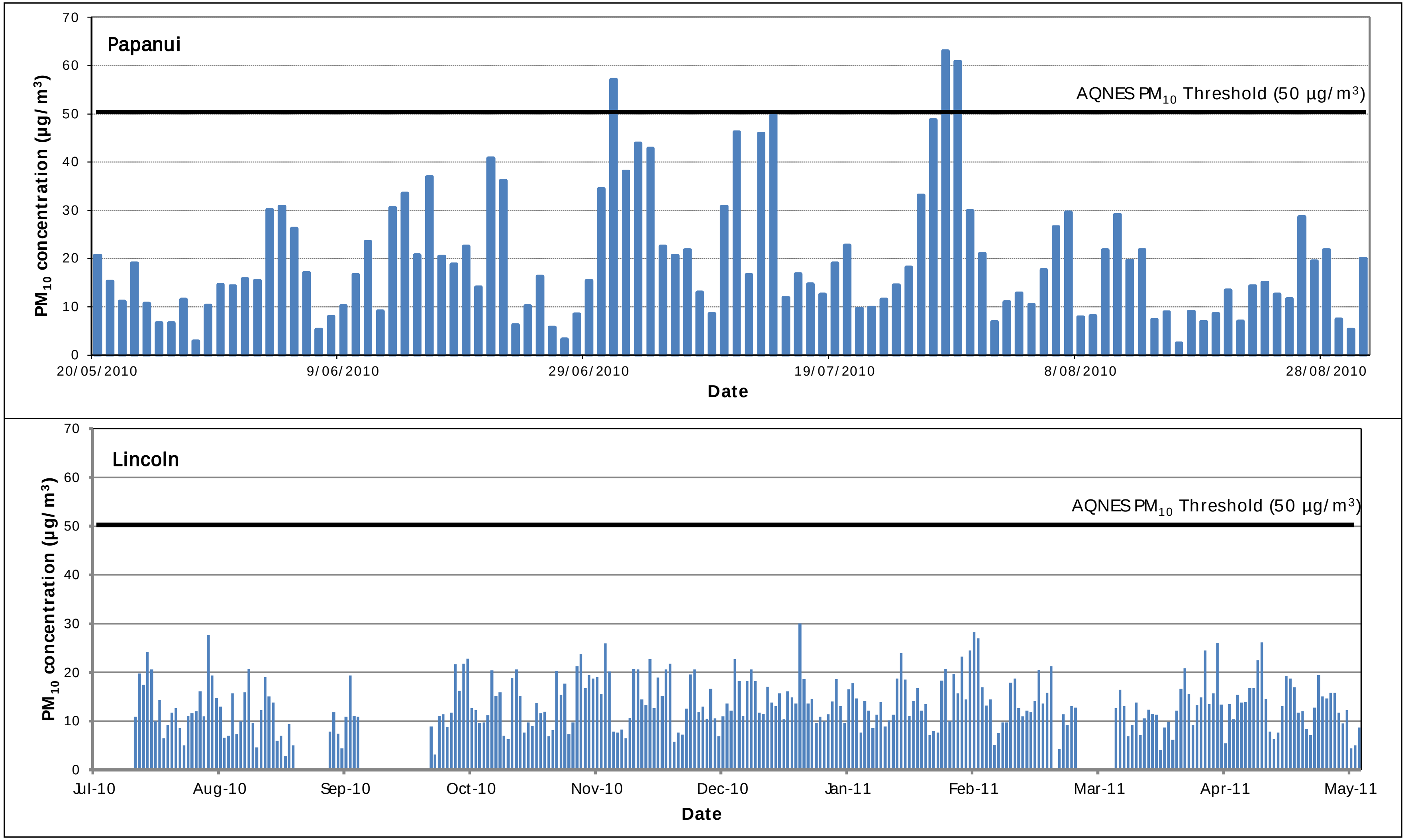

Figure 7: 24-Hour average PM_{10} concentrations recorded at the Papanui (top) and Lincoln (bottom) monitoring sites (µg/m³)

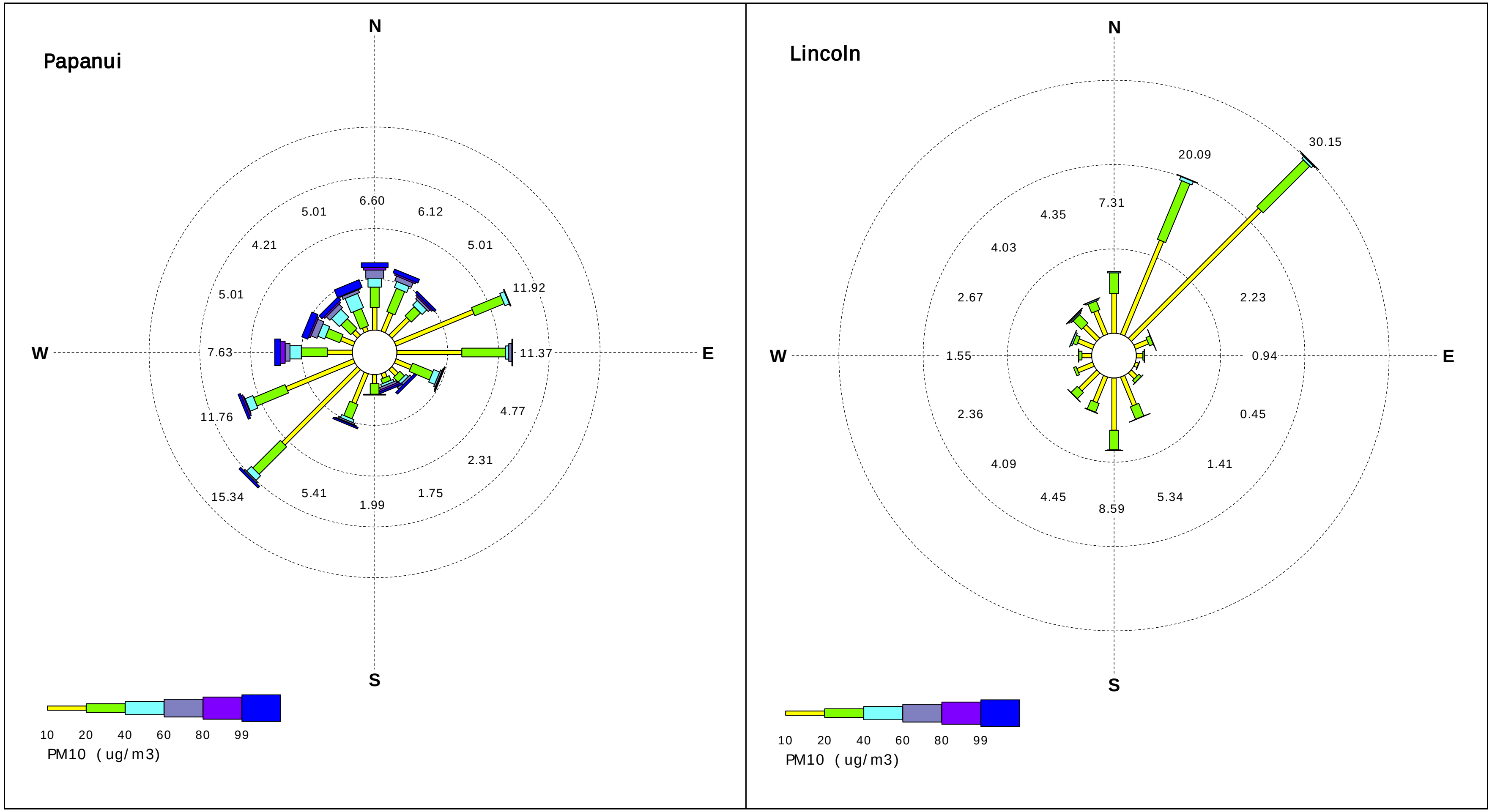

Figure 8: PM_{10} Pollution roses for the Papanui (left) and Lincoln (right) monitoring sites ($\mu g/m^3$)

5.2.3 Comparison of Lincoln and Papanui Monitoring Sites

Figure 9 shows a comparison of the winter (May-August) diurnal profiles of PM_{10} concentrations recorded at the Papanui (red) and Lincoln (blue) monitoring sites. This illustrates the significant contribution of night-time domestic heating to concentrations of PM_{10} recorded at the Papanui site. The diurnal profile for the Papanui site also indicates that there is may be a contribution to overall PM_{10} concentrations from traffic on the nearby Queen Elizabeth II Drive, approximately 50m to the northeast. In contrast, the profile for the Lincoln site does not indicate any particular influence from specific source groups.

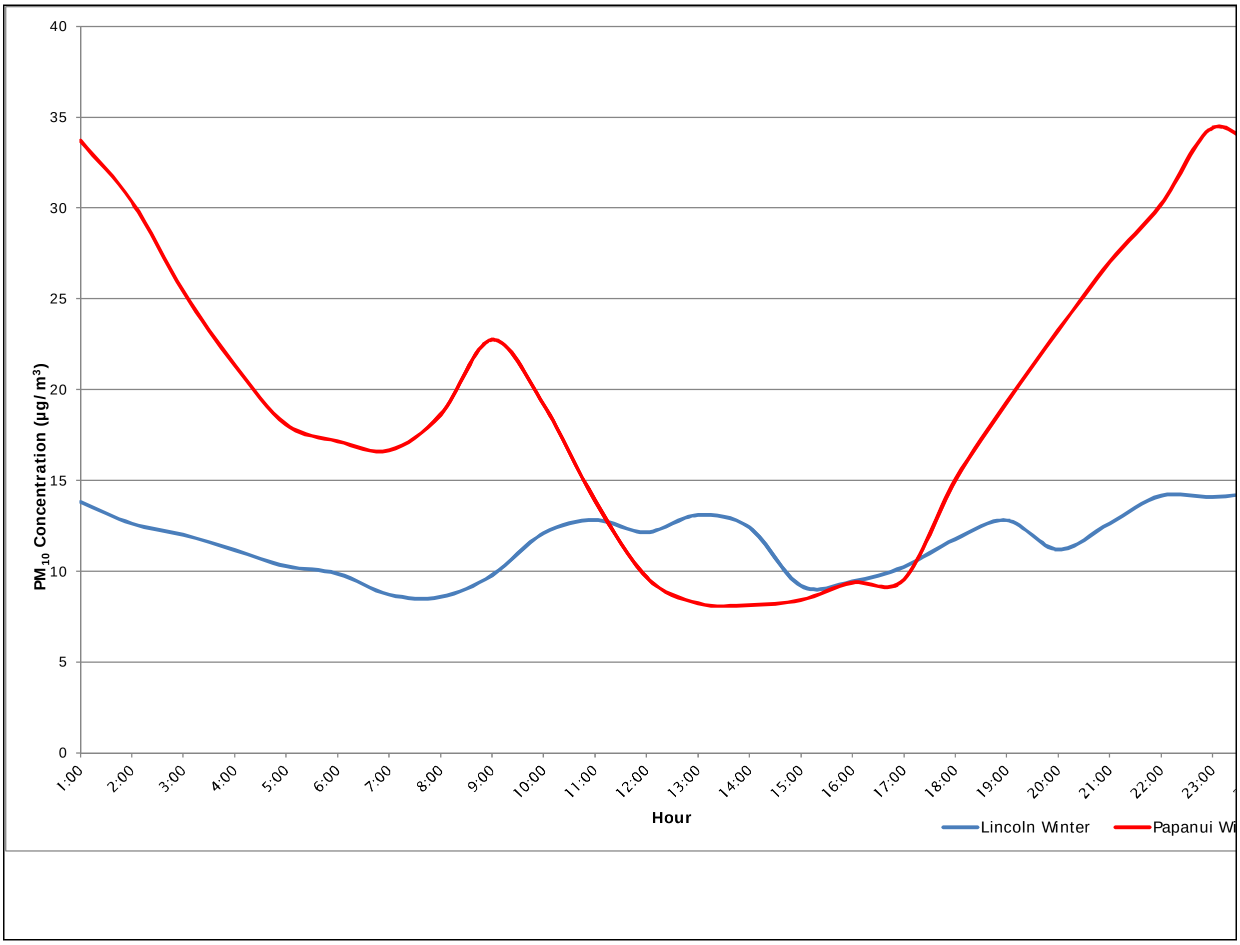

Figure 9: Diurnal Profile of Winter PM_{10} Concentrations Recorded at the Papanui and Lincoln Monitoring Sites (µg/m³)

5.2.4 Selection of Background Concentrations

As this is a Tier 2 screening assessment, it is considered appropriate to take a conservative approach to the selection of background concentrations, by using the maximum ambient concentrations of pollutants recorded in the Project area. It is assumed that these include contributions from all existing sources in the area – roads, industry, domestic heating, agriculture and natural sources.

5.2.5 PM_{10} Background Concentrations

The maximum 24-hour average concentration of PM_{10} recorded at the Lincoln monitoring site was 30 µg/m^3; this has been used as a background concentration for the calculation of all cumulative 24-hour average concentrations of PM_{10} for the Project. This avoids, for example, 'double counting' of contributions to background PM_{10} concentrations from traffic on Main South Road, which have been directly included in the dispersion modelling.

5.2.6 CO and NO_2 Background Concentrations

NO_x and CO monitoring was not undertaken at the Lincoln monitoring site. Notwithstanding reservations expressed above regarding the representativeness of PM_{10} concentrations recorded at the Papanui site for the Project, this site is probably more representative of ambient NO_2 or CO concentrations in the Project area than either the Hornby or Hoon Hay sites, given that both the latter are located within established residential areas, whereas the Papanui site is located on the urban fringe.

The maximum 1-hour and 24-hour average concentration of NO_2 recorded at the Papanui monitoring site were 63.5 µg/m^3 and 29.3 µg/m^3 respectively; these have been used as background concentrations for the calculation of all cumulative 1-hour and 24-hour average concentrations of NO_2 for the Project.

The maximum concentration of CO recorded at the Papanui monitoring site were 8.2 mg/m^3 and 5.4 mg/m^3 as 1-hour and running 8-hour averages respectively; these have been used as background concentrations for the calculation of all cumulative 1-hour and 8-hour average concentrations of CO for the Project.

5.2.7 Summary of Background Concentrations

Table 10 presents a summary of background concentrations of PM_{10}, NO_2 and CO used for this assessment. The ambient background concentration of benzene has been assumed to be zero.

Table 10: Summary of Background Concentrations of PM_{10}, NO_2 and CO

Parameter	Averaging Period		
	1-Hour	8-Hour	24-Hour
PM_{10}	-	-	30.0 µg/m^3
NO_2	63.5 µg/m^3	-	29.3 µg/m^3
CO	8.2 mg/m^3	5.4 mg/m^3	-

6. Modelling of Vehicle Emission Rates

As outlined in section 4.2 of this report, the effects of vehicle exhaust emissions are dependent upon a number of factors, including: mass emission rates of various contaminants, meteorology, background concentrations and the sensitivity of the receiving environment. This section outlines the key input data for and vehicle pollutant emission rates predicted by VEPM.

6.1 Factors which Affect Vehicle Emission Rates

The volume and concentrations of vehicle emissions depend on a number of factors, which include:

- Vehicle Age
- Whether vehicles are fitted with Catalytic Converters
- Vehicle Speed
- Fuel type
- Proportion of Heavy Vehicles
- Journey Length and Vehicle Mileage
- Road Surface and Gradient

A summary of the effects of each of these factors is presented in **Appendix D**.

6.2 Vehicle Emissions Prediction Model

6.2.1 Model Set-Up

Detailed emissions factors have been derived from VEPM v3 (Metcalfe, 2009)[11]. The key input parameters are summarised in Table 11, while further explanation of each parameter is presented in **Appendix E**. Diurnal emission profiles have been constructed for each road link as discussed in section 3.4 of this report.

[11] VEPM 5.0 (2012) is the latest version of this model. Beca has carried out a sensitivity analysis comparing emission rates for VEPM 3.0 and VEPM 5.0 for another state highway assessment (Mackays to Peka Peka). The general conclusions of that analysis are that mass emission rates for CO and NO_x are higher in VEPM 5.0 than in VEPM 3.0, but that mass emission rates for PM_{10} are lower.

Table 11: VEPM Input Parameters

Parameter	Settings
Modelling years	2016 and 2026
Vehicle fleet profile	VEPM default composition adjusted for %HCV from traffic model output
Average speed	Derived from traffic model output for each link
Non-exhaust emission factors	VEPM default settings
Catalytic Converters	VEPM default settings

6.2.2 Traffic Modelling Data

Vehicle emission rates calculated in this assessment are based on traffic volumes taken from an earlier version of the traffic model than that used for the final assessment of traffic effects report, generated in August 2011. An initial review of the differences between the versions of the traffic model indicates that, in the version used for the assessment of traffic effects report, predicted traffic volumes on CSM2 between Halswell Junction Road and Shands Road are substantially lower than those used in this report, with a consequent impact on mass emission rates and predicted pollutant concentrations. Conversely, predicted traffic volumes on MSR west of Weedons Road are higher than those used in this report, although this has less impact on the assessment of air quality effects because of the higher 'baseline' due to a parallel increase in predicted traffic on MSR in the Do Minimum scenarios. Overall, the differences between the two models do not affect the conclusions of this assessment.

6.3 Forecast Vehicle Emission Rates

6.3.1 Selection of Road Links

Road links to be used in the dispersion model were selected on the basis of predicted increases in traffic flow as a result of the Project and proximity to sensitive receptors[12]. Only those links for which the AADT was predicted to increase by greater than 10% compared to Do Minimum (MfE, 2008) and where identified sensitive receptors were located within 200m of either CSM2 or MSRFL have been included. In addition to CSM2 and MSRFL, these links include:

- Shands Road north of Marshs Road
- Shands Road south of Marshs Road
- Shands Road south of the Shands Road Intersection

[12] Traffic volumes used are taken from an earlier version of the traffic model, generated in August 2011.

- Marshs Road west of Shands Road
- Marshs Road east of Shands Road

6.3.2 Benzene Emission Rates

The VEPM emission factors do not directly calculate motor vehicle benzene emission rates, only the emission rate of total tail pipe hydrocarbon emissions. In this analysis, benzene emission rates have been estimated using the method detailed in the MfE Good Practice Guide for Assessing Discharges to Air from Land Transport (MfE, 2008), by assuming that approximately 5.9% of total hydrocarbon emitted by vehicle exhausts is in the form of benzene. Since emissions of benzene are primarily associated with exhaust emissions from petrol engines, this approach is likely to overestimate actual benzene emission rates. The small contribution from evaporative losses has not been incorporated into the emission estimates.

6.3.3 Predicted Pollutant Emission Rates

A summary of predicted PM_{10}, CO, NO_x and benzene emission rates for each of the road links used in dispersion modelling is attached at **Appendix F**. Pollutant emission rates in **Appendix F** are presented as grams per kilometre road per hour (g/km-hour) calculated by multiplying the predicted composite vehicle fleet emission rates by the predicted total hourly traffic volume.

7. Dispersion Modelling

7.1 Choice of Dispersion Model

Pollutant concentrations have been predicted using the AUSROADS dispersion model. AUSROADS is a simple Gaussian dispersion model developed by the Victorian Environmental Protection Agency (EPA), based on the Californian Department of Transportation's CALINE4 dispersion model. Compared to CALINE4, AUSROADS allows for an increased number of road links and receptor points, and ability to predicted pollutant concentrations using a full year of meteorological data.

AUSROADS is widely used throughout Australasia and is recognised in the MfE Good Practice Guide for Atmospheric Dispersion Modelling (MfE, 2004).

The model incorporates specific algorithms designed to simulate the dispersion of pollutants from roads. The dispersion algorithms simulate the effects of vehicle induced turbulence, thermal turbulence and surface roughness. AUSROADS is a 'near road' model and is intended for the assessment of pollutant concentrations within a few hundred metres of a road source. As a consequence, AUSROADS uses comparatively simple methods to account for terrain and structural effects on pollutant dispersion, e.g. allowing modelled road links to being classified as either elevated, depressed, or a bridge. AUSROADS does not take into consideration the effects that terrain has on pollutant dispersion, for instance the channelling of wind flows by hills or valleys. However, in this instance terrain is unlikely to have a significant effect on pollutant dispersion near the highway where peak pollutant levels are likely to occur. Similarly, as the buildings on either side of the highway are mostly one or two storey structures, recirculation effects associated with urban canyons are also not expected to occur.

Due to the comparatively simple terrain in the Project area and the fact that regional effects are not considered in the scope of the assessment, AUSROADS is a suitable model in this instance. A sample AUSROADS output file is attached at **Appendix I** to this report.

Dispersion modelling has only been undertaken for PM_{10}, since this is the pollutant of most concern. Maximum ground level concentrations of NO_2, CO and benzene have been estimated by prorating predicted PM_{10} concentrations by the relative emission rates for each parameter.

The key input parameters to the atmospheric dispersion modelling assessment are:

- Traffic volumes
- Vehicle emission rates

Traffic volumes on road links used in this assessment are summarised in **Appendix B** while a summary of the calculated pollutant emissions is presented in **Appendix F** to this report.

AUSROADS does not simulate the reactions of pollutant once discharged into the atmosphere. Consequently, NO_2 concentrations have been estimated from predicted NO_x concentrations using the method detailed in **Appendix G** to this report.

7.2 Modelled Emission Sources

Ground level pollutant concentrations have been predicted using AUSROADS for the following sections of road (**Appendix A**):

- Main South Road between Rolleston (500m north of Rolleston Drive) and Weedons Road (Interchange)
- CSM2 between Main South Road and Shands Road Interchange
- CSM2 between Shands Road Interchange and Halswell Junction Road
- Shands Road Interchange including Marsh Road and Shands Road

Each road link has been modelled as a single line source, with the overall mixing width based on the number of lanes and an aggregate two-way traffic flow calculated from the sum of one-way flows predicted by traffic modelling. The same diurnal flow profile has been assumed for all road links (refer section 3.4). In the model configuration it has been assumed that each individual lane is approximately 3.5m in width.

7.3 Configuration Options

AUSROADS was configured using the following options:

- Pasquill-Gifford horizontal dispersion profile
- Irwin Rural wind exponent (recommended by the Victorian EPA for rural environments)
- A surface roughness of 0.1m.

The selected surface roughness of 0.1m is representative of open, flat rural areas.

7.4 Receptor Grids

Due to the complexity of the modelled road network at the Shands Road Interchange (the two motorway carriageways, eastbound and westbound on- and off-ramps and two local roads, concentrations of pollutants have been predicted at specific receptors. For each of the other sections, rather than predicting concentrations of pollutants at specific receptors, a concentration profile has been estimated for distances up to 200m from the edge of the road, outside the Project's designation boundary. The designation boundary typically extends 25 - 30m from the road centre line. The receptors have been defined at ground level.

