Auckland Transport
An Auckland Council Organisation

Appendix K

Air Quality Assessment

AECOM

Mill Road Upgrade
Auckland Transport
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Air Quality Assessment

Redoubt Rd to Mill Road Corridor Upgrade

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Redoubt Rd to Mill Road Corridor Upgrade

Client: Auckland Transport

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Executive Summary

AECOM has been commissioned by Auckland Transport to carry out an Air Quality Assessment for the proposed Redoubt Road to Mill Road corridor upgrade as part of the Assessment of Environmental Effects to support the Notice of Requirement for designation(s).

This section of the corridor is an 8.9 km arterial route between Redoubt Road in Manukau and Mill Road in Alfriston, 20 kilometres south east of Auckland's Central Business District. The overall corridor provides an arterial road connection east of SH1 between Manukau, Papakura, Takanini and Drury.

The assessment examines the existing air quality in the area, the local meteorology and terrain and then considers the likely effect on air quality as a result of emissions during the construction and operational phases of the upgrade.

Local air quality monitoring data collected by New Zealand Transport Agency (NZTA) indicate that NO_2 annual mean pollutant concentrations in the vicinity of the corridor are below the Auckland Regional Target. No continuous monitoring of pollutants is conducted in the vicinity of the corridor. All of the background concentrations used in the assessment are below the relevant National Ambient Air Quality Standards and Regional Targets, with the exception of the default Auckland background 24-hour $PM_{2.5}$ mean used, which does exceed the Auckland Regional Standard.

During construction, the main potential impact would be expected to be from emissions of dust. If released in sufficient quantities, given the proximity of existing sensitive residential receptors to the corridor, this could result in a nuisance from soiling and also have potential health implications if not properly managed. Construction effects however would be controlled as far as possible through the implementation of best practise construction methods and the adoption of mitigation measures through a contractor's Construction Environmental Management Plan (CEMP), together with a Construction Dust Management Plan (CDMP) / Construction Air Quality Management Plan (CAQMP), including specific objectives and measures developed by Ministry for the Environment and the NZTA to ensure compliance with the relevant Standards and therefore limit residual impacts.

Atmospheric dispersion modelling has been undertaken using AUSROADS, to assess the impact of the operational changes in vehicle emissions both with and without the full upgrade in the modelled opening year of 2026 and 15 years from opening (2041). The meteorological data used in the modelling were supplied by Auckland Council for the worst-case years of 2005 and 2007 and no future improvement in background pollutant concentrations was assumed. The pollutants assessed were the principle transport-related pollutants listed in the National Environmental Standards for Ambient Air Quality; namely carbon monoxide (CO), nitrogen dioxide (NO_2) and fine particulate matter (PM_{10}). Additional transport related pollutants of fine particulate matter ($PM_{2.5}$) and benzene have also been included in the study, which are listed as Auckland Regional Air Quality Targets. Predicted pollutant concentrations were then forecast at identified worst-case receptor locations along the corridor.

The forecast concentrations indicate that all National Ambient Air Quality Standards for the modelled pollutants will be met at all worst-case receptor locations and in all future assessment years. In addition, all Auckland Regional Targets with the exception of 24-hour mean $PM_{2.5}$ concentrations are also predicted to be met at all locations and in all assessment years and the predicted levels of impact are considered to be less than minor. The predicted $PM_{2.5}$ exceedances are due to the use of the Auckland default background concentrations. No mitigation measures have been recommended with regards to the operation of the upgrade.

Overall, impacts on local air quality are considered to be less than minor as a result of the Mill Road upgrade, during both the construction and operational phases.

1.0 Introduction

AECOM New Zealand Pty Ltd (AECOM) was commissioned by Auckland Transport to undertake an Air Quality Assessment for the proposed Redoubt Road to Mill Road corridor upgrade, Auckland.

The study corridor is located 20 kilometres south east of Auckland's Central Business District and is situated in both the Metropolitan Urban and Rural Boundaries.

The proposal seeks to increase capacity on the increasingly important strategic link in south Auckland due to significant anticipated growth in traffic generated from development, combined with the corridor's current substandard quality and poor safety record.

The report considers and assesses the potential impact at sensitive receptors from the road upgrade against health-based National and Regional air quality standards and targets. It outlines the current regulatory system relevant to air quality management, the baseline air quality and meteorological conditions in the area and also the methodology used to carry out the assessment of the resultant air quality.

Emissions to air are associated with changes in traffic volumes and flow patterns, not only on the Redoubt Road to Mill Road corridor, but on the wider associated network. During the operation of the corridor upgrade, potential emissions to air are associated with products of vehicular fuel combustion. The primary pollutants of concern regarding road transport movement which are listed in the National Environmental Standards for Ambient Air Quality and have been included in the study are carbon monoxide (CO), nitrogen dioxide (NO_2) and fine particulate matter (PM_{10}). The additional road transport related pollutants of fine particulate matter ($PM_{2.5}$) and benzene, have also been included in the study but are listed as Auckland Regional Air Quality Targets. Computer based dispersion modelling has been used to predict pollutant concentrations for the baseline year of 2011, together with future 2026 and 2041 operational scenarios, both with and without the proposed full corridor upgrade in place. The meteorological data used in the modelling were supplied by Auckland Council for the worst-case years of 2005 and 2007 and no future improvement in background pollutant concentrations was assumed.

The predicted pollutant concentrations have been assessed through comparison of these concentrations with the regulatory air quality standards and targets at the closest identified receptors. Potential effects during construction have also been considered and mitigation measures developed to minimise any residual impacts.

2.0 Project Description

The purpose of the Notice(s) of Requirement (NoR) for designations, served by Auckland Transport on Auckland Council, will be to designate land for the construction, operation, maintenance and improvement of the existing and extended section of the Mill Road - Redoubt Road corridor between the SH1 on and off ramps terminating north of the Mill Road/Popes Road intersection. This section of the corridor is an 8.9 km arterial route between Redoubt Road in Manukau and Mill Road in Alfriston. The overall corridor provides an arterial road connection east of SH1 between Manukau, Papakura, Takanini and Drury.

The route is coming under increasing pressure due to growth and traffic loading from commuter traffic which is expected to become more acute over time as the Flat Bush, Takanini and Drury growth areas develop. In addition, crash analysis of the corridor indicates a significant safety issue, with five fatal crashes over the most recent 5 year period. The corridor is ill equipped to provide adequate pedestrian and cycling facilities along certain sections due to the narrow carriage and substandard road alignment. Provision for public transport is also inadequate as “in lane” position of bus stops causes traffic to wait behind stopped buses leading to significant congestion.

The corridor area commences at the SH1 on and off ramps on Redoubt Road and runs east then south along Redoubt Road to the Mill Road intersection. From here, the corridor continues south along Mill Road, concluding just south of Alfriston Road near Popes Road. Two side roads are also included within the project, Murphys Road between Redoubt Road and Flat Bush School Road (1.8km) and Hollyford Drive north of Redoubt Road (0.2km). Access to existing properties away from the new alignment will be maintained along the existing Mill Road where applicable, which will be downgraded and designated for local access only.

The corridor location in relation to the Auckland region is illustrated in **Figure 1** below.

Figure 1: Site Location Map

Image © 2013 DigitalGlobe

3.0 Methodology

The main elements of the proposed corridor upgrade relevant to air quality are emissions from the following sources:

- Construction activities, including construction related traffic; and
- Changes in the number of vehicles and patterns of travel during the operational phase, on both the directly affected Redoubt Rd to Mill Road corridor, together with the wider in-directly associated network.

3.1 Approach to Assessment of Effects

The air quality impact assessment has been conducted in-line with the Ministry for the Environment's *Good Practice Guide for Assessing Discharges to Air from Land Transport*[1] and *Good Practice Guide for Atmospheric Dispersion Modelling*[2], together with the New Zealand Transport Agency's (NZTA) draft air quality effects guide[3] to ensure a consistent and robust assessment approach.

This air quality impact assessment therefore comprises:

- A review of the legislative framework surrounding air quality;
- A review of the existing baseline environment;
- Assessment of the potential changes in air quality arising from the construction and operation of the corridor upgrade (inclusive of cumulative traffic effects);
- Formulation of mitigation measures, where appropriate, to ensure that any potential adverse impacts on air quality are minimised; and,
- Identification of likely residual effects, following application of the outlined mitigation measures.

3.1.1 Assessment Overview

The assessment process for land transport in New Zealand utilises a three-tiered approach, based on increasing levels of scrutiny as the project develops. The level of detail required for each study is also determined by the perceived level of risk posed to air quality, based on set criteria. The three tiers of assessment are summarised as follows:

- Tier 1 Assessment – High level review of potential impacts and existing environment, to identify any risks early in the project process.
- Tier 2 Assessment – Conservative screening assessment using published default data to understand the potential magnitude of impact. A simple screening tool[4] has been developed by NZTA to predict concentrations based on vehicle link flow data, composition and distances to the closest sensitive receptors.
- Tier 3 Assessment – Detailed assessment using dispersion modelling, incorporating emissions parameters, complex traffic modelling, site specific meteorological and background data where appropriate.

A checklist process for each Tier is available within the guidance documents however **Table 1** details the initial risk rating matrix conducted for Tier 1 of the study. A risk classification is then given based on whether two or more positive results are achieved within a certain rating. **Table 2** also details the significance criteria from NZTA which the risk rating exceedance score is based upon.

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[1] MfE, 2008. *Good Practice Guide for Assessing Discharges to Air from Land Transport*. New Zealand Ministry for the Environment, June 2008.
[2] MfE, 2004. *Good Practice Guide for Atmospheric Dispersion Modelling.* New Zealand Ministry for the Environment, June 2004.
[3] NZTA, 2012. *Draft Guide to assessing air quality effects for state highway asset improvement projects*. Version 0.6, New Zealand Transport Agency, September 2012
[4] NZTA, 2012. *State highway project – tier 2 air quality screening tool.* Available at www.air.nzta.govt.nz. New Zealand Transport Agency, September 2012

Table 1: NZTA Tier 1 Risk Ratings

Individual rating	NO_2 or PM_{10} exceeded?	No. sensitive land uses	Annual Average Daily Traffic (AADT) – Opening Year
Low (L)	No	<10	<10,000
Medium (M)	Yes	10 – 50	10,000 – 50,000
High (H)	Yes	>50	>50,000

Table 2: NZTA Air Quality Significance Criteria

Pollutant	Limit	Averaging time	Significance criteria
PM_{10}	50 µg/m^3	24-hour	2.5 µg/m^3
$PM_{2.5}$	25 µg/m^3	24-hour	1.25 µg/m^3
NO_2	40 µg/m^3	Annual	2.0 µg/m^3

Note – results to be determined using the Tier 2 Screening Tool

For projects identified as being low risk, a Tier 1 assessment is typically considered to be sufficient for reporting. Projects scoring 'medium' or 'high risk' ratings must automatically undergo Tier 2 or Tier 3 assessments depending on the potential level of impacts significance.

This tiered approach has therefore been used for this assessment and the following points are noted:

- The western end of Redoubt Road (approximately 1.2 kilometres) is located within a designated Urban Air Quality Management Area;
- No tunnels >90 metres in length are proposed;
- \> 50 high sensitivity air pollution land uses (HSAPLU) are identified within 200 metres of the corridor;
- Traffic volumes along the Redoubt Road to Mill Road corridor in the year of opening are projected to be in the order of 10,000 – 50,000 AADT;
- The Tier 2 screening assessment for the proposed upgrade identified that whilst 24 hour mean PM_{10} and $PM_{2.5}$ predicted concentrations do not exceed the stated significance criteria, predicted annual average NO_2 concentrations do exceed the stated criteria on a number of roads on the corridor in the proposed opening year.

As a result of this process and using the criteria in **Table 1** it is considered that this assessment report therefore represents a 'high risk' Tier 3 assessment, as two of the three outlined criteria are met.

3.1.2 Review of Existing Environment

The existing environment has been reviewed through data and tools available from Auckland Council, the New Zealand Transport Agency (NZTA) and New Zealand's National Climate Database (NIWA). More information on the data used in this assessment is detailed in **Section 5.0**.

No project specific air quality monitoring has been undertaken as part of the assessment and none is proposed as we do not consider it to be necessary at this stage in the project. This is due to the large amount of available background data in the general area which is considered sufficient to characterise the existing air quality conditions.

3.1.3 Consultation

Consultation with the Air Quality Policy Team Leader at Auckland Council was conducted in July 2013, where the Tier 3 assessment methodology and choice of dispersion model was discussed and agreed in principle[5].

The current New Zealand specific vehicle emission factor database model was subsequently provided by Auckland Council for the assessment, together with representative meteorological data files and Auckland Council's background monitoring data for use in the assessment.

[5] Record of telephone conversation between John Hodgson and Janet Petersen on 26th July 2013

3.1.4 Assessment of Construction Effects

During construction, the potential sources of emissions (for example, dust, exhaust and odour emissions) are as follows:

- those arising from construction traffic accessing the designated construction site(s).
- those arising from the construction activities themselves (site plant/vehicles and earth moving operations, etcetera)
- those arising from vehicle emissions caused by necessary road diversions.

Given the inherent uncertainty surrounding potential construction impacts, due to the temporal nature and duration of works and opportunities for a contractor to refine design and construction methods, the construction effects have therefore been assessed through a qualitative review of potential sources of air emissions. This has been based on the project description, detailed alignment plans and understood best practice construction methods.

The *Good Practice guide for assessing and managing the environmental effects of dust emissions*[6], prepared by the Ministry for the Environment has been used in this assessment as it serves as a useful document to help assess the potential construction impacts of the project. It also provides a series of recommendations and control methods to be included within a Construction Dust Management Plan (CDMP) or Construction Air Quality Management Plan (CAQMP) to minimise impacts. There are also no national air quality guidelines for nuisance dust impacts, however the document outlines commonly used criteria and 'trigger levels' based on observational data which should be specified.

The assessment has therefore taken into account the proximity and number of receptors (and their sensitivity) in the vicinity of the corridor upgrade and likely construction activities areas (such as work sites and construction lay down areas). In addition, the duration of activities and the local meteorological conditions have also been considered in the assessment. The guidance note acknowledges the use of air dispersion modelling to assess potential impacts in certain circumstances; however it adds that given the level of uncertainty during construction, the priority of the assessment should be given to specifying and employing best practice measures to control potential releases.

Recommendations for mitigation and control measures, to be included within a formal CDMP / CAQMP have been made as part of the assessment and are detailed in **Section 9.1**.

3.1.5 Assessment of Operational Effects

In order assess the potential impact of the project proposals on local air quality, in-line with the Tier 3 assessment approach identified in **Section 3.1.1**, estimated emissions of the pollutants are required within the computer-based dispersion model. The primary air pollutants of concern regarding road transport movement which are listed in the National Environmental Standards for Ambient Air Quality and have been included in the study are carbon monoxide (CO), nitrogen dioxide (NO_2) and fine particulate matter (PM_{10}). The additional road transport related pollutants of fine particulate matter ($PM_{2.5}$) and benzene (as volatile organic compounds (VOCs)), have also been included in the study but are listed as Auckland Regional Air Quality Targets. Predicted concentrations of these pollutants, at the identified worst case receptors will be compared with associated air quality standards and targets.

The primary factors that influence emissions from vehicles include the mode and speed of travel, the grade of the road and the mix, type and age of the vehicles. The general approach to derive total pollutant emission rates from a road section is simply to multiply the total number of vehicles on the road section by the pollutant emission per vehicle (the emission factor).

Pollutant emission rates have been calculated using traffic modelling data supplied by AECOM transport and Auckland Transport for a number of future scenarios, together with emission factors taken from NZTA's Vehicle Emissions Prediction Model (VEPM 5.1), provided for the assessment by Auckland Council.

