Ambient air quality (nitrogen dioxide) monitoring network

Annual report 2007 to 2013

NZ TRANSPORT AGENCY
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New Zealand Government

More information

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Record of amendment

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Foreword

The NZ Transport Agency (Transport Agency) is a Crown entity responsible for, among other things, managing almost 11,000 kilometres of state highways. The state highway system accounts for about 12 per cent of New Zealand's roads and around half of the 40 billion vehicle kilometres New Zealanders travel each year[1]. Motor vehicles travelling on roads emit an array of air pollutants which can contribute to harmful effects on human health and smog formation.

Section 96(1)(a) of the Land Transport Management Act requires that the Transport Agency exhibit a sense of social and environmental responsibility. The Transport Agency promotes an accessible and safe transport system that contributes positively to New Zealand's economic, social and environmental welfare and is committed to acting in an environmentally and socially responsible manner. The Transport Agency's Environmental Plan[2] gives effect to this policy by presenting approaches and implementation plans for a range of environmental and social impacts arising from the state highway network. The specific objectives for improving air quality include:

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

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

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

Annual assessment of vehicle emissions from the state highway network is undertaken using data gathered from selected sites using passive samplers to measure nitrogen dioxide (NO_2) as a general proxy for air pollution from motor vehicles. The overall aim is to see a decreasing trend in NO_2 concentrations measured at these sites. This aligns with the Transport Agency's desired long term impact which seeks a 'reduction in adverse environmental (air quality) effects from land transport'.

This report summarises the annual data measured at the Transport Agency national passive sampling network sites for 2007 to 2013. It is intended to complement the Transport Related Air Quality Monitoring System (TRAMS) database on the air.nzta.govt.nz website and the 2007-2012 site metadata report[3], which provides details on the location, type and distance to nearest roads/receptors for each site in the network.

Acknowledgements

The NZ Transport Agency wishes to acknowledge and thank Waikato Regional Council, Greater Wellington Regional Council, Auckland Council and Environment Canterbury for their in-kind support and financial contribution towards the operation of the monitoring network in 2013/14.

[1] MoT (2014). *The New Zealand vehicle fleet, annual fleet statistics 2013*, Ministry of Transport, August 2014.

[2] NZTA (2008). *Environmental plan: Improving environmental sustainability and public health in New Zealand*, version 2, NZ Transport Agency, June 2008.

[3] NZTA (2013a). *Ambient air quality (nitrogen dioxide) monitoring network - site metadata report 2007-2012*, prepared by Watercare Services Ltd for NZ Transport Agency, April 2013

Contents

1. Executive summary

This report describes the features of the NZ Transport Agency (Transport Agency) national NO_2 passive monitoring network and reviews data gathered from the beginning of 2007 up to the end of 2013. Results are compared *spatially* (ie at different sites) and *temporally* (ie year to year and seasonally).

In 2007, the Transport Agency instigated a national NO_2 passive monitoring programme to determine relative levels of vehicle pollution across the state highway network. During 2013, diffusion tubes (a type of passive sampler) were deployed in nearly 129 sites across New Zealand (including state highway, local road and background locations).

Passive samplers are easy to operate and relatively cheap, so they can be installed in large numbers over a wide area giving good spatial coverage, but their results are indicative only and provide monthly rather than daily averages. Passive sampling is therefore useful as a screening method rather than a regulatory method, for which continuous monitors are used.

Nitrogen dioxide (NO_2) is used as a general proxy for air pollution from motor vehicles. The World Health Organisation (WHO) states[4] that:

> *"Nitrogen dioxide concentrations closely follow vehicle emissions in many situations, so nitrogen dioxide levels are generally a reasonable marker of exposure to traffic-related emissions. Health risks from nitrogen oxides may potentially result from nitrogen dioxide itself, correlated exhaust components such as ultrafine particles and hydrocarbons, or nitrogen dioxide chemistry products, including ozone and secondary particles."*

The highest concentrations measured to date across the Transport Agency national NO_2 passive monitoring network have occurred in urban areas, including Auckland, Hamilton, Wellington and Christchurch. In 2013, the maximum readings were recorded at:

