Report

NZTA Tier 2 Screening Toolkit Validation

Prepared for NZ Transport Agency (NZTA)

By Beca Infrastructure Ltd (Beca)

7 October 2011

Revision History

Revision Nº	Prepared By	Description	Date
A	Mathew Noonan	Final report	10/10/11

Document Acceptance

Action	Name	Signed	Date
Prepared by	Mathew Noonan	[signature]	10/10/11
Reviewed by	Camilla Needham	[signature]	10/10/11
Approved by	Brent Meekan	[signature]	10/10/11
on behalf of	Beca Infrastructure Ltd		

Table of Contents

List of Figures

List of Tables

1 Introduction

The NZ Transport Agency (NZTA) has developed a web-based based screening tool (the “NZTA Air Quality Screening Toolkit for Tier 2 Assessment”) for the assessment of roading projects. The toolkit has been designed to assess the air quality risk associated with a road project at a level equivalent to a Tier 2 assessment. The screening tool assessed here is a Beta test version.

NZTA has commission Beca Infrastructure Ltd (Beca) to undertake a preliminary validation exercise of the screening tool using the SH16 Huruhuru Road Bridge to Hobsonville Tier 3 Assessment prepared by Beca in 2010 as a test case. The objective of the assessment is to assess whether the air quality effect predicted by the Tier 2 screening tool are conservative when compared to a full Tier 3 assessment and if so by what degree.

1.1 Scope of the Assessment

The screening tool predicts ground level concentrations of PM_{10}, $PM_{2.5}$ and NO_2. This assessment compares the air pollutant concentrations predicted using the Tier 2 screening tool against those predicted in the Tier 3 assessment.

Maximum 24-hour average concentrations of PM_{10} and $PM_{2.5}$ and annual average concentrations of NO_2 have been compared.

2 Project Description and Tier 3 assessment methodology

This section provides a brief description of the SH16 Huruhuru Road Bridge to Hobsonville Project and the methodology used in the Tier 3 air quality assessment of the Project. A full description of the scope and the methodology of the Tier 3 assessment is documented in the Air Quality Assessment Report (Beca, 2010)

2.1 Description of the Proposed Development

The upgrade of the existing Motorway between the Huruhuru Road Bridge and Westgate forms part of the Western Ring Route, one of NZ Transport Agency's (NZTA)'s Roads of National Significance (RONS). The Project encompasses almost 1.8km of carriageway widening and 2.7km of new off-road cycleway, including up-grades to the Royal Road Interchange and the replacement of the existing Royal Road Bridge.

The existing motorway consists of a divided carriageway with two general purpose 3.5m wide traffic lanes in each direction, and a 3m wide median dividing the two carriageways. This project aims to widen the motorway to three general-purpose 3.5m wide traffic lanes with a 3.5m bus shoulder in each direction, and a 3.0m wide cycleway running along the westbound carriageway. The overall motorway footprint is expected to increase in width varying between approximately 10 to 14m over the project area.

The existing Royal Road Interchange layout will be upgraded and improved to meet predicted future traffic growth demands, whilst improving the safe operation of the interchange.

Figure 1 shows the proposed development. The scope of the Tier 3 assessment is indicated in the figure by the two red vertical lines crossing SH16 after Huruhuru Road and before the Hobsonville Road interchange.

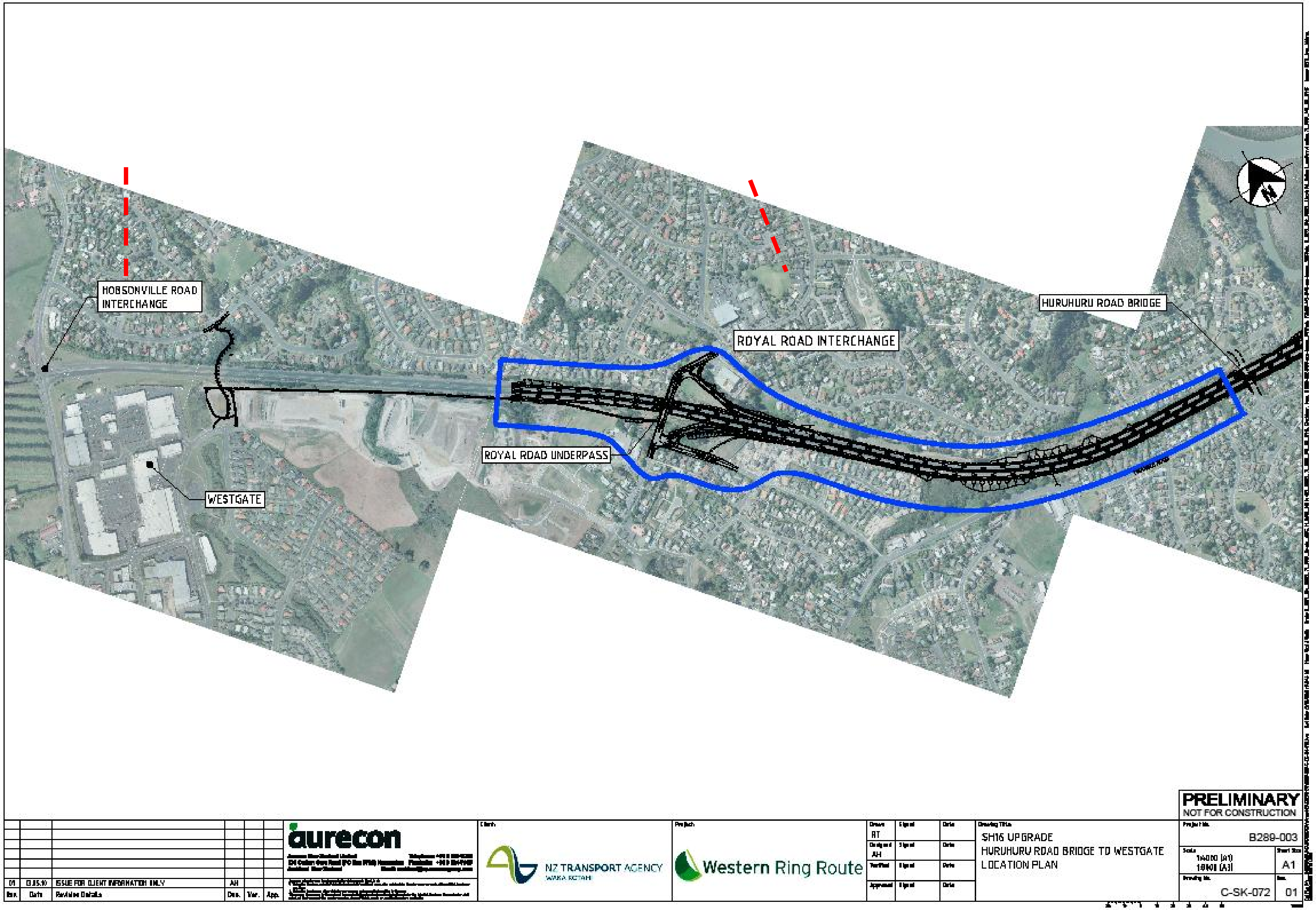

Figure 1. The Proposed Widening of State Highway 16 near the Royal Road Interchange (Courtesy of Aurecon/NZTA)

2.2 Tier 3 Assessment Methodology

The Tier 3 Assessment was based on predictions using the AUSROADS dispersion model. The AUSROADS dispersion model was run using a 1-year meteorological input representative of local dispersion conditions. The meteorological input file was developed by NIWA based on the outputs of a fine scale CALMET meteorological model.