Pollutant concentrations have been forecast for the following scenarios:

- The baseline (existing) traffic scenario of 2011;

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[6] MfE, 2001. *Good Practice guide for assessing and managing the environmental effects of dust emissions.* New Zealand Ministry for the Environment, September 2001.

- The 2026 ‘Do Minimum’ scenario (DM2026) in the modelled year of opening without the complete upgrade in place;
- The 2026 ‘Do Something’ option scenario (DS2026) in the modelled year of opening with the complete operational upgrade in place;
- The 2041 ‘Do Minimum’ scenario (DM2041) 15 years following the modelled year of opening without the complete upgrade in place; and,
- The 2041 ‘Do Something’ option scenario (DS2041) 15 years following the modelled year of opening with the complete operational upgrade in place.

It is understood that the western urban section of the corridor may be constructed and in operation by 2020, however with the remaining entire corridor unlikely to be operational until 2034. Since the traffic modelling and air quality assessment have been based on a fully operational corridor by 2026, whilst six years later than the potential initial section opening year, it is considered that the increase in vehicle numbers used in the assessment based on the complete corridor upgrade still represents a worst-case assessment of the potential impacts to air quality, when compared to the reduction in vehicle emission factors in later years.

All future year traffic modelling data is inclusive of predicted growth in the Auckland Plan, draft Unitary Plan, Drury, Takanini and Flatbush plan changes, in terms of cumulative impacts.

The level of impact from the upgrade proposals can be determined by comparing the predicted impact in the future years with the upgrade in place, against the same year without the road upgrade. The results of the dispersion modelling and the potential impact of the road upgrade during operation, incorporating existing air quality background concentrations, have been compared to the appropriate standards and targets detailed in **Section 4.0**.

4.0 Assessment Matters

In assessing any project with potential emissions to air, it is necessary to compare the impacts of the project with relevant air quality criteria. Air quality standards and targets and potential changes to them are used to assess the potential for ambient air quality to give rise to adverse health or nuisance effects.

The Minister for the Environment is responsible for recommending national environmental standards for the protection of health for all New Zealanders. In turn, regional councils and unitary authorities are then responsible for ensuring that these national standards are met in their regions and how air quality is managed. The Ministry for the Environment serves as a liaison between the parties and publishes guidance seeking to assist the regions with their duties. The New Zealand regulatory and policy framework includes the National environmental standards for air quality, National ambient air quality guidelines and objectives and policies in regional plans

4.1 National Planning Policy

The primary national legislation which all air quality policy stems from is the Resource Management Act 1991 (RMA).

4.1.1 Resource Management Act 1991

Air quality management is governed by the RMA. Whilst no air quality standards are specifically contained within the RMA (these are detailed in associated regulations noted below), the Act provides overall direction for the national and regional statutory regulations controlled by a number of agencies. Section 5 of the RMA 1991 states that:

> *"(1) The purpose of the Act is to promote the sustainable management of natural and physical resources."*
>
> *(2) In this Act, sustainable management means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while—*
>
> > *(a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
> >
> > *(b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and*
> >
> > *(c) avoiding, remedying, or mitigating any adverse effects of activities on the environment"*

Conditions surrounding the discharge of contaminants into the environment, which may ultimately affect air quality, are however expressed in Section 15 of the RMA, which states:

> *"(1) No person may discharge any—*
>
> > *(c) contaminant from any industrial or trade premises into air; or*
> >
> > *unless the discharge is expressly allowed by a national environmental standard or other regulations, a rule in a regional plan as well as a rule in a proposed regional plan for the same region (if there is one), or a resource consent.*
>
> *(2) No person may discharge a contaminant into the air, or into or onto land, from a place or any other source, whether moveable or not, in a manner that contravenes a national environmental standard unless the discharge—*
>
> > *(a) is expressly allowed by other regulations; or*
> >
> > *(b) is expressly allowed by a resource consent; or*
> >
> > *(c) is an activity allowed by section 20A.*
>
> *(2A) No person may discharge a contaminant into the air, or into or onto land, from a place or any other source, whether moveable or not, in a manner that contravenes a regional rule unless the discharge—*
>
> > *(a) is expressly allowed by a national environmental standard or other regulations; or*
> >
> > *(b) is expressly allowed by a resource consent; or*

(c) is an activity allowed by section 20A.

Whilst transport infrastructure upgrade projects typically do not require discharge consents under the RMA (unless including for example, tunnel ventilation stacks), the conditions give an insight into the subsequent development of the Resource Management (National Environmental Standards for Air Quality) Regulations 2004, in terms of '*safeguarding the life-supporting capacity of air*', The RMA discharge conditions could however be interpreted to cover potential construction phase impacts such as off-site dust or plant emissions and have therefore been included for completeness.

4.1.2 Land Transport Management Act

The Land Transport Management Act 2003 (LTMA), amended 2013, sets out the framework to operate, manage and fund New Zealand's transport network. One of the operating principles for the Auckland Transport in meeting its objectives and functions, is the expectation that it "*exhibits a sense of social and environmental responsibility"* in meeting the statutory objective of operating a network that contributes to an integrated, safe, responsive and sustainable land transport system.

4.1.3 Air Quality Standards and Guidelines

The National Environmental Standards for Ambient Air Quality are mandatory regulations, first introduced within the Resource Management (National Environmental Standards for Air Quality) Regulations 2004, under the Resource Management Act 1991. These regulations were subsequently amended in 2011.

Ambient air quality standards are listed within Schedule 1 of the amended 2011 Regulations and must not be exceeded unless for a stated permitted activity. The Standards, provided for varying pollutants and averaging periods, apply at any place in the open air where people may be exposed to pollutants for the quoted period of time (generally greater than one hour).

Locations where the standards are considered to apply include roadside verges, residential areas, central business districts, parks and beaches. Locations where the standards do not apply include inside houses, vehicles and tunnels. The National Environmental Standards for Ambient Air Quality are detailed below in **Table 3.**

Further details on the selection criteria for receptors are given in **Section 8.1**.

Table 3: **National Environmental Standards for Ambient Air Quality**

Contaminant	Averaging period	Threshold concentration	Number of exceedances allowed
Carbon monoxide (CO)	8-hour mean	10 mg/m^3	1
Nitrogen dioxide (NO_2)	1-hour mean	200 µg/m^3	9
Ozone (O_3)	1-hour mean	150 µg/m^3	0
Fine particulate matter (PM_{10})	24-hour mean	50 µg/m^3	1
Sulphur dioxide (SO_2)	1-hour mean (maximum)	570 µg/m^3	9
	1-hour mean	350 µg/m^3	0

With regards to dust impacts during construction of the upgrade, a series of trigger levels are specified within the Ministry for the Environment's 2001 *Good practice guide*[6], as there are no national air quality guidelines for assessing nuisance dust impacts. In this absence, recommended trigger levels for deposited and suspended insoluble particulates to be included with a formal CDMP / CAQMP, together with example areas of applicability, are detailed below in **Table 4**.

Table 4: Recommended Dust Trigger Levels

Dust type	Trigger level	Averaging times	Example locations
Deposited dust	4 g/m^2/day	30-day average	Above background levels
Total suspended particulates	80 $\mu g/m^3$	24-hour	Sensitive areas
	100 $\mu g/m^3$	24-hour	Moderate sensitivity areas
	120 $\mu g/m^3$	24-hour	Insensitive areas

Note – Sensi ive areas in this instance are classified as being locations with a large number of residential properties and typically apply at the property boundary.

4.2 Regional Planning Policy

As regional plans are statutory instruments under the RMA; where air quality standards are more stringent than those set in the National Standards quoted above, the regional standards apply. The National Standards however must be complied with throughout New Zealand.

Auckland Council has prepared Regional Air Quality Targets contained within the Auckland Regional Plan: Air, Land and Water 2012, using the key pollutants identified within the National environmental standards for air quality, however setting standards for additional averaging periods and pollutants specific for the region. The primary difference with the Auckland Regional Targets is that they do not contain allowable exceedances. The Auckland Regional Air Quality Targets for the pollutants of concern within this study are detailed below in **Table 5.**

Table 5: Auckland Regional Air Quality Targets

Contaminant	Target	Averaging Time
Fine particulate matter (PM_{10})	20 $\mu g/m^3$	Annual
Fine particulate matter ($PM_{2.5}$)	25 $\mu g/m^3$	24-hour
	10 $\mu g/m^3$	Annual
Nitrogen dioxide (NO_2)	100 $\mu g/m^3$	24-hour
	40 $\mu g/m^3$	Annual
Carbon monoxide (CO)	30 mg/m^3	1-hour
Sulphur dioxide (SO_2)	120 $\mu g/m^3$	24-hour
Ozone (O_3)	100 $\mu g/m^3$	8-hour
Benzene	3.6 $\mu g/m^3$	Annual

Through extensive ambient air quality monitoring, Auckland Council has designated a number of airsheds in the Auckland region where air quality is known, or considered likely, to exceed the air quality standards now or in the future. The Air Quality Management Areas are designated as Urban, Industrial and Rural. The urban airshed (Urban Air Quality Management Area) covers most of urban Auckland[7] and approximately 1.3km of the western end of the proposed corridor. The remainder of the corridor falls under the rural airshed.

The most pertinent air quality policy within the Auckland Regional Plan with regards to the Mill Road upgrade is contained within Policy 4.4.16 Mobile Sources, which states: -

> *"Any land use proposals with transportation effects, and any new transport projects or proposals for redeveloping transport infrastructure which have the potential to adversely affect air quality, should be assessed at a level considered appropriate for the size and scale of the project or proposal, and shall consider the following:*
>
> *(a) Effects on human health;*
>
> *(b) Effects on regional and local air quality; and*

[7] Auckland Council, 2010. *Chapter 4.1 Air, State of the Auckland Region report*, Auckland Council, March 2010

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

The Regional Plan also contains policies regarding the wider permitted release of contaminants to the air, particularly relevant to the upgrade during construction, following the conditions stated within the RMA.

Rule 4.5.1 of the document states: -

"Unless provided for otherwise in this plan, activities that discharge contaminants into air are Permitted Activities, subject to the following conditions:

(a) That beyond the boundary of the premises where the activity is being undertaken there shall be no noxious, dangerous, offensive or objectionable odour, dust, particulate, smoke or ash; and

(b) That there shall be no noxious, dangerous, offensive or objectionable visible emissions; and

(c) That beyond the boundary of the premises where the activity is being undertaken there shall be no discharge into air of hazardous air pollutants that does, or is likely to, cause adverse effects on human health, ecosystems or property."

Given the proximity of the existing sensitive receptors to the corridor, construction impacts therefore need to be managed appropriately so as not to be in breach of the Rules set out above. Recommended mitigation measures to be employed by the appointed site contractor to minimise any potential impacts are highlighted and discussed in **Section 9.1**.

To add to the air quality policies listed above in the Regional Plan, with regard to the assessment of transport projects and the discharge of contaminants to air, Policy 4.5.3 Mobile Sources – Permitted Activities, provides further clarification on the matter, stating that: -

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

5.0 Existing Environment

The major factors of the existing environment that can influence the level of air pollutants adjacent to a particular site and at sensitive receptors include:

- The presence of private, commercial and industrial facilities / sources that can emit similar air pollutants to those being assessed,
- Meteorological conditions and terrain features; and,
- Existing air quality due to regional sources of air pollution.

The following section describes the existing air quality, general meteorology and terrain of the study area.

5.1 Land use and Topography

The Redoubt Road to Mill Road upgrade corridor, given its approximate length of 13 kilometres and geographic location 20 kilometres south east of Auckland's Central Business District, is situated within both the Metropolitan Urban and Rural land use Boundaries. The land use can therefore be classified as a mix of both urban low-rise residential at the initial western end, with the remaining corridor (including Murphys Road) classified as rural residential, park and agricultural land.

The topography of the surrounding environment consists of gentle rolling hills as the corridor navigates around the central Totara Park, rising to 120 metres above sea level (ASL) at its peak, from a height of 60 metres ASL to the west as it approaches the State Southern Highway 1 and from 24 metres ASL at the southern end in Alfriston. The gradient of the road may increase vehicle emissions traveling up hill (the benefit of downhill emissions are typically not cancelled out) and therefore the effect of gradients has been taken into account within the emissions modelling and rate determination for the dispersion modelling.

Due to the width of the existing and proposed corridor and the relatively open non-industrial atmosphere, together with the absence of *'street canyons'*[8], the dispersion of pollutants from vehicles would not be considered to be negatively affected by the terrain and therefore the direct effects of terrain through a terrain data modelling file have not been used in the assessment. This is an industry standard approach.

5.2 Receptor Locations

Sensitive receptor locations are those individuals and communities who are likely to be susceptible to changes in air quality, such as an increase in air emissions. These receptors include locations where people spend extended periods of time, typically greater than one hour (sufficient to meet ambient air quality criteria averaging periods). Receptors sensitive to the construction (in particular, dust and combustion emissions) and operational air emissions from the project include schools, hospitals, childcare facilities, educational facilities, residential areas and sporting / recreational facilities (often people engaging in sporting activities have increased respiratory stress and are therefore more sensitive to air pollution).

Receptor locations have been selected where exposure to atmospheric emissions from traffic is potentially the greatest. Pollutant concentrations decrease significantly with distance from a road source and, provided there are no other major sources in the vicinity, concentrations are lower at locations located further away from the receptors chosen. Therefore, all selected receptors are locations in closest proximity to the roads most affected.

Table 6 details the most affected sensitive receptors in the study area, with regards to air quality, along the route corridor and other affected roads which have been considered for the air quality assessment. The receptors identified, the majority of which are residential properties, are considered to be representative of the worst case exposure in those particular locations, at distances up to 200 metres from the centre line of the proposed alignment. The receptor locations are also illustrated in **Figure 2**.

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[8] A term used to describe a location where the width of a road is less than the height of the buildings bordering it, resulting in the flow of air being dominated by vehicle induced turbulence due to the poor natural dispersal of pollutants.