- AUC009 - a state highway site at the central motorway junction in Auckland.
- AUC068 - a state highway site near the intersection of Kirkbride Road and George Bolt Memorial Drive on the way to Auckland airport.
- CHR017-019 - a local road site on Riccarton Road[5] in Christchurch.
- HAM013 – a state highway site at the intersection of Greenwood Street and Killarney Road in Hamilton

At these locations (in particular), it is likely that the WHO annual NO_2 guideline of 40µg/m^3 (set to protect human health) is being exceeded and therefore air quality effects of vehicle emissions need to be reduced. Many of these sites have been recording high values since they were first installed and for some, such as AUC009, as far back as 2007. However, for the majority of these high sites, the Transport Agency and other agencies have a number of planned projects that will improve traffic flow and air quality at these sites.

Across all of the monitored sites with complete data records, annual average NO_2 concentrations in 2013 are 19% higher on average than in 2007 but have only recorded a 4% increase on average between 2010 and 2013. This slowing may reflect the impact of improvements in vehicle technology counteracting some of the growth in vehicle travel or may be as a result of the state of the economy influencing vehicle movements or both.

NO_2 levels show strong seasonal variations, with higher concentrations being observed during winter. At the majority of sites, the average NO_2 concentration in winter (June to August) is typically double the concentration in summer (December to February).

[4] WHO (2006). *Air quality guidelines global update 2005: particulate matter, ozone, nitrogen dioxide, and sulphur dioxide*, World Health Organisation, October 2006.

[5] This location is a triplicate site where the passive samplers are co-located with a continuous monitor operated by Environment Canterbury.

Seven monitoring sites in the Transport Agency network were co-located with regional council continuous NO_2 monitors in 2013. Passive monitoring results are typically higher than the corresponding continuous data. However, the relationship between the passive and continuous monitoring data has not been consistent to date so results are presented without any adjustment in this report.

Quality assurance of the passive monitoring network has been undertaken using triplicate passive samplers, also at nine sites. A comparison of the triplicate data shows that the precision (repeatability) of the passive samplers is good, with an average coefficient of variation of less than 8%.

In recent years, the development of the passive sampling network by the Transport Agency has been largely in increasing the *quantity of sites* to improve the coverage and representativeness of the results. The wealth of data now available provides an opportunity for any future development to focus on enhancing the *value of the results*, by using the information to better understand how the Transport Agency can contribute to a reduction in adverse air quality effects from land transport and specifically by:

- Undertaking air quality investigations for any Transport Agency national network state highway passive monitoring sites where the annual average NO_2 concentration measured by passive samplers exceeds 40µg/m^3.
- Assessing the feasibility of measuring traffic volume, speed, and percentage of heavy vehicles in close proximity to key Transport Agency national NO_2 passive monitoring network sites. The highest priority will be monitoring of these parameters where the annual average NO_2 concentration measured by passive samplers exceeds the medium threshold (30µg/m^3).
- Investigating the relationship between continuous and passive NO_2 monitoring results and evaluate the suitability of statistical tools for developing appropriate correlation factors and establishing uncertainties.
- Investigating the relationship between continuous and passive NO_2 monitoring results and other pollutants measured at co-located sites to provide an indication of whether NO_2 concentrations and trends are providing a good proxy for overall vehicle pollution.

Annual data are uploaded annually into the Transport Related Air Quality Monitoring System (TRAMS) database, after receiving the last analysis report for December of the previous year. Annual and seasonal averages, together with links to the site metadata files as PDFs, can be viewed and accessed using either SpatialViewer (https://spatialviewer.nzta.govt.nz/) or via the Monitoring tab under the Transport and Air Quality website (http://air.nzta.govt.nz/transport-related-air-quality-monitoring-data).

2. Introduction

This section introduces key areas that underpin the report – how motor vehicles affect air quality and the objectives of the Transport Agency national NO_2 passive monitoring programme.