Three traffic scenarios were assessed in the dispersion modelling assessment:

- Baseline 2006
- 2026 With Project (2026 WP)
- 2026 Do Minimum (2026 DM)

The 2026 With Project scenario assumes, in addition to SH16 not being widened, other associated projects (for example the Waterview Connection) have also not been completed, including the development and realignment of the Lincoln Road interchange.

For each of the road links included in the dispersion model week day diurnal hourly traffic flows and emission profiles were constructed. Traffic volumes, traffic speeds, and the proportion of vehicles which were heavy vehicles were based on the output of Project traffic model. Vehicle emission rates were predicted using the VEPM v3 (2009) emission model using the output of the traffic model.

VEPM does not directly calculated $PM_{2.5}$ emission rates. Therefore, $PM_{2.5}$ emission rates were calculated assuming that 75% of the total (exhaust, and brake and tyre) PM_{10} emissions were $PM_{2.5}$.

2.2.1 Dispersion model configuration

Pollutant concentrations were predicted for three general areas in the vicinity of SH16. For each area separate dispersion model configurations were developed. These areas are:

1. The existing residential properties to the south of the Royal Road interchange (“south residential area”).
2. Current and future residential properties to the north of the Royal Road interchange (“north residential area”).
3. The Royal Road Primary School and Preschool and residential properties near the Royal Road Interchange (’interchange area”).

For the south and north residential areas only the contribution from vehicles travelling along SH16 to ambient air pollutant levels has been predicted.

For the assessment of air quality at the Royal Road Primary School and Preschool and nearby residential properties, vehicle emissions from Royal Road and Makora Road were also included in the model. A significant proportion of the traffic on Royal Road and Makora Road is associated with vehicles either exiting or turning onto SH16. These roads were included in the dispersion model in order to assess the cumulative effect of changes to traffic flows on the motorway and associated feeder roads at the school.

As a consequence of the distinctive diurnal profiles associated with northbound and southbound traffic, and the fact that SH16 has separate carriageways for northbound and southbound traffic, the northbound and southbound lanes of the motorway were modelled as separate line sources.

2.2.2 South Residential Area

Figure 2 shows the modelled line sources used to assess potential impacts in the residential areas on both sides of SH16 south of Royal Road. The northbound and southbound carriageways of SH16 have both been modelled as eight linked line sources (to represent the changes in surface topography between Huruhuru Road and the Royal Road interchange). The separation of the northbound and southbound line sources was increased for the 2026 ‘with project’ to account for the addition of the extra northbound and southbound lanes. Each line source was assumed to be “at grade” with the exception of a section of SH16 adjacent to Cedar Heights Avenue, which was defined as being “depressed” by 10m to represent the higher elevations of the residential properties to the east of the motorway. Discrete receptors were located in residential areas in the immediate vicinity of SH16 at distances of 30m, 50m, 75m and 100m from the centre line of SH16.

A summary of the daily average traffic parameters is shown in Table 1. These parameters were also used as inputs in the screening tool assessment.

Table 1. Summary of the South Residential Area Model Traffic Parameters

Scenario	Link	Average Daily Traffic Volumes (AADT)	% Heavy Vehicles	Average Vehicle Speed (km/hr)
2006	SH16	61,000	8%	96
2026 WP	SH16	96,200	11%	96
2026 DM	SH16	86,500	12%	94

2.2.3 North Residential Area

Figure 3 shows the modelled line sources used to assess potential air quality impacts in the residential areas both sides of SH16 to the north of Royal Road. The northbound and southbound carriageways of SH16 have both been modelled as separate line sources. Each line source was assumed to be “at grade”. The fence line of the closest residential property was assumed to be 25m from the centreline of SH16.

Pollutant levels discrete receptors were located in residential areas in the immediate vicinity of the SH16 at distances of 25m, 30m, 50m, 75m and 100m from the centre line of SH16. A discrete receptor height of 1.8m was used in the assessment.

A summary of the daily average traffic parameters is shown in Table 2**Error! Reference source not found.**. These parameters were also used as inputs in the screening tool assessment.

Table 2. Summary of the North Residential Area Model Traffic Parameters

Scenario	Link	AADT	% Heavy Vehicles	Average Vehicle Speed (km/hr)
2006	SH16	42,500	8%	96
2026 WP	SH16	75,300	11%	96
2026 DM	SH16	68,800	12%	96

Figure 2. Location of dispersion modelling line sources south of the Royal Road interchange

2.2.4 Interchange Area

Figure 4 shows the line sources and discrete receptors (red crosses) used to assess potential air quality impacts near the Royal Road interchange. Lines sources were defined for SH16 and the two roads closest to the Royal Road Primary and Preschool (Makora Road and Royal Road). Most of the modelled line sources were assumed to be “at grade” with the exception of sections of the SH16 running under Royal Road Bridge which were assumed to be depressed by 5 – 10m, and the bridge section of Royal Road.

Pollutant concentrations were predicted at two discrete receptor points located at Royal Road Primary School; the first receptor point corresponds to the closest building to Royal Road and SH16 (RRP1), while the second corresponds to the closest point on the school’s playing field to SH16 (RRP2). Three additional receptor points were defined at residential properties located near to SH16 and Royal Road (H1 to H3). In the model, the receptor points H1 to H3 are sited near the residential property fence lines, where the pollutant levels are expected to highest.

Links and Receptors selected for Validation exercise

For the validation exercise, pollutant concentrations predicted at the RRP1, H1 and H2 receptors have been compared against the screening model predictions. These sites have been chosen due to the proximity to Royal Road, and the proximity to the Royal Road Bridge and the depressed section of the motorway. Both of the bridge section and depressed section of the motorway has an effect of the way pollutant dispersion rates are modelled by AUSROADS.