7.5 Meteorological Inputs

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.

For this assessment a 1-year meteorological input file (corresponding to the year 2007) for AUSROADS was constructed using the TAPM v4 ('The Air Pollution Model') meteorological and dispersion model.

TAPM, developed by CSIRO, is a sophisticated computer model that predicts the three dimensional meteorology and air pollutant concentrations by solving the fundamental fluid dynamic and scalar transport equations. It consists of coupled diagnostic meteorological and air pollution components that predict the air flows important to local scale air pollution, such as sea breezes, against a background of larger scale synoptic meteorological patterns (Hurley, 1999).

One of the primary functions of the TAPM model is the provision of high quality meteorological data for dispersion models where suitable onsite information is not available. Using historical synoptic scale meteorological analyses in conjunction with local land use and terrain information, TAPM can produce realistic and high quality meteorological inputs for a number of air pollutant dispersion modelling systems including AUSROADS. Validation studies show that TAPM can accurately predict localised meteorological conditions.

To help ensure that the wind fields predicted by TAPM accurately reflects the meteorological conditions near the Project, hourly wind speed and wind direction data recorded at the Christchurch Airport meteorological monitoring station (station ID number 4843[13]) were assimilated into the model. The AUSROADS meteorological input file was extracted from TAPM model at the approximate location of Christchurch Airport AWS. At this location wind flows predicted by TAPM will be representative of those recorded at the Airport. Meteorological conditions recorded at the airport are expected to be comparable to those in the Project area. The distribution of wind speeds and wind directions recorded at the Christchurch Airport for the year 2007 are representative of typical annual wind flow conditions recorded at the meteorological monitoring station.

TAPM was configured with nested grid spacings of 30, 10, 3, and 1km. The 2007 meteorological data input file was generated from the 1km spaced nested grid. Each nested grid was defined using 25 grid points in the east/west direction, 25 grid points in the north/south direction, and 25 vertical layers. Surface vegetation effects, hydrostatic pressure, rain processes and prognostic eddy dissipation options were selected in the simulation (recommended as defaults by CSIRO). Monthly deep soil moisture content was varied with respect to better simulate seasonal variations.

It is important to note that there is always a degree of uncertainty in model predictions. However, TAPM is expected to provide a reasonable statistical assessment of the dispersion conditions at each of the modelled locations.

Figure 10 shows a summary of wind speed and direction extracted from the 1-year meteorological input file for AUSROADS.

[13] Data sourced from the CliFlo database, www.cliflo.niwa.co.nz.

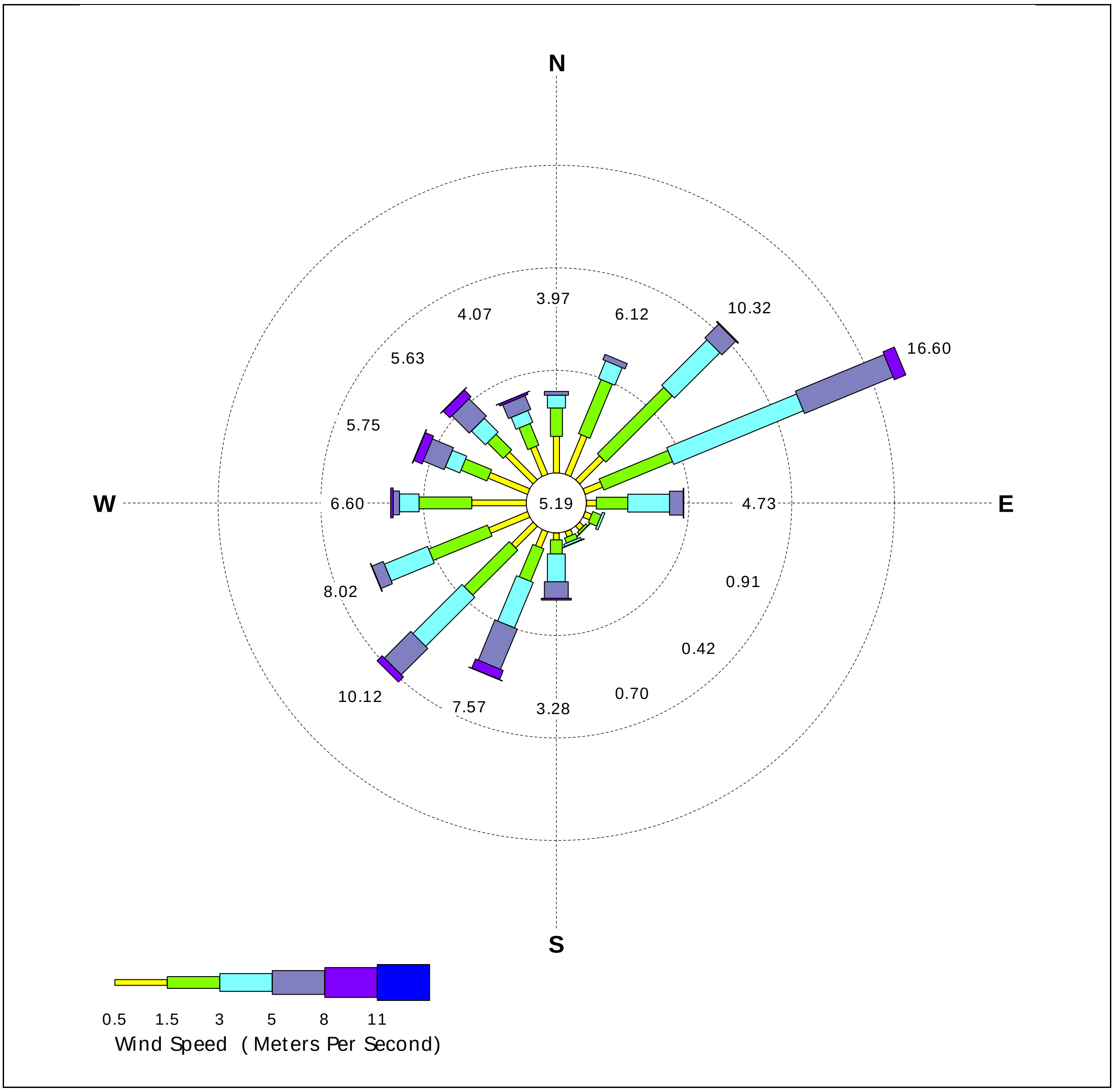

Figure 10: Wind speed and wind direction distributions taken from the AUSROADS meteorological input file (based on the Christchurch Airport monitoring station

7.6 Assessment of Nitrogen Dioxide

NO_2 passive sampling results indicate that current NO_2 concentrations near Main South Road are currently unlikely to exceed the AQNES and ARAQT air quality criteria level (refer to section 2.5). However, due to the reactivity of nitrogen oxides once released in the atmosphere, and the absence of any continuous monitoring data in the area, it is difficult to estimate precisely what actual NO_2 concentrations are likely to be in the vicinity of the Project. The methodology for estimating nitrogen dioxide concentrations is detailed in **Appendix G** to this report.

8. Assessment of Operational Effects

8.1 Introduction

This section of the report presents an assessment of the effects of air pollutants caused by vehicles using CSM2 and MSFRL. As explained in section 7, dispersion modelling was undertaken for the following sections of the Project:

- Main South Road – Rolleston to Weedons Road (Interchange)
- Main South Road – Weedons Road (Interchange) to CSM2
- CSM2 – Main South Road to Shands Road Interchange
- CSM2 – Shands Road Interchange
- CSM2 – Shands Road Interchange to Halswell Junction Road.

For each of these sections except Shands Road Interchange, maximum ground level concentrations of pollutants have been predicted at increasing distances from the road alignment. For Shands Road Interchange itself, maximum ground level concentrations of PM_{10} have been predicted at each identified sensitive receptor. In each case, maximum ground level concentrations of other pollutants have been 'pro-rated' from predicted PM_{10} concentrations, using the relative mass emission rates shown in **Appendix F** on a sector by sector basis. Detailed dispersion modelling results are presented in **Appendix H** to this report.

Cumulative concentrations of PM_{10}, NO_2 and CO have been calculated by adding the maximum concentrations predicted by dispersion modelling to the assumed maximum background concentration listed in Table 10 (refer section 5.2.7). The predicted maximum cumulative concentrations assumed that worst case background concentrations occur during the period when the contribution from the Project is predicted to be greatest. Predicted cumulative concentrations are therefore expected to be conservative and are likely to overestimate actual ground level concentrations.

All predicted concentrations are reported at the most impacted sensitive receptors located within 25-50m of the centreline of CSM2 which is equivalent to 10-35m from the edge of the alignment.

The following sections of this report present:

- the locations of sensitive receptors in the vicinity of each road section described above
- a summary of predicted concentrations of PM_{10}, $PM_{2.5}$, NO_2, CO and benzene
- a brief summary of regional cumulative effects
- a discussion of the operational effects of the Project.

Detailed results of dispersion modelling are presented in **Appendix H.**

8.2 Sensitive Receptors

All residential dwellings identified from the rates database have been considered in this assessment, excluding those located on properties that have been identified for complete purchase by the Crown for this Project, for reasons other than air quality effects. Locations of sensitive receptors in the vicinity of each road section are discussed below, while maps showing the locations of all selected sensitive receptors are attached at **Appendix A** to this report.

- Main South Road – Rolleston to Weedons Road (Interchange)
  - This is the only section of the Project where large numbers of sensitive receptors are located within 200m of this section of Main South Road – residential properties along Marlowe Place, Rolleston and the Living Z zoned land (currently undeveloped) to the northeast of Marlowe Place.
- Main South Road – Weedons Road (Interchange) to CSM2
  - There are a number of sensitive receptors located within 200m of this section of Main South Road.
- CSM2 – Main South Road to Shands Road Interchange
  - There are a small number of sensitive receptors located within 200m of this section of CSM2, mainly in the vicinity of Waterholes Road and Blakes Road. The closest of these receptors is located approximately 60m from the edge of the proposed alignment of CSM2. The southeastern corner of the Claremont subdivision is just within 200m of the alignment.
- CSM2 – Shands Road Interchange
  - There are a small number of sensitive receptors located within 200m of this section of CSM2, all close to Marsh Road and Halswell Junction Road. The closest of these receptors is located on Marsh Road, approximately 100m from the edge of the proposed alignment of CSM2, while a small part of the northern corner of the Aberdeen subdivision is within 100m-200m from the southbound off-ramp.
- CSM2 – Shands Road Interchange to Halswell Junction Road.
  - There are a limited number of sensitive receptors located within 200m of the Shands Road Intersection, all close to Marsh Road and Shands Road. The closest of these receptors is located on Shands Road, approximately 60m from the edge of the southbound on-ramp.

8.3 PM_{10} Concentrations

Between Shands Road and Halswell Junction Road, the maximum incremental increase in PM_{10} is 2.9 µg/m³, which is predicted to occur within 50m of the centreline of the alignment in the '2026 With Project' scenario. This is slightly higher than the MfE Tier 2 significance criterion of 2.5 µg/m³; however, the maximum predicted cumulative concentration of PM_{10} (i.e. including background) is considerably less than the AQNES of 50 µg/m³. The maximum increase in PM_{10} concentrations at the closest sensitive receptor to this section of the alignment (approximately 60m from the centreline) is 1.4 µg/m³.

In all other locations, the maximum predicted increase in 24-hour average PM_{10} concentrations at any identified sensitive receptors and at any receptor located more than 25m from the centreline of any part of the Project is less than the MfE Tier 2 significance criterion of 2.5 µg/m³, in all modelled scenarios.

8.4 NO_2 Concentrations

Between Shands Road and Halswell Junction Road, the maximum incremental increase is 13.7 µg/m³, which is predicted to occur in the '2026 With Project' option. This is lower than the MfE Tier 2 significance criterion of 20 µg/m³ as an 1-hour average and it is likely that the contribution to 24-hour average NO_2 concentrations due to the Project will be lower than the relevant MfE Tier 2 significance criterion of 5 µg/m³.

In all other locations, the maximum predicted increase in 1-hour average NO_2 concentrations at any identified sensitive receptor and at any receptor located more than 25m from the centreline of any part of the Project is less than the MfE Tier 2 significance criteria of 20 µg/m³ as a 1 hour average and 5 µg/m³ as a 24 hour average, in all modelled scenarios.

Predicted cumulative 1-hour average NO_2 concentrations at all locations are all considerably less than the AQNES of 200 µg/m³, and also less than the 24-hour average NZAAQG of 100 µg/m³.

8.5 CO Concentrations

The maximum predicted increase in 1-hour average CO concentrations at any identified sensitive receptor and at any receptor located more than 25m from the centreline of any part of the Project is less than the MfE Tier 2 significance criteria of 1 mg/m³ as an 8-hour average, in all modelled scenarios.

Predicted cumulative 1-hour average CO concentrations for each of the modelled emission scenarios are all considerably less than the NZAAQG of 30 mg/m³, and also less than the 8-hour average AQNES of 10 mg/m³.

8.6 Benzene Concentrations

The results indicate that, at distances greater then 50m from the centreline of Main South Road, there is effectively no difference in predicted maximum incremental benzene concentrations between the two Project options in either 2016 or 2026. Similarly, at distances greater then 50m from the centreline of CSM2, there is effectively no difference in predicted maximum incremental benzene concentrations between the 'With Project' options in either 2016 or 2026.

There is no MfE Tier 2 significance criterion for benzene. At the most impacted receptors (those located 15 - 25 m from the Main South Road between Weedons Road and CSM2), the predicted increase in annual average benzene concentrations between the 'Do Minimum' and With Project' emission scenarios is 0.07 µg/m^3. The results of the dispersion modelling indicate that annual average benzene concentrations for each of the modelled emission scenarios will be less than 6% of the NZAAQG at any receptor.

8.7 Predicted fine particulate ($PM_{2.5}$) concentrations

A proportion of the PM_{10} emitted from vehicles will be fine particulates with diameters less than 2.5 micrometres ($PM_{2.5}$). Fine particulates have the ability to penetrate deeper into the lungs and therefore have a greater potential to cause respiratory diseases compared to larger particulates. No long term ambient monitoring of $PM_{2.5}$ has been conducted in the Canterbury region.

Currently there is no air quality standard or guideline for $PM_{2.5}$. However, an indication of maximum 24-hour average incremental $PM_{2.5}$ levels has been derived based on predicted PM_{10} concentrations. Emissions of $PM_{2.5}$ from traffic have been estimated based on the proportion of particulates emitted from vehicle exhausts. Larger particles are expected to be emitted from tyre and brake wear.

Approximately 70% of total particulates emitted from vehicles for the years 2016 and 2026 are estimated to be emitted from vehicle exhausts (based on emission factors generated by VEPM). Therefore, at the most affected sensitive receptor, the maximum 24-hour average incremental $PM_{2.5}$ concentration for the 2026 'With Project' scenario is estimated to be 1.0 µg/m^3 (i.e. 70% of the predicted maximum PM_{10} concentration of 1.4 µg/m^3).

8.8 Air quality benefits

The Project is predicted to significantly improve travel times for through traffic between Rolleston and the southern side of Christchurch and relieve congestion and facilitate planned growth to the south and west of Christchurch and around Rolleston.

Heavy vehicles are expected to reroute from Main South Road through Templeton and Hornby onto CSM, with associated air quality benefits, as it removes this through traffic from the local streets in those areas and puts them onto a free flowing motorway facility.

As noted in section 3.4 of this report, traffic volumes on most minor roads in the Project area, and the section of Main South Road north of CSM2, are generally predicted to decrease following the opening of the Project. Consequently, there should be a proportionate reduction in in vehicle emissions and reduced exposure to vehicle-related air pollutants for residents in the vicinity of those roads.

8.9 Regional cumulative effects

Regional scale impacts on the wider airshed are expected to be insignificant, despite a slight increase in vehicle kilometres travelled overall. This is due to improvements in traffic flow through the Project area, combined with the continuing improvements in vehicle emissions generally. The Project will not affect the Canterbury Regional Council's ability to issue future resource consents within the airshed or to achieve compliance with the AQNES.

Total heavy commercial vehicle movements within the region are also forecast to increase regardless of whether the Project is built or not. Heavy commercial vehicles are higher emitters of pollutants per vehicle kilometre travelled than light vehicles.

8.10 Summary of Assessment of Operational Effects

The results of dispersion modelling indicate that only one link of the Project (CSM2 between Shands Road Intersection and Halswell Junction Road) is likely to cause the concentration of any air pollutant (specifically PM_{10}) to exceed any of the MfE Tier 2 significance criteria (i.e. criteria used to indicate if further assessment is required).

The results of dispersion modelling indicate that discharges of air pollutants caused by vehicles using CSM2 and the upgraded Main South Road will make only minor contributions to concentrations of PM_{10}, NO_2 and CO in the surrounding area. In no case are vehicle exhaust emissions predicted to contribute more than 5.7% of the AQNES threshold for PM_{10}, 6.9% of the AQNES threshold for NO_2 the AQNES, or 2.0% of the NZAAQG for CO.

The results of dispersion modelling indicate that discharges of air pollutants caused by vehicles using CSM2 and the upgraded Main South Road are unlikely to cause exceedences of any AQNES or NZAAQG at any nearby receptor.

The maximum increase in PM_{10} concentrations predicted to occur at an existing sensitive receptor is 1.4 µg/m^3, which is lower than the MfE Tier 2 significance criterion. For this reason, a Tier 3 assessment was not considered necessary for this Project.

Although vehicle numbers on Shands Road and Marshs Road are predicted to increase significantly in both 'With Project' scenarios (presumably as a consequence of traffic joining and leaving CSM2 at the Shands Road Intersection), maximum predicted ground level concentrations of air pollutants at sensitive receptors located close to these roads will still be well below the relevant health-based assessment criteria.

It can be inferred that discharges of air pollutants caused by vehicles using CSM2 and the upgraded Main South Road are also unlikely to cause more than minor adverse effects on human health or the environment in the surrounding area.

8.11 Operational Monitoring and Mitigation

The assessment of operational effects concluded that vehicle exhaust emissions from the Project are unlikely to cause exceedences of any relevant air discharge assessment criterion or to cause more than minor adverse effects on human health or the environment. Therefore, it is considered that no mitigation of effects is required.

Given the low relative predicted contribution of vehicles using the Project to ambient concentrations of pollutants, it is reasonable to conclude that monitoring of vehicle exhaust emissions associated with the Project is not required.

9. Construction Effects

9.1 Introduction

The main potential effect on air quality from road construction is dust. There may also be air discharge effects arising from discharges of odour or of engine exhaust emissions from construction traffic, but these are generally much less significant than those from dust emission.

Overall, it is considered that there is no more than a medium level of risk of adverse effects due to dust discharges during the construction of the Project. There are significant numbers of sensitive receptors within 200m of the construction footprint, but these are mostly rural properties scattered along the alignment. There is the *potential* for about 100 new houses to be built within 200m of the alignment just to the northeast of Rolleston; although actual development in this area has not yet commenced, these must be considered part of the receiving environment.

9.1.1 Dust

The construction of CSM2 and the widening of Main South Road between CSM2 and Rolleston will entail relatively large scale earthworks. 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 dust 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". Deposited particulates are particulates having an aerodynamic size range greater than about 20µm. 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 Project area. For example, other construction activities may also be occurring at the same time, while re-entrainment of road dust on existing roads will also contribute to overall dust levels. For example, during the construction of CSM1, dust discharges from the development of a nearby subdivision were reportedly more significant than those from CSM1 itself [14].

There are no published data on current levels of suspended particulate matter (TSP) or dust deposition rates in the Project area. The "*Good Practice Guide for Assessing and Managing the Environmental Effects of Dust Emissions*" (MfE Dust GPG) (MfE, 2001) states that background TSP levels in clean

[14] Personal communication to the author from Peter Savage, who is Fulton Hogan's construction environmental manager for the CSM1 project.

environments (such as rural areas) are about 10-20 µg/m^3, while general dust deposition rates range from 1-4 g/m^2/30 days. Both the TSP concentrations and dust deposition rates in the Project area are likely to be slightly higher than these values, as a consequence of dust arising from repairs and demolition work associated with the Christchurch earthquakes.

9.1.2 Other Discharges

Road construction activities in themselves are not usually regarded as a source of odour. In addition, there are no known potential odour sources (e.g. closed landfill sites) that are likely to be disturbed by the construction of the Project.

Most construction vehicles have diesel engines, which will discharge PM_{10}, CO and VOCs, while poorly maintained vehicles may also generate excessive smoke. These have the potential to cause adverse effects for nearby receptors.

Construction traffic will have access to Main South Road via Curraghs Road and Robinsons Road. There will also be direct access to Main South Road during the widening works. If construction traffic needs to travel through Templeton, it will be encouraged to remain on Main South Road rather than utilising Jones Road, to minimise adverse effects on these residents.

Compared to emissions from ‘normal’ traffic volumes, the actual air quality effects of engine exhaust emission from construction traffic will be minimal, due to the relatively small number of vehicles, while good engine maintenance will minimise or avoid adverse effects from engine exhaust smoke.

9.1.3 Approach to the Assessment of Effects from Construction Activities

This report focuses on the construction activities that are likely to generate dust and the measures to prevent dust nuisance. This is intended to inform the preparation of a construction dust management plan, which will form part of a Construction Environmental Plan (CEMP) for the Project.

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. As a result, the MfE Dust GPG[15] 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.

This approach has been followed in this assessment. With respect to dust discharges, this section will firstly summarise dust discharges in general, the various sources of dust discharges associated with

[15] MfE Dust GPG p.23 (MfE, 2001).

construction activities and the factors that contribute to dust discharges from those source. Finally, this section will consider appropriate mitigation, control and monitoring measures.

The factors that determine whether or not a discharge creates a nuisance are commonly referred to as the FIDOL factors – frequency, intensity, duration, offensiveness and location (MfE, 2001). These are outlined in the MfE Dust GPG as follows:

- the **frequency** of dust nuisance events
- the **intensity** of events, as indicated by dust quantity and the degree of nuisance
- the **duration** of each dust nuisance event
- the **offensiveness** of the discharge, having regard to the nature of the dust
- the **location** of the dust nuisance, having regard to the sensitivity of the receiving environment

Frequent low intensity discharges may create a nuisance, as may infrequent intense episodes. The offensiveness of a dust discharge may be influenced by a number of factors, e.g. whether it causes staining or surface damage. Locations such as residential dwellings are more sensitive to dust than open farmland.

9.2 Dust Generation during Construction

9.2.1 Source of Dust

Potential sources of dust that are able to cause nuisance beyond the site boundary during adverse weather 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
- 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 yard 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 the 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 when exposed to strong winds. It is anticipated that the Project will require approximately 1,035,000 m^3 of fill, a third of which will come from cuts undertaken for the Project, with the remainder sourced from earthquake demolition waste, local quarries and the Waimakariri River. In addition, there is likely to be approximately 85,000 m^3 of surplus material that is unsuitable for re-use as construction fill within the Project.