2.1 Effects and sources of air pollution

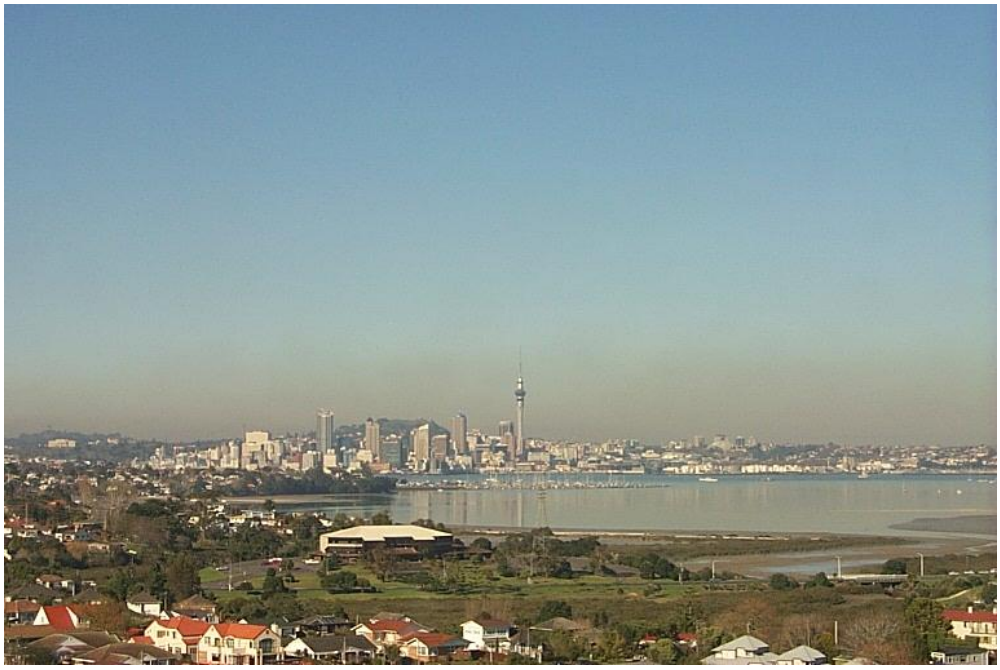

Figure 1: Auckland's skyline on a polluted day showing a characteristic brown haze (source: Auckland Council)

New Zealand has relatively good air quality due to our low population density, close proximity to the sea, and remoteness from other continents and sources of pollution. However, there are some areas, mostly in our cities and towns, where air quality is degraded. Air pollution usually occurs when a high level of emissions (caused by high traffic numbers or homes being heated by open fires or older wood burners) combines with poor dispersion conditions (such as calms, temperature inversions, valleys or street canyons).

Air pollution impacts human health as well as reducing visibility and causing brown haze (see figure 1). Health effects can range from respiratory irritation, headaches and coughing through to more serious conditions. More than 1175 people in New Zealand are estimated to die prematurely each year due to air pollution from human-generated sources (including motor vehicles)[6]. This pollution also results in approximately 600 extra hospital admissions for respiratory and cardiac illnesses, and 1.5 million restricted activity days[7] each year.

[6] Kuschel *et al.* (2012). *Updated health and air pollution in New Zealand study*, prepared for the Health Research Council of New Zealand, Ministry of Transport, Ministry for the Environment and NZ Transport Agency, March 2012.

[7] A restricted activity day is a day in which people cannot do the things they might otherwise have done if air pollution was not present.

Home heating and motor vehicles are the main sources of pollution in New Zealand. The relative amounts and types of pollutants produced by motor vehicles vary according to the age of the vehicle, whether it is petrol- or diesel-powered, how well-maintained and tuned it is, and how hard the engine is working. In addition, the amount and type of pollutants vary with the way the vehicle is being driven, the level of congestion, and the geography of the road network.

Some pollutants are emitted directly from the tailpipe of the vehicle – such as nitric oxide (NO), nitrogen dioxide (NO_2), benzene, carbon monoxide (CO) and particulate matter[8] (PM_{10} and $PM_{2.5}$) – whilst others are formed in the atmosphere afterwards – such as ozone.

2.2 Nitrogen dioxide as an indicator pollutant

The impact of road transport on air quality in New Zealand varies locally. It may be that in many (or even most) locations the impacts of road transport on air quality are minor, but how are we to know?