Figure 3. Location of dispersion modelling line sources north of the Royal Road interchange

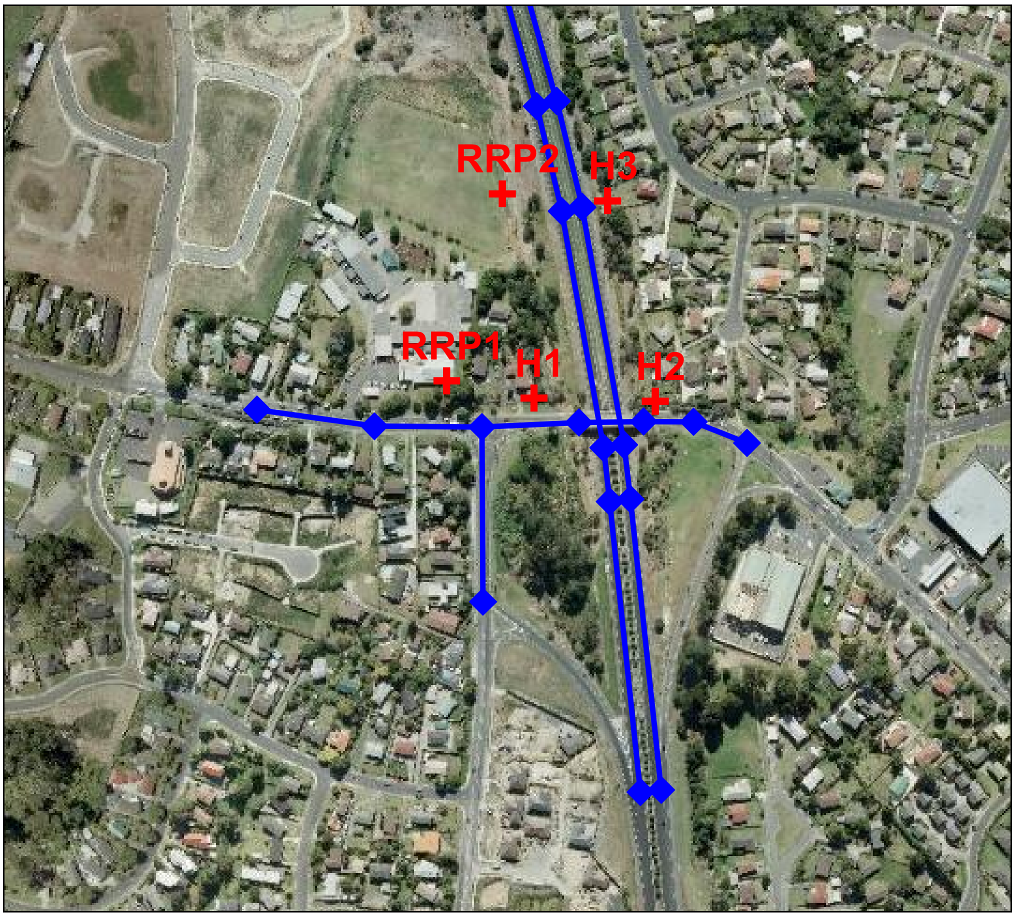

Figure 4. Location of dispersion modelling line sources near the Royal Road interchange

A summary of the daily average traffic parameters for the interchange area is shown in Table 3. These parameters were also used as inputs in the screening tool assessment.

Table 3. Summary of the Interchange Area Model Traffic Parameters

Scenario	Link	AADT	% Heavy Vehicles	Average Vehicle Speed (km/hr)
2006	SH16	42,500	8%	96
	Royal Rd (west of Makora Rd)	7,800	4%	29
	Royal Rd (east of Makora Rd)	11,500	7%	16
	Makora Rd	16,700	7%	16
2026 WP	SH16	75,300	11%	96
	Royal Rd (west of Makora Rd)	12,400	6%	27
	Royal Rd (east of Makora Rd)	21,500	7%	28
	Makora Rd	14,600	8%	14
2026 DM	SH16	68,800	12%	96
	Royal Rd (west of Makora Rd)	11,000	6%	27
	Royal Rd (east of Makora Rd)	19,400	8%	32
	Makora Rd	13,400	8%	15

3 Summary of Results

3.1 Comparison of Predicted PM_{10} concentrations

3.1.1 South Residential Area

Maximum 24-hour average PM_{10} concentrations predicted using the screening tool and the AUSROADS model in the southern residential area are shown in Table 4, Table 5 and Table 6 for the 2006 scenario, 2026 WP, and 2026 DM scenarios respectively. The tables also show the ratio of predicted concentrations using the screening tool to those predicted using the Tier 3 model. Toolkit calculations are based on distance from the kerbside, while the AUSROADS modelling was based on distance from the centreline.

Table 4. Predicted maximum 24-hour average PM_{10} concentrations in the southern residential areas, 2006

Distance from SH16 centre line	Distance from Kerbside	Maximum 24-hour PM_{10} concentration (µg/m³)		
		Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
30m	21m	7.2	3.7	1.9
50m	41m	4.2	2.4	1.8
75m	66m	2.5	1.7	1.5
100m	91m	1.6	1.4	1.1

Table 5. Predicted maximum 24-hour average PM_{10} concentrations in southern the residential areas, 2026 With Project

Distance from SH16 centre line	Distance from Kerbside	Maximum 24-hour PM_{10} concentration (µg/m³)		
		Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
30m	17m	7.8	3.4	2.3
50m	37m	4.3	2.1	2.0
75m	62m	2.5	1.5	1.7
100m	87m	1.6	1.2	1.3

Table 6. Predicted maximum 24-hour average PM_{10} concentrations in the southern residential areas, 2026 Do Minimum

Distance from SH16 centre line	Distance from Kerbside	Maximum 24-hour PM_{10} concentration (µg/m³)		
		Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
30m	17m	7.0	2.6	2.7
50m	37m	3.9	1.7	2.3
75m	62m	2.3	1.2	1.9
100m	87m	1.5	0.9	1.7

3.1.2 South Residential Area

Maximum 24-hour average PM_{10} concentrations predicted using the screening tool and the AUSROADS model in the southern residential area for the 2006, 2026 WP and 2026 DM are shown in Table 7, Table 8, and Table 9 respectively.