9.2.2 Construction Staging

Based on the indicative construction programme (refer Chapter 5 of the AEE), construction of the Project will take three to four years and will be carried out simultaneously at several locations along the Project alignment.

Construction of the main alignments of CSM2 and MSRFL is anticipated to take approximately 2¼ years. Construction of local road connections will be undertaken in parallel with construction of the main alignment, with rolling start dates from one end of the Project to the other, while certain local road connections (e.g. new rear access to properties on Main South Road) will form part of the 'early works' for the Project.

9.2.3 Site Compounds

The construction methodology in Chapter 5 of the AEE identifies four proposed locations for site construction compounds, as follows:

- A main site compound, including the main Project office, to the east of CSM2 at Robinsons Road
- At the southeast corner of the Marshs Road / Shands Road intersection
- Within the Weedons Interchange
- Near Trents Road where is crosses CSM2

There may also be additional small satellite compounds for the contractor at each interchange or bridge location.

The main site compound will contain features commonly associated with construction facilities, including:

- Temporary site buildings
- Material laydown areas
- Workers' office and workshop accommodation
- Plant and equipment maintenance facilities
- Refuelling facilities
- Wheel washing and cleaning facilities
- Car parking
- Plant and equipment storage areas.

9.3 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
- 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 dust prevention methods detailed in section 9.4 of this report 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[16] 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.*"

Because it is relatively large in size, deposited particulate usually falls out of the air within a short distance of the source and usually within 100 m to 200 m. In steady wind conditions, with average wind speeds of less than 10 m/s, 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, while wind gusts of over 15 m/s are not uncommon in the Project area.

[16] MfE Dust GPG p.40 (MfE, 2001).

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. 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 would be considered as potentially impacted by 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.

9.4 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 (via an Air Quality Management Plan). 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.

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 metaling, 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 metaling, 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.

Vehicles and Machinery

- 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.
- Should material be tracked out from the sites onto public roads, this can 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.

Stockpiles and Spoil Heaps

- 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.

Wet Suppression

- 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 meter per hour. The construction methodology for the Project[17] notes that the water demand for the Project will be up to 2,500 m^3 per day, part of which will be used for dust suppression and operation of wheel or tyre washes.

Wind Fencing

- Wind break fencing 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%.

Concrete

- There will be no use of bulk (dry) cement on the site. All concrete components required for the Project will either be pre-cast off-site (e.g. bridge beams) or cast *in situ* using wet concrete from local suppliers.

9.5 Monitoring

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

The objective of this programme is to identify conditions where dust nuisance may occur and to assess whether the proposed mitigation and control measures as implemented are effective in minimising dust emissions.

Table 12 outlines the dust monitoring methodology that is recommended. The frequency of monitoring is defined, although it should be noted that in the instance of strong winds, emissions of dust off-site or following a complaint, additional the monitoring may be required.

Dust deposition gauges, while simple to use, are unsuitable for active monitoring and control of dust emissions, due to the long measurement period (typically one month). Although TSP monitoring by gravimetric samplers or continuous analysers can provide useful information for such monitoring and control, given the largely rural location of the project, routine TSP monitoring is not considered necessary or appropriate. However, it may be appropriate to undertake such monitoring at key locations (where sensitive receptors are located close to major potential dust sources) or to assist in the management of known dust problems – for example, as identified by complaints. At this stage, no such 'key locations' have been identified.

Given the overall scale of the Project, much of the monitoring described in Table 12 below will only be necessary in areas that construction is actually taking place at the time.

[17] Chapter 5 of the AEE.

Table 12: Dust Monitoring Programme

Monitoring activities	Frequency
Active monitoring of total suspended particulate using e-BAMs, optical monitors or equivalent	Continuous where undertaken
Inspect land adjacent to the site, construction exits and adjoining roads for the presence of dust deposits.	Twice daily
Check weather forecasts for strong winds and rainfall to plan appropriate dust management response.	Daily
Observe weather conditions, wind via observations and data outputs from weather stations and presence of rain.	Daily and as conditions change
Inspect all unsealed surfaces (including earthworks sites) for dampness and to ensure that surface exposure is minimised.	Daily and as conditions change
Inspect all sealed surfaces to ensure that they are clean and all spillages have been cleared.	Daily
Inspect stockpiles to ensure enclosure, covering, stabilisation or dampness. Ensure stockpile height is less than 3m or appropriately stabilised.	Weekly and at times of expected high winds
Inspect dust generating activities to ensure dust emissions are effectively controlled	Daily and as new activities are commenced
Additional monitoring of dust generating activities and water application rate	In winds over 5.5 m/s
Inspect watering systems (sprays and water carts) to ensure equipment is maintained and functioning to effectively dampen all exposed areas.	Weekly
Inspect site access and egress points to ensure effective operation of wheelwash/truckwash systems and/or judder bars (if installed).	Weekly
Ensure site windbreak fences are intact.	Weekly
Review effectiveness of contractors' site induction training related to dust management	Monthly

10. Assumptions and Limitations

10.1 Introduction

Air quality assessments for roading improvement projects rely on statistical models to estimate likely impacts of those projects. The use of statistical models, by the very nature of those models, will introduce a degree of uncertainty into the outcomes, in addition to uncertainty in the raw data used as model inputs.

In this assessment, some raw data has been derived from measurements (e.g. ambient air quality and meteorological monitoring and traffic count data), while other data relies on the outputs from other models (e.g. traffic flows predicted by CSM2 CUBE Voyager, vehicle emission rates from VEPM).

No attempt has been made to quantify the degree of uncertainty in the modelling reported in this assessment. The only difference in inputs between the 'Do Minimum' and 'With Project' scenarios in 2016 and 2026 are CSM2 and MSRFL. Therefore, notwithstanding the inherent uncertainties in the actual results of dispersion modelling, it is reasonable to base conclusions on a comparison of the relative differences between the predicted results of this modelling, both with and without the Project.

10.1.1 Vehicle Emissions Modelling Assumptions

Key assumptions in the determination of vehicle emissions from CSM2 and MSRFL were:

- Vehicle emissions were modelled using the results of the traffic modelling as inputs (% HCV, total vehicles and speeds) for each link.
- Traffic flow profile on Main South Road in January and August 2006 is representative of traffic flow profiles on all roads in the Project area.
- The vehicle emission factors are a fleet average "composite" factor based on the New Zealand vehicle fleet. The average "composite" factor is generated using a vehicle fleet profile, which assumes that the overall fleet mix in VEPM is representative of fleet mix in Canterbury. A limited sensitivity analysis has been undertaken, by adjusting the composition of the light vehicle fleet in VEPM for the slightly higher proportion of light diesel vehicles registered in Canterbury (22.8%) compared to the national fleet (21.1%). The resultant increases of 3.5±0.5% and 0.8±0.1% in predicted fleet average emissions of PM_{10} and NO_x respectively are not considered to be significant.
- The proportion of heavy vehicles predicted to travel on roads in the study area in 2016 - 2026 is predicted from traffic modelling to range from 1% to 30%; these values have been used in VEPM. 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, except that the proportion of buses was held at 0.5%. The other categories were then adjusted proportionally so that the total fleet composition remained as 100%.
- Non tail pipe (brake and tyre wear) particulate emission factors have been included. 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. The proportion of vehicle particulate emission assumed associated with non-tail pipe sources increases between 2016 and 2026. All of the non-tail particulate emissions are assumed to be PM_{10}.

- 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 degradation option was used. This raises the emissions from both exhaust and non-exhaust sources with the age of vehicle modelled.
- Emission factors are calculated on the predicted average vehicle speed for the modelled section of road. The VEPM model is valid for average vehicle speed between 10 - 110 km/hr. The predicted fleet emission factors therefore do not directly model emission rates near intersections which may vary as consequence of acceleration, deceleration, and engine idling.

10.1.2 Dispersion Modelling Assumptions

Key assumptions in the dispersion modelling were:

- The background concentrations derived from ambient monitoring undertaken at Lincoln and Papanui have been assumed to be representative of current ambient air quality in the Project area
- 2007 meteorology, based on the results of meteorological monitoring undertaken at Christchurch Airport, is representative of 'worst case' meteorology in the Project area.

11. Conclusions

The results of dispersion modelling indicate that only one link of the Project (CSM2 between Shands Road Intersection and Halswell Junction Road) is likely to cause concentration of air pollutants to exceed any of the MfE Tier 2 significance criteria.

The maximum cumulative PM_{10} concentration predicted to occur anywhere within 200m of the centreline of any section of either CSM2 or MSRFL is 32.9 µg/m^3 including background, of which the contribution from the Project is 2.9 µg/m^3. However, at the most affected existing sensitive receptor, the maximum contribution from the Project to PM_{10} concentrations is 1.4 µg/m^3. Because this is lower than the MfE Tier 2 significance criterion, a Tier 3 assessment is not required.

In general, maximum ground level concentrations for all links of the Project for any given year are predicted to be highest in the 'With Project' scenario and lowest in the 'Do Minimum' scenario. In the Main South Road sections, this is most probably due to the increased vehicle numbers associated with the 'With Project' scenario compared to the Do Minimum' scenario, while the new section of the Southern Motorway adds a major road where there is none at present.

Changes in traffic volumes on local roads, including the significant increases in vehicle numbers on some roads (e.g. Shands Road and Marshs Road) are unlikely to have a significant impact of concentrations of air pollutants at nearby receptors.

The results of dispersion modelling indicate that discharges of air pollutants caused by vehicles using CSM2 and the upgraded Main South Road are unlikely to cause exceedences of any relevant air discharge assessment criterion at any nearby sensitive receptor. It can therefore be inferred that discharges of air pollutants caused by vehicles using CSM2 and the upgraded Main South Road are also unlikely to cause more than minor adverse effects on human health or the environment in the surrounding area.

Given the low level of effects, neither mitigation nor monitoring of operational air quality effects is required.

The main adverse effects arising from discharges to air associated with the construction of the Project are associated with discharges of construction dust. This report identifies key dust control methods that should be applied (via an Air Quality Management Plan) to mitigate the effects of those emissions. These control measures can be refined to be more project and site specific once a detailed construction methodology is available.

12. References

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Appendix A
Project Layout and Locations of Identified Sensitive Receptors

Refer to Plan Set in Volume 5

Appendix B
Traffic Modelling Outputs

Traffic Modelling Outputs

The CSM2 CUBE Voyager traffic model generates average weekday traffic flows for three two-hour periods – AM Peak, PM Peak and interpeak (IP), along with the numbers of heavy commercial vehicles (HCV) and average vehicle speed for each period. AM Peak and PM Peak flows are generated as 2-hour totals for the period 07:00-09:00 and 16:00-18:00 respectively, while the IP is generated as a 7-hour total for the period 09:00-16:00. These are presented as maximum 1-hour AM and PM Peak flows and average 1-hour IP flows using the following relationship (Beca, 2011):

- AM Peak x 0.600
- IP x 0.142
- PM Peak x 0.633.

For the purposes of this assessment, these have been used to generate average hourly flows and average mass emission rates for PM_{10} (grams per vehicle kilometre, g/km) for each hour of the day, based on an 'average' weekday. To do this, hourly traffic volumes outside the modelled peak periods (AM and PM) were calculated from the IP hourly flow using factors developed from the results of automatic traffic counts at the following locations on Main South Road:

- Site: 01S00349 South of Halswell Junction Rd (22 – 28 August 2006)
- Site: 01S00355 1.74km South of Templeton (12 – 20 August 2006)
- Site: 01S00366 Rolleston - South of Weedons Ross Rd (26 – 31 January 2006).

Hourly traffic volumes during the AM and PM peak periods were estimated by halving the 2-hour AM and PM Peak traffic numbers. Figure B1 illustrates the average weekday and weekend hourly flow profiles recorded at the three sites, while the factors derived from the weekday profile are summarised in Table B1.

Table B1: 24-hour traffic flow factors

Hour	Weekday Factor	Hour	Weekday Factor
00:00 - 01:00	0.078	12:00 - 13:00	0.929
01:00 - 02:00	0.049	13:00 - 14:00	0.984
02-00 - 03:00	0.047	14:00 - 15:00	1.081
03:00 - 04:00	0.053	15:00 - 16:00	1.188
04:00 - 05:00	0.117	16:00 - 17:00	PM
05:00 - 06:00	0.239	17:00 - 18:00	PM
06:00 - 07:00	0.523	18:00 - 19:00	0.903
07:00 - 08:00	AM	19:00 - 20:00	0.563
08:00 - 09:00	AM	20:00 - 21:00	0.421
09:00 - 10:00	0.950	21:00 - 22:00	0.367
10:00 - 11:00	0.938	22:00 - 23:00	0.273
11:00 - 12:00	0.931	23:00 - 00:00	0.176

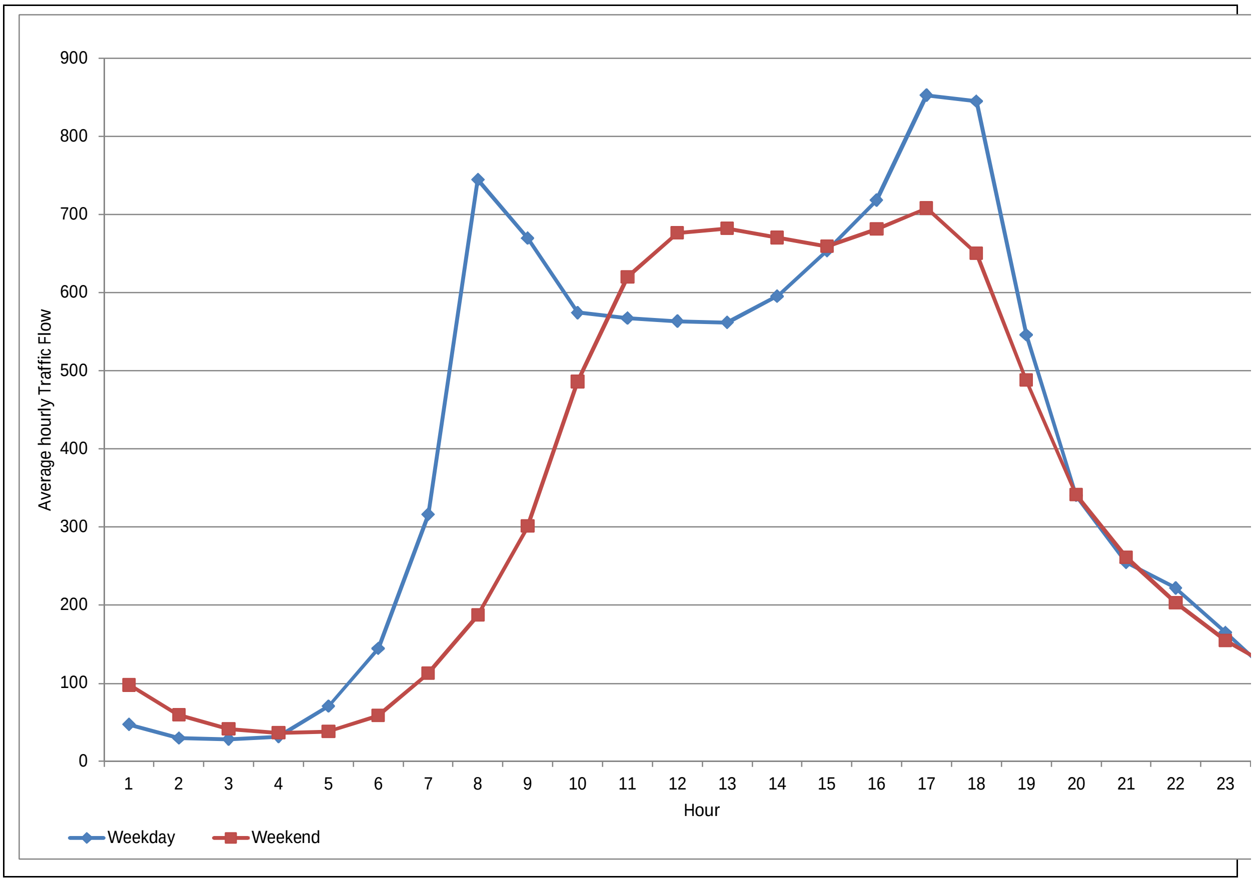

Figure B1: Average weekday and weekend hourly flow profiles between Templeton and Rolleston

Traffic volumes used in this assessment are taken from an early version of the traffic model, generated in August 2011. Predicted traffic volumes on MSRFL and CSM2 between Weedons Road Interchange and Shands Road Interchange from that version of the model are similar to the August 2012 traffic modelling outputs (+/- 3%), while traffic volumes on CSM2 between Shands Road Intersection and Halswell Junction Road are 30-40% higher in the August 2011 version of the traffic compared to the August 2012 version. Conversely, predicted traffic volumes on MSRFL between Rolleston and Weedons Road Interchange are substantially (10 to 30%) lower than in the August 2012 version.

Table B2 presents a summary of AADT for each road link in the Project and for a number of minor roads in the Project area, extracted from the traffic model in August 2012.

Table B2 - Annual Average Daily Traffic Volumes and Average Speeds for Each Road in the Project Area

Link	2016		2026		Average speed
	Do Min	CSM +MSRFL	Do Min	CSM+MSRFL	
Main South Road					
Rolleston Dr-Hoskyns	22978	20361	28504	23899	90
Hoskyns-Weedons	19930	20361	23571	23899	90
Weedons Rd Northbound Off-ramp	-	538	-	595	
Weedons Rd Northbound On-ramp	-	3987	-	6923	
Weedons Rd Southbound Off-ramp	-	2129	-	4473	
Weedons Rd Southbound On-ramp	-	578	-	757	
Weedons-Larcombs	22324	25361	27843	33942	90
Larcombs-Berketts	22013	25205	27471	33765	90
Berketts-Robinsons	23259	25892	28641	34459	90
Robinsons Rd-CSM2	23730	25892	29076	34459	90
CSM2					
Halswell Junction Road to Shands Rd	-	28222	-	36417	100
Shands Rd Interchange	-	21873	-	27922	100
Shands Rd Northbound Off-ramp	-	2395	-	3509	
Shands Rd Northbound On-ramp	-	7774	-	9972	
Shands Rd Southbound Off-ramp	-	7119	-	9312	
Shands Rd Southbound On-ramp	-	2046	-	3015	
Shands Rd-MSR	-	16495	-	21459	100
Local Roads					
Rolleston Dr	7580	-	10838	-	60
Hoskyns Road	7396	-	11246	-	60
Weedons Ross Road	497	4790	861	7212	65
Weedons Road	3039	6738	5231	11499	70

Link	2016		2026		Average speed
	Do Min	CSM +MSRFL	Do Min	CSM+MSRFL	
Larcombs	311	156	373	177	-
Berketts	969	680	921	689	-
Main South Road (north of CSM2)	23730	7975	29076	10627	67
Waterholes Road (north of CSM2)	1263	1118	1709	1440	
Waterholes Road (south of CSM2)	293	335	291	411	
Hamptons Road	970	783	1419	1029	
Trents Road	349	664	293	708	56
Marsh Road (west of Shands Road)	1156	3736	1872	4266	63
Marsh Road (east of Shands Road)	1932	4434	4648	9029	60
Shands Road (south of CSM2)	5527	11854	8312	13232	74
Shands Road (south of Marsh's Road)	5527	14294	8312	20460	59
Shands Road (north of Marsh's Road)	4973	7847	8933	11924	59
Springs Road	17202	11834	20028	14502	63
Halswell Junction Road	7562	8514	12080	14046	60

Appendix C
Summary of Relevant Statutory and Strategic Requirements

Summary of Relevant Statutory and Strategic Requirements

Canterbury Regional Policy Statement

Chapter 13 of the Canterbury Regional Policy Statement 1998 identifies a number of issues related to air quality in the region and policies for management of the contribution of vehicle emissions to those issues, as follows:

Issue 1

Existing and potential health and nuisance effects of low ambient air quality in the urban and settled areas of Canterbury, particularly in Christchurch and Timaru.

Policy 2

Promote measures that reduce emissions from the use of carbon based fuels.

The explanation to Policy 2 notes that the principal sources of air pollution include motor vehicle exhaust emissions, especially in the Christchurch area. This policy is given effect through the Air Chapter of the Canterbury Natural Resources Regional Plan (NRRP) and through the Regional Land Transport Strategy (RLTS).

Regional Land Transport Strategy

The Canterbury Regional Land Transport Strategy 2012-2042 (RLTS) identifies a number of issues, challenges and outcomes related to the air quality effects of transport, including:

- Managing the environmental impacts of transport.
- Reduced community exposure to vehicle pollutants, noise and vibration.

The Strategic Direction of the RLTS aims to contribute to these outcomes as follows:

"*Focusing heavy traffic movements to most appropriate routes through urban areas, calming of residential streets and increased use of walking and cycling translates into reduced community exposure. A reduction in traffic growth and development of new technologies also contribute positively to minimising effects in the long term*.

Appendix D to the RLTS provides more detail underlying the challenges. In relation to the environmental impacts of transport, Appendix D notes:

"*The use of motor vehicles and development of transport infrastructure has significant impacts on the environment including air pollution, dust, greenhouse gas emissions, visual intrusion, polluted storm water run-off, noise and vibration.*"

Appendix F to the RLTS provides more detail underlying the desired outcomes. In relation to reducing community exposure to vehicle pollutants, noise and vibration, Appendix F notes:

"*High levels of pollution, noise or vibration can have significant effects on the health of individuals and communities. Negative health effects are generally associated with exposure to high levels of pollution, noise or vibration and/or exposure long periods of time. Therefore these issues tend to be localised in nature.*"

"*Transport activities, particularly the use of heavy vehicles, can have significant negative effects on the heath of individuals or communities. These health effects need to be taken into consideration when making decisions on how transport networks and services are provided so that effects can be avoided or mitigated as far as possible.*"

Natural Resources Regional Plan

Chapter 3 of the NRRP addresses air quality issues across the Canterbury region. This chapter is largely operative, with the exception of provisions related to outdoor burning in residential areas.

Regional Objectives and Policies

The relevant objectives and policies of the NRRP are Objectives AQL1, AQL2, AQL3 and Policies AQL3, AQ6, AQL9 and AQL20, which state:

Objective AQL1 Objective for localised air quality

Localised contaminant discharges into air do not, either on their own or in combination with other discharges, result in significant adverse effects on the environment, including:

(a) The loss of air as a taonga to Tangata Whenua; and

(b) adverse effects on human health and safety; and

(c) offensive or objectionable odours; and

(d) diminished visibility, as a consequence of human activities; and

(e) corrosion and soiling of structures, not being property owned by those causing the discharge; and

(f) adverse effects on health and functioning of ecosystems, plants and animals; and

(g) contamination of water.