Motor vehicles produce a complex mix of contaminants. It is not feasible to monitor all of these, so theTransport Agency has identified one pollutant, nitrogen dioxide (NO_2) as a proxy for motor vehicle pollutants. This is consistent with the recommendations of the World Health Organisation (WHO), which states[9] that:

> *"Nitrogen dioxide concentrations closely follow vehicle emissions in many situations, so nitrogen dioxide levels are generally a reasonable marker of exposure to traffic-related emissions. Health risks from nitrogen oxides may potentially result from nitrogen dioxide itself, correlated exhaust components such as ultrafine particles and hydrocarbons, or nitrogen dioxide chemistry products, including ozone and secondary particles."*

Nitrogen oxides incorporate several species that exist in the atmosphere, which collectively are referred to as NO_x and result principally from fossil fuel combustion, when nitrogen in the air that is used to burn the fuel gets oxidised. The most common NO_x compounds are nitrogen dioxide (NO_2) and nitric oxide (NO). NO is the primary product emitted directly but this is eventually oxidised by other pollutants present in ambient air to form NO_2. Motor vehicles are a major source of NO_x emissions in most parts of New Zealand.

2.3 Passive sampling as a screening method

Ambient NO_2 concentrations can be measured by continuous analysers or passive samplers.

Continuous analysers measure instantaneous concentrations and are the regulatory method for assessing compliance against national environmental standards and guidelines (based on 1-hour and 24-hour averages). Passive sampling is only able to measure longer term averages (such as monthly) and is less accurate than continuous monitoring but it provides a means for assessment of NO_2 at many sites.

In 2013, the Transport Agency national NO_2 monitoring network consisted of passive samplers deployed at 129 locations around New Zealand. The passive monitoring network is not meant to replace continuous monitoring. It is screening monitoring technique which provides a snapshot using a well-established and well-understood method that is relatively cheap and effective.

[8] PM_{10} is fine particulate matter smaller than 10µm (10 millionths of a metre) in diameter and $PM_{2.5}$ is smaller than 2.5µm. Both are invisible to the naked eye but are able to be inhaled deep into the lungs.

[9] WHO (2006). *op. cit.*

2.4 How the network data are utilised

The Transport Agency funds a substantial amount of air quality measurements, predictions and assessments through projects, network management, complaint investigations and research as shown in figure 2.

The Transport Agency has developed a transport related air quality monitoring system (TRAMS) to collate all relevant air quality data commissioned by the Transport Agency (including the national passive NO_2 data) so that greater utilisation can be made of it, significantly increasing value-for-money. Collation of data is providing the Transport Agency with a national overview of transport-related air quality work, allowing more informed policy development and better prioritisation and focus on critical areas of the state highway network.