Table 7. Predicted maximum 24-hour average PM_{10} concentrations in the northern residential areas, 2006

Distance from SH16 centre line	Distance from Kerbside	Maximum 24-hour PM_{10} concentration		
		Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
25m	15m	6.2	3.2	1.9
30m	20m	5.2	2.8	1.9
50m	40m	3.0	1.9	1.6
75m	65m	1.8	1.3	1.4
100m	90m	1.1	1.0	1.1

Table 8. Predicted maximum 24-hour average PM_{10} concentrations in the northern residential areas, 2026 With Project

Distance from SH16 centre line	Distance from Kerbside	Maximum 24-hour PM_{10} concentration		
		Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
25m	12m	7.4	3.3	2.2
30m	17m	6.1	2.9	2.1
50m	37m	3.4	1.8	1.9
75m	62m	2.0	1.3	1.6
100m	87m	1.3	0.9	1.4

Table 9. Predicted maximum 24-hour average PM_{10} concentrations in the northern residential areas, 2026 Do Minimum

Distance from SH16 centre line	Distance from Kerbside	Maximum 24-hour PM_{10} concentration		
		Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
25m	12m	6.8	3.1	2.2
30m	17m	5.6	2.7	2.1
50m	37m	3.1	1.7	1.8
75m	62m	1.8	1.2	1.5
100m	87m	1.2	0.9	1.4

3.1.3 Royal Rd Interchange Area

Maximum 24-hour average PM_{10} concentrations predicted using the screening tool and the Tier 3 model for receptors RRP1, H1 and H2 (refer Figure 4) are shown for the 2006 and 2026 scenarios in Table 10, Table 11, and Table 12. Tier 3 model predictions are calculated from the cumulative contribution of traffic from SH16, Royal Rd and Makora Rd.

In contrast, the screening tool only predicts the pollutant levels associated with a single road source. The screening tool does not assess the contribution that multiple road sources may make to air pollutant levels at a particular receptor point. The screening tool currently provides no guidance as to how, or even if, cumulative effects from multiple road sources should be assessed using the toolkit.

In Table 10, Table 11, Table 12 the maximum 24-hour average PM_{10} concentration associated with emissions from SH16 and Royal Rd have been presented separately. An estimate of cumulative effect has also been calculated as the sum of the maximum concentration predicted for each of the roads. This approach is expected to be conservative as it takes no account of the geometrical relationship of the receptors and road sources to each other and whether the receptor will be potentially downwind of one or both of sources during worst case dispersion conditions.

It should be noted that the traffic volume on Royal Rd east of Makora Rd is significantly higher than on Royal Rd west of Makora Rd (refer Table 3). The contribution from Royal Rd to PM_{10} concentrations at receptor RRP1 has been calculated based on the Royal Rd west traffic volume although concentrations at the receptor are also likely to be influenced by higher traffic volumes on Royal Rd east of Makora Rd, and Makora Rd which are unaccounted for in the predictions.

Table 10. Predicted maximum 24-hour average PM_{10} concentrations in the Royal Rd interchange area, 2006

Receptor	Source	Distance from Kerbside	Maximum 24-hour PM_{10} concentration		
			Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
H1	SH16	24m	4.6	3.1	1.5
	Royal Rd (east)	11m	3.3		1.1
	Sum	NA	7.9		2.6
H2	SH16	40m	3.0	1.9	1.6
	Royal Rd (east)	16m	2.6		1.4
	Sum	NA	5.6		3.0
RRP1	SH16	98m	1.0	1.1	0.9
	Royal Rd (west)	28m	0.9		0.9
	Sum	NA	1.9		1.8

Table 11. Predicted maximum 24-hour average PM_{10} concentrations in the Royal Rd interchange area, 2026 With Project

Receptor	Source	Distance from Kerbside	Maximum 24-hour PM_{10} concentration		
			Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
H1	SH16	23m	5.0	2.9	1.7
	Royal Rd (east)	11m	1.9		0.7
	Sum	NA	6.9		2.4
H2	SH16	37m	3.4	1.7	2.1
	Royal Rd (east)	16m	1.6		1.0
	Sum	NA	5.0		3.0
RRP1	SH16	95m	1.1	0.9	1.3
	Royal Rd (west)	28m	0.6		0.7
	Sum	NA	1.7		2.0

Table 12. Predicted maximum 24-hour average PM_{10} concentrations in the Royal Rd interchange area, 2026 Do Minimum

Receptor	Source	Distance from Kerbside	Maximum 24-hour PM_{10} concentration		
			Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
H1	SH16	24m	4.4	2.4	1.9
	Royal Rd (east)	11m	1.7		0.7
	Sum	NA	6.1		2.6
H2	SH16	40m	2.9	1.4	2.1
	Royal Rd (east)	16m	1.4		1.0
	Sum	NA	4.3		3.1
RRP1	SH16	98m	1.0	0.7	1.4
	Royal Rd (west)	28m	0.5		0.7
	Sum	NA	1.5		2.1

3.2 Comparison of Predicted $PM_{2.5}$ concentrations

3.2.1 South Residential Area

Maximum 24-hour average $PM_{2.5}$ concentrations predicted using the screening tool and the Tier 3 model in the southern residential area are shown in Table 13 for the 2006 scenario, Table 14 for the 2026 with project scenario, and Table 15 for the 2026 do minimum scenario.

Table 13. Predicted maximum 24-hour average $PM_{2.5}$ concentrations in the southern residential areas, 2006

Distance from SH16 centre line	Distance from Kerbside	Maximum 24-hour $PM_{2.5}$ concentration		
		Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
30m	21m	7.0	2.8	2.5
50m	41m	4.1	1.8	2.3
75m	66m	2.4	1.3	1.9
100m	91m	1.6	1.1	1.5

Table 14. Predicted maximum 24-hour average $PM_{2.5}$ concentrations in the southern residential areas, 2026 With Project

Distance from SH16 centre line	Distance from Kerbside	Maximum 24-hour $PM_{2.5}$ concentration		
		Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
30m	17m	5.9	2.6	2.3
50m	37m	3.3	1.6	2.1
75m	62m	1.9	1.1	1.7
100m	87m	1.2	0.9	1.3

Table 15. Predicted maximum 24-hour average $PM_{2.5}$ concentrations in the southern residential areas, 2026 Do Minimum

Distance from SH16 centre line	Distance from Kerbside	Maximum 24-hour $PM_{2.5}$ concentration		
		Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
30m	17m	5.3	2.0	2.7
50m	37m	2.9	1.3	2.3
75m	62m	1.7	0.9	1.9
100m	87m	1.1	0.7	1.6

3.2.2 North Residential Area

Maximum 24-hour average $PM_{2.5}$ concentrations predicted using the screening tool and the Tier 3 model in the northern residential area are shown for the 2006, 2026 WP and 2026 DM scenarios in Table 16, Table 17, and Table 18 respectively.