Table 6: Sensitive Receptor Locations

Receptor Reference	Receptor Location	Receptor Type	Receptor Coordinates (UTM Zone 60S)	
			x	Y
R1	Cnr of Mill Road and Alfriston Road	Residential	316710	5901280
R2	Alfriston School, Mill Road	School	316672	5901250
R3	Cnr of Mill Road and Ranfurly Road	Residential	316319	5901996
R4	5 Polo Prince Road	Residential	315857	5902596
R5	182 Mill Road	Residential	316324	5902462
R6	361 Redoubt Road	Residential	315301	5903466
R7	323 Redoubt Road	Residential	314850	5903540
R8	280 Redoubt Road	Residential	314764	5903732
R9	246 Redoubt Road	Residential	314715	5904140
R10	51 Murphys Road	Residential	314801	5904251
R11	34 Murphys Road	Residential	314722	5904325
R12	208 Redoubt Road	Residential	314373	5904324
R13	170 Redoubt Road	Residential	313917	5904372
R14	189 Redoubt Road	Residential	313973	5904309
R15	156 Redoubt Road	Residential	313640	5904389
R16	141 Redoubt Road	Residential	313443	5904276
R17	1 Santa Monica Place	Residential	313107	5904321
R18	12 Elsted Place	Residential	313244	5904295
R19	2 Everglade Drive	Residential	312808	5904147
R20	38 Redoubt Road	Residential	312575	5904123
R21	22 Redoubt Road	Residential	312403	5904067
R22	12 Redoubt Road	Residential	312268	5904022

Note – Receptor addresses have been iden ified from Project alignment drawings and plans

Figure 2: Location of Receptors use in Assessment

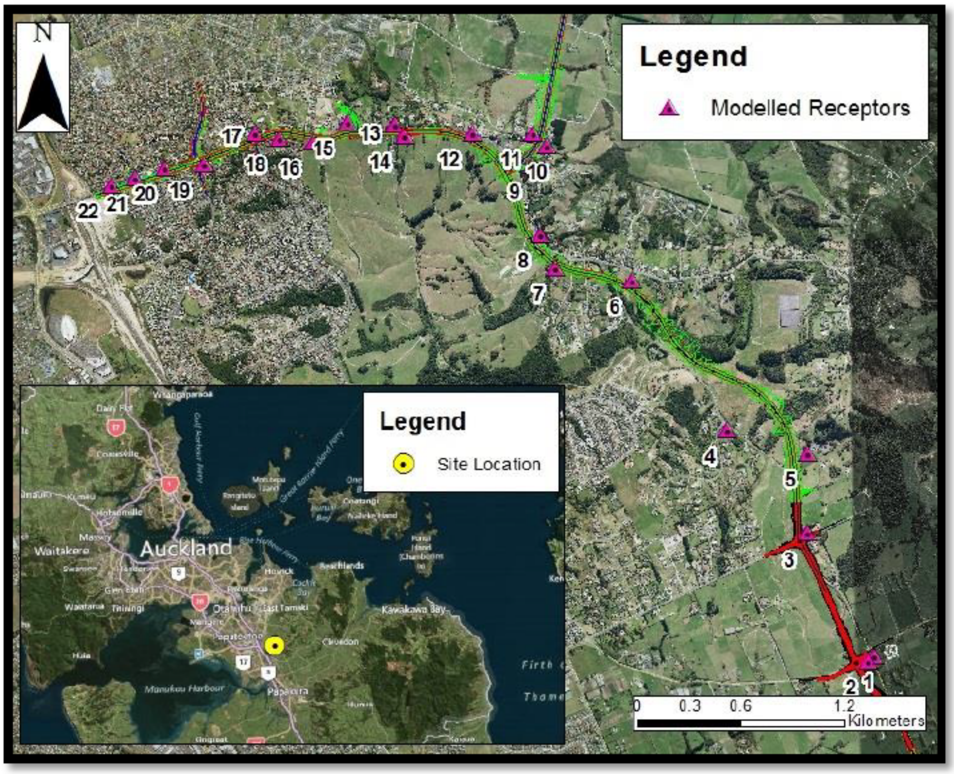


Image © 2013 DigitalGlobe

5.3 Meteorology

Meteorology in the area surrounding the proposed corridor upgrade is affected by several factors such as the land use and proximity to coastal waters, resulting in complex land-sea breeze interactions. Wind speed and direction are largely affected by topography at the small scale, while factors such as synoptic scale winds (which are modified by sea breezes) affect wind speed and direction on the larger scale.

Auckland's sub-tropical, temperate climate experiences warm, humid summers with mild, damp winters and rarely experiences extremes in weather. The maritime climatic aspect however means that high levels of rainfall can occur almost all year round.

The National Institute of Water and Atmospheric Research (NIWA) and New Zealand's National Climate Database detail long-term meteorological data at a large number of automatic weather stations across the country. The closest stations to the corridor are located at Wiri meteorological station, approximately 2 km west of the project site, together with Auckland Airport meteorological station approximately 8km west.

The long term average wind roses for the sites at Wiri and Auckland Airport Meteorological Station are provided in **Figure 3** and **Figure 4**. The wind roses show the frequency of occurrence of winds by direction and strength. The length of the bar represents the frequency of occurrence of winds from that direction, and the widths of the bar sections correspond to wind speed categories, the narrowest representing the lightest winds. Overall, both wind roses indicate that south westerly winds dominate the Auckland region, with north easterly winds also featuring. The interesting difference between the two sites however is the percentage of higher wind speeds recorded at Auckland Airport compared to at Wiri, which is considered to be due to the Airport's direct coastal location and Wiri's location further inland.

Figure 3: Wiri Meteorological Station Wind Roses 2008–2012

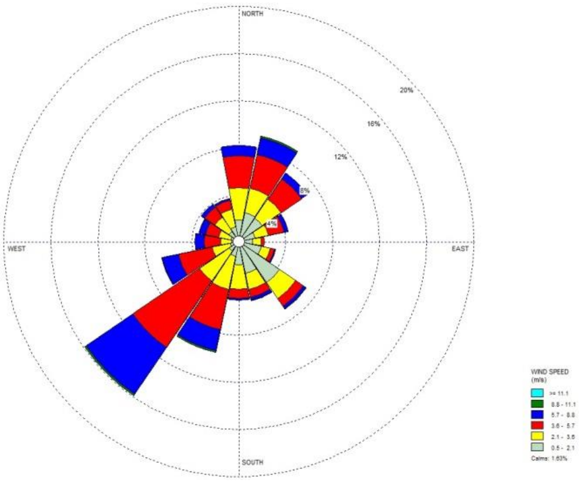
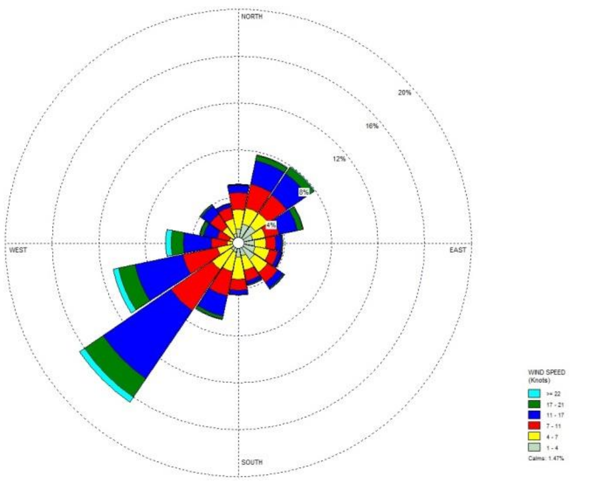


Figure 4: Auckland Airport Meteorological Station Wind Roses 2008–2012



The location of the Wiri Meteorological Station, which is the closest station to the corridor and has been used in this assessment (see **Section 7.2.2**), is illustrated in **Figure 5**.

5.4 Background Ambient Air Quality

Air quality at sensitive receptor locations generally depends on the proximity to roads and industry. For receptors close to main roads during peak hours, vehicle emissions will be the primary source of air pollution. Air quality at locations more than 500 metres from major existing roads will tend to be dominated by other local activities (e.g. industrial sources) or by the mix of regional air pollutant sources.

Auckland Council and the New Zealand Transport Agency (NZTA) operate an extensive network of continuous and non-continuous air quality monitoring stations across the Auckland region. The network ensures compliance with the Auckland air quality targets and National air quality standards is measured across a broad area. Auckland Council currently operate 15 continuous monitoring stations across the Auckland region, however none are located near to the road corridor. NZTA detail the locations and results of their passive diffusion tube network monitoring programme within their annual report[9], of which two roadside sites are located 700 metres and 1700 metres to the southwest and northwest, respectively.

Auckland Council's draft *Use of Background Air Quality Data in Resource Consent Applications*[10] document has been prepared to provide guidance for both applicants and assessors alike in how to incorporate background pollutant concentrations, to ensure consistency within assessments. Whilst an industrial source and assessment focussed document, it does contain details on how to appropriately apply continuous monitoring data from the existing network within transport studies. The document states that for hourly sequential modelling, data from the roadside Kingsland continuous monitoring station should be used. However, since the document is intended for industry assessment and within this Tier 3 study we will be explicitly modelling the vehicle emissions component from the road, using the Kingsland data is considered to result in the double counting of vehicle emissions. The published urban classification 'Default Values', which summarise a number of measured urban sites over a series of years, have therefore been used to avoid the potential gross estimation of predicted pollutant concentrations at sensitive receptor locations.

It is acknowledged that at the time of the assessment, the NZTA is preparing a guidance document detailing the application of default background concentrations for use within roadway assessment. Unfortunately the assessment was completed prior to this document being formally issued and therefore Auckland Council's draft document has been used in its absence. The NZTA guidance document however will be reviewed alongside this

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[9] NZTA, 2012. *Ambient air quality (nitrogen dioxide) monitoring network – annual report 2007-11*. NZ Transport Agency, September 2012.
[10] Metcalfe, J. Wickham, L. and Rolfe, K. (2012). *Draft - Use of Background Air Quality Data in Resource Consent Applications*. Prepared by Emission Impossible Ltd and Kevin Rolfe & Associates Ltd for Auckland Council. Auckland Council Guideline

assessment report once it is available. Whilst no considerable differences in methodology are anticipated in the NZTA document, this review will ensure consistency of approach.

A summary of the most recent 2012 monitoring results recorded from the closest identified air quality monitoring stations are provided in **Table 7** and **Table 9**. The locations of the closest monitoring stations in relation to the project corridor are illustrated in **Figure 5**. Details of the background concentrations used within the assessment are detailed in **Section 7.2.3**.

Figure 5: Meteorological and Air Quality Monitoring Sites

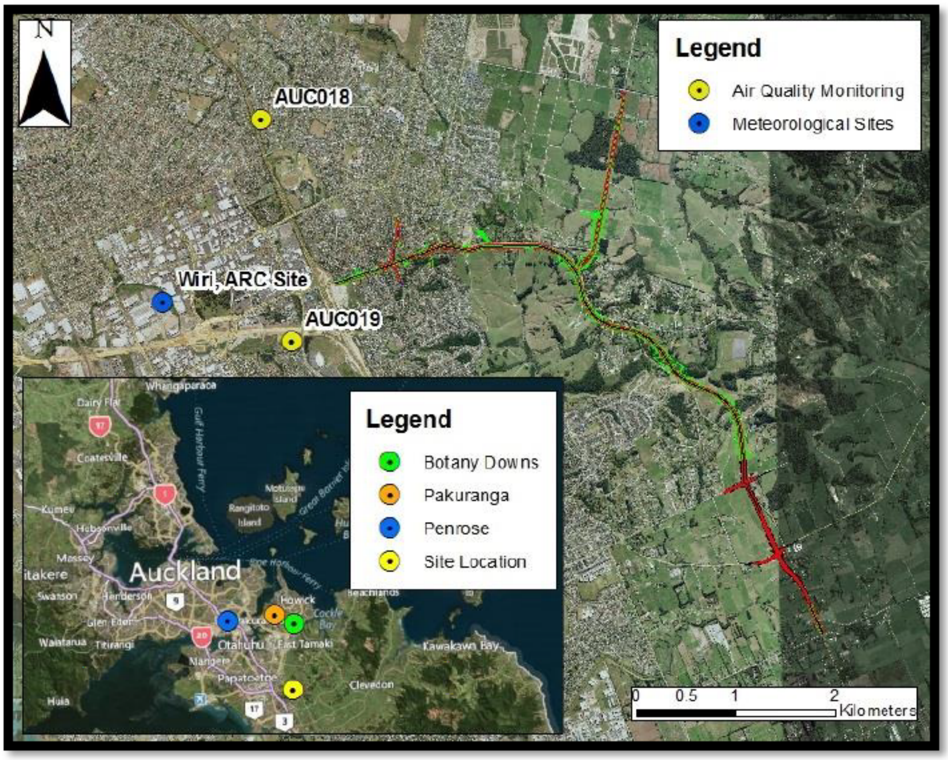

Image © 2013 DigitalGlobe

Table 7 which details the historic passive NO_2 monitoring conducted in the vicinity of the study area and further afield, shows that the Auckland NO_2 annual mean Regional Target is met at all monitored locations. Importantly for this study, data from AUC018 and AUC072 also show that the Target has been continuously met within 60 metres of a State Highway and also 5 metres from a busy local roadside, respectively. Given the proximity of existing sensitive residential receptors to the corridor upgrade, these data are considered to give an indication as to the potential annual mean NO_2 concentrations experienced along the Redoubt Road – Mill Road corridor.

Table 9 also shows that whilst the maximum 24-hour PM_{10} concentration exceeds the National Air Quality Standard of 50 µg/m^3 at Pakuranga monitoring station, the 75th percentile (commonly used as the percentile for a background concentration), is well below the Standard. This is considered to be reasonable given the site's location within 5 metres from the roadside. The same can be said for the maximum 24-hour $PM_{2.5}$ concentration at Penrose monitoring station, which exceeds the national standard of 25 µg/m^3. Given the 75th percentile concentration of 7.4 µg/m^3 is well below the standard, the maximum recorded concentration is therefore not considered typical of the general ambient concentrations in the area. The monitored NO_2 concentrations also meet each of the respective Regional Targets and National Standards at Penrose monitoring station for each averaging period, which further supports the passive NO_2 summary data presented in **Table 7** earlier.

The low recorded 24 hour mean PM_{10} concentrations at Botany Downs give an indication as to the likely urban background concentrations experienced around the study corridor in the less urban areas of the route alignment. The maximum 8 hour CO concentrations recorded at the Pakuranga site are also well below the National Standard, even being in close proximity to the roadside location. The much lower 75th percentile concentrations however do give a better indication of the likely urban background concentration experienced at the Mill Road corridor.

Table 7: Non-Continuous Ambient Air Quality Monitoring Data – Nitrogen Dioxide Annual Average

Monitoring Zone	Site ID	Location	UTM Zone 60S Coordinates	Pollutants	Site Type	Receptor Distance (m)	State Highway Distance (m)	Local Road Distance (m)	Distance to Site (m)	Auckland Air Quality Target = 40 µg/m^3			
										2008	2009	2010	2011
Auckland - Southern	AUC018	Southern Motorway / Waimate Street	305434, 5905351	NO_2 diffusion tubes	State Highway	20	60	250	1800	26	30.7	30.2	33.1
	AUC019	Southern Motorway / Liggitt Drive	311774, 5903372	NO_2 diffusion tubes	State Highway	10	100	60	750	21.2	19.6	23.0	24.1
	AUC072	Bell Reserve / Pakuranga Road	312047, 5913532	NO_2 diffusion tubes	Local	5	4320	3	9000	n/a	24.7	24.0	26.1
	AUC073	Botany Downs / Oakridge Way	315069, 5912074	NO_2 diffusion tubes	Background	10	7040	250	6500	n/a	17.9	13.8	16.5

Table 8: Continuous Monitoring Site Locations in Vicinity of Mill Road

Monitoring Site	Pollutants Monitored	Site Type	UTM Zone 60S Coordinates	Distance to Site (km)
Penrose	NOx, PM_{10}, $PM_{2.5}$, PM_1, TSP/Lead, SO_2	State Highway	305381, 5913487	11
Pakuranga	CO, PM_{10}	Local	312042, 5913534	9
Botany Downs	PM_{10}	Background	315062, 5912066	6.5

Table 9: Continuous Ambient Air Quality Monitoring Concentrations

Pollutant	Averaging Period	2012	Auckland Regional Air Quality Targets	National Environmental Standards for Ambient Air Quality
Penrose (305381, 5913487)				
Nitrogen dioxide (NO_2)	1-hour (Maximum)	92.3 µg/m³		200 µg/m³
	1-hour (75th %ile)	28.3 µg/m³		
	1-hour (50th %ile)	16.0 µg/m³		
	24-hour (Maximum)	49.6 µg/m³	100 µg/m³	
	24-hour (75th %ile)	26.0 µg/m³		
	24-hour (50th %ile)	16.7 µg/m³		
	Annual mean	18.8 µg/m³	40 µg/m³	
Fine particulate matter (PM_{10})	24-hour (Maximum)	42.8 µg/m³		50 µg/m³
	24-hour (75th %ile)	18.1 µg/m³		
	24-hour (50th %ile)	13.7 µg/m³		
	Annual mean	14.6 µg/m³	20 µg/m³	
Fine particulate matter ($PM_{2.5}$)	24-hour (Maximum)	27.9 µg/m³	25 µg/m³	
	24-hour (75th %ile)	7.4 µg/m³		
	24-hour (50th %ile)	5.9 µg/m³		
	Annual mean	6.6 µg/m³	10 µg/m³	
Pakuranga (312042, 5913534)				
Fine particulate matter (PM_{10})	24-hour (Maximum)	57.1 µg/m³		50 µg/m³
	24-hour (75th %ile)	18.8 µg/m³		
	24-hour (50th %ile)	13.8 µg/m³		
	Annual mean	15.1 µg/m³	20 µg/m³	
Carbon monoxide(CO)	8-hour (Maximum)	3.9 mg/m³		10 mg/m³
	8-hour (75th %ile)	0.5 mg/m³		
	8-hour (50th %ile)	0.3 mg/m³		
Botany Downs (315062, 5912066)				
Fine particulate matter (PM_{10})	24-hour (Maximum)	25.1 µg/m³		50 µg/m³
	24-hour (75th %ile)	14.6 µg/m³		
	24-hour (50th %ile)	10.8 µg/m³		
	Annual mean	11.4 µg/m³	20 µg/m³	

6.0 Traffic Data and Emission Rates

6.1 Traffic Modelling and Data

Traffic data for the corridor upgrade were obtained from AECOM transport for the forecast years of 2026 and 2041, as detailed earlier in **Section 3.1.5**. The data consisted of total Annual Average Daily Traffic (AADT) flow data together with the percentage of heavy duty vehicle (HDV) classes on the local road network. Vehicle speeds used in the model were also provided by the AECOM Transport team, however professional judgement was also made with regards to speeds at junctions.