Policy AQL3 Promote measures to address motor vehicle exhaust emissions

(a) Promote traffic management that avoids the occurrence of localised air quality problems associated with exhaust emissions from motor vehicles.

(b) Promote initiatives to reduce the occurrence of smoky motor vehicle exhaust emissions

Policy AQL6 Avoid Dust Nuisance

(a) The discharge to air of dust shall not be corrosive, noxious, dangerous, objectionable, or offensive to the extent that it has or is likely to cause an adverse effect on the environment beyond the boundary of the site where the discharge originates.

Objective AQL2 Objectives for ambient air quality in Canterbury

(a) Where existing ambient air quality is equivalent to or better than the acceptable target specified in the Regional Ambient Air Quality Targets in Schedule AQL1 maintain air quality at its existing level.

(b) Where monitoring identifies existing ambient air quality to be poorer than the acceptable target specified in the Regional Ambient Air Quality Targets in Schedule AQL1, improve

ambient air quality to at least the level identified as acceptable so as to protect human health and safety and reduce the nuisance effects of poor ambient air quality.

Objective AQL3 Objective for ambient air quality in Christchurch

In the Christchurch Clean Air Zones 1 and 2, improve current poor winter ambient air quality so that by the year 2012 there is a reduction in the concentration of PM_{10} to less than 50 µg/m³ (24 hour average), with no more than one annual exceedence (averaged over three years) so as to reduce nuisance effects and adverse effects on human health.

Policy AQL9 Applying Regional Ambient Air Quality Targets (RAAQT)

Specify clean air zones and specific management regimes for improving ambient air quality in those areas where monitoring identifies that the 'alert' target of the RAAQT is already exceeded, giving priority to Christchurch and Timaru.

Policy AQL20 Promote measures to address discharges to air from motor vehicles in the Christchurch Clean Air Zones 1 and 2

(a) Promote a nationally co-ordinated initiative to reduce the adverse effects of motor vehicle exhaust emissions. This initiative shall:

- *(i) Develop national motor vehicle exhaust emission criteria; and*
- *(ii) encourage the use of transport fuels or energy sources which minimise contaminant discharges to air; and*
- *(iii) promote the use of vehicle technologies which minimise contaminant discharges to air; and*
- *(iv) promote the use of efficient and well-maintained vehicles; and*
- *(v) encourage the use of models of transport that have low or no emissions.*

(b) Promote land use planning that results in land use patterns encouraging less polluting methods of transportation.

(c) Promote traffic management that avoids eh occurrence of ambient air quality problems associated with exhaust emissions from motor vehicles.

Regional Rules

Rule AQL12B defines discharges into air from mobile sources generally as a permitted activity.

Rule AQL12B Discharge to air from mobile sources – permitted activity

The discharge of contaminants into air from a mobile source such as an aircraft, except when it is on an industrial or trade premise for testing, repair, or maintenance, is a permitted activity.

The explanation to Rule AQL12B states:

Moveable sources will include aircraft, cars, and other forms of transport. When such items are being used for transportation, the resulting discharge of contaminants into air should be treated as being from a moveable source, and there should be no requirement that they obtain a resource consent.

Rule AQL38 defines discharges of dust from unconsolidated surfaces as a permitted activity. This rule principally applies to industrial and trade premises/processes. While it does not specifically identify road construction *per se*, the explanation to the rule clearly indicates that it should apply to construction sites.

Rule AQL38 Fugitive dust emissions from unconsolidated surfaces – permitted activity

Discharge of contaminants into air from unsealed or unconsolidated surfaces on industrial or trade premises and/or from industrial or trade processes, not otherwise addressed by rules in the NRRP, is a permitted activity.

Condition 1: The dispersal or deposition of particles shall not cause an objectionable or offensive effect beyond the boundary of the property where the discharge originates.

The explanation to Rule AQL38 states:

Discharges from unsealed or unconsolidated surfaces on industrial or trade premises and construction sites are common, but mitigation measures can be employed to prevent windblown dust emissions from these sites causing nuisance effects. Condition 1 has been adopted to control potential adverse effects on neighbouring properties. Consideration will be given to the assessment guidelines for dust in assessing the offensive or objectionable nature of any dust discharged beyond the property boundary.

There are no other rules in Chapter 3 of the NRRP that apply to discharges into air from either the construction or operation of roads.

Regional Assessment Criteria

Appendix AQL3 to Chapter 3 of the NRRP describes the assessment criteria that Environment Canterbury will consider when assessing whether a dust discharge has caused an objectionable or offensive effect, as follows:

(i) the frequency of dust nuisance events;

(ii) the intensity of dust nuisance events, as indicated by dust quantity and the degree of nuisance;

(iii) the duration of each dust nuisance event;

(iv) the offensiveness of the discharge, having regard to the nature of the dust; and

(v) the location of the dust nuisance, having regard to the sensitivity of the receiving environment, including taking into account the relevant zone(s) and provisions in the Operative District Plan.

Information that will normally be used to inform such an assessment includes:

(a) Other validated dust complaints or events relating to discharges from the same site, including previous validated complaints from one location.

(b) Collection of dust samples and analysis to identify source (where necessary and appropriate).

(c) Weather conditions at the time of the dust event, notably wind speed, wind direction and rainfall.

(d) Information regarding process conditions that may have caused the complaint. The effectiveness of dust control measures at the site will be taken into account.

(e) *A complaints register held at the site. Environment Canterbury may require the discharger to keep such a register and identify any cause of an alleged dust nuisance, including remedial action taken.*

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 …"

Government Policy Statement on Land Transport Funding

The Government Policy Statement on Land Transport Funding (GPS) sets out the government's outcomes and priorities for the land transport sector. The GPS includes the following short to medium term impacts that should be achieved:

- *Reductions in adverse environmental effects from land transport.*
- *Contributions to positive health outcomes.*

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.

The NZTA (Transit) Environmental Plan (Version 2 in 2008) sets out how the NZTA's obligations under the LTMA are to be exercised in practice. 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: easing congestion and improving traffic flow; Improving vehicle performance through use of road surface treatments and smoothing techniques; minimising the effect of road gradient and vehicle movements at intersections; taking into account effect of vehicle speed and fleet composition and balancing this effect with function and purpose of the State highway; and … ensuring alignment of vehicle lanes is optimised within State highway designation to minimise exposure to vehicle-related air pollution at adjoining sensitive locations.

This assessment of effects considers the requirements of these objectives, in particular objective A2, in the context of the proposed Project.

Appendix D
Factors that Affect Vehicle Emission Rates

Factors which Affect Vehicle Emission Rates

The volume and concentrations of vehicle emissions depend on a number of factors as described below.

Vehicle Age

- Relatively old vehicle fleet in comparison to other countries.
- Older vehicles tend to have higher emission levels for both CO and NO_x; as vehicle emissions deteriorate with age.
- Average ages (NZTA, 2011):
  - cars – 13.6 years
  - trucks – 13.8 years
  - buses – 13.3 years.

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.
- Older vehicles tend not to have catalytic converters (Metcalfe, 2009).
- Majority of newer cars (e.g. petrol vehicles manufactured since 2000) are assumed to have catalytic converters installed.

Vehicle Speed

- Maintaining a steady flow of traffic will produce fewer pollutants than stop/start traffic.
- In general:
  - Reducing traffic speed reduces emissions of CO and PM_{10}
  - NO_x emissions increase slightly with speed.

Fuel

- Most cars in New Zealand are fuelled by petrol.
- 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 especially are significantly higher.

Proportion of Heavy Vehicles

- Heavy vehicles (usually diesel fuelled) have relatively higher emissions of particulate matter per kilometre travelled compared to light vehicles.

Journey Length and Vehicle Mileage

- Vehicle exhaust emissions tend to be highest when the engine is cold ('cold start') and decrease substantially once the engine has warmed up.
- This is especially true of vehicles fitted with catalytic converters – these tend to be ineffective until they have reached operating temperature.
- Vehicles with high mileage (especially older vehicles) are likely to have increased exhaust emissions compared to new vehicles, as engine wear increases and catalytic converter efficiency decreases.

Road Surface and Gradient

- Road surfaces of all the roads considered in this assessment are asphalt. Therefore, no correction has been made for the effects of road surface.
- Within the Project area, the terrain is relatively level, without any significant hills that would significantly affect vehicle exhaust emissions. Therefore, road gradients have not been considered in this assessment.

Appendix E
Vehicle Emissions Prediction Model

Vehicle Emissions Prediction Model

Background

The VEPM database calculates emissions factors for European origin vehicles and also draws on emissions data from New Zealand, the Japan Clean Air Program, the European Environment Agency (COPERT III), and the European Program 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.

Vehicle fleet profile

Predicted vehicles emission rates were calculated using VEPM's default vehicle fleet composition for both 2016 (the year of opening) and 2026.

The percentage of light and heavy vehicles on each link was varied according to the traffic model outputs. The relative distribution of sub-categories of light and heavy vehicles within two classifications was assumed to be the same as those predicted by VEPM. The percentage of buses is assumed to be constant and equal to 0.6% for the entire network.

The fleet profile in VEPM is based on vehicle kilometres travelled (VKT) for the New Zealand vehicle fleet; there is no published data for VKT for the Canterbury fleet. In 2009, the national fleet comprised a slightly lower proportion of HCVs (4.0%) and diesel powered cars and LCVs (15.1%) than the Canterbury fleet (4.1% and 16.5% respectively)[18]. Diesel powered vehicles tend to emit more PM_{10} and NO_x per vehicle kilometre than similar vehicles with petrol engines.

Assuming that VKT for light and heavy diesel vehicles for the national fleet are comparable to the regional Canterbury vehicle fleet, the use of the VEPM default fleet profile still represents a reasonably conservative approach.

Non Exhaust Emission Factors

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 modelling assessment.

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 has been included in the modelling.

[18] Canterbury fleet profile provided by Deborah Ryan of Sinclair Knight Merz, based on data from Stuart Badger of the Ministry of Transport, 14 May 2010.

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 of 15% for older cars and 0% for newer cars was used in this assessment. As this assumption is constant across all modelled scenarios, comparisons of predicted ground level concentrations between the various scenarios remain valid.

Appendix F
Mass Emission Rates for Pollutants

Table F1: Predicted PM_{10} Emission Rates for all Road Links used in Dispersion Modelling (g/km-hour)

Link	Period	2016		2026	
		Do Min	With Project	Do Min	With Project
Main South Road					
Rolleston to Weedons Road	AM Peak	95	96	96	90
	IP	77	76	72	69
	PM Peak	112	122	97	119
Weedons Road to CSM2	AM Peak	119	138	113	152
	IP	87	94	91	99
	PM Peak	143	168	131	189
CSM2					
Shands Rd-MSR	AM Peak	-	93	-	110
	IP	-	57	-	66
	PM Peak	-	110	-	129
Shands Rd Interchange	AM Peak	-	75	-	86
	IP	-	40	-	44
	PM Peak	-	89	-	102
Shands Rd Northbound Off-ramp	AM Peak	-	10	-	12
	IP	-	9	-	11
	PM Peak	-	8	-	10
Shands Rd Northbound On-ramp	AM Peak	-	37	-	41
	IP	-	21	-	22
	PM Peak	-	50	-	52
Shands Rd Southbound Off-ramp	AM Peak	-	30	-	35
	IP	-	17	-	20
	PM Peak	-	54	-	54
Shands Rd Southbound On-ramp	AM Peak	-	7	-	8
	IP	-	7	-	9
	PM Peak	-	11	-	13
Shands Rd to Halswell Junction Road	AM Peak	N/A	155	N/A	180
	IP	N/A	84	N/A	95
	PM Peak	N/A	215	N/A	235
Local Roads					
Marsh Road (west of Shands Road)	AM Peak	15	17	22	27
	IP	5	17	10	25

Link	Period	2016		2026	
		Do Min	With Project	Do Min	With Project
	PM Peak	15	15	21	27
Marsh Road (east of Shands Road)	AM Peak	7	15	8	16
	IP	4	9	5	8
	PM Peak	10	25	10	24
Shands Road (south of CSM2)	AM Peak	30	53	40	49
	IP	15	35	16	31
	PM Peak	33	53	41	48
Shands Road (south of Marsh's Road)	AM Peak	30	57	40	62
	IP	15	37	16	39
	PM Peak	33	73	41	70
Shands Road (north of Marsh's Road)	AM Peak	31	58	40	67
	IP	15	39	16	46
	PM Peak	33	84	40	90

Table F2: Summary of Predicted CO Emission Rates for all Road Links used in Dispersion Modelling (g/km-hour)

Link	Period	2016		2026	
		Do Min	With Project	Do Min	With Project
Main South Road					
Rolleston to Weedons Road	AM Peak	2,257	2,401	2,002	1,868
	IP	1,832	1,890	1,502	1,428
	PM Peak	2,660	3,033	2,017	2,466
Weedons Road to CSM2	AM Peak	2,833	3,440	2,344	3,145
	IP	2,077	2,335	1,891	2,041
	PM Peak	3,391	4,180	2,721	3,897
CSM2					
Shands Rd-MSR	AM Peak	-	2,305	-	2,275
	IP	-	1,431	-	1,367
	PM Peak	-	2,735	-	2,676
Shands Rd Interchange	AM Peak	-	1,860	-	1,777
	IP	-	995	-	908
	PM Peak	-	2,211	-	2,114
Shands Rd Northbound	AM Peak	-	248	-	255

Link	Period	2016		2026	
		Do Min	With Project	Do Min	With Project
Off-ramp	IP	-	225	-	219
	PM Peak	-	198	-	206
Shands Rd Northbound On-ramp	AM Peak	-	925	-	841
	IP	-	513	-	458
	PM Peak	-	1,236	-	1,072
Shands Rd Southbound Off-ramp	AM Peak	-	756	-	732
	IP	-	433	-	411
	PM Peak	-	1,351	-	1,119
Shands Rd Southbound On-ramp	AM Peak	-	165	-	175
	IP	-	185	-	180
	PM Peak	-	266	-	264
Shands Rd to Halswell Junction Road	AM Peak	N/A	3,849	N/A	3,721
	IP	N/A	2,093	N/A	1,971
	PM Peak	N/A	5,341	N/A	4,851
Local Roads					
Marsh Road (west of Shands Road)	AM Peak	177	380	160	327
	IP	99	233	102	166
	PM Peak	226	626	197	491
Marsh Road (east of Shands Road)	AM Peak	359	421	460	551
	IP	123	414	210	515
	PM Peak	345	373	428	559
Shands Road (south of CSM2)	AM Peak	721	1,317	830	1,017
	IP	348	872	322	650
	PM Peak	785	1,329	849	991
Shands Road (south of Marsh's Road)	AM Peak	721	1,417	830	1,289
	IP	348	929	322	803
	PM Peak	785	1,808	849	1,437
Shands Road (north of Marsh's Road)	AM Peak	732	1,438	826	1,382
	IP	359	970	325	950
	PM Peak	790	2,082	841	1,854

Table F3: Summary of Predicted NO_x Emission Rates for all Road Links used in Dispersion Modelling (g/km-hour)

Link	Period	2016		2026	
		Do Min	With Project	Do Min	With Project
Main South Road					
Rolleston to Weedons Road	AM Peak	1,006	961	990	863
	IP	817	756	743	660
	PM Peak	1,186	1,214	997	1,140
Weedons Road to CSM2	AM Peak	1,263	1,376	1,159	1,453
	IP	926	934	935	943
	PM Peak	1,512	1,673	1,345	1,801
CSM2					
Shands Rd-MSR	AM Peak	-	922	-	1,052
	IP	-	572	-	632
	PM Peak	-	1,094	-	1,237
Shands Rd Interchange	AM Peak	-	744	-	821
	IP	-	398	-	420
	PM Peak	-	885	-	977
Shands Rd Northbound Off-ramp	AM Peak	-	99	-	118
	IP	-	90	-	101
	PM Peak	-	79	-	95
Shands Rd Northbound On-ramp	AM Peak	-	370	-	389
	IP	-	205	-	212
	PM Peak	-	495	-	495
Shands Rd Southbound Off-ramp	AM Peak	-	303	-	338
	IP	-	173	-	190
	PM Peak	-	541	-	517
Shands Rd Southbound On-ramp	AM Peak	-	66	-	81
	IP	-	74	-	83
	PM Peak	-	106	-	122
Shands Rd to Halswell Junction Road	AM Peak	N/A	1,540	N/A	1,720
	IP	N/A	838	N/A	911
	PM Peak	N/A	2,137	N/A	2,242

Link	Period	2016		2026	
		Do Min	With Project	Do Min	With Project
Local Roads					
Marsh Road (west of Shands Road)	AM Peak	79	152	79	151
	IP	44	93	51	77
	PM Peak	101	250	98	227
Marsh Road (east of Shands Road)	AM Peak	160	169	228	255
	IP	55	166	104	238
	PM Peak	154	149	211	258
Shands Road (south of CSM2)	AM Peak	322	527	410	470
	IP	155	349	159	301
	PM Peak	350	532	420	458
Shands Road (south of Marsh's Road)	AM Peak	322	567	410	596
	IP	155	372	159	371
	PM Peak	350	723	420	664
Shands Road (north of Marsh's Road)	AM Peak	326	576	408	639
	IP	160	388	160	439
	PM Peak	352	833	416	857

Table F4: Summary of Predicted Benzene Emission Rates for all Road Links used in Dispersion Modelling (g/km-hour)

Link	Period	2016		2026	
		Do Min	With Project	Do Min	With Project
Main South Road					
Rolleston to Weedons Road	AM Peak	0.9	0.9	0.9	0.8
	IP	0.8	0.7	0.7	0.6
	PM Peak	1.1	1.1	0.9	1.0
Weedons Road to CSM2	AM Peak	1.2	1.2	1.1	1.3
	IP	0.9	0.8	0.9	0.8
	PM Peak	1.4	1.5	1.2	1.6
CSM2					
MSR-Shands Rd	AM Peak	-	0.8	-	0.9
	IP	-	0.5	-	0.6
	PM Peak	-	1.0	-	1.1

Link	Period	2016		2026	
		Do Min	With Project	Do Min	With Project
Shands Rd Interchange	AM Peak	-	0.7	-	0.7
	IP	-	0.4	-	0.4
	PM Peak	-	0.8	-	0.9
Shands Rd Northbound Off-ramp	AM Peak	-	0.1	-	0.1
	IP	-	0.1	-	0.1
	PM Peak	-	0.1	-	0.1
Shands Rd Northbound On-ramp	AM Peak	-	0.3	-	0.3
	IP	-	0.2	-	0.2
	PM Peak	-	0.4	-	0.4
Shands Rd Southbound Off-ramp	AM Peak	-	0.3	-	0.3
	IP	-	0.2	-	0.2
	PM Peak	-	0.5	-	0.5
Shands Rd Southbound On-ramp	AM Peak	-	0.1	-	0.1
	IP	-	0.1	-	0.1
	PM Peak	-	0.1	-	0.1
Shands Rd to Halswell Junction Road	AM Peak		1.4		1.5
	IP		0.8		0.8
	PM Peak		1.9		2.0
Local Roads					
Marsh Road (west of Shands Road)	AM Peak	0.1	0.1	0.1	0.1
	IP	0.0	0.1	0.0	0.1
	PM Peak	0.1	0.2	0.1	0.2
Marsh Road (east of Shands Road)	AM Peak	0.2	0.2	0.2	0.2
	IP	0.1	0.1	0.1	0.2
	PM Peak	0.1	0.1	0.2	0.2
Shands Road (south of CSM2)	AM Peak	0.3	0.5	0.4	0.4
	IP	0.1	0.3	0.1	0.3
	PM Peak	0.3	0.5	0.4	0.4
Shands Road (south of Marsh's Road)	AM Peak	0.3	0.5	0.4	0.5
	IP	0.1	0.3	0.1	0.3
	PM Peak	0.3	0.7	0.4	0.6
Shands Road (north of Marsh's Road)	AM Peak	0.3	0.5	0.4	0.6
	IP	0.2	0.3	0.1	0.4

Link	Period	2016		2026	
		Do Min	With Project	Do Min	With Project
	PM Peak	0.3	0.7	0.4	0.8

Appendix G
Assessment of Nitrogen Dioxide

Assessment of Nitrogen Dioxide

Nitrogen oxides (NO_x) are emitted mainly in the form of nitric oxide (NO) but, once released into the atmosphere, variable proportions are oxidised to the more harmful nitrogen dioxide (NO_2), predominantly by ozone (O_3). Typically only about 10% or less of the total nitrogen oxides released from a combustion source are in the form of NO_2. Air quality standards and guidelines are defined only for NO_2. Therefore, when assessing the potential impact of NO_x emissions from the Project it is important to consider the chemical processes that occur in the atmosphere.

The most important short-term transformation is the reaction of NO in the emission plume with ambient ozone to form NO_2:

$$NO + O_3 \rightarrow NO_2 + O_2$$

Since the reaction is a 1-to-1 molecular transformation, the maximum possible concentration of NO_2 that can occur in the emission plume is directly related to the maximum ambient concentration of ozone. During the daytime, the main competing reaction in the short term is the photo-dissociation of NO_2 to form NO, which can decrease the concentrations of NO_2 to some degree.

$$3\ NO_2 + hv \rightarrow 3NO + O3$$

Near an emission source, the formation of NO_2 is in general limited by the availability of NO in the emission plume to react with ambient ozone (reactant limited), or alternatively the availability of ambient ozone to react with NO (oxidant limited). At the highest recorded background ozone concentrations of 37 ppb (Gomez, 1996), up to 37 ppb of nitrogen dioxide (equivalent to 72 µg/m^3) could be formed in the emission plume by the oxidation of NO, if sufficient NO is present, in addition to the NO_2 in the plume originally released in the emissions. Therefore, there is effectively a limit to the maximum concentration of NO_2 that could actually occur near an emission source.

Elevated levels of ozone can, on occasion, occur from photochemical smog formation processes. These episodes require significant emissions of both NO_x and reactive organic compounds, usually from large city areas, under conditions where the dispersion of the polluted air mass is limited for periods of several hours combined with warm air temperatures and sunlight. However, Wellington is well ventilated so it is unlikely these events would to occur in the region.

Figure G1 shows the relationship of 1-hour average NO_2 and NO_x concentration recorded at the Papanui monitoring site operated on behalf of the NZTA near Queen Elizabeth II Drive (2010). Pollutant levels recorded at the site are indicative of concentrations near a main road within the region.