Table 16. Predicted maximum 24-hour average $PM_{2.5}$ concentrations in the northern residential areas, 2006

Distance from SH16 centre line	Distance from Kerbside	Maximum 24-hour $PM_{2.5}$ concentration		
		Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
25m	15m	6.1	2.4	2.5
30m	20m	5.1	2.1	2.4
50m	40m	2.9	1.4	2.0
75m	65m	1.7	1.0	1.7
100m	90m	1.1	0.8	1.5

Table 17. Predicted maximum 24-hour average $PM_{2.5}$ concentrations in the northern residential areas, 2026 With Project

Distance from SH16 centre line	Distance from Kerbside	Maximum 24-hour $PM_{2.5}$ concentration		
		Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
25m	12m	5.6	2.5	2.2
30m	17m	4.6	2.2	2.1
50m	37m	2.6	1.4	1.9
75m	62m	1.5	0.9	1.6
100m	87m	1.0	0.7	1.4

Table 18. Predicted maximum 24-hour average $PM_{2.5}$ concentrations in the northern residential areas, 2026 Do Minimum

Distance from SH16 centre line	Distance from Kerbside	Maximum 24-hour $PM_{2.5}$ concentration		
		Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
25m	12m	5.1	2.3	2.2
30m	17m	4.2	2.0	2.1
50m	37m	2.3	1.3	1.8
75m	62m	1.4	0.9	1.6
100m	87m	0.9	0.7	1.4

3.2.3 Royal Rd Interchange Area

Maximum 24-hour average $PM_{2.5}$ concentrations predicted using the screening tool and the Tier 3 model for the receptors RRP1, H1 and H2 (refer Figure 4) are shown for the 2006 and 2026 scenarios in Table 19, Table 20, and

Table 21. Predicted $PM_{2.5}$ concentrations for the Tier 3 are based on the cumulative effect of emissions of PM_{10} from SH16, Royal Rd and Makora Rd. Predicted $PM_{2.5}$ concentrations using the screening tool at each of the receptors have been calculated for SH16 and Royal Rd separately. An estimate of cumulative PM2.5 levels has also been calculated as the sum of contributions from both roads. This approach is discussed in Section 3.1.3.

Table 19. Predicted maximum 24-hour average $PM_{2.5}$ concentrations in the Royal Rd interchange area, 2006

Receptor	Source	Distance from Kerbside	Maximum 24-hour $PM_{2.5}$ concentration		
			Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
H1	SH16	24m	4.4	2.3	1.9
	Royal Rd (east)	11m	3		1.3
	Sum	NA	7.4		3.2
H2	SH16	40m	2.9	1.4	2.1
	Royal Rd (east)	16m	2.4		1.7
	Sum	NA	5.3		3.8
RRP1	SH16	98m	1.0	0.8	1.3
	Royal Rd (west)	28m	0.8		1.0
	Sum	NA	1.8		2.3

Table 20. Predicted maximum 24-hour average $PM_{2.5}$ concentrations in the Royal Rd interchange area, 2026 With Project

Receptor	Source	Distance from Kerbside	Maximum 24-hour $PM_{2.5}$ concentration		
			Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
H1	SH16	23m	3.8	2.2	1.7
	Royal Rd (east)	11m	1.8		0.8
	Sum	NA	5.6		2.6
H2	SH16	37m	2.6	1.2	2.1
	Royal Rd (east)	16m	1.5		1.2
	Sum	NA	4.1		3.3
RRP1	SH16	95m	0.9	0.6	1.4
	Royal Rd (west)	28m	0.6		0.9
	Sum	NA	1.5		2.3

Table 21. Predicted maximum 24-hour average $PM_{2.5}$ concentrations in the Royal Rd interchange area, 2026 Do Minimum

Receptor	Source	Distance from Kerbside	Maximum 24-hour $PM_{2.5}$ concentration		
			Screening Tool (Tier 2)	Tier 3	Ratio (Screening Tool/Tier 3)
H1	SH16	24m	3.3	1.8	1.9
	Royal Rd (east)	11m	1.7		1.0
	Sum	NA	5		2.8
H2	SH16	40m	2.2	1.0	2.1
	Royal Rd (east)	16m	1.4		1.4
	Sum	NA	3.6		3.5
RRP1	SH16	98m	0.7	0.5	1.3
	Royal Rd (west)	28m	0.5		0.9
	Sum	NA	1.2		2.2

3.3 Comparison of Predicted NO_2 concentrations

The Tier 3 assessment (Beca 2010) did not originally assess annual average NO_2 concentrations, instead focussing on 1-hour and 24-hour NO_2 concentration consistent with the National Environmental Standard and the ambient air quality guideline. In this report the annual average NO_2 concentrations have been estimated based on the simplified approach used by the screening model. Therefore, annual average NO_2 concentrations have been estimated at each receptor as being 20% of annual average NO_X concentrations predicted using the AUSROAD dispersion model.

It should be noted that currently the screening tool only estimates annual average NO_2 concentrations at a receptor located 20m from the modelled road kerbside.

NO_2 concentrations have also been assessed using an algorithm proposed by NIWA which models NO_2 at varying distances from the centre line of road. The algorithm is presented below.

$$\text{Additional } NO_2 = 0.00077 * \text{AADT} * D^{-0.65}$$

Where:

AADT = Annual Average Daily Traffic volumes

D = Shortest distance from road centreline to receptor

The validity of this relationship has not been be reviewed by Beca.

3.3.1 South Residential Area

Maximum annual average NO_2 concentrations predicted using the screening tool (20m from the road), the NIWA NO_2 algorithm, and the Tier 3 model in the southern residential area are shown in Table 22, Table 23 and Table 24 for the 2026 WP and 2026 DM scenarios respectively. Predicted annual average NO_X concentrations using the Tier 3 model are shown in parenthesis. The tables also show the ratio of predicted annual average NO_2 concentrations using the NIWA algorithm compared to those predicted using the Tier 3 model.