Traffic data were supplied for use into the air dispersion model for the following scenarios: -

- The baseline (existing) traffic scenario of 2011;
- The 2026 ‘Do Minimum’ scenario (DM2026) in the modelled year of opening without the complete upgrade in place;
- The 2026 ‘Do Something’ option scenario (DS2026) in the modelled year of opening with the complete operational upgrade;
- The 2041 ‘Do Minimum’ scenario (DM2041) 15 years after the modelled year of opening without the complete upgrade in place; and,
- The 2041 ‘Do Something’ option scenario (DS2041) 15 years after the modelled year of opening with the complete operational upgrade in place.

It is understood that the western urban section of the corridor may be constructed and in operation by 2020, however with the remaining entire corridor unlikely to be operational until 2034. Since the traffic modelling and air quality assessment have been based on a fully operational corridor by 2026, whilst six years later than the potential initial section opening year, it is considered that the increase in vehicle numbers used in the assessment based on the complete corridor upgrade still represents a worst-case assessment of the potential impacts to air quality, when compared to the reduction in vehicle emission factors in later years.

A total of 20 surrounding roads were modelled in the assessment. A link is a straight-line segment that may represent an entire road, or a portion of the road that has a break in it (thereby defining a new link segment) due to the presence of a stoplight, an intersection, a bend in the road, or a significant change in the road gradient. Link geometry for the existing traffic network and proposed road realignment were also provided by AECOM transport team for input to the air quality dispersion model.

All future year traffic modelling data is inclusive of predicted growth in the Auckland Plan, draft Unitary Plan, Drury, Takanini and Flatbush plan changes, in terms of cumulative impacts.

The traffic data used within the assessment are detailed in **Appendix A**.

The data assumes that 10% HGVs are present on the State Highway only, with the remaining roads comprising 5% heavy vehicles. Using these values provided by AECOM transport, the vehicle fleet mix has been amended, taking into account the default fleet composition contained within the NZTA’s emission factor database (discussed in **Section 6.2**).

6.2 Emission Modelling and Rates

In order to assess the potential impact of the corridor upgrade on local air quality, estimated emissions of the pollutants are required. The pollutants of primary concern for motor vehicles are CO, NO_x, VOCs and PM_{10} and predicted concentrations of these pollutants, in identified areas will be compared with the National air quality Standards and Regional Targets. The primary factors that influence emissions from vehicles include the mode and speed of travel, the grade of the road and the mix, type and age of the vehicles.

Emission factors for this project have been derived based upon the emissions and fleet data within the Vehicle Emissions Prediction Model (VEPM version 5.1). The Toolkit has been developed by the NZTA and Auckland Council and comprehensively incorporates updated vehicle exhaust emissions factors for the current New Zealand vehicle fleet and forecasts emissions up to the year 2040. It is important to ensure the correct assessment year is selected when calculating emission rates, as emissions are forecast to reduce with time, due to improvements in vehicle emission control technologies and legislative requirements.

The VEPM database also includes the consideration for brake and tyre wear for PM_{10} and $PM_{2.5}$, cold-start emissions and the effects of catalytic converters; all of which have been included within the emissions modelling and assessment. In addition, road gradients are also accounted for within the VEPM and their effects have been included in the assessment through the generated emission factors. Using the assumed composition of heavy vehicles on each of the provided roads, the vehicle fleet mix has been amended taking into account the default fleet composition contained within the VEPM 5.1 database.

The output of the VEPM database provided a series of pollutant emission rates in grams per vehicle kilometre for each assessment year based on vehicle speed and link composition, for input into the dispersion model.

7.0 Dispersion Modelling

The air dispersion modelling conducted for this Tier 3 assessment has been based on the modelling approach using the air dispersion model, AUSROADS, together with observed meteorological data provided by Auckland Council. The data that was available for this project and a discussion of the data processing methodologies that were required in order to implement AUSROADS will be discussed in the following sections.

7.1 Modelling Approach

Ministry for the Environment guidance[11] advocates the use of the simple Gaussian line source AUSROADS model for the assessment of roadways, released by the Environment Protection Authority (EPA) Victoria in Australia. The model uses the same algorithms as those within the commonly used CALINE4 line-source model, however with increased functionality. Its use was agreed in principle with Auckland Council[5].

7.2 Modelling Input Data

The AUSROADS model requires the following input data to perform an assessment.

7.2.1 Emissions Inventory

For the Tier 3 detailed modelling, the details of the affected roads provided by AECOM transport team have been split into a series of links, which represent sections where traffic conditions have reasonably homogenous flow and average speed, to allow emission estimations to be estimated.

Pollutant emission rates from vehicles were calculated using the Vehicle Emission Prediction Model (VEPM version 5.1) published in 2012, as detailed previously in **Section 6.2** for the pollutants carbon monoxide (CO), nitrogen dioxide (NO_2) as oxides of nitrogen dioxide (NO_x), fine particulate matter (PM_{10} and $PM_{2.5}$) and benzene as volatile organic compounds (VOC).

7.2.2 Meteorological Data

Meteorological data are required to assess the pollutant concentrations over the various time periods defined by the air quality objectives (i.e. 1 hour, 24 hour and annual means).

Hourly sequential observation data for the Auckland region for 2005 and 2007 were provided by Auckland Council for use in the modelling assessment in an AUSPLUME format. Wind speed, wind direction, temperature, stability class and mixing height observations made at Wiri meteorological station (operated by NIWA as part of a national network of sites) 2 km west of the study area were included in the modelling. This meteorological station was used in the assessment after it was identified to be the closest site for the area. The AUSPLUME format data set was provided by Auckland Council after its use was recommended for within the study.

Figure 6 below illustrates the 2007 wind roses for the meteorological data, which were used within the assessment for the baseline traffic year of 2011 and all future scenarios. The data from 2007 were used instead of the 2005 data in the assessment, as the data were found to result in greater predicted pollutant concentrations in the initial modelling carried out for the project, therefore representing a worst case assessment.

Figure 7 below also illustrates the additional meteorological data recorded for 2005 from Wiri meteorological station to confirm the predominant south westerly wind patterns used in the assessment.

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[11] MfE, 2004. *Good Practice Guide for Atmospheric Dispersion Modelling.* New Zealand Ministry for the Environment, June 2004.

Figure 6: Wiri Meteorological Station 2007 AUSPLUME Wind Roses used in Assessment

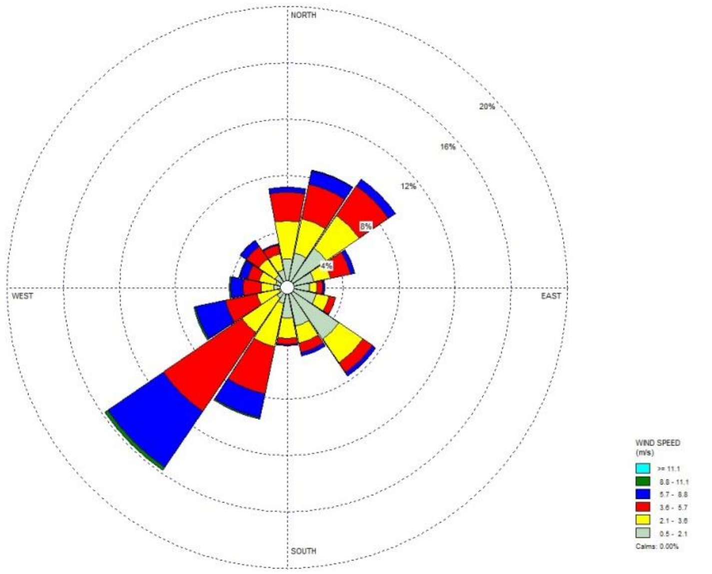
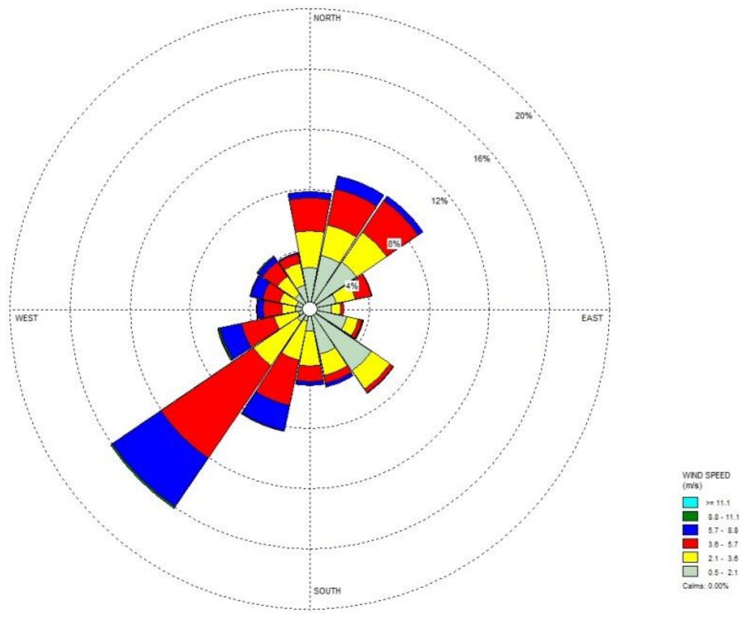


Figure 7: Wiri Meteorological Station 2005 AUSPLUME Wind Roses



7.2.3 Background Pollutant Concentrations

In the absence on a representative urban background continuous monitoring station in the vicinity of the corridor, background concentrations have been used in the modelling to provide an assessment of the cumulative impacts, in-line with documentation prepared for Auckland Council[12]. Discussed earlier in **Section 5.4**, the guidance document (whilst industry focussed) does detail how to use background concentrations appropriately for transport projects.

Accounting for background concentrations is difficult because the listed monitoring stations are affected to varying degrees by emissions from local sources and, consequently, may provide an overestimate of background pollutant levels. *'Auckland Urban'* data were used in the assessment, in-line with the guidance to avoid the double

[12] Metcalfe, J. Wickham, L. and Rolfe, K. (2012). *Draft - Use of Background Air Quality Data in Resource Consent Applications*. Prepared by Emission Impossible Ltd and Kevin Rolfe & Associates Ltd for Auckland Council. Auckland Council Guideline

counting of vehicle emissions and potential over-estimation of predicted pollutant concentrations at identified sensitive receptors and are detailed in **Table 10** below. The table shows that all background pollutant concentrations directly relevant to this study are below the relevant national standard or regional target, with the exception of fine particulate matter as $PM_{2.5}$. Given the mixed residential / rural land use along the corridor, the use of the data is considered to be a conservative assumption.

All future year modelling was also conducted using the same background concentrations used for the baseline year, i.e. it would not be assumed that background air quality would improve in coming years as is generally expected through legislation and tighter controls on emissions. The approach used in this assessment is therefore considered to be a conservative assumption.

Table 10: Background Concentrations used in Assessment

Pollutant	Averaging Period	Air Quality Standard / Target	Concentration	Source
Nitrogen dioxide (NO_2)	1-hour mean	200 µg/m^3	80 µg/m^3	Table 3.1 - Auckland Urban Airshed values
	24-hour mean	100 µg/m^3	41 µg/m^3	Table 3.1 - Auckland Urban Airshed values
	Annual mean	40 µg/m^3	14 µg/m^3	Table 3.1 - Auckland Urban Airshed values
Fine Particulate matter (PM_{10})	24-hour mean	50 µg/m^3	40.1 µg/m^3	Table A3-2 Average of Auckland Urban Airshed Concentrations
	Annual mean	20 µg/m^3	16.6 µg/m^3	Table A3-2 Average of Auckland Urban Airshed Concentrations
Fine Particulate matter ($PM_{2.5}$)	24-hour mean	25 µg/m^3	29.8 µg/m^3	Table A3-3 Average of Auckland Urban Airshed Concentrations
	Annual mean	10 µg/m^3	8.0 µg/m^3	Table A3-3 Average of Auckland Urban Airshed Concentrations
Carbon monoxide (CO)	1-hour mean	30 mg/m^3	5 mg/m^3	Table 3.1 - Auckland Urban Airshed values
	8-hour mean	10 mg/m^3	2.5 mg/m^3	Table 3.1 - Auckland Urban Airshed values
Benzene	Annual mean	3.6 µg/m^3	1 µg/m^3	Table 3.1 - Auckland Urban Airshed values

7.2.4 Receptor Locations

A series of discrete sensitive receptors were identified within close proximity to the corridor upgrade, which may be affected by the changes in vehicle patterns and road alignment. A total of 22 discrete receptors, detailed in **Section 5.2**, were entered into the model. The receptors were considered to be representative of the worst case exposure in those particular locations, at distances up to 200 metres from the centre line of the affected roads.

The predicted concentrations for the existing baseline year and future year scenarios, both with and without the proposed upgrade, at the identified sensitive receptors are detailed in **Section 8.2**.

7.2.5 Additional Model Parameters

Table 11 below lists the other parameters that were used as input into the AUSROADS model.

Table 11: Additional Parameters used in the Model

Parameter	Value
Surface Roughness (m)	0.4
Urban/rural setting	Rural
Dispersion profile	Pasquill-Gifford
Receptor height (m)	0 (ground level)
Source height (m)	0 (ground level)

7.3 Conversion of NO_x to NO_2

The oxidation of NO to form NO_2 is a complex process that is dependent on several factors, including the relative availability of these two gases as well as of ozone, volatile organic compounds, carbon monoxide, sunlight, temperature and residence time.

AUSROADS assumes that the pollutants are inert gases i.e. the model does not account for any chemical transformations and therefore the transformation of NO_x to NO_2 needs to be done in the post-processing stage.

The Ministry for the Environment (MfE) *Good Practice Guide for Assessing Discharges to Air from Land Transport*[13] , details a methodology to calculate the effects of NO to NO_2 pollutant transformation based on measured data within New Zealand together with wider international documentation from Australia and the UK.

A ratio of 0.2 or conversion rate of 20% is summarised within the guide as being appropriate and therefore this has been used within this assessment for all receptor locations. The effects of this assumption however will be discussed in the results section, where applicable

7.4 Assumptions and Limitations

- Traffic data used within the assessment was provided in 24-hour annual average daily traffic (AADT) format and therefore the potential effects of diurnal traffic have not been included in the assessment.
- The potential effects of terrain on pollutant concentrations through an external terrain data file have not been assessed, as the AUSROADS model does not include this feature. Its exclusion is not considered to be significant given the local topography and land use. The effect of gradients on the calculation of vehicle emissions however has been taken into account.
- Model verification has not been possible due to the absence of continuous air quality monitoring stations in the vicinity of the modelled road network.
- $PM_{2.5}$ concentrations have been assumed to be 75% of the modelled PM_{10} concentrations, in-line with previous studies conducted for the New Zealand Transport Agency[14].
- Emissions of volatile organic compounds (VOC) have been assumed to be 100% benzene, for comparison against the Regional Standard. In reality, the fraction of benzene within the total VOC emissions will be small and therefore the assessment represents a worst case approach.