The limiting effect of ambient ozone on NO_2 concentrations is clearly evident in the figure when NO_x concentrations exceed approximately 80-100 µg/m^3. For NO_x concentrations above 100 µg/m^3, NO_2 concentrations are shown to increase only gradually. This increase in NO_2 with NO_x concentrations above 80 µg/m^3 is primarily associated with NO_2 directly emitted from vehicle tail pipes; the slope of this increase correlates to the percentage of NO_x emitted as NO_2.

The figure shows that 1-hour average NO_2 concentrations rarely exceed 60 µg/m^3, even though 1-hour average NO_x concentrations on occasion do exceed 400 µg/m^3.

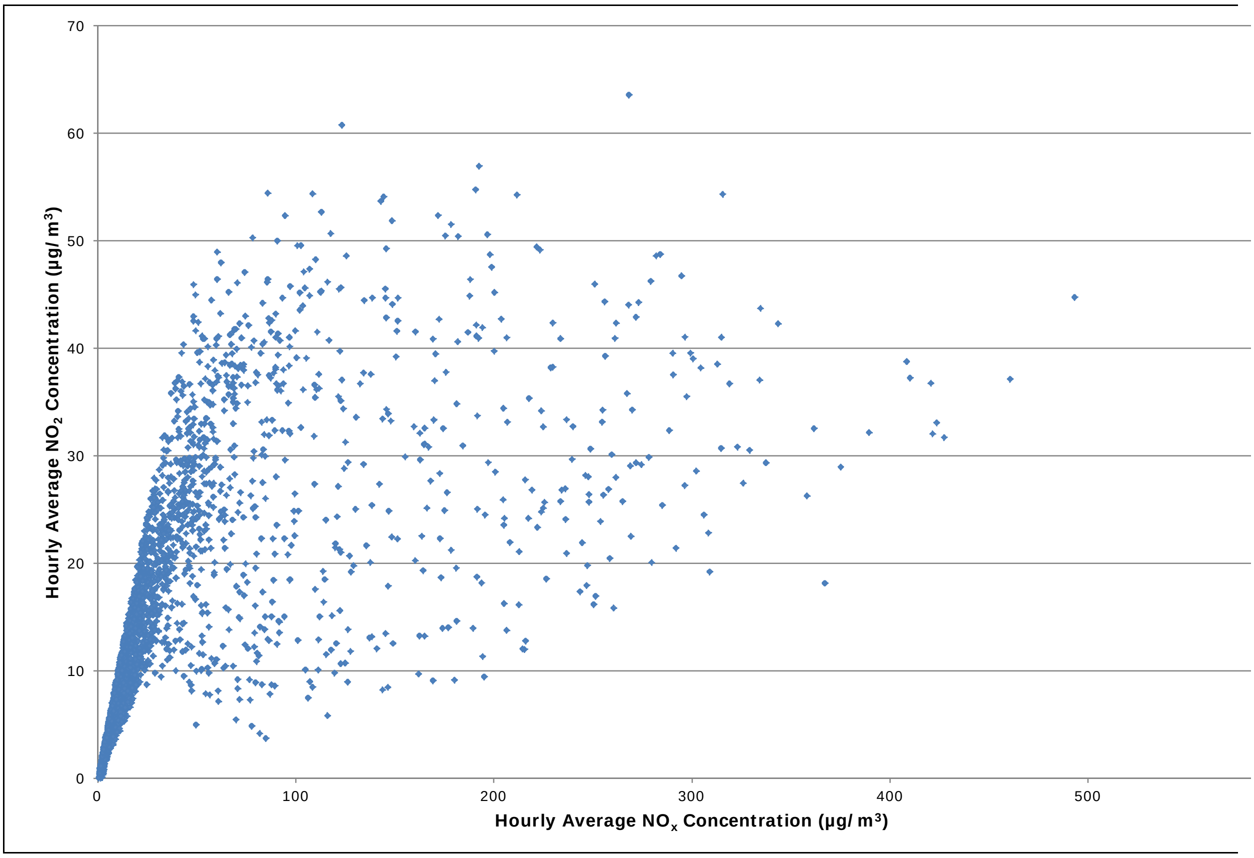

Figure G1: Relationship between 1-hour average NO_2 and NO_x concentrations recorded at the Papanui monitoring site in 2010

Minoura & Ito (2009) estimated 7.3% of NO_x vehicle emissions were emitted as NO_2, based on studies of Japanese roads. A UK study of ambient air quality estimated the percentage as varying between 8-14% (Abbott, 2005). From the average NO_2 to NO_x slope observed in Figure G1 when NO_x concentrations exceed 100 µg/m³, the percentage of NO_2 emitted as NO_x can be estimated to be less than 5%, which is lower but comparable to these reported emission ratios. The lower ratio may be due to the older vehicle fleet and lower proportion of diesel vehicles in the New Zealand fleet compared to Japan and UK.

In the analysis, cumulative NO_2 levels have been estimated by assuming a worse case background NO_2 concentration equal to the maximum 1-hour average NO_2 recorded at the Papanui monitoring site of 63.5 µg/m³ occurs during the same hour as the maximum ground level concentrations associated with the modelled road source also occurs. During these periods the formation of NO_2 is expected to be ozone limited, as indicated in Figure G1 by the flattening of the NO_2-NO_x curve. During these conditions additional NO_2 is expected to be associated with NO_2 emitted at the point of discharge. Therefore, the contribution from the modelled road sources to ambient pollutant levels has been calculated by multiplying the predicted incremental maximum 1-hour average NO_x concentration by the percentage of NO_x assumed to be emitted as NO_2. In this instance it has been assumed that 10% of NO_x is emitted as NO_2. The expression used to calculate cumulative maximum 1-hour average NO_2 concentrations is shown below:

$$[NO_2]_{cumulative}\ \text{1-hour average} = 0.10 * [NO_x]_{predicted}\ \text{1-hour average} + 63.5$$

A similar method can been used to estimate maximum 24-hour average NO_2 concentrations. However, NO_x and ambient ozone concentrations can vary significantly throughout any 24-hour period. Therefore during any 24-hour period, the formation of NO_2 may be both NO limited and ozone limited. Figure G2 shows the relationship between recorded 24-hour average NO_2 and NO_x concentrations at the Papanui monitoring site (2010).

The figures show comparatively linear relationships between 24-hour average NO_2 and NO_x concentrations when 24-hour NO_x concentrations are higher than 50µg/m³. At these concentrations, 24-hour average NO_2 concentrations increase only slowly with respect to increases in 24-hour average NO_x concentrations. The results suggest that at these concentrations, increases are predominantly associated with increases in NO_2 tail pipe emission rates.

Therefore cumulative NO_2 levels can be estimated by assuming a worst case background NO_2 concentration equal to the average of the maximum 24-hour average NO_2 concentration recorded at the Papanui monitoring site of 29.3 µg/m³. The contribution from the modelled motorway sources to ambient pollutant levels has been calculated by multiplying the predicted maximum incremental 24-hour average NO_x concentration by 10%. The expression used to calculate cumulative 24-hour average NO_2 concentrations is shown below:

$$[NO_2]_{cumulative}\ 24\text{-hour average} = 0.10 * [NO_x]_{predicted}\ 24\text{-hour average} + 29$$

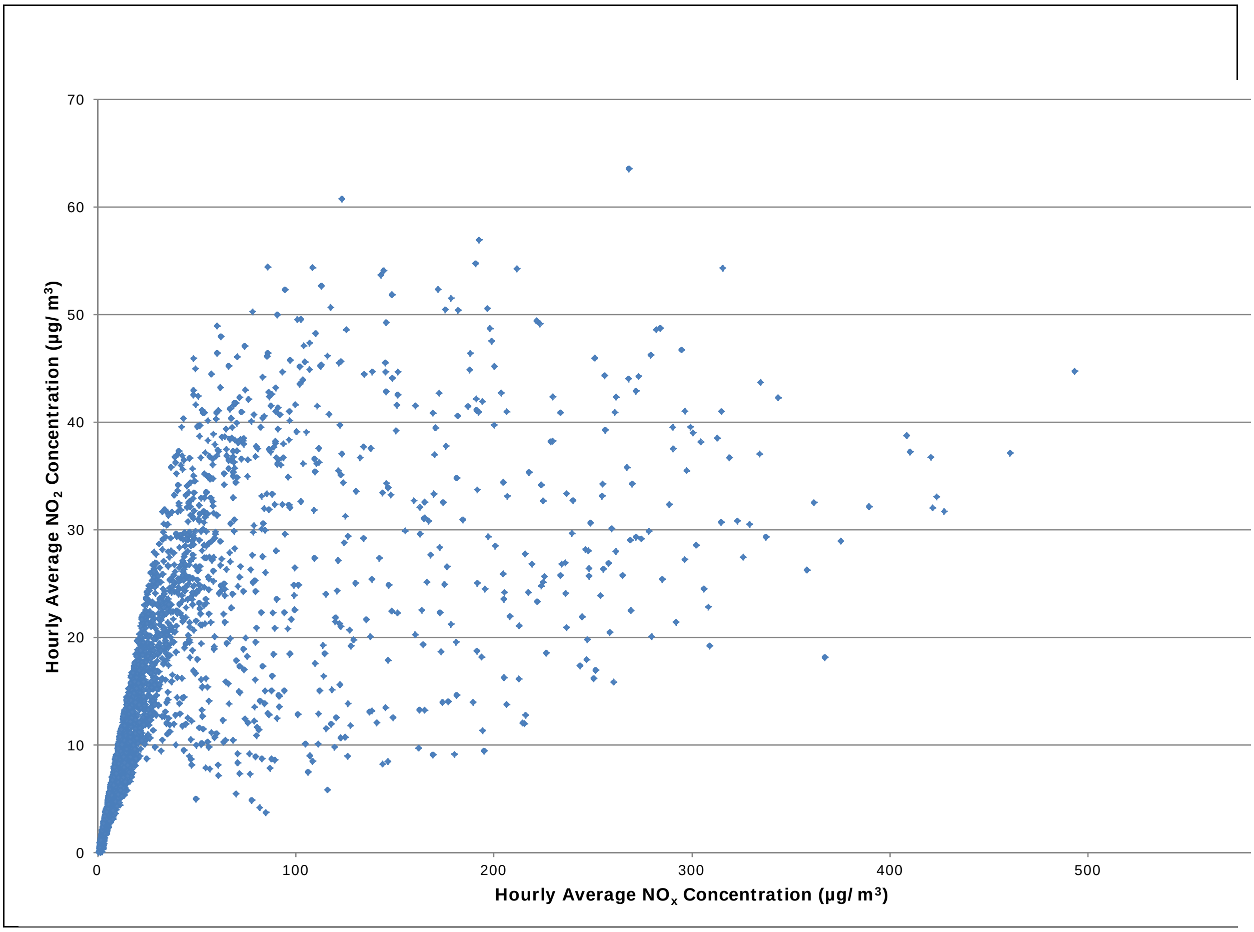

Figure G2: Relationship between 24-hour average NO_2 and NO_x concentrations recorded at the Papanui monitoring site in 2010

Appendix H
Results of Dispersion Modelling

Results of Dispersion Modelling

H1 Main South Road between Rolleston and Weedons Road Interchange

H1.1 Residential Receptors

This section of Main South Road includes the only section of the Project where large numbers of residential receptors are located – i.e. residential properties along Marlowe Place, Rolleston. The locations of identified residential receptors are shown on maps attached at Appendix A.

H1.2 Modelled Scenarios

The road link included in the dispersion modelling for this section is Main South Road between 500m north of Rolleston Drive and Weedons Road. Concentrations are presented for all four emission scenarios relative to distance from the centreline of the road.

H1.3 PM_{10} Concentrations

Table H1 presents predicted incremental and cumulative maximum 24-hour average PM_{10} concentrations at different distances from the centreline of Main South Road between Rolleston and Weedons Road Interchange.

The results show predicted maximum incremental concentrations slightly increase in all of the 'With Project' emission scenarios compared to the 'Do Minimum' for the same year. At the most impacted receptors located 25 – 50 m from the motorway centreline, 24-hour average PM_{10} concentrations are predicted to increase by 0.15 µg/m^3 between '2016 Do Minimum' and '2016 With Project' options.

Predicted cumulative concentrations for each of the modelled emission scenario are all considerably less than the AQNES of 50 µg/m^3. The maximum contribution from the Project is predicted to be less than the MfE Tier 2 significance criterion of 2.5 µg/m^3.

Table H1: Predicted maximum 24-hour average PM_{10} concentrations associated with motor vehicle emissions from Main South Road between Rolleston and Weedons Road (µg/m^3)

Distance from centreline	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
	Predicted maximum incremental 24-hour average PM_{10} concentrations			
25-50m	1.5	1.7	1.4	1.5
50-100m	0.9	1.0	0.8	0.9
100-150m	0.5	0.6	0.5	0.5
150-200m	0.4	0.4	0.3	0.3
	Predicted maximum cumulative 24-hour average PM_{10} concentrations			
25-50m	31.5	31.7	31.4	31.5
50-100m	30.9	31.0	30.8	30.9
100-150m	30.5	30.6	30.5	30.5
150-200m	30.4	30.4	30.3	30.3

H1.4 NO_2 Concentrations

Table H2 presents predicted incremental and cumulative maximum 1-hour average NO_2 concentrations at different distances from the centreline of Main South Road between Rolleston and Weedons Road Interchange.

The results show predicted maximum incremental concentrations increase in all of the 'With Project' emission scenarios compared to the 'Do Minimum' for the same year. At the most impacted receptors located 25 – 50 m from the motorway centreline, 1-hour average NO_2 concentrations are predicted to increase by 1.4 µg/m³ between '2026 Do Minimum' and '2026 With Project' options.

Predicted cumulative 1-hour average NO_2 concentrations for each of the modelled emission scenario are all considerably less than the AQNES of 200 µg/m³, and also less than the 24-hour average NZAAQG of 100 µg/m³.The maximum contribution from the Project is predicted to be less than the MfE Tier 2 significance criteria of 20 µg/m³ as a 1 hour average and 5 µg/m³ as a 24 hour average.

Table H2: Predicted maximum 1-hour average NO_2 concentrations associated with motor vehicle emissions from Main South Road between Rolleston and Weedons Road (µg/m³)

Distance from centreline	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
	Predicted maximum incremental 1-hour average NO_2 concentrations			
25-50m	6.8	7.9	4.9	6.3
50-100m	4.3	4.8	3.0	3.8
100-150m	2.6	2.9	1.8	2.3
150-200m	1.9	2.1	1.4	1.7
	Predicted maximum cumulative 1-hour average NO_2 concentrations			
25-50m	70.3	71.4	68.4	69.8
50-100m	67.8	68.3	66.5	67.3
100-150m	66.1	66.4	65.3	65.8
150-200m	65.4	65.6	64.9	65.2

H1.5 CO Concentrations

Table H3 presents predicted incremental and cumulative maximum 1-hour average CO concentrations at different distances from the centreline of Main South Road between Rolleston and Weedons Road Interchange.

The results show predicted maximum incremental concentrations slightly increase in all of the 'With Project' emission scenarios compared to the 'Do Minimum' for the same year. At the most impacted receptors located 25 – 50 m from the motorway centreline, 1-hour average CO concentrations are predicted to increase by 0.03 mg/m³ between '2026 Do Minimum' and '2026 With Project' options.

Predicted cumulative 1-hour average CO concentrations for each of the modelled emission scenario are all considerably less than the NZAAQG of 30 mg/m³, and also less than the running 8-hour average AQNES of 10 mg/m³.The maximum contribution from the Project is predicted to be less than the MfE Tier 2 significance criterion of 1 mg/m³ as an 8-hour average.

Table H3: Predicted maximum 1-hour average CO concentrations associated with motor vehicle emissions from Main South Road between Rolleston and Weedons Road (mg/m³)

Distance from centreline	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
	Predicted maximum incremental 1-hour average CO concentrations			
25-50m	0.22	0.25	0.09	0.12
50-100m	0.14	0.15	0.06	0.07
100-150m	0.08	0.09	0.03	0.04
150-200m	0.06	0.07	0.03	0.03
	Predicted maximum cumulative 1-hour average CO concentrations			
25-50m	8.42	8.45	8.29	8.32
50-100m	8.34	8.35	8.26	8.27
100-150m	8.28	8.29	8.23	8.24
150-200m	8.26	8.27	8.23	8.23

H1.6 Benzene Concentrations

Table H4 presents predicted maximum annual average benzene concentrations at different distances from the centreline of Main South Road between Rolleston and Weedons Road Interchange

The results indicate that, at distances greater then 50m from the centreline of Main South Road, there is effectively no difference in predicted maximum incremental benzene concentrations between the Do Minimum and With Project scenario in either 2016 or 2026. At the most impacted receptors located 25 – 50 m from the motorway centreline, annual average benzene concentrations are predicted to increase by 0.013 µg/m³ between '2016 Do Minimum' and '2026 With Project' options.

The predicted incremental annual average benzene concentrations for each of the modelled emission scenarios are all less than 3% of the NZAAQG of 3.6 µg/m³.

Table H4: Predicted maximum annual average benzene concentrations associated with motor vehicle emissions from Main South Road between Rolleston and Weedons Road (µg/m³)

Distance from centreline	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
25-50m	0.09	0.10	0.07	0.07
50-100m	0.05	0.06	0.04	0.04
100-150m	0.03	0.03	0.02	0.02
150-200m	0.04	0.05	0.03	0.03

H2 Main South Road between Weedons Road and CSM2

H2.1 Sensitive Receptors

There are a number of sensitive receptors located within 200m of this section of Main South Road. The locations of identified sensitive receptors are shown on maps attached at Appendix A.

H2.2 Modelled Scenarios

The road link included in the dispersion modelling for this section is Main South Road between Weedons Road and the western end of CSM2. Concentrations are presented for the all emission scenarios with distance from the centreline of the road section.

H2.3 PM_{10} Concentrations

Table H5 presents predicted incremental and cumulative maximum 24-hour average PM_{10} concentrations at different distances from the centreline of Main South Road between Weedons Road and CSM2.

The results show predicted maximum incremental concentrations increase slightly between the 'Do Minimum' and the 'With Project' option in each modelled year. 24-hour average PM_{10} concentrations are predicted to increase by 0.9 µg/m^3 between '2026 Do Minimum' and ''2026 With Project' options.

Predicted cumulative concentrations for each of the modelled emission scenario are all considerably less than the AQNES of 50 µg/m^3.

Table H5: Predicted maximum 24-hour average PM_{10} concentrations associated with motor vehicle emissions from Main South Road between Weedons Road and CSM2 (µg/m^3)

Distance from centreline	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
	Predicted maximum incremental 24-hour average PM_{10} concentrations			
25-50m	1.6	2.3	1.5	2.4
50-100m	0.9	1.3	0.9	1.3
100-150m	0.5	0.7	0.5	0.7
150-200m	0.4	0.5	0.3	0.5
	Predicted maximum cumulative 24-hour average PM_{10} concentrations			
25-50m	31.6	32.3	31.5	32.4
50-100m	30.9	31.3	30.9	31.3
100-150m	30.5	30.7	30.5	30.7
150-200m	30.4	30.5	30.3	30.5

The maximum increase in 24-hour average PM_{10} concentrations between "Do Minimum" and either "With Project" option at any identified receptor is predicted to be less the MfE Tier 2 significance criterion of 2.5 µg/m^3.

H2.4 NO_2 Concentrations

Table H6 presents predicted incremental and cumulative maximum 1-hour average NO_2 concentrations at different distances from the centreline of Main South Road between Weedons Road and CSM2.

The results show predicted maximum incremental concentrations increase in the 'With Project' emission scenarios compared to the 'Do Minimum' for the same year. 1-hour average NO_2 concentrations are predicted to increase by 3.5 µg/m³ between the '2026 Do Minimum' and '2026 With Project' options.

Predicted cumulative 1-hour average NO_2 concentrations for each of the modelled emission scenarios are all considerably less than the AQNES of 200 µg/m³, and also less than the 24-hour average NZAAQG of 100 µg/m³.

The maximum increase in 1 hour average NO_2 concentrations between "Do Minimum" and the "With Project" option at any identified receptor is predicted to be less the MfE Tier 2 significance criterion of 20 µg/m³ as a 1 hour average. It is also likely that the increase in 24-hour average NO_2 concentrations due to the Project will be lower than the relevant MfE Tier 2 significance criterion of 5 µg/m³.

Table H6: Predicted maximum 1-hour average NO_2 concentrations associated with motor vehicle emissions from Main South Road between Weedons Road and CSM2 (µg/m³)

Distance from centreline	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
	Predicted maximum incremental 1-hour average NO_2 concentrations			
25-50m	6.8	9.9	5.0	8.5
50-100m	3.8	5.5	3.0	4.6
100-150m	2.1	3.0	1.6	2.5
150-200m	1.6	2.2	1.2	1.9
	Predicted maximum cumulative 1-hour average NO_2 concentrations			
25-50m	70.3	73.4	68.5	72.0
50-100m	67.3	69.0	66.5	68.1
100-150m	65.6	66.5	65.1	66.0
150-200m	65.1	65.7	64.7	65.4

H2.5 CO Concentrations

Table H7 presents predicted incremental and cumulative maximum 1-hour average CO concentrations at different distances from the centreline of Main South Road between Weedons Road and CSM2.

The results show predicted maximum incremental concentrations slightly increase in the 'With Project' With Project' emission scenarios compared to the 'Do Minimum' for the same year. 1-hour average CO concentrations are predicted to increase by 0.11 mg/m³ between the '2016 Do Minimum' and '2026 With Project ' options.

Predicted cumulative 1-hour average CO concentrations for each of the modelled emission scenario are all considerably less than the NZAAQG of 30 mg/m^3, and also less than the running 8-hour average AQNES of 10 mg/m^3.

The maximum increase in 1-hour average CO concentrations between "Do Minimum" and either "With Project" option at any identified receptor is predicted to be less the MfE Tier 2 significance criterion of 1 µg/m^3.

Table H7: Predicted maximum 1-hour average CO concentrations associated with motor vehicle emissions from Main South Road between Weedons Road and CSM2 (mg/m^3)

Distance from centreline	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
	Predicted maximum incremental 1-hour average CO concentrations			
25-50m	0.22	0.33	0.09	0.16
50-100m	0.12	0.18	0.06	0.09
100-150m	0.07	0.10	0.03	0.05
150-200m	0.05	0.07	0.02	0.04
	Predicted maximum cumulative 1-hour average CO concentrations			
25-50m	8.42	8.53	8.29	8.36
50-100m	8.32	8.38	8.26	8.29
100-150m	8.27	8.30	8.23	8.25
150-200m	8.25	8.27	8.22	8.24

H2.6 Benzene Concentrations

Table H8 presents predicted maximum annual average benzene concentrations at different distances from the centreline of Main South Road between Weedons Road and CSM2.