Table 22. Predicted maximum annual average NO_2 concentrations in the southern residential areas for 2006 scenario

Distance from SH16 centre line	Distance from Kerbside	Maximum annual average NO_2 concentration (µg/m³)			
		Screening Tool	NIWA algorithm	Tier 3	Ratio (NIWA/Tier 3)
29m	20m	3.6	-	-	-
30m	21m	NA	5.1	4.1 (20.4)	1.3
50m	41m	NA	3.7	2.7 (13.4)	1.4
75m	66m	NA	2.8	1.9 (9.5)	1.5
100m	91m	NA	2.4	1.5 (7.5)	1.6

Table 23. Predicted maximum annual average NO_2 concentrations in the southern residential areas for 2026 with project scenario

Distance from SH16 centre line	Distance from Kerbside	Maximum annual average NO_2 concentration (µg/m³)			
		Screening Tool	NIWA algorithm	Tier 3	Ratio (NIWA/Tier 3)
33m	20m	1.9	-	-	-
30m	17m	NA	8.1	2.8 (13.8)	3.0
50m	37m	NA	5.8	1.7 (8.7)	3.3
75m	62m	NA	4.5	1.2 (6.1)	3.7
100m	87m	NA	3.7	0.9 (4.7)	3.9

Table 24. Predicted maximum annual average NO_2 concentrations in the southern residential areas for 2026 do minimum scenario

Distance from SH16 centre line	Distance from Kerbside	Maximum annual average NO_2 concentration (µg/m³)			
		Screening Tool	NIWA algorithm	Tier 3	Ratio (NIWA/Tier 3)
33m	20m	1.7	-	-	-
30m	17m	NA	7.3	2.1 (10.6)	3.4
50m	37m	NA	5.2	1.4 (6.9)	3.8
75m	62m	NA	4.0	1.0 (4.9)	4.1
100m	87m	NA	3.3	0.8 (3.8)	4.4

3.3.2 North Residential Area

Maximum annual average NO_2 concentrations predicted using the screening tool (20m from the road), the NIWA NO_2 algorithm, and the Tier 3 model in the northern residential area for the 2006, 2026 WP and 2026 DM scenarios are shown in Table 25, Table 26, and Table 27 respectively.

Table 25. Predicted maximum annual average NO_2 concentrations in the northern residential areas, 2006

Distance from SH16 centre line	Distance from Kerbside	Maximum annual average NO_2 concentration			
		Screening Tool	NIWA algorithm	Tier 3	Ratio (NIWA/Tier 3)
25m	15m	NA	4.0	3.3 (16.5)	1.2
30m	20m	3.6	3.6	2.9 (14.5)	1.2
50m	40m	NA	2.6	1.9 (9.5)	1.4
75m	65m	NA	2.0	1.4 (6.8)	1.5
100m	90m	NA	1.6	1.1 (5.4)	1.5

Table 26. Predicted maximum annual average NO_2 concentrations in the northern residential area, 2026 With Project

Distance from SH16 centre line	Distance from Kerbside	Maximum annual average NO_2 concentration			
		Screening Tool	NIWA algorithm	Tier 3	Ratio (NIWA/Tier 3)
33m	20m	1.9	-	-	-
25m	12m	NA	7.2	2.5 (12.5)	2.9
30m	17m	NA	6.4	2.2 (10.9)	2.9
50m	37m	NA	4.6	1.4 (6.9)	3.3
75m	62m	NA	3.5	1.0 (4.8)	3.6
100m	87m	NA	2.9	0.7 (3.7)	3.9

Table 27. Predicted maximum annual average NO_2 concentrations in the northern residential areas, 2026 Do Minimum

Distance from SH16 centre line	Distance from Kerbside	Predicted maximum annual average NO_2 concentration			
		Screening Tool	NIWA algorithm	Tier 3	Ratio (NIWA/Tier 3)
33m	20m	1.7	-	-	-
25m	12m	NA	6.5	2.3 (11.6)	2.8
30m	17m	NA	5.8	2 (10.1)	2.9
50m	37m	NA	4.2	1.3 (6.4)	3.2
75m	62m	NA	3.2	0.9 (4.5)	3.5
100m	87m	NA	2.7	0.7 (3.5)	3.8

3.3.3 Royal Rd Interchange Area

Maximum annual average NO_2 concentrations predicted using the screening tool, the NIWA NO_2 algorithm, and the Tier 3 model are shown for the three Royal Rd interchange receptors in Table 28, Table 29, and Table 30. Predicted NO_X concentrations using the Tier 3 model are shown in parenthesis.

Neither the screening tool nor the NIWA NO_2 conversion algorithm provides a method for assessing the cumulative effect from multiple road sources. An estimate of cumulative NO_2 concentration has therefore been assessed as the sum of the NO_2 concentrations predicted for the two road sources. This approach is expected to be conservative as it takes no account of the relative location of the emission sources and receptor, or the chemistry of NO_X once discharged into the atmosphere.

Table 28. Predicted maximum annual average NO_2 concentrations in the Royal Rd interchange area, 2006

Receptor	Source	Distance from Kerbside	Maximum annual average NO_2 concentration			
			Screening Tool	NIWA algorithm	Tier 3	Ratio (NIWA/Tier 3)
H1	SH16	24m	2.5	3.8	3.1 (15.4)	1.2
	Royal Rd	11m	0.6	1.6		0.5
	Sum	NA	3.1	5.4		1.7
H2	SH16	40m	2.5	2.8	1.8 (9.1)	1.6
	Royal Rd	16m	0.6	1.3		0.7
	Sum	NA	3.1	4.1		2.3
RRP1	SH16	98m	2.5	1.6	0.9 (4.5)	1.8
	Royal Rd	28m	0.3	0.6		0.7
	Sum	NA	2.8	2.3		2.5

Table 29. Predicted maximum annual average NO_2 concentrations in the Royal Rd interchange area, 2026 With Project

Receptor	Source	Distance from Kerbside	Maximum annual average NO_2 concentration			
			Screening Tool	NIWA algorithm	Tier 3	Ratio (NIWA/Tier 3)
H1	SH16	23m	1.5	6.6	2.3 (11.3)	2.9
	Royal Rd	11m	0.4	2.9		1.3
	Sum	NA	1.9	9.5		4.2
H2	SH16	37m	1.5	5.1	1.3 (6.3)	4.0
	Royal Rd	16m	0.4	2.4		1.9
	Sum	NA	1.9	7.5		5.9
RRP1	SH16	95m	1.5	2.9	0.6 (3.1)	4.7
	Royal Rd	28m	0.2	1.0		1.6
	Sum	NA	1.7	3.9		6.3

Table 30. Predicted maximum annual average NO_2 concentrations in the Royal Rd interchange area, 2026 Do Minimum

Receptor	Source	Distance from Kerbside	Maximum annual average NO_2 concentration			
			Screening Tool	NIWA algorithm	Tier 3	Ratio (NIWA/Tier 3)
H1	SH16	24m	1.4	6.1	1.8 (9.2)	3.3
	Royal Rd	11m	0.4	2.6		1.4
	Sum	NA	1.8	8.8		4.7
H2	SH16	40m	1.4	4.6	1.1 (5.4)	4.2
	Royal Rd	16m	0.4	2.2		2.0
	Sum	NA	1.8	6.7		6.2
RRP1	SH16	98m	1.4	2.6	0.5 (2.7)	4.9
	Royal Rd	28m	0.2	0.9		1.7
	Sum	NA	1.6	3.5		6.5