[13] MfE, 2008. *Good Practice Guide for Assessing Discharges to Air from Land Transport*. New Zealand Ministry for the Environment, June 2008.
[14] NZTA, 2010. *Western Ring Route: SH16 Henderson Creek to Huruhuru Road Bridge – Air Quality Assessment.* Prepared by BECA for New Zealand Transport Agency. May 2010

8.0 Assessment of Effects

The potential effects of the proposed upgrade upon local air quality have been assessed during both the construction and operational phases using the methodology detailed in **Section 3.1**.

8.1 Construction Activities

Atmospheric emissions from construction activities typically depend on a combination of the potential for emission (the type of activities) and the effectiveness of control measures. There are in general terms, two sources of emissions that need to be controlled to minimise the potential for adverse environmental effects. These include:

- exhaust emissions from site plant, equipment and vehicles
- fugitive dust emissions from site activities.

Given the inherent uncertainty surrounding potential construction impacts, due to the temporal nature and duration of works and opportunities for a contractor to refine design and construction methods, the construction effects have been assessed through a qualitative review of potential sources of air emissions. This has been based on the project description, detailed alignment plans and understood best practice construction methods. No main construction lay down areas or compounds had been identified at the time of writing the assessment report.

Exhaust emission impacts

The operation of vehicles and equipment powered by internal combustion engines results in the emission of waste exhaust gases containing the pollutants NOx, PM_{10}, VOCs, and CO. The quantities emitted depend on factors such as engine type, service history, pattern of usage and composition of fuel. The operation of site equipment, vehicles and machinery would result in emission to the atmosphere of un-quantified levels of waste exhaust gases but such emissions are unlikely to be significant, particularly in comparison to levels of similar emissions from road traffic. The traffic effects of construction for the project would primarily be along the traffic routes employed by haulage vehicles, construction vehicles and employees.

The principal construction activities with transportation implications are:

- removal of materials from any demolition work and excavated tunnel or station material/spoil
- delivery of materials
- movement of heavy plant
- diversions of existing traffic.

Entry to the main construction site for labour and vehicles will be via dedicated access points only. Construction traffic could have an adverse impact on the air quality at adjoining occupiers if not properly controlled however introduced mitigation measures would be able to reduce these impacts. It would be expected that a Construction Environmental Management Plan (CEMP) would be prepared at a later date once detailed site information was available, which would detail the identified traffic haulage corridors and site operation hours.

Indirect impacts would also be likely to occur across the study area due to the effects of traffic management and road diversions/the use of alternative routes. The impacts of traffic management will vary depending on the particular precinct however this too is expected to be contained with an approved CEMP.

Fugitive dust impacts

Fugitive dust emissions from earthworks and construction activities are likely to be variable and would depend upon type and extent of the activity, soil conditions (soil type and moisture) road surface condition and weather conditions. Soils are inevitably drier during the summer period and periods of dry weather combined with higher than average winds have the potential to generate the most dust. Due to the expected construction duration, a consistent level of attention to manage dust impacts would be required. The construction activities that are the most significant potential sources of fugitive emissions are:

- piling, rock breaking and open excavation activities
- earth moving: due to the excavation, handling and disposal of soil and other materials
- construction aggregate usage: due to the transport, unloading, storage and use of dry and dusty materials (such as cement powder and sand)

- movement of heavy site vehicles on dry untreated or hard surfaces
- movement of vehicles over surfaces contaminated by muddy materials brought off the site.

Fugitive emissions from construction sites are also commonly associated with the storage of spoil and stockpiles however best practice techniques of minimum storage, covering spoil and the use of water as a dust suppressant where necessary should largely eliminate this potential emissions source.

Fugitive dust arising from construction activities is generally of particle size greater than the human health-based PM_{10} fraction. In assessing the impact of fugitive dust there are two different effects that need to be considered:

- the effects on human health
- dust nuisance.

The former relates to the concentration of dust in suspension in the atmosphere which can be inhaled (respirable) and the latter relates to the amount of dust falling onto and soiling surfaces (referred to as the rate of dust deposition). If not effectively controlled, fugitive dust emissions can lead to dust nuisance. Most of the dust emitting activities outlined above respond well to appropriate dust control/mitigation measures and adverse effects can be greatly reduced or eliminated.

The sensitivity of different land uses and facilities to dust can be categorised from low to high, examples of which are listed in **Table 12** below[15]. Facilities within the corridor range from high sensitivity to low sensitivity classifications, as they comprise residential and open space recreation/conservation to rural areas.

Table 12: Sensitivity of Differing Types of Land Use

Land use	Rating
Hospitals, schools, childcare facilities, rest homes	High
Residential	High
Open space recreational	High
Tourist, cultural, conservation	High
Commercial, retail, business	Medium to High
Rural residential / countryside living	Medium to High
Rural	Low
Heavy industrial	Low
Light industrial	Low

Dust has a limited ability to remain airborne and readily drops from suspension as a deposit. Research undertaken for the United States Environmental Protection Agency[16] concluded that large particulate matter (particles over 30 micrometres in diameter), return to the surface quite rapidly after suspension and the majority of this particulate matter (60 – 90 per cent) stays between one to two metres above the ground. Under average wind conditions (mean wind speed of 2 - 6 metres per second), these particles, which comprise around 95 per cent of total dust emissions were found to return to the surface within 60 - 90 metres of the emission source.[17]

Actual deposition rates and dust dispersion patterns will vary depending on the amount of material released, the proximity of sensitive receptors and also the local meteorological conditions. The greatest dust impacts can therefore be experienced at distances of up to 60 – 90 metres away from the source, however wind speeds at the site may cause nuisance impacts at up to 350 metres away. Residential receptors along Redoubt Road are located within 10 metres from the existing roadside and it is likely that the construction footprint may extend even

[15] MfE, 2008. *Good Practice Guide for Assessing Discharges to Air from Land Transport*. New Zealand Ministry for the Environment, June 2008.
[16] JG Watson and JC Chow, *Reconciling Urban Fugitive Dust Emissions Inventory and Ambient Source Contribution Estimates: Summary of Current Knowledge and Needed Research.* Desert Research Institute, DRI Document No. 6110.4F, May, 2000.
[17] C Cowherd, P Englehart, GE Muleski, JS Kinesy and KD Rosbury; *Control of Fugitive and Hazardous Dusts*, Noyes Data Corp, Park Ridge, NJ (1990), pp. 261–321

closer to properties. Given the predominant south westerly wind direction in the Auckland area however, it is considered locations to the north east of any construction activities are potentially the most susceptible to dust nuisance during the construction period and therefore a significant level of care should be maintained throughout the construction phase to minimise potential impacts along the corridor.

The Preliminary Site Investigation (PSI) carried out as part of the study[18] also identified a number of locations where potential ground contamination may exist and affect local air quality if disturbed. Sites identified include asbestos contamination within the roadside verge adjacent to Redoubt Road, together with asbestos containing material (ACM) within five properties in the Flat Bush area. As a result, the presence of further ground contamination at potentially additional unidentified locations along the corridor should therefore be considered throughout the construction period in relation to the potential impact to human health and air quality. Should ACM be found within the verges, specialist service contractors would need to be appointed to ensure the health and well-being of workers and non-workers alike is not affected during construction. Potentially odorous ground material has not been identified.

Mitigation measures to be employed to minimise any impacts are consistent across the corridor and are discussed in **Section 9.1**.

8.2 Operational Effects

The potential effects of the corridor upgrade upon local air quality have been assessed and summarised during the operational phase using the methodology detailed in **Section 7.1**. Results are expressed as the maximum ground level concentrations and include the relevant background concentrations, for comparison to the National Environmental Standards for Ambient Air Quality and Auckland Regional Air Quality Targets.

The potential level of impact from the upgrade can be determined by comparing the predicted impact in the future year with the upgrade in place against the same year without the upgrade. Full details of the predicted pollutant concentrations for each of the modelled receptors and scenarios are contained in **Appendix B**, with the predicted changes in concentrations detailed in **Appendix C**.

8.2.1 Carbon monoxide (CO)

The potential changes in the 8-hour and 1-hour mean CO concentrations, resulting from the change in vehicle emissions and road alignment on the Mill Road corridor, at the identified worst-case sensitive receptors are summarised below.

- The predictive modelling inclusive of default background concentrations, indicates that there will be no ground level exceedances of the 8-hour mean CO National Ambient Air Quality Standard (10 mg/m^3), or the 1-hour CO Auckland Regional Target (30 mg/m^3) in any of the assessment years with or without the corridor upgrade in place.
- The maximum predicted 8-hour CO mean concentration of 2.7 mg/m^3 in the proposed opening year is predicted to occur at six receptors (Receptors 16, 17, 19 – 22) and is well below the National Standard. The greatest predicted increase in the 8-hour CO mean with the Mill Road Upgrade in place, is forecast to occur at eight receptors, with all predicted to experience an increase in concentrations of 0.1 mg/m^3.
- The maximum predicted 1-hour CO mean concentration in the proposed opening year is forecast to occur at Receptor 16: 141 Redoubt Road, with a concentration of 5.5 mg/m^3, which is well below the Regional Target. The greatest predicted increases in the 8-hour CO mean with the Mill Road Upgrade in place are forecast to occur at Receptor 16, with predicted increases in concentrations of 0.3 and 0.2 mg/m^3, in the proposed opening year and 15 years after opening, respectively.
- Five of the identified worst-case receptors are predicted to experience either an improvement or no change in CO pollutant concentrations across both 1-hour and 8-hour mean averaging periods and in both future years as a result of the Mill Road upgrade. The greatest predicted improvements in CO concentrations at the identified modelled receptors are forecast to occur at Receptor 1: Cnr of Mill Road and Alfriston Road and Receptor 4: 5 Polo Prince Drive.

The predicted CO concentrations and incremental changes in CO concentrations at the modelled receptors are detailed in **Appendix B** and **Appendix C**. The results indicate that, taking into account the default urban

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[18] AECOM, 2013. *Preliminary Site Investigation, Redoubt Road/Mil Road Corridor – Contaminated Lane Assessment*. Prepared for Auckland Transport. July 2013

background concentrations, there are no predicted CO exceedances of either the National Standards or Regional Targets at any of the selected worst-case locations. A health risk assessment for CO is therefore not considered to be necessary as part of the assessment and the potential impact on CO concentrations is considered to be less than minor.

8.2.2 Nitrogen dioxide (NO_2)

The potential changes in the 1-hour, 24-hour and annual mean NO_2 concentrations, resulting from the change in vehicle emissions and road alignment on the Mill Road corridor, at the identified worst-case sensitive receptors are summarised below**.** A NO_x to NO_2 ratio of 0.2 (or NO_x conversion rate of 20%) has been used within this assessment for all receptor locations as detailed in **Section 7.3**, in-line with MfE guidance[19].

- The predictive modelling inclusive of default background concentrations, based on a 20% NO_x to NO_2 conversion, indicates that there will be no ground level exceedances of the 1-hour mean NO_2 National Ambient Air Quality Standard (200 μg/m^3), or the 24-hour or annual mean NO_2 Auckland Regional Targets (100 μg/m^3 and 40 μg/m^3, respectively) in any of the assessment years with or without the corridor upgrade in place.
- The maximum predicted NO_2 1-hour mean concentration in the proposed opening year is forecast to occur at Receptor 16: 141 Redoubt Road, with a concentration of 101.2 μg/m^3, and is well below the National Standard. The greatest predicted increase in the NO_2 1-hour mean with the Mill Road Upgrade in place is also forecast to occur at Receptor 16 in the proposed opening year, with a predicted increase in concentrations of 10.7 μg/m^3. This increase equates to 5% of the National Standard.
- The maximum predicted NO_2 24-hour mean concentration in the proposed opening year is forecast to occur at Receptor 22: 12 Redoubt Road, with a concentration of 47.7 μg/m^3, and is well below the Regional Target. The greatest predicted increases in the NO_2 24-hour mean with the Mill Road upgrade in place, are forecast to occur at Receptor 16, with predicted increases in concentrations of 2.6 and 2.7 μg/m^3, in the proposed opening year and 15 years after opening, respectively. These increases equate to less than 3% of the Regional Target.
- The maximum predicted NO_2 annual mean concentration in the proposed opening year is forecast to occur at Receptor 22: 12 Redoubt Road, with a concentration of 16.3 μg/m^3, and is well below the Regional Target. The greatest predicted increases in the NO_2 annual mean with the Mill Road Upgrade in place, are forecast to occur at Receptor 16, with predicted increases in concentrations of 0.7 μg/m^3 in both the proposed opening year and 15 years after opening. These increases equate to less than 2% of the Regional Target.
- Assuming a worst-case100% NO_x as NO_2 conversion, the National 1-hour mean NO_2 Standard is predicted to be marginally exceeded at two identified sensitive receptor locations in the baseline year of 2011 (Receptor 1 - 202 μg/m^3 and Receptor 4 – 205 μg/m^3). No future exceedances however are predicted in either the proposed 2026 opening year or 15 years following scheme opening, both with or without the upgrade in place.
- Six of the identified worst-case receptors are predicted to experience an improvement in pollutant concentrations across all 1-hour, 24-hour and annual mean averaging periods and in both future years as a result of the Mill Road upgrade. The greatest predicted improvement in NO_2 concentrations at the identified modelled receptors is forecast to occur at Receptor 4: 5 Polo Prince Drive.

The predicted NO_2 concentrations and incremental changes in NO_2 concentrations at the modelled receptors are detailed in **Appendix B** and **Appendix C**. The results indicate that, taking into account the default urban background concentrations, there are no predicted NO_2 exceedances of either the National Standards or Regional Targets at any of the selected worst-case locations. A health risk assessment for NO_2 is therefore not considered to be necessary as part of the assessment and the potential impact on NO_2 concentrations is considered to be less than minor.

[19] MfE, 2008. *Good Practice Guide for Assessing Discharges to Air from Land Transport*. New Zealand Ministry for the Environment, June 2008.

8.2.3 Fine particulate matter (PM_{10})

The potential changes in the 24-hour and annual mean PM_{10} concentrations, resulting from the change in vehicle emissions and road alignment on the Mill Road corridor, at the identified worst-case sensitive receptors are summarised below.

- The predictive modelling inclusive of default background concentrations, indicates that there will be no ground level exceedances of the 24-hour mean PM_{10} National Ambient Air Quality Standard (50 μg/m^3), or the annual mean PM_{10} Auckland Regional Target (20 μg/m^3) in any of the assessment years with or without the corridor upgrade in place.
- The maximum predicted PM_{10} 24-hour mean concentration of 42.5 μg/m^3 is predicted to occur in the scenario 15 years after opening (DS2041) at both Receptors 21 and 22 (22 and 12 Redoubt Road, respectively). The greatest predicted increase in the 24-hour PM_{10} mean with the Mill Road Upgrade in place, is forecast to occur at Receptor 16: 141 Redoubt Road, with a predicted increase in concentrations of 1.0 μg/m^3. This increase equates to 2% of the National Standard.
- The maximum predicted PM_{10} annual mean concentration of 17.4 μg/m^3 is also predicted to occur in the scenario 15 years after opening (DS2041), however at Receptors 20 – 22 and both with and without the Mill Road upgrade in place. The greatest predicted increases in the annual mean with the Mill Road Upgrade in place, are forecast to occur at Receptor 16, with predicted increases in concentrations of 0.2 and 0.3 μg/m^3, in the proposed opening year and 15 years after opening, respectively. These increases equate to less than 1% of the Regional Target.
- Nine of the identified worst-case receptors are predicted to experience either an improvement or no change in PM_{10} pollutant concentrations across both 24-hour and annual mean averaging periods and in both future years as a result of the Mill Road upgrade. The greatest predicted improvements in PM_{10} concentrations at the identified modelled receptors are forecast to occur at Receptor 1: Cnr of Mill Road and Alfriston Road, Receptor 2: Alfriston School and Receptor 4: 5 Polo Prince Drive.