The results show predicted maximum incremental concentrations are somewhat higher in the 'With Project' option compared to the 'Do Min' for the same year. Annual average benzene concentrations are predicted to increase by 0.04 µg/m^3 between the '2016 Do Minimum' and '2026 With Project' options.

The predicted incremental annual average benzene concentrations for each of the modelled emission scenarios are all less than 4% of the NZAAQG of 3.6 µg/m^3.

Table H8: Predicted maximum incremental annual average benzene concentrations associated with motor vehicle emissions from Main South Road between Weedons Road and CSM2 (µg/m^3)

Distance from centreline	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
25-50m	0.07	0.11	0.06	0.09

50-100m	0.04	0.06	0.03	0.05
100-150m	0.02	0.03	0.02	0.03
150-200m	0.02	0.02	0.01	0.02

H3 CSM2 between Main South Road and Shands Road

H3.1 Residential Receptors

There are a limited number of residential receptors located within 200m of this section of CSM2, mainly in the vicinity of Waterholes Road and Blakes Road. The closest of these receptors is located approximately 60m from the edge of the proposed alignment of CSM2. The locations of identified residential receptors are shown on maps attached at Appendix A.

H3.2 Modelled Scenarios

The road link included in the dispersion modelling for this section is CSM2 between Main South Road and the southern end of the Shands Road intersection. Concentrations are presented for the four 'With Project' emission scenarios only with distance from the centreline of the road section.

H3.3 PM_{10} Concentrations

Table H9 presents predicted incremental and cumulative maximum 24-hour average PM_{10} concentrations at different distances from the centreline of CSM2 between Main South Road and Shands Road.

The maximum incremental increase at the most impacted locations – i.e. those located within 25-50m of the centreline of the road (10-35m from the edge of the alignment) – is 2.0 µg/m³, which is predicted to occur in the '2026 With Project' option.

Predicted cumulative concentrations for each of the modelled emission scenario are all considerably less than the AQNES of 50 µg/m³. The maximum contribution from the project is predicted to be less than the MfE Tier 2 significance criterion of 2.5 µg/m³.

Table H9: Predicted maximum 24-hour average PM_{10} concentrations associated with motor vehicle emissions from CSM2 between Main South Road and Shands Road (µg/m³)

Distance from centreline	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
	Predicted maximum incremental 24-hour average PM_{10} concentrations			
25-50m	N/A	1.7	N/A	2.0
50-100m	N/A	0.9	N/A	1.0
100-150m	N/A	0.5	N/A	0.6
150-200m	N/A	0.4	N/A	0.5
	Predicted maximum cumulative 24-hour average PM_{10} concentrations			
25-50m	30.0	31.7	30.0	32.0
50-100m	30.0	30.9	30.0	31.0
100-150m	30.0	30.5	30.0	30.6
150-200m	30.0	30.4	30.0	30.5

H3.4 NO_2 Concentrations

Table H10 presents predicted incremental and cumulative maximum 1-hour average NO_2 concentrations at different distances from the centreline of CSM2 between Main South Road and Shands Road.

The maximum incremental increase at the most impacted receptors – i.e. those located within 25-50m of the centreline of the road (10-35m from the edge of the alignment) – is 7.6 µg/m³, which is predicted to occur in the '2016 With Project' option.

Predicted cumulative 1-hour average NO_2 concentrations for each of the modelled emission scenarios are all considerably less than the AQNES of 200 µg/m³, and also less than the 24-hour average NZAAQG of 100 µg/m³.

The maximum contribution to 1 hour average NO_2 concentrations from the Project at any receptor is predicted to be less the MfE Tier 2 significance criterion of 20 µg/m³ as a 1 hour average. It is also likely that the contribution to 24-hour average NO_2 concentrations due to the Project will be lower than the relevant MfE Tier 2 significance criterion of 5 µg/m³.

Table H10: Predicted maximum 1-hour average NO_2 concentrations associated with motor vehicle emissions from CSM2 between Main South Road and Shands Road (µg/m³)

Distance from centreline	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
	Predicted maximum incremental 1-hour average NO_2 concentrations			
25-50m	N/A	7.6	N/A	6.4
50-100m	N/A	4.9	N/A	4.0
100-150m	N/A	2.8	N/A	2.3
150-200m	N/A	2.0	N/A	1.7
	Predicted maximum cumulative 1-hour average NO_2 concentrations			
25-50m	63.5	71.1	63.5	69.9
50-100m	63.5	68.4	63.5	67.5
100-150m	63.5	66.3	63.5	65.8
150-200m	63.5	65.5	63.5	65.2

H3.5 CO Concentrations

Table H11 presents predicted incremental and cumulative maximum 1-hour average CO concentrations at different distances from the centreline of CSM2 between Main South Road and Shands Road.

The maximum incremental increase at the most impacted receptors – i.e. those located within 25-50m of the centreline of the road (10-35m from the edge of the alignment) – is 0.33 mg/m³, which is predicted to occur in the '2016 With Project' option.

Predicted cumulative 1-hour average CO concentrations for each of the modelled emission scenarios are all considerably less than the NZAAQG of 30 mg/m³, and also less than the running 8-hour average AQNES of 10 mg/m³.

The maximum contribution to 1-hour average CO concentrations from the Project at any receptor is predicted to be less the MfE Tier 2 significance criterion of 1 µg/m³.

Table H11: Predicted maximum 1-hour average CO concentrations associated with motor vehicle emissions from CSM2 between Main South Road and Shands Road (mg/m³)

Distance from centreline	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
	Predicted maximum incremental 1-hour average CO concentrations			
25-50m	N/A	0.33	N/A	0.15
50-100m	N/A	0.21	N/A	0.09
100-150m	N/A	0.12	N/A	0.05
150-200m	N/A	0.09	N/A	0.04
	Predicted maximum cumulative 1-hour average CO concentrations			
25-50m	8.20	8.53	8.20	8.35
50-100m	8.20	8.41	8.20	8.29
100-150m	8.20	8.32	8.20	8.25
150-200m	8.20	8.29	8.20	8.24

H3.6 Benzene Concentrations

Table H12 presents predicted maximum annual average benzene concentrations at different distances from the centreline of CSM2 between Main South Road and Shands Road.

The maximum incremental increase at the most impacted receptors – i.e. those located within 25-50m of the centreline of the road (10-35m from the edge of the alignment) – is 0.08 µg/m³, which is predicted to occur in the '2016 With Project' option.

The predicted incremental annual average benzene concentrations for each of the modelled emission scenarios are all less than 2.2% of the NZAAQG of 3.6 µg/m³.

Table H12: Predicted maximum incremental annual average benzene concentrations associated with motor vehicle emissions from CSM2 between Main South Road and Shands Road (µg/m³)

Distance from centreline	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
25-50m	N/A	0.08	N/A	0.06
50-100m	N/A	0.04	N/A	0.03
100-150m	N/A	0.02	N/A	0.02

150-200m	N/A	0.02	N/A	0.01

H4 CSM2 between Shands Road to Halswell Junction Road

H4.1 Sensitive Receptors

There are a very limited number of sensitive receptors located within 200m of this section of CSM2, in the vicinity of Marsh Road and Halswell Junction Road. The closest of these receptors is located on Marsh Road, approximately 30m from the edge of the proposed alignment of CSM2. The locations of identified sensitive receptors are shown on maps attached at Appendix A.

H4.2 Modelled Scenarios

The road link included in the dispersion modelling for this section is CSM2 between the northern end of the Shands Road intersection South Road and Halswell Junction Road (where CSM2 connects to Stage 1 of the Christchurch Southern Motorway. Concentrations are presented for the four 'With Project' emission scenarios only with distance from the centreline of the road section.

H4.3 PM_{10} Concentrations

Table H13 presents predicted incremental and cumulative maximum 24-hour average PM_{10} concentrations at different distances from the centreline of CSM2 between Shands Road and Halswell Junction Road.

The maximum incremental increase at the most impacted receptors – i.e. those located within 25-50m of the centreline of the road (10-35m from the edge of the alignment) – is 2.9 µg/m^3, which is predicted to occur in the '2026 With Project' option.

Predicted cumulative concentrations for each of the modelled emission scenario are all considerably less than the AQNES of 50 µg/m^3. The maximum contribution from the Project is predicted to exceed the MfE Tier 2 significance criterion at receptors located within 50m of the centreline of the motorway.

Table H13: Predicted maximum 24-hour average PM_{10} concentrations associated with motor vehicle emissions from CSM2 between Shands Road and Halswell Junction Road (µg/m^3)

Distance from centreline	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
	Predicted maximum incremental 24-hour average PM_{10} concentrations			
25-50m	N/A	2.6	N/A	2.9
50-100m	N/A	1.3	N/A	1.4
100-150m	N/A	0.8	N/A	0.8
150-200m	N/A	0.5	N/A	0.6
	Predicted maximum cumulative 24-hour average PM_{10} concentrations			
25-50m	30.0	32.6	30.0	32.9
50-100m	30.0	31.3	30.0	31.4
100-150m	30.0	30.8	30.0	30.8
150-200m	30.0	30.5	30.0	30.6

H4.4 NO_2 Concentrations

Table H14 presents predicted incremental and cumulative maximum 1-hour average NO_2 concentrations at different distances from the centreline of CSM2 between Shands Road and Halswell Junction Road.

The maximum incremental increase at the most impacted receptors – i.e. those located within 25-50m of the centreline of the road (10-35m from the edge of the alignment) – is 13.7 µg/m^3, which is predicted to occur in the '2016 With Project' option. Predicted cumulative 1-hour average NO_2 concentrations for each of the modelled emission scenario are all considerably less than the AQNES of 200 µg/m^3, and also less than the 24-hour average NZAAQG of 100 µg/m^3.

The maximum contribution to 1 hour average NO_2 concentrations from the Project at any receptor is predicted to be less the MfE Tier 2 significance criterion of 20 µg/m^3 as a 1 hour average. It is also likely that the contribution to 24-hour average NO_2 concentrations due to the Project will be lower than the relevant MfE Tier 2 significance criterion of 5 µg/m^3

Table H14: Predicted maximum 1-hour average NO_2 concentrations associated with motor vehicle emissions from CSM2 between Shands Road and Halswell Junction Road (µg/m^3)

Distance from centreline	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
	Predicted maximum incremental 1-hour average NO_2 concentrations			
25-50m	N/A	13.7	N/A	10.5
50-100m	N/A	7.5	N/A	5.7
100-150m	N/A	4.6	N/A	3.4
150-200m	N/A	2.7	N/A	2.1
	Predicted maximum cumulative 1-hour average NO_2 concentrations			
25-50m	63.5	77.2	63.5	74.0
50-100m	63.5	71.0	63.5	69.2
100-150m	63.5	68.1	63.5	66.9
150-200m	63.5	66.2	63.5	65.6

H4.5 CO Concentrations

Table H15 presents predicted incremental and cumulative maximum 1-hour average CO concentrations at different distances from the centreline of CSM2 between Shands Road and Halswell Junction Road.

The maximum incremental increase at the most impacted receptors – i.e. those located within 25-50m of the centreline of the road (10-35m from the edge of the alignment) – is 0.60 mg/m^3, which is predicted to occur in the '2016 With Project' option.

Predicted cumulative 1-hour average CO concentrations for each of the modelled emission scenario are all considerably less than the NZAAQG of 30 mg/m^3, and also less than the running 8-hour average AQNES of 10 mg/m^3.

The maximum contribution to 1-hour average CO concentrations from the Project at any receptor is predicted to be less the MfE Tier 2 significance criterion of 1 µg/m^3.

Table H15: Predicted maximum 1-hour average CO concentrations associated with motor vehicle emissions from CSM2 between Shands Road and Halswell Junction Road (mg/m^3)

Distance from centreline	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
	Predicted maximum incremental 1-hour average CO concentrations			
25-50m	N/A	0.60	N/A	0.25
50-100m	N/A	0.33	N/A	0.13
100-150m	N/A	0.20	N/A	0.08
150-200m	N/A	0.12	N/A	0.05
	Predicted maximum cumulative 1-hour average CO concentrations			
25-50m	8.20	8.80	8.20	8.45
50-100m	8.20	8.53	8.20	8.33
100-150m	8.20	8.40	8.20	8.28
150-200m	8.20	8.32	8.20	8.25

H4.6 Benzene Concentrations

Table H16 presents predicted maximum annual average benzene concentrations at different distances from the centreline of CSM2 between Shands Road and Halswell Junction Road.

The maximum incremental increase at the most impacted receptors – i.e. those located within 25-50m of the centreline of the road (10-35m from the edge of the alignment) – is 0.12 µg/m^3, which is predicted to occur in the '2026 With Project' option.

The predicted incremental annual average benzene concentrations for each of the modelled emission scenarios are all less than 4% of the NZAAQG of 3.6 µg/m^3.

Table H16: Predicted maximum incremental annual average benzene concentrations associated with motor vehicle emissions from CSM2 between Shands Road and Halswell Junction Road (µg/m^3)

Distance from centreline	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
25-50m	N/A	0.12	N/A	0.09
50-100m	N/A	0.06	N/A	0.04

100-150m	N/A	0.03	N/A	0.02
150-200m	N/A	0.02	N/A	0.01

H5 Shands Road Intersection

H5.1 Sensitive Receptors

There are a limited number of sensitive receptors located within 200m of the Shands Road Intersection, in the vicinity of Marsh Road and Shands Road. The closest of these receptors is located on Shands Road, approximately 60m from the edge of the southbound on-ramp. The locations of identified sensitive receptors are shown on maps attached at Appendix A.

H5.2 Modelled Scenarios

Road links included in the dispersion modelling for the Shands Road Intersection include the section of CSM2 between off- and on-ramps in both directions, northbound and southbound on- and off-ramps and Shands Road and Marsh Road in the vicinity of the intersection. Concentrations are presented for all emission scenarios at each of the identified sensitive receptors in this section.

H5.3 PM_{10} Concentrations

Table H17 presents predicted incremental and cumulative maximum 24-hour average PM_{10} concentrations at sensitive receptors in the vicinity of the Shands Road Intersection.

The maximum incremental increase between ‘Do minimum’ and either ‘With Project’ scenarios at the most impacted receptors – i.e. 191 and 197 Marsh Road – is 0.7 $\mu g/m^3$, which is predicted to occur in the ‘2016 With Project’ option.

Predicted cumulative concentrations for each of the modelled emission scenario are all considerably less than the AQNES of 50 $\mu g/m^3$. The maximum contribution from the Project is predicted to be less than the MfE Tier 2 significance criterion of 2.5 $\mu g/m^3$.

Table H17: Predicted maximum 24-hour average PM_{10} concentrations associated with motor vehicle emissions from Shands Road Intersection (µg/m³)

Receptor	Distance from Edge of Alignment	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
	Predicted maximum incremental 24-hour average PM_{10} concentrations				
516 - 518 Shands Road	66	0.1	0.5	0.1	0.5
523 Shands Road	131	0.3	0.7	0.4	0.7
181 Marshs Road	142	0.1	0.5	0.2	0.5
183 Marshs Road	111	0.2	0.7	0.2	0.7
191 Marshs Road	100	0.3	1.0	0.4	1.0
197 Marshs Road	95	0.3	0.9	0.3	0.9
	Predicted maximum cumulative 1-hour average PM_{10} concentrations				
516 - 518 Shands Road	66	30.1	30.5	30.1	30.5
523 Shands Road	131	30.3	30.7	30.4	30.7
181 Marshs Road	142	30.1	30.5	30.2	30.5
183 Marshs Road	111	30.2	30.7	30.2	30.7
191 Marshs Road	100	30.3	31.0	30.4	31.0
197 Marshs Road	95	30.3	30.9	30.3	30.9

H5.3 NO_2 Concentrations

Table H18 presents predicted incremental and cumulative maximum 1-hour average NO_2 concentrations at sensitive receptors in the vicinity of the Shands Road Intersection.

The maximum incremental increase between ‘Do minimum’ and the ‘With Project’ scenario at the most impacted receptors – i.e. 191 and 197 Marsh Road – is 3.3 µg/m³, which is predicted to occur in the ‘2016 With Project’ option.

Predicted cumulative 1-hour average NO_2 concentrations for each of the modelled emission scenarios are all considerably less than the AQNES of 200 µg/m³, and also less than the 24-hour average NZAAQG of 100 µg/m³.The maximum contribution from the Project is predicted to be less than the MfE Tier 2 significance criterion of 20 µg/m³ as a 1 hour average. It is also likely that the contribution to 24-hour average NO_2 concentrations due to the Project will be lower than the relevant MfE Tier 2 significance criterion of 5 µg/m³.

Table H18: **Predicted maximum 1-hour average NO_2 concentrations associated with motor vehicle emissions from Shands Road Intersection (µg/m³)**

Receptor	Distance from Edge of Alignment	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
	Predicted maximum incremental 1-hour average NO_2 concentrations				
516 - 518 Shands Road	66	0.5	2.4	0.5	2.0
523 Shands Road	131	1.1	4.0	1.1	3.2
181 Marshs Road	142	0.8	3.1	0.8	2.5
183 Marshs Road	111	1.1	4.0	1.1	3.2
191 Marshs Road	100	0.2	2.5	0.2	2.0
197 Marshs Road	95	2.2	5.5	2.2	4.4
	Predicted maximum cumulative 24-hour average NO_2 concentrations				
516 - 518 Shands Road	66	64.0	65.9	64.0	65.5
523 Shands Road	131	64.6	67.5	64.6	66.7
181 Marshs Road	142	64.3	66.6	64.3	66.0
183 Marshs Road	111	64.6	67.5	64.6	66.7
191 Marshs Road	100	63.7	66.0	63.7	65.5
197 Marshs Road	95	65.7	69.0	65.7	67.9

H5.3 CO Concentrations

Table H19 presents predicted incremental maximum 1-hour average CO concentrations at sensitive receptors in the vicinity of the Shands Road Intersection.

The maximum incremental increase between 'Do minimum' and the 'With Project' scenario at the most impacted receptors – i.e. 191 and 197 Marsh Road – is 0.15 mg/m³, which is predicted to occur in the '2016 With Project' option.

Predicted cumulative 1-hour average CO concentrations for each of the modelled emission scenario are all considerably less than the NZAAQG of 30 mg/m³, and also less than the running 8-hour average AQNES of 10 mg/m³.

The maximum contribution to 1-hour average CO concentrations from the Project at any receptor is predicted to be less the MfE Tier 2 significance criterion of 1 µg/m³.

Table H19: Predicted maximum incremental 1-hour average CO concentrations associated with motor vehicle emissions from Shands Road Intersection (mg/m³)

Receptor	Distance from Edge of Alignment	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
516 - 518 Shands Road	66	0.02	0.10	0.01	0.05
523 Shands Road	131	0.04	0.16	0.02	0.08
181 Marshs Road	142	0.03	0.12	0.02	0.06
183 Marshs Road	111	0.04	0.16	0.02	0.08
191 Marshs Road	100	0.01	0.10	0.00	0.05
197 Marshs Road	95	0.07	0.22	0.05	0.11

H5.3 Benzene Concentrations

Table H20 presents predicted incremental and cumulative maximum 1-hour average Benzene concentrations at sensitive receptors in the vicinity of the Shands Road Intersection.

The maximum incremental increase between 'Do minimum' and either 'With Project' scenarios at the most impacted receptors – i.e. 191 and 197 Marsh Road – is 0.01 µg/m³, which is predicted to occur in the 'With Project' option.

The predicted incremental annual average benzene concentrations for each of the modelled emission scenarios are all very small – less than 0.3% of the NZAAQG of 3.6 µg/m³.