3.4 Overview of model validation results

3.4.1 PM_{10} and $PM_{2.5}$

The comparison of the screening tool with the Tier 3 assessment shows the following:

- Predicted PM_{10} and $PM_{2.5}$ concentrations are higher with the screening tool than those predicted using the Tier 3 model.
- The Tier 2/Tier 3 ratio of PM_{10} and $PM_{2.5}$ concentrations was highest at receptors located closest to SH16. For instance, at distances of 25-30m from the centreline, the screening model prediction for PM_{10} is 1.9 -2.7 times higher than Tier 3 predictions.
- At distances of 100m from SH16 centreline, the screening tool predicted concentrations are 1.1 – 1.7 times higher than the Tier 3. A similar trend is observed for $PM_{2.5}$.
- The Tier 2/Tier 3 ratio predictions for PM_{10} and $PM_{2.5}$ were higher for the projected year of 2026 compared to 2006 (i.e. the screening model predictions were proportionally higher as modelling year increases).
- The screening model predictions of PM_{10} and $PM_{2.5}$ were higher for the three receptors located near the Royal Rd interchange compared with Tier 3 model predictions than for all of the modelled scenarios.

How the models performed at distances closer than 12m-15m from road side of SH16 was not assessed, although based on the Tier 3 modelling results the degree of conservatism of the screening model is expected to increase with increasing proximity to road sources.

Differences in predictions for future years may be due to differences in assumed vehicle emission rates but could also be partly associated with the effect of widening SH16 from 4 to 6 lanes between 2006 and 2026 which would increase the volume in which pollutants in the AUSROADS model are assumed to mix, decreasing pollutant concentrations, before being dispersed downwind.

Another effect could be the greater vehicle numbers in 2026 which would improve predicted pollutant dispersion rates in AUSROADS.

The appropriate application of the screening model to receptors located near intersections where multiple road sources contribute to ambient pollutant levels is uncertain and further guidance in the toolkit for such circumstances would be appropriate. There are similar uncertainties associated with the prediction of NO_2 near intersections.

3.4.2 NO_x and NO_2

It is understood that it is proposed to replace the existing NO_2 algorithm in the screening tool with the NIWA regression model. Our comparison indicates the following:

- Predicted annual average NO_2 concentrations using the Tier 3 model (assuming 20% of annual average NO_X concentrations are NO_2) were lower than those predicted using the NIWA NO_2 prediction algorithm.
- Predicted concentrations using the NIWA algorithm for the 2006 scenario were 22% to 38% higher than the Tier 3 model at receptors 25m to 50m from the SH16 centre line.
- For the 2026 scenarios, the NIWA algorithm predicts NO_2 concentrations which are 180% to 280% higher than the Tier 3 model at receptors 25m to 50m from centreline of SH16.

The increasing disparity between the NIWA model and Tier 3 model predictions for the 2006 and 2026 scenarios can largely be attributed to the predicted decrease in vehicle NO_X emission rates per vehicle for the 2026 scenarios that are incorporated into the Tier 3 model. The NIWA algorithm does not incorporates projected changes in the vehicle fleet's emission rates. Predicted NO_2 are based only on the road's daily traffic volume. The model therefore assumes a fixed NO_X emission rates per vehicle, and a fixed percentage of NO_X emitted as NO_2. Since the model has been developed based on NO_2 sampling monitoring data, the relationship between traffic volume and NO_2 level is representative of existing vehicle fleet emission conditions only.

Therefore, applying the NIWA model to the 2026 scenario does not take into account the VEPM projected changes in vehicle emission rates. If the decrease in the VEPM derived 2026 emission rates are assumed to be reasonably accurate, the NIWA model effectively assumes in 2026 that a much higher proportion of NO_X is in the form NO_2 compared to emissions in 2006. For example, Table 31 shows the predicted maximum annual average NO_2 concentrations with increasing distance from SH16 in the northern residential areas using the NIWA algorithm, maximum annual average NO_X concentration using the Tier 3 model, and the percentage NO_2 assumed to be NO_X.

Table 31. Comparison of annual average NO_2 concentration predicted using the NIWA algorithm and Tier 3 model NO_X concentrations in the northern residential areas

Distance from SH16 centre line	2006			2026 WP			2026 DM		
	NIWA NO_2	Tier 3 NO_X	% NO_2*	NIWA NO_2	Tier 3 NO_X	% NO_2*	NIWA NO_2	Tier 3 NO_X	% NO_2*
25m	4.0	16.5	24%	7.2	12.5	57%	6.5	11.6	56%
30m	3.6	14.5	25%	6.4	10.9	58%	5.8	10.1	57%
50m	2.6	9.5	27%	4.6	6.9	67%	4.2	6.4	65%
75m	2.0	6.8	29%	3.5	4.8	73%	3.2	4.5	71%
100m	1.6	5.4	31%	2.9	3.7	78%	2.7	3.5	76%

* % NO_2 is the effective NIWA NO_2 as a percentage of Tier 3 NOx

Possible uncertainties with universally applying the NIWA algorithm to all traffic assessments include;

1. Predicted concentrations currently do not incorporate assumed changes vehicle emission rates over time (as discussed above) or vary with respect to vehicle operating conditions (i.e. speed). Total emissions of NO_X may vary, as well as the proportion of NO_X emitted in the form of NO_2 (primary NO_2 emissions). For instance, a comparable model developed by the DEFRA (UK) which is used to predict annual average traffic related NO_2 levels incorporates future projected changes in primary NO_2 and total NO_X emission rates. [1]

2. Predicted NO_2 concentrations do not account for differences in background ambient pollutant levels. Differences in the oxidative capacity of the air will have an influence on the NO_2 concentration. In highly polluted areas, for instance CBD areas with high traffic densities, where ambient ozone levels are likely to be low, increases in NO_2 concentrations will be primary associated with tail pipe emission of NO_2. In less polluted areas, for instance rural environments where there are few background sources, vehicle emissions may have a proportionally greater effect on ambient NO_2 levels due to the greater availability of ambient ozone to react with NO. For example, Figure 5 shows the percentage of annual average NO_X as NO_2 with respect to annual average NO_X concentrations measured at Auckland Council's ambient air monitoring stations between 2006 and 2008. The monitoring data show that in areas where there is low annual average NO_X levels a higher proportion of NO_X is in the form of NO_2. The proportion of NO_X which is NO_2 decreases with increasing annual average NO_X levels. (The relationship is approximately log-linear in nature (R^2 = 0.87)).