The predicted PM_{10} concentrations and incremental changes in PM_{10} concentrations at the modelled receptors are detailed in **Appendix B** and **Appendix C**. The results indicate that, taking into account the default urban background concentrations, there are no predicted PM_{10} exceedances of either the National Standards or Regional Targets at any of the selected worst-case locations. A health risk assessment for PM_{10} is therefore not considered to be necessary as part of the assessment and the potential impact on PM_{10} concentrations is considered to be less than minor.

8.2.4 Fine particulate matter ($PM_{2.5}$)

The potential changes in the 24-hour and annual mean $PM_{2.5}$ concentrations, resulting from the change in vehicle emissions and road alignment on the Mill Road corridor, at the identified sensitive receptors are summarised below.

- The predictive modelling inclusive of default background concentrations, indicates that the 24-hour mean $PM_{2.5}$ Auckland Regional Target (25 μg/m^3) will be exceeded at all identified receptors and in all modelled scenarios. This is due to the default urban background concentration used within the assessment (29.8μg/m^3) already exceeding the Target. The annual mean $PM_{2.5}$ Regional Target (20 μg/m^3) however is predicted to be met in all of the assessment years with or without the corridor upgrade in place.
- The maximum predicted $PM_{2.5}$ 24-hour mean concentration of 31.6 μg/m^3 is predicted to occur in the scenario 15 years after opening (DS2041) at both Receptors 21 and 22 (22 and 12 Redoubt Road, respectively). The greatest predicted increase in the 24-hour $PM_{2.5}$ mean with the Mill Road Upgrade in place is forecast to occur at Receptor 16: 141 Redoubt Road, with a predicted increase in concentrations of 0.7 μg/m^3 in the 2041 future scenario. This increase equate to less than 3% of the Regional Target.
- The maximum predicted $PM_{2.5}$ annual mean concentration of 8.6 μg/m^3 is also predicted to occur in the scenario 15 years after opening, however at Receptors 20 – 22 and both with and without the Mill Road upgrade in place. The greatest predicted increases in the annual mean with the Mill Road Upgrade in place are forecast to occur at Receptors 7, 14 and 16, with predicted increases in concentrations of 0.2μg/m^3, 15 years after opening. These increases equate to less than 1% of the Regional Target.
- Nine of the identified worst-case receptors are predicted to experience either an improvement or no change in $PM_{2.5}$ pollutant concentrations across both 24-hour and annual mean averaging periods and in

both future years as a result of the Mill Road upgrade. The greatest predicted improvements in $PM_{2.5}$ concentrations at the identified modelled receptors are forecast to occur at Receptor 1: Cnr of Mill Road and Alfriston Road, Receptor 2: Alfriston School and Receptor 4: 5 Polo Prince Drive.

The predicted $PM_{2.5}$ concentrations and incremental changes in $PM_{2.5}$ concentrations at the modelled receptors are detailed in **Appendix B** and **Appendix C**. The results indicate that, taking into account the default urban background concentrations, the $PM_{2.5}$ 24-hour mean Auckland Regional Target of 25 μg/m^3 will be exceeded at all modelled receptors in all scenarios, due to the background concentration used in the assessment already exceeding the Target. The $PM_{2.5}$ annual mean Regional Target is however predicted to be met at all of the selected worst-case locations. Whilst exceedances of the $PM_{2.5}$ 24-hour mean are predicted, as these exceedances are not as a result of the proposed upgrade. A health risk assessment for $PM_{2.5}$ is therefore not considered to be necessary as part of the assessment and the potential impact on $PM_{2.5}$ concentrations is considered to be less than minor.

8.2.5 Benzene (as Volatile Organic Compounds)

The potential changes in the annual mean benzene concentrations, modelled as volatile organic compounds (VOCs), resulting from the change in vehicle emissions and road alignment on the Mill Road corridor, at the identified sensitive receptors are summarised below.

- The predictive modelling inclusive of default background concentrations, indicates that the benzene annual mean (modelled as VOCs) Auckland Regional Target (3.6 μg/m^3) will be met at all identified receptors and in all modelled scenarios with and without the corridor upgrade in place.
- The maximum predicted benzene annual mean concentration of 3.2 μg/m^3 is predicted to occur in the scenario 15 years after opening (DS2041) at Receptor 21 (22 Redoubt Road). The greatest predicted increases in the benzene annual mean with the Mill Road Upgrade in place are forecast to occur at Receptors 14 and 16 (189 and 141 Redoubt Road, respectively) with a predicted increase in concentrations of 0.6 μg/m^3 in both the 2026 opening year and 2041 future year scenario.
- Nine of the identified worst-case receptors are predicted to experience either an improvement or no change in annual mean benzene pollutant concentrations in both future years as a result of the Mill Road upgrade. The greatest predicted improvements in benzene concentrations at the identified modelled receptors are forecast to occur at Receptor 1: Cnr of Mill Road and Alfriston Road, and Receptor 4: 5 Polo Prince Drive, with predicted concentration reductions of 0.7 and 0.9 μg/m^3 in 2026 and 2041, respectively.

The predicted benzene concentrations and predicted incremental changes at the modelled receptors are detailed in **Appendix B** and **Appendix C**. The results indicate that, taking into account the default urban background concentrations and assuming 100% VOCs as benzene, there are no predicted exceedances of the benzene Regional Target at any of the selected worst-case locations. A health risk assessment for benzene is therefore not considered to be necessary as part of the assessment and the potential impact on benzene concentrations is considered to be less than minor.

9.0 Mitigation of Effects

9.1 Construction Effects

Given the corridor construction length as well as the proximity of sensitive receptors to the activities, there is the potential for the project to create significant emissions and dust nuisance across the project area if not properly managed.

Potential air quality impacts arising from construction activities would be mitigated using best practice management measures. The appointed contractors would be required to produce a Construction Environmental Management Plan (CEMP), together with a Construction Dust Management Plan (CDMP) or Construction Air Quality Management Plan (CAQMP), which would set out all of the steps to be taken to control and mitigate the effects of construction dust. Most of the identified dust emitting activities respond well to appropriate dust control/mitigation measures and adverse effects would be greatly reduced. These measures typically involve water suppression and reducing surface wind speeds using windbreaks/enclosures. Effective dust mitigation measures prevent dust becoming airborne or contain dust within enclosures to prevent dispersion beyond the emission source. The CEMP would also include likely traffic routing, site access points and hours of operation, to ensure the potential for adverse environmental effects on local receptors is avoided.

The Ministry for the Environment good practice guide for assessing and managing dust emissions[20] outlines a series of dust control methods and technologies as key considerations. It is therefore expected that the following measures from the guide would be incorporated into the approved CEMP.

Site Planning

- Erection of solid barriers to site boundary, where appropriate.
- Plan site layout – machinery and dust causing activities will be located away from sensitive receptors.
- All site personnel to be fully trained.
- Trained and responsible manager on site during working times to maintain logbook and carry out daily vidual inspections.
- Regular liaison with local communities.
- Complaints register to monitoring nuisance and mitigation effectiveness.
- Consider the placement of real-time dust monitoring at the site boundary, with trigger levels set.

Construction traffic

- All vehicles will switch off engines when not in use – no idling vehicles.
- Effective vehicle cleaning and specific fixed wheel washing on leaving site and damping of haul routes.
- All loads entering and leaving site to be covered.
- No site run-off of water or mud.
- On-road vehicles to comply to set emission standards.
- Minimise movement of construction traffic around site.

Demolition Activities

- Use water as a dust suppressant.
- Cutting equipment to use water as suppressant or local extract ventilation.
- Use covered skips.
- Limit drop heights.
- Wrap building(s) to be demolished – where applicable.

[20] MfE, 2001. *Good Practice guide for assessing and managing the environmental effects of dust emissions.* New Zealand Ministry for the Environment, September 2001.

Site Activities

- Minimise dust generating activities.
- Use water as dust suppressant where applicable.
- Reduce work during periods of increased wind or when blowing toward sensitive areas.
- Cover, seed or fence stockpiles to prevent wind whipping.

In addition, whilst the project is not controlled by the New Zealand Transport Agency (NZTA), the NZTA has prepared guidance which outlines suggested conditions to be placed within a Construction Air Quality Management Plan (CAQMP)[21] that could be incorporated for the construction phase of the upgrade. As the project is classified as a '*high risk'* project (see **Section 3.1.1**), the following example conditions have been listed that are considered to be appropriate in relation to the upgrade, to be contained within a CAQMP.

"*Condition CAQ1*

The CAQMP shall describe the measures to be adopted that, so far as practicable, seek to:

a) Reduce the odour, dust or fumes arising as a result of the project at any point within 100 m that borders a highly sensitive air pollution land use;

b) Ensure that the 24-hour average concentration, measured midnight to midnight, of Total Suspended Particulate (TSP) at any point within 100 m of the designation boundary that borders a highly sensitive air pollution land use does not exceed 80 micrograms per cubic metre (μg/m³).

The CAQMP shall, as a minimum, address the following:

I. Description of the works, anticipated equipment/processes and durations;

II. Periods of time when emissions of odour, dust or fumes might arise from construction activities;

III. Identification of highly sensitive air pollution land uses likely to be adversely affected by emissions of odour, dust or fumes from construction activities;

IV. Methods for mitigating dust emitted from construction yards, haul roads, stock-piles and construction site exits used by trucks, potentially including the use of vacuum sweeping, water sprays or wheel washes for trucks;

V. Methods for mitigating odour that may arise from ground disturbing construction activities;

VI. Methods for maintaining and operating construction equipment and vehicles in order to seek to minimise visual emissions of smoke from exhaust tailpipes;

VII. Methods for undertaking and reporting (to council) on the results of daily inspections of construction activities that might give rise to odour, dust or fumes;

VIII. Methods for monitoring and reporting (to council) on the state of air quality during construction, including Total Suspended Particulate, wind speed, wind direction, air temperature and rainfall;

IX. Procedures for maintaining contact with stakeholders, notifying of proposed construction activities and handling complaints about odour, dust or fumes;

X. Construction operator training procedures on mitigation odour, dust or fumes;

XI. Contact numbers for key construction staff, staff responsible for managing air quality during construction and council officers.

Condition CAQ2

Monitoring of Total Suspended Particulate (TSP) shall be undertaken;

a) using a continuous or gravimetric monitor with a maximum measurement time resolution of 24 hours;

[21] NZTA, 2012. *Draft Guide to assessing air quality effects for state highway asset improvement projects*. Version 0.6, New Zealand Transport Agency, September 2012

b) in general accordance with the Good Practice Guide for air quality monitoring and data management, Ministry for Environment, 2009;

c) at a minimum of [one] site within 100 m of the designation boundary that borders an appropriate number of highly sensitive air pollution land uses and that, so far as practicable, comply with the requirements of AS/NZ 3580.1.1:2007 Method for sampling and analysis of ambient air – guide to siting air monitoring equipment;

d) for a minimum of one week at each monitoring site;

e) between October and April inclusive during the construction phase of the project."

It is expected that the air quality monitoring program to be implemented during the construction phase will be designed by the appointed contractors, once a detailed understanding of the schedule of site activities and construction methods is available. The exact frequency and extent of the monitoring program, together with timings of when reviews of the monitoring effectiveness will be conducted are also expected to be contained in the document. Trigger levels to measure the effectiveness of mitigation measures against should also be detailed, as outlined in **Section 4.1.3**.

The monitoring program should however be fully operational during the initial site clearance and earthworks phases, as these phases inherently involve dust generating activities and may therefore cause nuisance impacts at adjacent receptors. It would be reasonable to expect the need for ongoing air quality / dust monitoring to be reviewed after the initial six months of site works based on site management and operations.

Incorporating all of the measures outlined above into the CEMP and CDMP / CAQMP would ensure that potential air quality impacts would be reduced as far as possible, maintaining fugitive dust levels and fine particulate matter concentrations (PM_{10} and $PM_{2.5}$) within the respective thresholds; thus limiting any residual impacts.

9.2 Operational Effects

No exceedances of the National Environmental Standards for Ambient Air Quality are predicted to occur at any of the modelled worst-case receptor locations in any of the future assessment scenarios, along the Mill Road upgrade corridor, based on the assessment methodology and assumptions.

The $PM_{2.5}$ 24-hour mean Auckland Regional Air Quality Target (25 µg/m^3) is predicted to be exceeded at all modelled worst-case receptors and in all assessment scenarios, however this is due to the default urban background concentration used in the assessment (29.8 µg/m^3). All other Regional Air Quality Targets are predicted to be met in all scenarios and at all identified worst-case receptors.

As the predicted impacts at all identified worst case receptors and for all modelled pollutants are considered to be less than minor, no mitigation measures are suggested in relation to the operation of the Mill Road upgrade.

10.0 Summary and conclusion

An assessment has been carried out to determine the potential air quality impact of the proposed Redoubt Road to Mill Road corridor upgrade, Auckland, in relation to the National Environmental Standards for Ambient Air Quality and Auckland Regional Air Quality Targets.

The assessment examines the existing air quality in the area, the local meteorology and terrain and then considers the likely effect on air quality as a result of emissions during the construction and operational phases of the upgrade. Potential odour impacts have also been considered.

Non-continuous local air quality monitoring data collected by New Zealand Transport Agency indicate that NO_2 annual mean pollutant concentrations in the vicinity of the corridor are below the Auckland Regional Target. The continuous monitoring of pollutants however is not conducted in the vicinity of the corridor and therefore the assessment has utilised published Auckland urban default background concentrations. All of the background concentrations used in the assessment are below the relevant National Standards and Regional Targets, with the exception of the default Auckland urban background 24-hour $PM_{2.5}$ mean used, which does exceed the Auckland Regional Standard.

The main potential air quality impact during the construction of the corridor upgrade would be expected to be from emissions of dust. If released in sufficient quantities, given the proximity of existing sensitive residential receptors to the Redoubt Road – Mill Road corridor, this could result in a nuisance from soiling and also have potential health implications if not properly managed. Construction-related plant and vehicle emissions associated with direct truck movements and in-direct wider diversions / congestion are also likely to occur, however these impacts will be temporary. In addition, the Preliminary Site Investigation report conducted for the upgrade study, identified the potential for asbestos containing materials (ACM) within the roadside verges, which should be taken into consideration. Should ACM be found within the verges, specialist service contractors would need to be appointed to ensure the health and well-being of workers and non-workers alike is not affected during construction.

Atmospheric dispersion modelling has been undertaken using AUSROADS, to assess the impact of the operational changes in vehicle emissions both with and without the upgrade in place, in the modelled opening year of 2026 and 15 years from opening (2041). The pollutants assessed were carbon monoxide, nitrogen dioxide, fine particulate matter (PM_{10} and $PM_{2.5}$) and benzene and have been forecast at identified worst-case receptor locations along the existing and proposed corridor. In addition, no future improvement in background pollutant concentrations was assumed within the study and the meteorological data were supplied by Auckland Council for the worst-case years of 2005 and 2007.

The forecast concentrations indicate that all National Environmental Standards for Ambient Air Quality for the modelled pollutants will not be exceeded at all worst-case receptor locations and in all future assessment years, both with and without the corridor upgrade in place. In addition, all Auckland Regional Air Quality Targets with the exception of 24-hour mean $PM_{2.5}$ concentrations are also predicted to not be exceeded at all locations and in all assessment years. The predicted $PM_{2.5}$ exceedances are due to the use of the Auckland urban default background concentrations, which already exceed the Regional Target.