Table H20: Predicted maximum incremental annual average benzene concentrations associated with motor vehicle emissions from Shands Road Intersection (µg/m³)

Receptor	Distance from Edge of Alignment	2016 Do Minimum	2016 With Project	2026 Do Minimum	2026 With Project
516 - 518 Shands Road	66	0.002	0.006	0.001	0.003
523 Shands Road	131	0.001	0.004	0.001	0.002
181 Marshs Road	142	0.002	0.006	0.001	0.003
183 Marshs Road	111	0.000	0.003	0.000	0.001
191 Marshs Road	100	0.003	0.011	0.003	0.005
197 Marshs Road	95	0.003	0.010	0.002	0.005

Appendix I
Sample AUSROADS Output File

2026 Shands intersection CSM+MSRFL

VARIABLES AND OPTIONS SELECTED FOR THIS RUN

Emission rate units:	g/v-km
Concentration units:	micrograms/m3
Aerodynamic roughness:	0.10 (M)
Aerodynamic roughness at wind vane site:	0.10 (M)
Anemometer height:	10.0 (M)
Read sigma theta values from the met file?	No
Use Pasquill Gifford for horizontal dispersion?	Yes
Sigma theta averaging periods:	60 (min.)
Wind profile exponents set to:	Irwin Rural
Use hourly varying background concentrations?	No
Use constant background concentrations?	Yes
Constant background concentrations set to:	0.00E+00 micrograms/m3

External file for emission rates and traffic volumes? Yes

LINK GEOMETRY

LINK NAME	TYPE	X1	Y1	X2	Y2	HEIGHT (M)	MIXING ZONE WIDTH (M)
LNK1	AG	200.9	1782.0	1162.0	1578.0	0.0	26.0
LNK2	AG	1162.0	1578.0	1784.0	1541.0	0.0	26.0
LNK3	AG	1784.0	1541.0	2070.0	1553.0	0.0	26.0
LNK22	AG	1028.0	1549.0	1162.0	1578.0	0.0	10.0
LNK4	AG	742.0	1494.0	820.0	1474.0	0.0	10.0
LNK5	AG	820.0	1474.0	919.0	1514.0	0.0	10.0
LNK6	AG	919.0	1514.0	1028.0	1549.0	0.0	10.0
LNK20	AG	200.9	1782.0	410.0	1704.0	0.0	10.0
LNK7	AG	720.0	1503.0	548.0	1632.0	0.0	10.0
LNK8	AG	548.0	1632.0	410.0	1704.0	0.0	10.0
LNK9	AG	458.0	1786.0	629.0	1805.0	0.0	10.0
LNK23	AG	458.0	1786.0	200.9	1782.0	0.0	10.0
LNK10	AG	629.0	1805.0	707.0	1805.0	0.0	10.0
LNK11	AG	707.0	1805.0	793.0	1788.0	0.0	10.0
LNK12	AG	793.0	1788.0	880.0	1745.0	0.0	10.0
LNK13	AG	898.0	1732.0	1069.0	1619.0	0.0	10.0
LNK21	AG	1069.0	1619.0	1162.0	1578.0	0.0	10.0
LNK14	AG	728.0	1494.0	892.0	1743.0	0.0	13.0
LNK15	AG	892.0	1743.0	931.0	1801.0	0.0	13.0
LNK17	AG	931.0	1801.0	355.0	2210.0	0.0	13.0
LNK16	AG	931.0	1801.0	1296.0	2303.0	0.0	13.0
LNK18	AG	931.0	1801.0	2015.0	1176.0	0.0	13.0
LNK19	AG	728.0	1492.0	295.0	851.0	0.0	13.0
LNK24	AG	2207.0	1553.0	2701.0	1687.0	0.0	13.0

RECEPTOR LOCATIONS

NAME	No.	X	Y	Z	NAME	No.	X	Y	Z
RCP1	1	798.9	1938.6	0.0	RCP2	2	826.9	1899.9	0.0
RCP3	3	905.1	1840.2	0.0	RCP4	4	913.1	1844.2	0.0
RCP5	5	926.4	1842.8	0.0	RCP6	6	564.8	1531.9	0.0
RCP7	7	682.2	1370.5	0.0	RCP8	8	1354.8	1449.2	0.0
RCP9	9	1481.5	1518.6	0.0	RCP10	10	1757.5	1285.1	0.0
RCP11	11	2533.4	1449.8	0.0	RCP12	12	2544.9	1472.9	0.0

(Coordinates (M) for X, Y, Z.)

```
RCP13   13   2635.5    1463.0    0.0 | RCP14   14   2584.5    1548.6    0.0
```

METEOROLOGICAL DATA

Meteorolofical data entered via the input file:
Z:\3390691\Model\modelling met\t010a_m01301301.met

Title of the meteorological data file is:
AUSPLUME METFILE

HOURLY VARIABLE EMISSION FACTOR INFORMATION

Hourly varying traffic volumes and emission factors
entered via the input file:
Z:\3390691\Model\CSM Shand intersection\Shands Int 2026 CSM+MSRFL.act

Title of input hourly emission factor file is:
Shands Int to Halswell

AVERAGE OVER ALL HOURS AND FOR ALL SOURCES
in micrograms/m3

Concentrations at the discrete receptors (No. : Value):

```
   1:1.01E-01    2:1.36E-01    3:2.25E-01    4:2.17E-01    5:2.46E-01
6:1.50E-01    7:2.49E-01    8:2.74E-01
   9:6.67E-01   10:1.83E-01   11:7.95E-02   12:8.79E-02   13:6.41E-02
14:1.35E-01
```

HIGHEST RECORDINGS FOR EACH RECEPTOR - in micrograms/m3

AVERAGING TIME = 1 HOUR

At the discrete receptors:

```
  1: 2.84E+00 @Hr17,20/07/07
  2: 3.60E+00 @Hr17,20/07/07
  3: 4.71E+00 @Hr18,25/08/07
  4: 4.34E+00 @Hr18,09/07/07
  5: 5.03E+00 @Hr18,09/07/07
  6: 2.22E+00 @Hr09,16/12/07
  7: 3.27E+00 @Hr17,18/06/07
  8: 3.67E+00 @Hr18,07/07/07
  9: 8.12E+00 @Hr08,23/04/07
 10: 2.60E+00 @Hr18,07/07/07
 11: 2.45E+00 @Hr08,28/06/07
 12: 2.57E+00 @Hr08,10/04/07
 13: 2.28E+00 @Hr08,10/04/07
 14: 3.82E+00 @Hr17,06/08/07
```

HIGHEST RECORDINGS FOR EACH RECEPTOR - in micrograms/m3

AVERAGING TIME = 8 HOURS

At the discrete receptors:

```
  1: 8.43E-01 @Hr24,03/06/07
  2: 1.07E+00 @Hr24,03/06/07
  3: 1.44E+00 @Hr24,03/06/07
  4: 1.30E+00 @Hr24,03/06/07
  5: 1.33E+00 @Hr24,03/06/07
  6: 8.83E-01 @Hr16,28/07/07
  7: 1.03E+00 @Hr16,25/04/07
  8: 1.36E+00 @Hr16,28/07/07
  9: 2.56E+00 @Hr16,28/07/07
 10: 1.06E+00 @Hr16,28/07/07
 11: 6.25E-01 @Hr16,23/07/07
 12: 6.90E-01 @Hr16,23/07/07
 13: 6.04E-01 @Hr16,23/07/07
 14: 9.99E-01 @Hr16,23/07/07
```

HIGHEST RECORDINGS FOR EACH RECEPTOR - in micrograms/m3

AVERAGING TIME = 24 HOURS

At the discrete receptors:

```
  1: 5.01E-01 @Hr24,03/06/07
  2: 6.63E-01 @Hr24,15/06/07
  3: 1.02E+00 @Hr24,15/06/07
  4: 9.49E-01 @Hr24,15/06/07
  5: 1.02E+00 @Hr24,15/06/07
  6: 5.07E-01 @Hr24,28/07/07
  7: 7.14E-01 @Hr24,27/07/07
  8: 8.58E-01 @Hr24,27/07/07
  9: 1.74E+00 @Hr24,10/04/07
 10: 7.15E-01 @Hr24,27/07/07
 11: 3.56E-01 @Hr24,23/07/07
 12: 3.93E-01 @Hr24,23/07/07
 13: 3.43E-01 @Hr24,23/07/07
 14: 5.70E-01 @Hr24,23/07/07
```

SECOND-HIGHEST RECORDINGS FOR EACH RECEPTOR - in micrograms/m3

AVERAGING TIME = 1 HOUR

At the discrete receptors:

SECOND-HIGHEST RECORDINGS FOR EACH RECEPTOR - in micrograms/m3

AVERAGING TIME = 8 HOURS

At the discrete receptors:

SECOND-HIGHEST RECORDINGS FOR EACH RECEPTOR - in micrograms/m3

AVERAGING TIME = 24 HOURS

At the discrete receptors:

Peak values for the 100 worst cases - in micrograms/m3

AVERAGING TIME = 1 HOUR

Rank	Value	Time Recorded hour,date	Coordinates		
1	8.12E+00	@Hr08,23/04/07	(1481.5,	1518.6,	0.0)
2	8.04E+00	@Hr08,26/08/07	(1481.5,	1518.6,	0.0)
3	7.93E+00	@Hr08,06/09/07	(1481.5,	1518.6,	0.0)
4	7.32E+00	@Hr18,07/07/07	(1481.5,	1518.6,	0.0)
5	7.19E+00	@Hr09,19/06/07	(1481.5,	1518.6,	0.0)
6	7.14E+00	@Hr09,07/05/07	(1481.5,	1518.6,	0.0)
7	6.91E+00	@Hr08,25/04/07	(1481.5,	1518.6,	0.0)
8	6.91E+00	@Hr09,17/06/07	(1481.5,	1518.6,	0.0)
9	6.90E+00	@Hr08,20/04/07	(1481.5,	1518.6,	0.0)
10	6.43E+00	@Hr09,27/08/07	(1481.5,	1518.6,	0.0)
11	6.03E+00	@Hr18,09/05/07	(1481.5,	1518.6,	0.0)
12	6.01E+00	@Hr18,22/07/07	(1481.5,	1518.6,	0.0)
13	6.01E+00	@Hr08,28/06/07	(1481.5,	1518.6,	0.0)
14	5.89E+00	@Hr10,28/06/07	(1481.5,	1518.6,	0.0)
15	5.83E+00	@Hr08,18/02/07	(1481.5,	1518.6,	0.0)
16	5.74E+00	@Hr09,25/04/07	(1481.5,	1518.6,	0.0)
17	5.71E+00	@Hr08,19/10/07	(1481.5,	1518.6,	0.0)
18	5.62E+00	@Hr09,15/08/07	(1481.5,	1518.6,	0.0)
19	5.57E+00	@Hr08,10/04/07	(1481.5,	1518.6,	0.0)
20	5.57E+00	@Hr08,13/05/07	(1481.5,	1518.6,	0.0)
21	5.51E+00	@Hr09,08/09/07	(1481.5,	1518.6,	0.0)
22	5.47E+00	@Hr08,05/03/07	(1481.5,	1518.6,	0.0)
23	5.47E+00	@Hr09,29/08/07	(1481.5,	1518.6,	0.0)
24	5.39E+00	@Hr18,06/08/07	(1481.5,	1518.6,	0.0)
25	5.31E+00	@Hr08,27/08/07	(1481.5,	1518.6,	0.0)
26	5.27E+00	@Hr17,18/06/07	(1481.5,	1518.6,	0.0)
27	5.26E+00	@Hr09,23/04/07	(1481.5,	1518.6,	0.0)
28	5.25E+00	@Hr08,12/09/07	(1481.5,	1518.6,	0.0)
29	5.24E+00	@Hr09,16/12/07	(1481.5,	1518.6,	0.0)
30	5.24E+00	@Hr08,09/04/07	(1481.5,	1518.6,	0.0)
31	5.14E+00	@Hr18,27/07/07	(1481.5,	1518.6,	0.0)
32	5.14E+00	@Hr09,10/04/07	(1481.5,	1518.6,	0.0)
33	5.11E+00	@Hr11,13/06/07	(1481.5,	1518.6,	0.0)
34	5.03E+00	@Hr18,09/07/07	(926.4,	1842.8,	0.0)
35	4.98E+00	@Hr08,02/12/07	(1481.5,	1518.6,	0.0)
36	4.97E+00	@Hr18,15/06/07	(926.4,	1842.8,	0.0)
37	4.93E+00	@Hr08,17/06/07	(1481.5,	1518.6,	0.0)
38	4.88E+00	@Hr17,08/06/07	(1481.5,	1518.6,	0.0)
39	4.85E+00	@Hr08,08/08/07	(1481.5,	1518.6,	0.0)
40	4.79E+00	@Hr08,04/07/07	(1481.5,	1518.6,	0.0)
41	4.71E+00	@Hr18,01/03/07	(1481.5,	1518.6,	0.0)
42	4.71E+00	@Hr18,25/08/07	(905.1,	1840.2,	0.0)
43	4.68E+00	@Hr17,03/06/07	(905.1,	1840.2,	0.0)
44	4.65E+00	@Hr09,25/05/07	(1481.5,	1518.6,	0.0)
45	4.64E+00	@Hr08,03/04/07	(1481.5,	1518.6,	0.0)
46	4.64E+00	@Hr08,15/08/07	(1481.5,	1518.6,	0.0)
47	4.63E+00	@Hr08,10/12/07	(1481.5,	1518.6,	0.0)
48	4.60E+00	@Hr09,11/06/07	(1481.5,	1518.6,	0.0)
49	4.58E+00	@Hr18,10/04/07	(1481.5,	1518.6,	0.0)
50	4.57E+00	@Hr08,28/07/07	(1481.5,	1518.6,	0.0)
51	4.56E+00	@Hr18,09/06/07	(1481.5,	1518.6,	0.0)
52	4.55E+00	@Hr18,26/05/07	(1481.5,	1518.6,	0.0)
53	4.55E+00	@Hr08,04/06/07	(1481.5,	1518.6,	0.0)
54	4.55E+00	@Hr09,24/08/07	(1481.5,	1518.6,	0.0)
55	4.55E+00	@Hr17,20/07/07	(905.1,	1840.2,	0.0)
56	4.52E+00	@Hr09,04/06/07	(1481.5,	1518.6,	0.0)
57	4.52E+00	@Hr08,06/04/07	(1481.5,	1518.6,	0.0)

58	4.50E+00	@Hr08,10/03/07	(	1481.5,	1518.6,	0.0)
59	4.49E+00	@Hr08,11/09/07	(	1481.5,	1518.6,	0.0)
60	4.47E+00	@Hr08,13/09/07	(	1481.5,	1518.6,	0.0)
61	4.47E+00	@Hr09,31/05/07	(	1481.5,	1518.6,	0.0)
62	4.47E+00	@Hr09,18/09/07	(	1481.5,	1518.6,	0.0)
63	4.46E+00	@Hr18,18/06/07	(	1481.5,	1518.6,	0.0)
64	4.45E+00	@Hr18,21/03/07	(	1481.5,	1518.6,	0.0)
65	4.45E+00	@Hr08,30/08/07	(	1481.5,	1518.6,	0.0)
66	4.44E+00	@Hr08,10/09/07	(	1481.5,	1518.6,	0.0)
67	4.44E+00	@Hr08,18/07/07	(	1481.5,	1518.6,	0.0)
68	4.44E+00	@Hr17,30/08/07	(	1481.5,	1518.6,	0.0)
69	4.43E+00	@Hr09,28/07/07	(	1481.5,	1518.6,	0.0)
70	4.42E+00	@Hr08,04/01/07	(	1481.5,	1518.6,	0.0)
71	4.40E+00	@Hr18,03/06/07	(	905.1,	1840.2,	0.0)
72	4.38E+00	@Hr09,12/09/07	(	1481.5,	1518.6,	0.0)
73	4.35E+00	@Hr08,21/03/07	(	1481.5,	1518.6,	0.0)
74	4.34E+00	@Hr09,26/05/07	(	1481.5,	1518.6,	0.0)
75	4.34E+00	@Hr08,30/05/07	(	1481.5,	1518.6,	0.0)
76	4.33E+00	@Hr09,05/03/07	(	1481.5,	1518.6,	0.0)
77	4.30E+00	@Hr08,20/03/07	(	1481.5,	1518.6,	0.0)
78	4.29E+00	@Hr09,13/07/07	(	1481.5,	1518.6,	0.0)
79	4.28E+00	@Hr08,08/02/07	(	1481.5,	1518.6,	0.0)
80	4.28E+00	@Hr08,23/03/07	(	926.4,	1842.8,	0.0)
81	4.26E+00	@Hr09,06/09/07	(	1481.5,	1518.6,	0.0)
82	4.26E+00	@Hr09,28/04/07	(	1481.5,	1518.6,	0.0)
83	4.26E+00	@Hr08,26/07/07	(	1481.5,	1518.6,	0.0)
84	4.25E+00	@Hr09,18/05/07	(	1481.5,	1518.6,	0.0)
85	4.22E+00	@Hr08,18/08/07	(	1481.5,	1518.6,	0.0)
86	4.21E+00	@Hr09,26/08/07	(	1481.5,	1518.6,	0.0)
87	4.20E+00	@Hr09,01/04/07	(	1481.5,	1518.6,	0.0)
88	4.19E+00	@Hr12,26/07/07	(	1481.5,	1518.6,	0.0)
89	4.19E+00	@Hr18,13/06/07	(	926.4,	1842.8,	0.0)
90	4.18E+00	@Hr18,18/01/07	(	1481.5,	1518.6,	0.0)
91	4.15E+00	@Hr08,28/11/07	(	1481.5,	1518.6,	0.0)
92	4.14E+00	@Hr18,23/07/07	(	1481.5,	1518.6,	0.0)
93	4.13E+00	@Hr09,08/06/07	(	926.4,	1842.8,	0.0)
94	4.09E+00	@Hr09,16/07/07	(	1481.5,	1518.6,	0.0)
95	4.05E+00	@Hr10,19/08/07	(	1481.5,	1518.6,	0.0)
96	4.04E+00	@Hr09,30/05/07	(	1481.5,	1518.6,	0.0)
97	4.02E+00	@Hr08,25/05/07	(	1481.5,	1518.6,	0.0)
98	4.01E+00	@Hr14,15/06/07	(	1481.5,	1518.6,	0.0)
99	4.00E+00	@Hr13,08/06/07	(	1481.5,	1518.6,	0.0)
100	3.98E+00	@Hr17,04/07/07	(	1481.5,	1518.6,	0.0)

Peak values for the 100 worst cases - in micrograms/m3

AVERAGING TIME = 8 HOURS

Rank	Value	Time Recorded hour,date		Coordinates		
1	2.56E+00	@Hr16,28/07/07	(	1481.5,	1518.6,	0.0)
2	2.55E+00	@Hr16,08/06/07	(	1481.5,	1518.6,	0.0)
3	2.49E+00	@Hr16,23/07/07	(	1481.5,	1518.6,	0.0)
4	2.48E+00	@Hr16,17/06/07	(	1481.5,	1518.6,	0.0)
5	2.30E+00	@Hr16,25/04/07	(	1481.5,	1518.6,	0.0)
6	2.27E+00	@Hr16,26/08/07	(	1481.5,	1518.6,	0.0)
7	2.26E+00	@Hr16,08/09/07	(	1481.5,	1518.6,	0.0)
8	2.24E+00	@Hr24,27/07/07	(	1481.5,	1518.6,	0.0)
9	2.22E+00	@Hr16,28/06/07	(	1481.5,	1518.6,	0.0)
10	2.18E+00	@Hr16,04/06/07	(	1481.5,	1518.6,	0.0)
11	2.11E+00	@Hr16,10/04/07	(	1481.5,	1518.6,	0.0)
12	2.11E+00	@Hr16,24/08/07	(	1481.5,	1518.6,	0.0)
13	2.01E+00	@Hr16,16/07/07	(	1481.5,	1518.6,	0.0)
14	1.99E+00	@Hr24,10/04/07	(	1481.5,	1518.6,	0.0)
15	1.99E+00	@Hr16,29/08/07	(	1481.5,	1518.6,	0.0)
16	1.98E+00	@Hr16,26/07/07	(	1481.5,	1518.6,	0.0)

17	1.95E+00	@Hr16,15/06/07	(1481.5,	1518.6,	0.0)
18	1.93E+00	@Hr16,29/04/07	(1481.5,	1518.6,	0.0)
19	1.92E+00	@Hr16,27/07/07	(1481.5,	1518.6,	0.0)
20	1.87E+00	@Hr24,07/07/07	(1481.5,	1518.6,	0.0)
21	1.82E+00	@Hr16,27/08/07	(1481.5,	1518.6,	0.0)
22	1.82E+00	@Hr24,29/05/07	(1481.5,	1518.6,	0.0)
23	1.82E+00	@Hr16,06/09/07	(1481.5,	1518.6,	0.0)
24	1.82E+00	@Hr16,31/08/07	(1481.5,	1518.6,	0.0)
25	1.79E+00	@Hr24,06/08/07	(1481.5,	1518.6,	0.0)
26	1.78E+00	@Hr16,08/04/07	(1481.5,	1518.6,	0.0)
27	1.78E+00	@Hr16,12/09/07	(1481.5,	1518.6,	0.0)
28	1.77E+00	@Hr24,18/06/07	(1481.5,	1518.6,	0.0)
29	1.75E+00	@Hr16,19/08/07	(1481.5,	1518.6,	0.0)
30	1.75E+00	@Hr24,04/06/07	(1481.5,	1518.6,	0.0)
31	1.75E+00	@Hr16,08/07/07	(1481.5,	1518.6,	0.0)
32	1.74E+00	@Hr16,28/05/07	(1481.5,	1518.6,	0.0)
33	1.72E+00	@Hr24,12/05/07	(1481.5,	1518.6,	0.0)
34	1.71E+00	@Hr16,10/06/07	(1481.5,	1518.6,	0.0)
35	1.71E+00	@Hr16,25/05/07	(1481.5,	1518.6,	0.0)
36	1.69E+00	@Hr16,20/04/07	(1481.5,	1518.6,	0.0)
37	1.69E+00	@Hr16,13/06/07	(1481.5,	1518.6,	0.0)
38	1.67E+00	@Hr24,23/07/07	(1481.5,	1518.6,	0.0)
39	1.64E+00	@Hr16,09/08/07	(1481.5,	1518.6,	0.0)
40	1.63E+00	@Hr24,20/04/07	(1481.5,	1518.6,	0.0)
41	1.63E+00	@Hr24,09/05/07	(1481.5,	1518.6,	0.0)
42	1.63E+00	@Hr16,04/07/07	(1481.5,	1518.6,	0.0)
43	1.62E+00	@Hr16,18/06/07	(1481.5,	1518.6,	0.0)
44	1.61E+00	@Hr08,06/09/07	(1481.5,	1518.6,	0.0)
45	1.60E+00	@Hr08,23/04/07	(1481.5,	1518.6,	0.0)
46	1.59E+00	@Hr16,25/08/07	(1481.5,	1518.6,	0.0)
47	1.59E+00	@Hr16,06/06/07	(1481.5,	1518.6,	0.0)
48	1.58E+00	@Hr16,07/05/07	(1481.5,	1518.6,	0.0)
49	1.57E+00	@Hr16,26/05/07	(1481.5,	1518.6,	0.0)
50	1.57E+00	@Hr24,15/05/07	(1481.5,	1518.6,	0.0)
51	1.57E+00	@Hr16,15/08/07	(1481.5,	1518.6,	0.0)
52	1.56E+00	@Hr16,14/05/07	(1481.5,	1518.6,	0.0)
53	1.56E+00	@Hr24,17/06/07	(1481.5,	1518.6,	0.0)
54	1.56E+00	@Hr16,11/06/07	(1481.5,	1518.6,	0.0)
55	1.55E+00	@Hr24,23/04/07	(1481.5,	1518.6,	0.0)
56	1.55E+00	@Hr24,24/04/07	(1481.5,	1518.6,	0.0)
57	1.54E+00	@Hr16,19/06/07	(1481.5,	1518.6,	0.0)
58	1.53E+00	@Hr16,21/10/07	(1481.5,	1518.6,	0.0)
59	1.52E+00	@Hr16,21/08/07	(1481.5,	1518.6,	0.0)
60	1.51E+00	@Hr16,09/05/07	(1481.5,	1518.6,	0.0)
61	1.51E+00	@Hr16,09/04/07	(1481.5,	1518.6,	0.0)
62	1.49E+00	@Hr16,23/04/07	(1481.5,	1518.6,	0.0)
63	1.49E+00	@Hr24,22/07/07	(1481.5,	1518.6,	0.0)
64	1.48E+00	@Hr16,13/07/07	(1481.5,	1518.6,	0.0)
65	1.46E+00	@Hr24,07/04/07	(1481.5,	1518.6,	0.0)
66	1.46E+00	@Hr16,30/05/07	(1481.5,	1518.6,	0.0)
67	1.45E+00	@Hr16,05/03/07	(1481.5,	1518.6,	0.0)
68	1.45E+00	@Hr16,18/09/07	(1481.5,	1518.6,	0.0)
69	1.44E+00	@Hr24,03/06/07	(905.1,	1840.2,	0.0)
70	1.43E+00	@Hr16,27/06/07	(1481.5,	1518.6,	0.0)
71	1.43E+00	@Hr24,28/07/07	(1481.5,	1518.6,	0.0)
72	1.43E+00	@Hr16,24/03/07	(1481.5,	1518.6,	0.0)
73	1.43E+00	@Hr24,18/01/07	(1481.5,	1518.6,	0.0)
74	1.42E+00	@Hr08,19/10/07	(1481.5,	1518.6,	0.0)
75	1.42E+00	@Hr16,23/11/07	(1481.5,	1518.6,	0.0)
76	1.41E+00	@Hr16,16/12/07	(1481.5,	1518.6,	0.0)
77	1.41E+00	@Hr08,20/04/07	(1481.5,	1518.6,	0.0)
78	1.40E+00	@Hr24,08/07/07	(1481.5,	1518.6,	0.0)
79	1.39E+00	@Hr24,09/04/07	(1481.5,	1518.6,	0.0)
80	1.38E+00	@Hr16,12/08/07	(1481.5,	1518.6,	0.0)
81	1.38E+00	@Hr16,10/09/07	(1481.5,	1518.6,	0.0)
82	1.37E+00	@Hr24,16/04/07	(1481.5,	1518.6,	0.0)
83	1.37E+00	@Hr24,06/09/07	(1481.5,	1518.6,	0.0)
84	1.37E+00	@Hr08,26/08/07	(1481.5,	1518.6,	0.0)