   It is noted that the DEFRA model for assessing traffic relation NO_2 concentrations incorporates background pollutant levels assumptions.

3. Predicted concentrations do not account for regional differences in background ambient pollutant levels. The relative effect of increases in NO_2 with increases in NO_X is expected to vary with respect to the regional oxidative condition. For example, generally lower oxidative conditions would be expected in Wellington compared to Auckland. Therefore, for the same annual average NO_X concentration, the proportion which is NO_2 is likely to be lower in Wellington compared to Auckland. This is generally backed up by the monitoring data.

4. NO_2 concentrations are predicted to increase rapidly with proximity to road sources. Since peak concentration will be predicted at receptor points located close to the kerbside it is important to gain an understanding as to how close to a road source the algorithm becomes too conservative.

5. Similarly, the algorithm is based on the distance from the centreline of the road to the receptor. Therefore, an increase in the number of lanes of a motorway will reduce the distance between the motorway kerbside (and the closest vehicles) and the receptor (assuming the centreline does not change). However, for the same daily traffic volumes, predicted NO_2 concentrations at the receptor point will not change with the increased number of lanes. Therefore, the model in its present form may not be appropriate for assessing road widening effects, or should be reformulated with respect to distance between kerbside and receptor location.

[1] It is noted that these projected changes in the UK to NO_2 emission rates are mainly associated with the high percentage of vehicle fleet which is projected to be diesel which is different from the New Zealand situation.

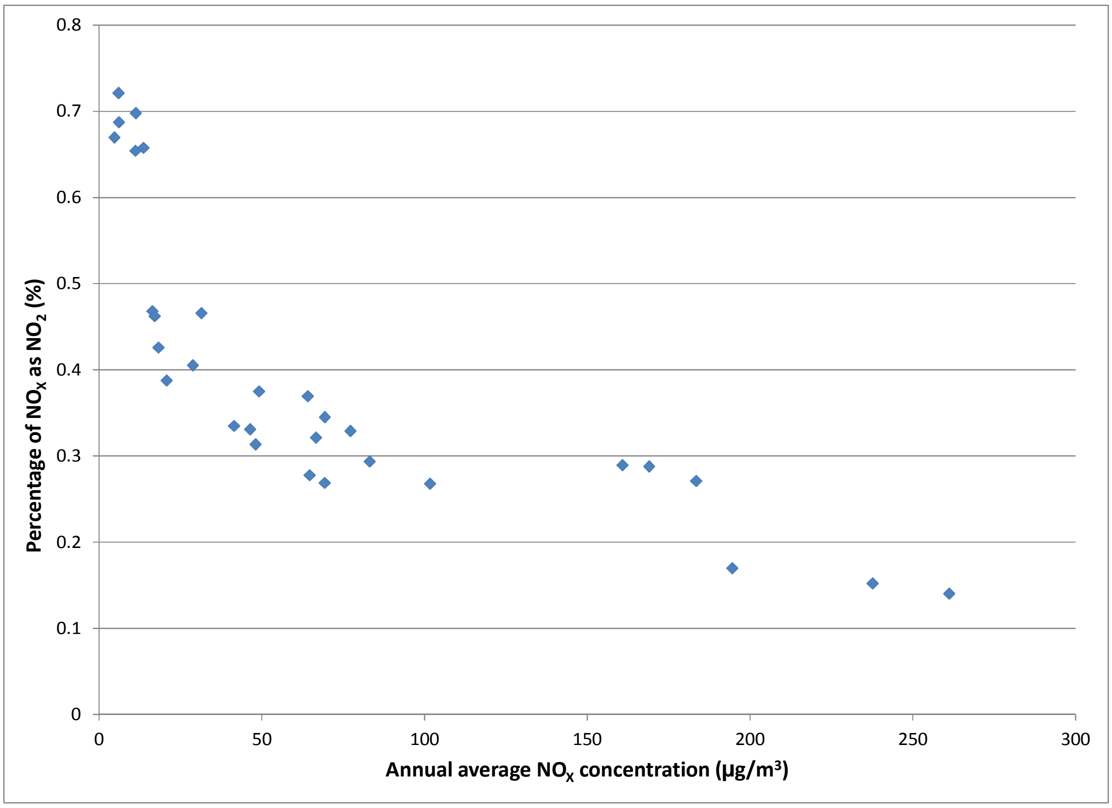

Figure 5. Percentage annual average NO_X as NO_2 with respect annual average NO_X concentrations for Auckland (2006-2008)

4 Summary of findings

The main findings of the validation exercise to compare the NZTA Tier 2 screening tool with Tier 3 AUSROADs modelling predictions are as follows:

- All predicted concentrations using the screening tool were higher than those using the Tier 3 model.
- The screening model was increasingly conservative for PM_{10} and $PM_{2.5}$ with proximity to the road, ie at distances of 25-30m from the centreline, the screening model prediction for PM_{10} is 1.9 -2.7 times higher than Tier 3.
- Predicted NO_2 concentrations for 2006 scenario using the NIWA algorithm were higher compared to predictions using the Tier 3 model (assuming that assuming 20% of annual average NO_X was in the form of NO_2).
- Predicted NO_2 concentrations for the 2026 scenarios were substantially higher using NIWA algorithm compared to the Tier 3 model. For the 2026 scenarios, the NIWA algorithm predicts NO_2 concentrations which are 1.8 to 2.8 times higher than the Tier 3 model at receptors 25m to 50m from centreline of SH16.
- There is some uncertainty how, or if, the screening model should be applied to multiple road sources, and intersections. It is recommended that the circumstances under which the screening model should and should not be used is defined.
- There is uncertainty as to how close to the road source the screening tool and the NIWA NO_2 algorithm predictions are valid. The increasing conservatism in the screening model suggests that very high concentrations may be predicted by the model for receptors located near to road kerbsides.
- The potential confounding factors of traffic vehicle emissions rates, and background pollutant levels should be assessed if the NIWA NO_2 algorithm is to be universally applied to all road sources.

5 References

Beca, 2010b. *Western Ring Route. SH16 Lincoln Road Interchange Air Quality Assessment.* Report prepared for the NZ Transport Agency.

Beca, 2010c. *Western Ring Route – Waterview Connection: Air Quality Assessment*. Report prepared for the NZ Transport Agency

Ministry for the Environment. 2004. *Good Practice Guide for Atmospheric Dispersion Modelling*. ISBN 0-478-18941-9. Ministry for the Environment, Wellington.

Ministry for the Environment. 2008. *Good Practice Guide for Assessing Discharges to Air from Land Transport*. ISBN 0-978-0-0478-30237-0. Ministry for the Environment, Wellington.