Construction effects on air quality would be controlled as far as possible through the implementation of best practise construction methods and the adoption of mitigation measures through a contractor's Construction Environmental Management Plan (CEMP), together with a Construction Dust Management Plan (CDMP) / Construction Air Quality Management Plan (CAQMP), during the construction phase of the Mill Road. The CAQMP would include specific objectives and measures developed by Ministry for the Environment and the New Zealand Transport Agency for managing construction impacts; thus ensuring that potential adverse impacts are minimised or avoided, ensuring compliance with the relevant National Standards, Regional Targets and industry recommended guidelines and therefore limiting any potential residual impacts.

No mitigation measures have been recommended with regards to the operation of the Mill Road upgrade.

Overall, with appropriate mitigation for construction impact in place, the impacts on local air quality as a result of the Mill Road upgrade, during both the construction and operational phases, are considered to be less than minor.

Appendix A

Traffic data for Air Quality Assessment

Appendix A Traffic data for Air Quality Assessment

Scenario	Annual Average Daily Traffic Flow (AADT)	% Heavy Goods Vehicle	Posted Speed (kph)	Typical Peak Hour Traffic Flow
Link 1) State Highway - North of Redoubt Road				
Existing 2011	60000	10	100	6000
Do Minimum 2026	80000	10	100	8000
Do Something 2026	90000	10	100	9000
Do Minimum 2041	90000	10	100	9000
Do Something 2041	94000	10	100	9400
Link 2) State Highway 2 - South of Redoubt Road				
Existing 2011	80000	10	100	8000
Do Minimum 2026	100000	10	100	10000
Do Something 2026	100000	10	100	10000
Do Minimum 2041	108000	10	100	10800
Do Something 2041	110000	10	100	11000
Link 3) Diorella Drive				
Existing 2011	2500	5	45	250
Do Minimum 2026	3000	5	45	300
Do Something 2026	4000	5	45	400
Do Minimum 2041	3000	5	45	300
Do Something 2041	4000	5	45	400
Link 4) Everglade Drive				
Existing 2011	10000	5	50	1000
Do Minimum 2026	11000	5	50	1100
Do Something 2026	13000	5	50	1300
Do Minimum 2041	12000	5	50	1200
Do Something 2041	13000	5	50	1300
Link 5) Hollyford Drive				
Existing 2011	15000	5	50	1500
Do Minimum 2026	17000	5	50	1700
Do Something 2026	20000	5	50	2000
Do Minimum 2041	19500	5	50	1950
Do Something 2041	20000	5	50	2000
Link 6) Goodwood Drive				
Existing 2011	4500	5	50	450
Do Minimum 2026	6000	5	50	600
Do Something 2026	6000	5	50	600

Scenario	Annual Average Daily Traffic Flow (AADT)	% Heavy Goods Vehicle	Posted Speed (kph)	Typical Peak Hour Traffic Flow
Do Minimum 2041	6000	5	50	600
Do Something 2041	6500	5	50	650
Link 7) Hilltop Road				
Existing 2011	3500	5	45	350
Do Minimum 2026	5500	5	45	550
Do Something 2026	5500	5	45	550
Do Minimum 2041	5500	5	45	550
Do Something 2041	5500	5	45	550
Link 8) Murphys Road				
Existing 2011	10000	5	50	1000
Do Minimum 2026	17500	5	50	1750
Do Something 2026	20000	5	50	2000
Do Minimum 2041	18000	5	50	1800
Do Something 2041	24000	5	50	2400
Link 9) Redoubt Road – Between Murphys Road and Mill Road				
Existing 2011	14000	5	65	1400
Do Minimum 2026	21000	5	65	2100
Option 2026	26000	5	65	2600
Do Minimum 2041	22500	5	65	2250
Option 2041	29500	5	65	2950
Link 10) Redoubt Road - East of Mill Road				
Existing 2011	3000	5	45	300
Do Minimum 2026	5000	5	45	500
Do Something 2026	5500	5	45	550
Do Minimum 2041	7000	5	45	700
Do Something 2041	7000	5	45	700
Link 11) Mill Road – South of Redoubt Road				
Existing 2011	13500	5	65	1350
Do Minimum 2026	23000	5	65	2300
Do Something 2026	24500	5	65	2450
Do Minimum 2041	27000	5	65	2700
Do Something 2041	28500	5	65	2850
Link 12) Polo Prince Drive				
Existing 2011	1100	5	35	110
Do Minimum 2026	1300	5	35	130

Scenario	Annual Average Daily Traffic Flow (AADT)	% Heavy Goods Vehicle	Posted Speed (kph)	Typical Peak Hour Traffic Flow
Do Something 2026	1350	5	35	135
Do Minimum 2041	1500	5	35	150
Do Something 2041	1500	5	35	150
Link 13) Mill Road – South of Polo Prince Drive				
Existing 2011	14000	5	85	1400
Do Minimum 2026	21000	5	85	2100
Do Something 2026	25000	5	85	2500
Do Minimum 2041	25000	5	85	2500
Do Something 2041	30000	5	85	3000
Link 14) Ranfurly Road				
Existing 2011	4000	5	80	400
Do Minimum 2026	10500	5	80	1000
Do Something 2026	13000	5	80	1300
Do Minimum 2041	11000	5	80	1050
Do Something 2041	15000	5	80	1500
Link 15) Alfriston Road – East of Mill Road				
Existing 2011	6000	5	80	600
Do Minimum 2026	10000	5	80	1000
Do Something 2026	11000	5	80	1100
Do Minimum 2041	10500	5	80	1050
Do Something 2041	11000	5	80	1100
Link 16) Alfriston Road – West of Mill Road				
Existing 2011	6000	5	80	600
Do Minimum 2026	9500	5	80	950
Do Something 2026	9500	5	80	950
Do Minimum 2041	9500	5	80	950
Do Something 2041	9500	5	80	350
Link 17) Phillip Road				
Existing 2011	700	5	35	70
Do Minimum 2026	900	5	35	90
Do Something 2026	900	5	35	90
Do Minimum 2041	1300	5	35	130
Do Something 2041	1300	5	35	130
Link 18) Popes Road				
Existing 2011	3200	5	80	500

Scenario	Annual Average Daily Traffic Flow (AADT)	% Heavy Goods Vehicle	Posted Speed (kph)	Typical Peak Hour Traffic Flow
Do Minimum 2026	5000	5	80	500
Do Something 2026	8000	5	80	800
Do Minimum 2041	7500	5	80	750
Do Something 2041	9000	5	80	900
Link 19) Redoubt Road between State Highway 1 and Hollyford Road				
Existing 2011	20000	5	55	2000
Do Minimum 2026	24000	5	55	2400
Do Something 2026	33000	5	55	3300
Do Minimum 2041	26500	5	55	2650
Do Something 2041	35000	5	55	3500
Link 20) Redoubt Road between Hollyford Road and Murphys Road				
Existing 2011	12000	5	55	1200
Do Minimum 2026	14000	5	55	1400
Do Something 2026	22000	5	55	2200
Do Minimum 2041	17000	5	55	1700
Do Something 2041	25000	5	55	2500

Appendix B

Modelling Results

Appendix B Modelling Results

Pollutant	Carbon monoxide		Nitrogen dioxide			Particles as PM_{10}		Particles as $PM_{2.5}$		Benzene
Averaging Period	1-hour mean	8-hour mean	1-hour mean	24-hour mean	Annual mean	24-hour mean	Annual mean	24-hour mean	Annual mean	Annual mean
National Standards		10mg/m^3	200µg/m^3			50µg/m^3				
Auckland Targets	30mg/m^3			100µg/m^3	40µg/m^3		20µg/m^3	25µg/m^3	10µg/m^3	3.6µg/m^3
Receptor 1: Cnr of Mill Road and Alfriston Road (316710, 5901280)										
2011	5.6	2.8	104.4	46.9	16.0	41.7	17.2	31.0	8.4	2.8
DM2026	5.3	2.6	96.4	45.0	15.4	41.0	16.9	30.5	8.2	2.2
DS2026	5.1	2.6	86.7	42.6	14.5	40.5	16.7	30.1	8.1	1.5
DM2041	5.4	2.7	96.5	45.1	15.1	41.6	17.1	31.0	8.4	2.3
DS2041	5.1	2.6	86.4	42.5	14.5	40.7	16.8	30.2	8.1	1.4
Receptor 2: Alfriston School, Mill Road (316672, 5901250)										
2011	5.4	2.7	94.5	46.8	16.1	41.7	17.2	31.0	8.4	2.8
DM2026	5.2	2.6	89.8	45.0	15.5	41.0	16.9	30.5	8.2	2.3
DS2026	5.2	2.6	88.7	42.9	14.7	40.5	16.8	30.1	8.1	1.6
DM2041	5.2	2.6	89.8	45.1	15.1	41.6	17.2	31.0	8.4	2.3
DS2041	5.2	2.6	88.5	42.8	14.6	40.8	16.8	30.3	8.2	1.6
Receptor 3: Cnr of Mill Road and Ranfurly Road (316319, 5901996)										
2011	5.3	2.7	94.3	44.6	15.4	41.1	17.0	30.5	8.3	2.2
DM2026	5.1	2.6	89.6	43.7	15.0	40.7	16.8	30.3	8.2	1.9
DS2026	5.2	2.6	88.4	43.0	14.7	40.6	16.8	30.1	8.1	1.6
DM2041	5.2	2.6	89.8	43.7	14.8	41.1	17.0	30.6	8.3	1.9
DS2041	5.2	2.6	88.5	43.1	14.7	40.9	16.9	30.4	8.2	1.6
Receptor 4: 5 Polo Prince Road (315857, 5902596)										
2011	5.6	2.8	105.0	46.3	15.8	41.5	17.1	30.9	8.4	2.5
DM2026	5.3	2.6	98.6	44.7	15.2	40.9	16.9	30.4	8.2	2.0
DS2026	5.1	2.5	84.0	41.9	14.3	40.3	16.7	30.0	8.1	1.3
DM2041	5.4	2.7	98.2	44.9	15.0	41.6	17.1	30.9	8.4	2.2
DS2041	5.1	2.5	83.9	41.9	14.3	40.4	16.7	30.0	8.1	1.3
Receptor 5: 182 Mill Road (316324, 5902462)										
2011	5.1	2.5	84.9	42.0	14.3	40.4	16.7	30.0	8.1	1.3
DM2026	5.1	2.5	83.3	41.7	14.2	40.3	16.6	29.9	8.0	1.2
DS2026	5.2	2.5	87.4	42.0	14.3	40.3	16.7	30.0	8.1	1.3
DM2041	5.1	2.5	83.2	41.7	14.2	40.4	16.7	30.0	8.1	1.2

Pollutant	Carbon monoxide		Nitrogen dioxide			Particles as PM_{10}		Particles as $PM_{2.5}$		Benzene
Averaging Period	1-hour mean	8-hour mean	1-hour mean	24-hour mean	Annual mean	24-hour mean	Annual mean	24-hour mean	Annual mean	Annual mean
National Standards		**10mg/m^3**	**200µg/m^3**			**50µg/m^3**				
Auckland Targets	**30mg/m^3**			**100µg/m^3**	**40µg/m^3**		**20µg/m^3**	**25µg/m^3**	**10µg/m^3**	**3.6µg/m^3**
DS2041	5.2	2.5	87.3	42.0	14.3	40.5	16.7	30.1	8.1	1.3
Receptor 6: 361 Redoubt Road (315301, 5903466)										
2011	5.2	2.6	88.4	42.7	14.6	40.6	16.8	30.2	8.1	1.6
DM2026	5.1	2.5	85.8	42.2	14.4	40.4	16.7	30.0	8.1	1.4
DS2026	5.2	2.6	91.5	43.6	14.9	40.7	16.8	30.3	8.2	1.8
DM2041	5.1	2.5	85.6	42.2	14.4	40.6	16.8	30.2	8.1	1.5
DS2041	5.2	2.6	91.4	43.6	14.9	41.2	17.0	30.6	8.3	1.9
Receptor 7: 323 Redoubt Road (314850, 5903540)										
2011	5.3	2.6	90.8	43.1	14.6	40.7	16.8	30.3	8.1	1.6
DM2026	5.1	2.5	87.2	42.5	14.4	40.4	16.7	30.1	8.1	1.4
DS2026	5.3	2.6	94.4	44.0	15.0	40.8	16.8	30.3	8.2	1.8
DM2041	5.1	2.6	86.4	42.4	14.3	40.7	16.8	30.2	8.1	1.4
DS2041	5.3	2.6	94.1	43.9	15.0	41.3	17.0	30.7	8.3	1.9
Receptor 8: 280 Redoubt Road (314764, 5903732)										
2011	5.4	2.7	94.8	46.3	16.0	41.6	17.2	30.9	8.4	2.9
DM2026	5.2	2.6	90.0	44.7	15.4	41.0	16.9	30.5	8.2	2.2
DS2026	5.1	2.6	86.0	42.9	14.7	40.6	16.8	30.1	8.1	1.6
DM2041	5.2	2.6	89.4	44.5	15.0	41.5	17.1	30.9	8.4	2.3
DS2041	5.1	2.6	85.8	42.9	14.7	40.9	16.9	30.4	8.2	1.7
Receptor 9: 246 Redoubt Road (314715, 5904140)										
2011	5.2	2.6	88.4	42.9	14.7	40.6	16.8	30.2	8.2	1.7
DM2026	5.1	2.5	85.2	42.2	14.5	40.4	16.7	30.0	8.1	1.4
DS2026	5.2	2.6	87.5	42.7	14.6	40.5	16.7	30.1	8.1	1.6
DM2041	5.1	2.5	85.0	42.2	14.4	40.6	16.8	30.2	8.1	1.5
DS2041	5.2	2.6	87.6	42.7	14.6	40.8	16.8	30.3	8.2	1.7
Receptor 10: 51 Murphys Road (314801, 5904251)										
2011	5.3	2.6	89.0	42.6	14.6	40.6	16.8	30.1	8.1	1.6
DM2026	5.1	2.5	86.5	42.1	14.4	40.4	16.7	30.0	8.1	1.4
DS2026	5.2	2.6	86.9	42.5	14.5	40.5	16.7	30.1	8.1	1.5
DM2041	5.1	2.6	85.8	42.0	14.3	40.5	16.8	30.1	8.1	1.4
DS2041	5.2	2.6	86.8	42.5	14.5	40.7	16.8	30.3	8.1	1.5