85	1.37E+00	@Hr16,25/10/07	(1481.5,	1518.6,	0.0)
86	1.36E+00	@Hr16,05/05/07	(1481.5,	1518.6,	0.0)
87	1.36E+00	@Hr24,25/10/07	(1481.5,	1518.6,	0.0)
88	1.35E+00	@Hr16,03/04/07	(1481.5,	1518.6,	0.0)
89	1.34E+00	@Hr24,20/07/07	(1481.5,	1518.6,	0.0)
90	1.33E+00	@Hr24,11/09/07	(1481.5,	1518.6,	0.0)
91	1.33E+00	@Hr08,28/06/07	(1481.5,	1518.6,	0.0)
92	1.32E+00	@Hr16,18/02/07	(1481.5,	1518.6,	0.0)
93	1.31E+00	@Hr16,28/12/07	(1481.5,	1518.6,	0.0)
94	1.30E+00	@Hr24,19/09/07	(1481.5,	1518.6,	0.0)
95	1.30E+00	@Hr24,15/03/07	(1481.5,	1518.6,	0.0)
96	1.30E+00	@Hr24,19/03/07	(1481.5,	1518.6,	0.0)
97	1.29E+00	@Hr16,19/07/07	(1481.5,	1518.6,	0.0)
98	1.29E+00	@Hr16,20/06/07	(1481.5,	1518.6,	0.0)
99	1.29E+00	@Hr24,27/06/07	(1481.5,	1518.6,	0.0)
100	1.29E+00	@Hr24,19/07/07	(1481.5,	1518.6,	0.0)

Peak values for the 100 worst cases - in micrograms/m3

AVERAGING TIME = 24 HOURS

Rank	Value	Time Recorded hour,date	Coordinates		
1	1.74E+00	@Hr24,10/04/07	(1481.5,	1518.6,	0.0)
2	1.67E+00	@Hr24,23/07/07	(1481.5,	1518.6,	0.0)
3	1.67E+00	@Hr24,17/06/07	(1481.5,	1518.6,	0.0)
4	1.63E+00	@Hr24,04/06/07	(1481.5,	1518.6,	0.0)
5	1.61E+00	@Hr24,28/06/07	(1481.5,	1518.6,	0.0)
6	1.60E+00	@Hr24,06/09/07	(1481.5,	1518.6,	0.0)
7	1.59E+00	@Hr24,28/07/07	(1481.5,	1518.6,	0.0)
8	1.59E+00	@Hr24,27/07/07	(1481.5,	1518.6,	0.0)
9	1.58E+00	@Hr24,20/04/07	(1481.5,	1518.6,	0.0)
10	1.55E+00	@Hr24,23/04/07	(1481.5,	1518.6,	0.0)
11	1.50E+00	@Hr24,26/08/07	(1481.5,	1518.6,	0.0)
12	1.48E+00	@Hr24,25/04/07	(1481.5,	1518.6,	0.0)
13	1.37E+00	@Hr24,08/09/07	(1481.5,	1518.6,	0.0)
14	1.32E+00	@Hr24,08/07/07	(1481.5,	1518.6,	0.0)
15	1.31E+00	@Hr24,12/09/07	(1481.5,	1518.6,	0.0)
16	1.29E+00	@Hr24,26/07/07	(1481.5,	1518.6,	0.0)
17	1.28E+00	@Hr24,08/06/07	(1481.5,	1518.6,	0.0)
18	1.28E+00	@Hr24,27/08/07	(1481.5,	1518.6,	0.0)
19	1.28E+00	@Hr24,09/04/07	(1481.5,	1518.6,	0.0)
20	1.25E+00	@Hr24,18/06/07	(1481.5,	1518.6,	0.0)
21	1.25E+00	@Hr24,09/05/07	(1481.5,	1518.6,	0.0)
22	1.24E+00	@Hr24,24/08/07	(1481.5,	1518.6,	0.0)
23	1.24E+00	@Hr24,29/08/07	(1481.5,	1518.6,	0.0)
24	1.23E+00	@Hr24,05/03/07	(1481.5,	1518.6,	0.0)
25	1.22E+00	@Hr24,12/05/07	(1481.5,	1518.6,	0.0)
26	1.20E+00	@Hr24,20/06/07	(1481.5,	1518.6,	0.0)
27	1.17E+00	@Hr24,08/04/07	(1481.5,	1518.6,	0.0)
28	1.17E+00	@Hr24,11/09/07	(1481.5,	1518.6,	0.0)
29	1.16E+00	@Hr24,25/05/07	(1481.5,	1518.6,	0.0)
30	1.16E+00	@Hr24,10/09/07	(1481.5,	1518.6,	0.0)
31	1.15E+00	@Hr24,19/10/07	(1481.5,	1518.6,	0.0)
32	1.14E+00	@Hr24,16/07/07	(1481.5,	1518.6,	0.0)
33	1.14E+00	@Hr24,29/04/07	(1481.5,	1518.6,	0.0)
34	1.13E+00	@Hr24,24/04/07	(1481.5,	1518.6,	0.0)
35	1.13E+00	@Hr24,31/08/07	(1481.5,	1518.6,	0.0)
36	1.12E+00	@Hr24,25/08/07	(1481.5,	1518.6,	0.0)
37	1.12E+00	@Hr24,25/10/07	(1481.5,	1518.6,	0.0)
38	1.11E+00	@Hr24,19/07/07	(1481.5,	1518.6,	0.0)
39	1.10E+00	@Hr24,30/05/07	(1481.5,	1518.6,	0.0)
40	1.09E+00	@Hr24,18/02/07	(1481.5,	1518.6,	0.0)
41	1.09E+00	@Hr24,24/03/07	(1481.5,	1518.6,	0.0)
42	1.09E+00	@Hr24,30/08/07	(1481.5,	1518.6,	0.0)
43	1.08E+00	@Hr24,26/05/07	(1481.5,	1518.6,	0.0)

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 44     1.08E+00  @Hr24,23/11/07  (  1481.5,    1518.6,      0.0)
 45     1.07E+00  @Hr24,06/06/07  (  1481.5,    1518.6,      0.0)
 46     1.07E+00  @Hr24,18/07/07  (  1481.5,    1518.6,      0.0)
 47     1.07E+00  @Hr24,11/06/07  (  1481.5,    1518.6,      0.0)
 48     1.06E+00  @Hr24,15/03/07  (  1481.5,    1518.6,      0.0)
 49     1.05E+00  @Hr24,15/08/07  (  1481.5,    1518.6,      0.0)
 50     1.04E+00  @Hr24,27/06/07  (  1481.5,    1518.6,      0.0)
 51     1.04E+00  @Hr24,04/07/07  (  1481.5,    1518.6,      0.0)
 52     1.03E+00  @Hr24,13/07/07  (  1481.5,    1518.6,      0.0)
 53     1.03E+00  @Hr24,16/04/07  (  1481.5,    1518.6,      0.0)
 54     1.02E+00  @Hr24,21/10/07  (  1481.5,    1518.6,      0.0)
 55     1.02E+00  @Hr24,15/06/07  (   905.1,    1840.2,      0.0)
 56     9.98E-01  @Hr24,08/08/07  (  1481.5,    1518.6,      0.0)
 57     9.98E-01  @Hr24,15/05/07  (  1481.5,    1518.6,      0.0)
 58     9.98E-01  @Hr24,13/09/07  (  1481.5,    1518.6,      0.0)
 59     9.96E-01  @Hr24,06/04/07  (  1481.5,    1518.6,      0.0)
 60     9.95E-01  @Hr24,05/05/07  (  1481.5,    1518.6,      0.0)
 61     9.92E-01  @Hr24,03/04/07  (  1481.5,    1518.6,      0.0)
 62     9.91E-01  @Hr24,21/03/07  (  1481.5,    1518.6,      0.0)
 63     9.89E-01  @Hr24,09/08/07  (  1481.5,    1518.6,      0.0)
 64     9.88E-01  @Hr24,28/05/07  (  1481.5,    1518.6,      0.0)
 65     9.81E-01  @Hr24,06/08/07  (  1481.5,    1518.6,      0.0)
 66     9.70E-01  @Hr24,19/04/07  (  1481.5,    1518.6,      0.0)
 67     9.68E-01  @Hr24,30/04/07  (  1481.5,    1518.6,      0.0)
 68     9.62E-01  @Hr24,10/06/07  (  1481.5,    1518.6,      0.0)
 69     9.57E-01  @Hr24,18/05/07  (  1481.5,    1518.6,      0.0)
 70     9.40E-01  @Hr24,29/05/07  (  1481.5,    1518.6,      0.0)
 71     9.33E-01  @Hr24,12/12/07  (  1481.5,    1518.6,      0.0)
 72     9.26E-01  @Hr24,10/03/07  (  1481.5,    1518.6,      0.0)
 73     9.21E-01  @Hr24,19/08/07  (  1481.5,    1518.6,      0.0)
 74     9.21E-01  @Hr24,31/05/07  (  1481.5,    1518.6,      0.0)
 75     9.19E-01  @Hr24,07/09/07  (  1481.5,    1518.6,      0.0)
 76     9.18E-01  @Hr24,15/07/07  (  1481.5,    1518.6,      0.0)
 77     9.18E-01  @Hr24,03/11/07  (  1481.5,    1518.6,      0.0)
 78     9.15E-01  @Hr24,09/09/07  (  1481.5,    1518.6,      0.0)
 79     9.06E-01  @Hr24,14/05/07  (  1481.5,    1518.6,      0.0)
 80     9.04E-01  @Hr24,18/01/07  (  1481.5,    1518.6,      0.0)
 81     9.01E-01  @Hr24,13/06/07  (  1481.5,    1518.6,      0.0)
 82     8.96E-01  @Hr24,12/08/07  (  1481.5,    1518.6,      0.0)
 83     8.94E-01  @Hr24,08/02/07  (  1481.5,    1518.6,      0.0)
 84     8.93E-01  @Hr24,07/05/07  (  1481.5,    1518.6,      0.0)
 85     8.93E-01  @Hr24,16/08/07  (  1481.5,    1518.6,      0.0)
 86     8.90E-01  @Hr24,21/11/07  (  1481.5,    1518.6,      0.0)
 87     8.88E-01  @Hr24,03/06/07  (   905.1,    1840.2,      0.0)
 88     8.86E-01  @Hr24,06/03/07  (  1481.5,    1518.6,      0.0)
 89     8.83E-01  @Hr24,13/05/07  (  1481.5,    1518.6,      0.0)
 90     8.81E-01  @Hr24,19/09/07  (  1481.5,    1518.6,      0.0)
 91     8.73E-01  @Hr24,25/02/07  (  1481.5,    1518.6,      0.0)
 92     8.71E-01  @Hr24,20/03/07  (  1481.5,    1518.6,      0.0)
 93     8.70E-01  @Hr24,30/12/07  (  1481.5,    1518.6,      0.0)
 94     8.69E-01  @Hr24,15/01/07  (  1481.5,    1518.6,      0.0)
 95     8.68E-01  @Hr24,15/02/07  (  1481.5,    1518.6,      0.0)
 96     8.63E-01  @Hr24,16/12/07  (  1481.5,    1518.6,      0.0)
 97     8.57E-01  @Hr24,25/03/07  (  1481.5,    1518.6,      0.0)
 98     8.55E-01  @Hr24,03/02/07  (  1481.5,    1518.6,      0.0)
 99     8.54E-01  @Hr24,21/08/07  (  1481.5,    1518.6,      0.0)
100     8.53E-01  @Hr24,22/04/07  (  1481.5,    1518.6,      0.0)
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Simulation started at 16:14:51 on 17/08/2011
Simulation finished at 16:15:04 on 17/08/2011

Shands Int to Halswell

24	LNK1		LNK2		LNK3		LNK22		LNK4		LNK5		LNK6		LNK20		LNK7		LNK8		LNK9		LNK23	
7010101	76	0.0445	164	0.0464	164	0.0464	42	0.0394	42	0.0394	42	0.0394	42	0.0394	13	0.0406	13	0.0406	13	0.0406	16	0.0404	16	0.0404
7010102	48	0.0445	103	0.0464	103	0.0464	27	0.0394	27	0.0394	27	0.0394	27	0.0394	9	0.0406	9	0.0406	9	0.0406	10	0.0404	10	0.0404
7010103	46	0.0445	99	0.0464	99	0.0464	26	0.0394	26	0.0394	26	0.0394	26	0.0394	8	0.0406	8	0.0406	8	0.0406	9	0.0404	9	0.0404
7010104	51	0.0445	111	0.0464	111	0.0464	29	0.0394	29	0.0394	29	0.0394	29	0.0394	9	0.0406	9	0.0406	9	0.0406	11	0.0404	11	0.0404
7010105	114	0.0445	245	0.0464	245	0.0464	64	0.0394	64	0.0394	64	0.0394	64	0.0394	20	0.0406	20	0.0406	20	0.0406	24	0.0404	24	0.0404
7010106	232	0.0445	502	0.0464	502	0.0464	130	0.0394	130	0.0394	130	0.0394	130	0.0394	41	0.0406	41	0.0406	41	0.0406	48	0.0404	48	0.0404
7010107	509	0.0445	1099	0.0464	1099	0.0464	285	0.0394	285	0.0394	285	0.0394	285	0.0394	91	0.0406	91	0.0406	91	0.0406	106	0.0404	106	0.0404
7010108	1533	0.0467	3150	0.0476	3150	0.0476	753	0.0392	753	0.0392	753	0.0392	753	0.0392	172	0.041	172	0.041	172	0.041	257	0.04	257	0.04
7010109	1533	0.0467	3150	0.0476	3150	0.0476	753	0.0392	753	0.0392	753	0.0392	753	0.0392	172	0.041	172	0.041	172	0.041	257	0.04	257	0.04
7010110	938	0.0445	1951	0.0464	1951	0.0464	479	0.0394	479	0.0394	479	0.0394	479	0.0394	204	0.0406	204	0.0406	204	0.0406	248	0.0404	248	0.0404
7010111	926	0.0445	1927	0.0464	1927	0.0464	473	0.0394	473	0.0394	473	0.0394	473	0.0394	202	0.0406	202	0.0406	202	0.0406	245	0.0404	245	0.0404
7010112	920	0.0445	1914	0.0464	1914	0.0464	470	0.0394	470	0.0394	470	0.0394	470	0.0394	200	0.0406	200	0.0406	200	0.0406	243	0.0404	243	0.0404
7010113	918	0.0445	1908	0.0464	1908	0.0464	469	0.0394	469	0.0394	469	0.0394	469	0.0394	200	0.0406	200	0.0406	200	0.0406	243	0.0404	243	0.0404
7010114	973	0.0445	2023	0.0464	2023	0.0464	497	0.0394	497	0.0394	497	0.0394	497	0.0394	212	0.0406	212	0.0406	212	0.0406	257	0.0404	257	0.0404
7010115	1068	0.0445	2221	0.0464	2221	0.0464	546	0.0394	546	0.0394	546	0.0394	546	0.0394	232	0.0406	232	0.0406	232	0.0406	283	0.0404	283	0.0404
7010116	1174	0.0445	2441	0.0464	2441	0.0464	600	0.0394	600	0.0394	600	0.0394	600	0.0394	255	0.0406	255	0.0406	255	0.0406	311	0.0404	311	0.0404
7010117	1723	0.0469	3868	0.0479	3868	0.0479	1098	0.0389	1098	0.0389	1098	0.0389	1098	0.0389	253	0.0398	253	0.0398	253	0.0398	198	0.0399	198	0.0399
7010118	1723	0.0469	3868	0.0479	3868	0.0479	1098	0.0389	1098	0.0389	1098	0.0389	1098	0.0389	253	0.0398	253	0.0398	253	0.0398	198	0.0399	198	0.0399
7010119	878	0.0445	1896	0.0464	1896	0.0464	492	0.0394	492	0.0394	492	0.0394	492	0.0394	156	0.0406	156	0.0406	156	0.0406	182	0.0404	182	0.0404
7010120	548	0.0445	1182	0.0464	1182	0.0464	307	0.0394	307	0.0394	307	0.0394	307	0.0394	97	0.0406	97	0.0406	97	0.0406	114	0.0404	114	0.0404
7010121	410	0.0445	885	0.0464	885	0.0464	230	0.0394	230	0.0394	230	0.0394	230	0.0394	73	0.0406	73	0.0406	73	0.0406	85	0.0404	85	0.0404
7010122	357	0.0445	770	0.0464	770	0.0464	200	0.0394	200	0.0394	200	0.0394	200	0.0394	63	0.0406	63	0.0406	63	0.0406	74	0.0404	74	0.0404
7010123	266	0.0445	574	0.0464	574	0.0464	149	0.0394	149	0.0394	149	0.0394	149	0.0394	47	0.0406	47	0.0406	47	0.0406	55	0.0404	55	0.0404

	LNK10		LNK11		LNK12		LNK13		LNK21		LNK14		LNK15		LNK17		LNK16		LNK18		LNK19		LNK24	
7010101	16	0.0404	16	0.0404	16	0.0404	45	0.0394	45	0.0394	77	0.0368	93	0.0366	19	0.0372	54	0.0368	41	0.0374	60	0.0369	164	0.0464
7010102	10	0.0404	10	0.0404	10	0.0404	29	0.0394	29	0.0394	49	0.0368	58	0.0366	12	0.0372	34	0.0368	26	0.0374	38	0.0369	103	0.0464
7010103	9	0.0404	9	0.0404	9	0.0404	27	0.0394	27	0.0394	47	0.0368	56	0.0366	12	0.0372	32	0.0368	24	0.0374	36	0.0369	99	0.0464
7010104	11	0.0404	11	0.0404	11	0.0404	31	0.0394	31	0.0394	52	0.0368	63	0.0366	13	0.0372	37	0.0368	28	0.0374	40	0.0369	111	0.0464
7010105	24	0.0404	24	0.0404	24	0.0404	68	0.0394	68	0.0394	116	0.0368	139	0.0366	29	0.0372	81	0.0368	61	0.0374	89	0.0369	245	0.0464
7010106	48	0.0404	48	0.0404	48	0.0404	139	0.0394	139	0.0394	237	0.0368	284	0.0366	59	0.0372	165	0.0368	125	0.0374	183	0.0369	502	0.0464
7010107	106	0.0404	106	0.0404	106	0.0404	305	0.0394	305	0.0394	519	0.0368	622	0.0366	130	0.0372	362	0.0368	273	0.0374	400	0.0369	1099	0.0464
7010108	257	0.04	257	0.04	257	0.04	864	0.0393	864	0.0393	1433	0.0363	1550	0.0359	371	0.0356	919	0.036	597	0.0372	1122	0.0365	3150	0.0476
7010109	257	0.04	257	0.04	257	0.04	864	0.0393	864	0.0393	1433	0.0363	1550	0.0359	371	0.0356	919	0.036	597	0.0372	1122	0.0365	3150	0.0476
7010110	248	0.0404	248	0.0404	248	0.0404	533	0.0394	533	0.0394	1002	0.0368	1192	0.0366	205	0.0372	684	0.0368	633	0.0374	810	0.0369	1951	0.0464
7010111	245	0.0404	245	0.0404	245	0.0404	527	0.0394	527	0.0394	989	0.0368	1176	0.0366	202	0.0372	675	0.0368	625	0.0374	800	0.0369	1927	0.0464
7010112	243	0.0404	243	0.0404	243	0.0404	523	0.0394	523	0.0394	983	0.0368	1169	0.0366	201	0.0372	671	0.0368	621	0.0374	795	0.0369	1914	0.0464
7010113	243	0.0404	243	0.0404	243	0.0404	522	0.0394	522	0.0394	980	0.0368	1165	0.0366	200	0.0372	669	0.0368	619	0.0374	793	0.0369	1908	0.0464
7010114	257	0.0404	257	0.0404	257	0.0404	553	0.0394	553	0.0394	1039	0.0368	1235	0.0366	212	0.0372	709	0.0368	656	0.0374	840	0.0369	2023	0.0464
7010115	283	0.0404	283	0.0404	283	0.0404	607	0.0394	607	0.0394	1140	0.0368	1356	0.0366	233	0.0372	778	0.0368	721	0.0374	922	0.0369	2221	0.0464
7010116	311	0.0404	311	0.0404	311	0.0404	667	0.0394	667	0.0394	1253	0.0368	1490	0.0366	256	0.0372	855	0.0368	792	0.0374	1014	0.0369	2441	0.0464
7010117	198	0.0399	198	0.0399	198	0.0399	1047	0.0391	1047	0.0391	1540	0.0357	2026	0.035	534	0.0352	1205	0.0349	589	0.0363	1049	0.0361	3868	0.0479
7010118	198	0.0399	198	0.0399	198	0.0399	1047	0.0391	1047	0.0391	1540	0.0357	2026	0.035	534	0.0352	1205	0.0349	589	0.0363	1049	0.0361	3868	0.0479
7010119	182	0.0404	182	0.0404	182	0.0404	526	0.0394	526	0.0394	896	0.0368	1073	0.0366	225	0.0372	625	0.0368	471	0.0374	691	0.0369	1896	0.0464
7010120	114	0.0404	114	0.0404	114	0.0404	328	0.0394	328	0.0394	559	0.0368	669	0.0366	140	0.0372	389	0.0368	294	0.0374	431	0.0369	1182	0.0464
7010121	85	0.0404	85	0.0404	85	0.0404	246	0.0394	246	0.0394	418	0.0368	501	0.0366	105	0.0372	292	0.0368	220	0.0374	323	0.0369	885	0.0464
7010122	74	0.0404	74	0.0404	74	0.0404	214	0.0394	214	0.0394	364	0.0368	436	0.0366	91	0.0372	254	0.0368	192	0.0374	281	0.0369	770	0.0464
7010123	55	0.0404	55	0.0404	55	0.0404	159	0.0394	159	0.0394	271	0.0368	324	0.0366	68	0.0372	189	0.0368	143	0.0374	209	0.0369	574	0.0464