Pollutant	Carbon monoxide		Nitrogen dioxide			Particles as PM_{10}		Particles as $PM_{2.5}$		Benzene
Averaging Period	1-hour mean	8-hour mean	1-hour mean	24-hour mean	Annual mean	24-hour mean	Annual mean	24-hour mean	Annual mean	Annual mean
National Standards		**10mg/m³**	**200µg/m³**			**50µg/m³**				
Auckland Targets	**30mg/m³**			**100µg/m³**	**40µg/m³**		**20µg/m³**	**25µg/m³**	**10µg/m³**	**3.6µg/m³**
Receptor 11: 34 Murphys Road (314722, 5904325)										
2011	5.3	2.6	92.1	43.9	15.2	41.0	16.9	30.4	8.3	2.3
DM2026	5.1	2.5	87.8	43.2	14.9	40.6	16.8	30.2	8.2	1.9
DS2026	5.1	2.6	85.6	43.4	14.9	40.7	16.8	30.2	8.2	1.9
DM2041	5.2	2.6	87.5	43.0	14.6	40.9	16.9	30.4	8.3	2.0
DS2041	5.1	2.6	85.7	43.4	14.9	41.1	17.0	30.5	8.3	2.1
Receptor 12: 208 Redoubt Road (314373, 5904324)										
2011	5.5	2.8	97.6	46.4	15.7	41.7	17.1	31.0	8.4	2.8
DM2026	5.2	2.6	89.6	44.2	15.0	40.9	16.8	30.4	8.2	2.0
DS2026	5.3	2.6	93.2	43.9	14.9	40.8	16.8	30.3	8.2	1.8
DM2041	5.2	2.6	89.3	44.2	14.8	41.4	17.0	30.8	8.3	2.1
DS2041	5.3	2.6	92.6	43.9	14.8	41.3	16.9	30.7	8.3	1.9
Receptor 13: 170 Redoubt Road (313917, 5904372)										
2011	5.6	2.8	102.8	46.2	15.7	41.7	17.1	31.0	8.4	2.9
DM2026	5.3	2.6	92.6	44.0	15.0	40.8	16.8	30.3	8.2	2.0
DS2026	5.2	2.6	90.5	43.5	14.8	40.7	16.8	30.3	8.2	1.8
DM2041	5.3	2.6	92.4	44.1	14.8	41.4	17.0	30.8	8.3	2.1
DS2041	5.2	2.6	89.9	43.5	14.8	41.1	16.9	30.6	8.3	1.9
Receptor 14: 189 Redoubt Road (313973, 5904309)										
2011	5.2	2.6	88.3	43.3	14.8	40.8	16.8	30.3	8.2	1.8
DM2026	5.1	2.5	84.6	42.3	14.5	40.4	16.7	30.0	8.1	1.4
DS2026	5.2	2.6	88.9	44.1	15.0	40.8	16.8	30.4	8.2	2.0
DM2041	5.1	2.6	84.5	42.2	14.4	40.6	16.8	30.2	8.1	1.5
DS2041	5.2	2.6	88.6	44.0	15.0	41.4	17.0	30.7	8.3	2.1
Receptor 15: 156 Redoubt Road (313640, 5904389)										
2011	5.3	2.7	91.8	45.6	15.6	41.5	17.1	30.8	8.4	2.8
DM2026	5.1	2.6	86.9	43.6	15.0	40.7	16.8	30.3	8.2	2.0
DS2026	5.2	2.6	88.2	43.4	14.9	40.7	16.8	30.2	8.2	1.9
DM2041	5.2	2.6	86.7	43.6	14.7	41.2	17.0	30.6	8.3	2.1
DS2041	5.2	2.6	87.5	43.3	14.8	41.0	16.9	30.5	8.2	1.9

Pollutant	Carbon monoxide		Nitrogen dioxide			Particles as PM_{10}		Particles as $PM_{2.5}$		Benzene
Averaging Period	1-hour mean	8-hour mean	1-hour mean	24-hour mean	Annual mean	24-hour mean	Annual mean	24-hour mean	Annual mean	Annual mean
National Standards		**10mg/m^3**	**200µg/m^3**			**50µg/m^3**				
Auckland Targets	**30mg/m^3**			**100µg/m^3**	**40µg/m^3**		**20µg/m^3**	**25µg/m^3**	**10µg/m^3**	**3.6µg/m^3**
Receptor 16: 141 Redoubt Road (313443, 5904276)										
2011	5.5	2.8	98.2	46.3	15.4	41.7	17.0	31.0	8.3	2.5
DM2026	5.2	2.6	90.5	44.1	14.8	40.9	16.8	30.4	8.1	1.8
DS2026	5.5	2.7	101.2	46.7	15.5	41.5	17.0	30.8	8.3	2.4
DM2041	5.2	2.6	90.0	43.5	14.6	41.3	16.9	30.7	8.2	1.9
DS2041	5.4	2.7	99.6	46.2	15.3	42.3	17.2	31.4	8.4	2.5
Receptor 17: 1 Santa Monica Place (313107, 5904321)										
2011	5.8	2.9	109.2	49.8	16.9	42.7	17.5	31.8	8.6	4.1
DM2026	5.3	2.7	96.7	46.0	15.6	41.3	17.0	30.7	8.3	2.6
DS2026	5.4	2.7	98.0	45.7	15.4	41.3	16.9	30.7	8.3	2.4
DM2041	5.4	2.7	96.0	45.8	15.3	42.1	17.3	31.3	8.5	2.8
DS2041	5.4	2.7	96.7	45.4	15.3	41.9	17.1	31.2	8.4	2.5
Receptor 18: 12 Elsted Place (313244, 5904295)										
2011	5.4	2.7	94.6	44.1	15.1	41.0	16.9	30.5	8.3	2.2
DM2026	5.2	2.6	88.3	42.8	14.6	40.5	16.8	30.1	8.1	1.6
DS2026	5.3	2.6	92.0	43.9	15.1	40.8	16.9	30.3	8.2	2.0
DM2041	5.2	2.6	87.9	42.6	14.5	40.8	16.9	30.3	8.2	1.7
DS2041	5.3	2.6	91.2	43.6	15.0	41.2	17.0	30.6	8.3	2.1
Receptor 19: 2 Everglade Drive (312808, 5904147)										
2011	5.6	2.8	101.0	47.9	16.5	42.2	17.4	31.4	8.6	3.8
DM2026	5.2	2.6	91.6	44.9	15.4	41.0	16.9	30.5	8.2	2.4
DS2026	5.3	2.7	94.5	45.1	15.6	41.1	17.0	30.5	8.3	2.6
DM2041	5.3	2.6	91.3	44.8	15.1	41.7	17.2	31.0	8.4	2.6
DS2041	5.3	2.6	93.3	44.8	15.5	41.6	17.2	31.0	8.4	2.7
Receptor 20: 38 Redoubt Road (312575 , 5904123)										
2011	5.7	2.9	106.4	50.8	17.4	43.0	17.6	32.0	8.7	4.5
DM2026	5.3	2.7	95.0	46.4	15.9	41.4	17.0	30.8	8.3	2.8
DS2026	5.4	2.7	96.0	46.9	16.0	41.5	17.1	30.9	8.4	2.9
DM2041	5.3	2.7	94.3	46.4	15.5	42.3	17.4	31.5	8.6	3.0
DS2041	5.3	2.7	94.8	46.5	15.9	42.3	17.4	31.5	8.6	3.0

Pollutant	Carbon monoxide		Nitrogen dioxide			Particles as PM_{10}		Particles as $PM_{2.5}$		Benzene
Averaging Period	1-hour mean	8-hour mean	1-hour mean	24-hour mean	Annual mean	24-hour mean	Annual mean	24-hour mean	Annual mean	Annual mean
National Standards		**10mg/m^3**	**200µg/m^3**			**50µg/m^3**				
Auckland Targets	**30mg/m^3**			**100µg/m^3**	**40µg/m^3**		**20µg/m^3**	**25µg/m^3**	**10µg/m^3**	**3.6µg/m^3**
Receptor 21: 22 Redoubt Road (312403, 5904067)										
2011	5.8	2.9	108.4	51.6	17.7	43.2	17.7	32.1	8.8	4.8
DM2026	5.3	2.7	95.9	46.6	16.0	41.5	17.1	30.8	8.4	2.9
DS2026	5.4	2.7	96.4	47.5	16.2	41.7	17.1	31.0	8.4	3.1
DM2041	5.3	2.7	95.3	47.0	15.6	42.5	17.4	31.6	8.6	3.1
DS2041	5.3	2.7	95.8	47.0	16.0	42.5	17.4	31.6	8.6	3.2
Receptor 22: 12 Redoubt Road (312268, 5904022)										
2011	5.8	2.9	107 8	51.7	17.7	43.1	17.7	32.1	8.8	4.6
DM2026	5.3	2.7	95.8	46.4	15.9	41.4	17.1	30.8	8.3	2.7
DS2026	5.4	2.7	96.5	47.7	16.3	41.7	17.2	31.0	8.4	3.0
DM2041	5.3	2.7	95.1	47.1	15.6	42.4	17.4	31.5	8.6	3.0
DS2041	5.3	2.7	96.9	47.2	16.1	42.5	17.4	31.6	8.6	3.1

Appendix C

Predicted Change in Pollutant Concentrations

Appendix C Predicted Change in Pollutant Concentrations

Pollutant	Carbon monoxide		Nitrogen dioxide			Particles as PM_{10}		Particles as $PM_{2.5}$		Benzene
Averaging Period	1-hour mean	8-hour mean	1-hour mean	24-hour mean	Annual mean	24-hour mean	Annual mean	24-hour mean	Annual mean	Annual mean
Receptor 1: Cnr of Mill Road and Alfriston Road (316710, 5901280)										
DM/DS2026	-0.2	0.0	-9.7	-2.4	-0.9	-0.5	-0.2	-0.4	-0.1	-0.7
DM/DS 2041	-0.3	-0.1	-10.1	-2.6	-0.6	-0.9	-0.3	-0.8	-0.3	-0.9
Receptor 2: Alfriston School, Mill Road (316672, 5901250)										
DM/DS2026	0.0	0.0	-1.1	-2.1	-0.8	-0.5	-0.1	-0.4	-0.1	-0.7
DM/DS 2041	0.0	0.0	-1.3	-2.3	-0.5	-0.8	-0.4	-0.7	-0.2	-0.7
Receptor 3: Cnr of Mill Road and Ranfurly Road (316319, 5901996)										
DM/DS2026	+0.1	0.0	-1.2	-0.7	-0.3	-0.1	0.0	-0.2	-0.1	-0.3
DM/DS 2041	0.0	0.0	-1.3	-0.6	-0.1	-0.2	-0.1	-0.2	-0.1	-0.3
Receptor 4: 5 Polo Prince Road (315857, 5902596)										
DM/DS2026	-0.2	-0.1	-14.6	-2.8	-0.9	-0.6	-0.2	-0.4	-0.1	-0.7
DM/DS 2041	-0.3	-0.2	-14.3	-3.0	-0.7	-1.2	-0.4	-0.9	-0.3	-0.9
Receptor 5: 182 Mill Road (316324, 5902462)										
DM/DS2026	+0.1	0.0	+4.1	+0.3	+0.1	0.0	+0.1	+0.1	+0.1	+0.1
DM/DS 2041	+0.1	0.0	+4.1	+0.3	+0.1	+0.1	0.0	+0.1	0.0	+0.1
Receptor 6: 361 Redoubt Road (315301, 5903466)										
DM/DS2026	+0.1	+0.1	+5.7	+1.4	+0.5	+0.3	+0.1	+0.3	+0.1	+0.4
DM/DS 2041	+0.1	+0.1	+5.8	+1.4	+0.5	+0.6	+0.2	+0.4	+0.2	+0.4
Receptor 7: 323 Redoubt Road (314850, 5903540)										
DM/DS2026	+0.2	+0.1	+7.2	+1.5	+0.6	+0.4	+0.1	+0.2	+0.1	+0.4
DM/DS 2041	+0.2	0.0	+7.7	+1.5	+0.7	+0.6	+0.2	+0.5	+0.2	+0.5
Receptor 8: 280 Redoubt Road (314764, 5903732)										
DM/DS2026	-0.1	0.0	-4.0	-1.8	-0.7	-0.4	-0.1	-0.4	-0.1	-0.6
DM/DS 2041	-0.1	0.0	-3.6	-1.6	-0.3	-0.6	-0.2	-0.5	-0.2	-0.6
Receptor 9: 246 Redoubt Road (314715, 5904140)										
DM/DS2026	+0.1	+0.1	+2.3	+0.5	+0.1	+0.1	0.0	+0.1	0.0	+0.2
DM/DS 2041	+0.1	+0.1	+2.6	+0.5	+0.2	+0.2	0.0	+0.1	+0.1	+0.2
Receptor 10: 51 Murphys Road (314801, 5904251)										
DM/DS2026	+0.1	+0.1	+0.4	+0.4	+0.1	+0.1	0.0	+0.1	0.0	+0.1
DM/DS 2041	+0.1	0.0	+1.0	+0.5	+0.2	+0.2	0.0	+0.2	0.0	+0.1
Receptor 11: 34 Murphys Road (314722, 5904325)										
DM/DS2026	0.0	+0.1	-2.2	+0.2	0.0	+0.1	0.0	0.0	0.0	0.0
DM/DS 2041	-0.1	0.0	-1.8	+0.4	+0.3	+0.2	+0.1	+0.1	0.0	+0.1

Pollutant	Carbon monoxide		Nitrogen dioxide			Particles as PM_{10}		Particles as $PM_{2.5}$		Benzene
Averaging Period	1-hour mean	8-hour mean	1-hour mean	24-hour mean	Annual mean	24-hour mean	Annual mean	24-hour mean	Annual mean	Annual mean
Receptor 12: 208 Redoubt Road (314373, 5904324)										
DM/DS2026	+0.1	0.0	+3.6	-0.3	-0.1	-0.1	0.0	-0.1	0.0	-0.2
DM/DS 2041	+0.1	0.0	+3 3	-0.3	0.0	-0.1	-0.1	-0.1	0.0	-0.2
Receptor 13: 170 Redoubt Road (313917, 5904372)										
DM/DS2026	-0.1	0.0	-2.1	-0.5	-0.2	-0.1	0.0	0.0	0.0	-0.2
DM/DS 2041	-0.1	0.0	-2.5	-0.6	0.0	-0.3	-0.1	-0.2	0.0	-0.2
Receptor 14: 189 Redoubt Road (313973, 5904309)										
DM/DS2026	+0.1	+0.1	+4 3	+1.8	+0.5	+0.4	+0.1	+0.4	+0.1	+0.6
DM/DS 2041	+0.1	0.0	+4.1	+1.8	+0.6	+0.8	+0.2	+0.5	+0 2	+0.6
Receptor 15: 156 Redoubt Road (313640, 5904389)										
DM/DS2026	+0.1	0.0	+1 3	-0.2	-0.1	0.0	0.0	-0.1	0.0	-0.1
DM/DS 2041	0.0	0.0	+0 8	-0.3	0.1	-0.2	-0.1	-0.1	-0.1	-0.2
Receptor 16: 141 Redoubt Road (313443, 5904276)										
DM/DS2026	+0.3	+0.1	+10.7	+2.6	+0.7	+0.6	+0.2	+0.4	+0 2	+0.6
DM/DS 2041	+0.2	+0.1	+9.6	+2.7	+0.7	+1.0	+0.3	+0.7	+0 2	+0.6
Receptor 17: 1 Santa Monica Place (313107, 5904321)										
DM/DS2026	+0.1	0.0	+1 3	-0.3	-0.2	0.0	-0.1	0.0	0.0	-0.2
DM/DS 2041	0.0	0.0	+0.7	-0.4	0.0	-0.2	-0.2	-0.1	-0.1	-0.3
Receptor 18: 12 Elsted Place (313244, 5904295)										
DM/DS2026	+0.1	0.0	+3.7	+1.1	+0.5	+0.3	+0.1	+0.2	+0.1	+0.4
DM/DS 2041	+0.1	0.0	+3 3	+1.0	+0.5	+0.4	+0.1	+0.3	+0.1	+0.4
Receptor 19: 2 Everglade Drive (312808, 5904147)										
DM/DS2026	+0.1	+0.1	+2 9	+0.2	+0.2	+0.1	+0.1	0.0	+0.1	+0.2
DM/DS 2041	0.0	0.0	+2 0	0.0	+0.4	-0.1	0.0	0.0	0.0	+0.1
Receptor 20: 38 Redoubt Road (312575 , 5904123)										
DM/DS2026	+0.1	0.0	+1 0	+0.5	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1
DM/DS 2041	0.0	0.0	+0 5	+0.1	+0.4	0.0	0.0	0.0	0.0	0.0
Receptor 21: 22 Redoubt Road (312403, 5904067)										
DM/DS2026	+0.1	0.0	+0 5	+0.9	+0.2	+0.2	0.0	+0.2	0.0	+0.2
DM/DS 2041	0.0	0.0	+0.5	0.0	+0.4	0.0	0.0	0.0	0.0	+0.1
Receptor 22: 12 Redoubt Road (312268, 5904022)										
DM/DS2026	+0.1	0.0	+0.7	+1.3	+0.4	+0.3	+0.1	+0.2	+0.1	+0.3
DM/DS 2041	0.0	0.0	+1.8	+0.1	+0.5	+0.1	0.0	+0.1	0.0	+0.1