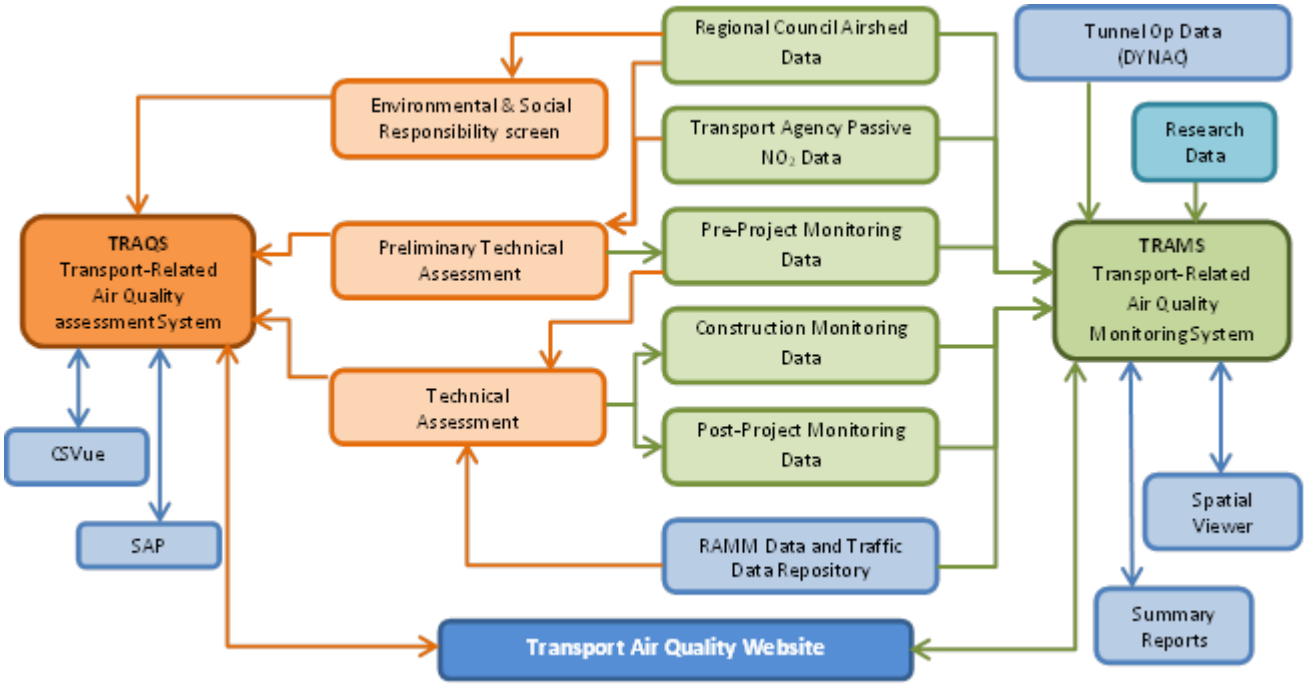

Figure 2: Where the national passive NO_2 data and other monitoring sources feed into TRAMS

2.5 Aims of this report

The Transport Agency's Environmental Plan[10] sets out objectives for improving air quality as follows:

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

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

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

The corresponding air quality performance indicator from the Environmental Plan is:

> "*annual assessment of vehicle emissions from the state highway network gathered from selected sites using diffusion tubes to measure nitrogen dioxide (NO_2) as a surrogate measure. The objective is to monitor a decreasing trend in emissions of NO_2.*"

[10] NZTA (2008). *op. cit.*.

The primary objectives of this report are to:

1. Report against Transport Agency's air quality performance indicator.
2. Identify where there may be an air quality problem on the Transport Agency road network.
3. Indicate trends and seasonal variations.

2.6 Report layout

This report is structured as follows:

- Chapter 3 outlines the sampling method, sites and analysis techniques used in the monitoring programme
- Chapter 4 presents the results for 2007 through to 2013
- Chapter 5 discusses the sites with high NO_2 concentrations
- Chapter 6 summarises the key findings and recommendations

A full list of references, a glossary of terms, and two appendices containing detailed maps and tables are provided at the end of the report.

3. Methodology

This section deals with the methodological aspects of the report - including the monitoring method, monitoring sites and analysis of results.

3.1 Monitoring method

Passive monitoring of NO_2 is described[11] as follows:

> *"Diffusion tubes are a type of passive sampler; that is, they absorb the pollutant to be monitored directly from the surrounding air and need no power supply. Passive samplers are easy to use and relatively inexpensive, so they can be deployed in large numbers over a wide area, giving good spatial coverage. This has made them a popular choice for Local Authorities, who often use diffusive samplers to complement more expensive automatic monitoring techniques, or at locations where it would not be feasible to install an automatic monitor.*
>
> *It should be noted that diffusion tubes have two limitations. Firstly, they are an indicative monitoring technique. Whilst ideal for screening surveys, or for identifying locations where NO_2 concentrations are highest, they do not provide the same level of accuracy as automatic monitoring techniques. Secondly, as the exposure period is typically several weeks, the results cannot be compared with air quality standards and objectives based on shorter averaging periods such as hourly means.*
>
> *The development and use of passive samplers originated in the field of occupational exposure monitoring. However, diffusion sampling techniques have been further developed and tested, and now are widely used for ambient air quality monitoring, where concentrations are generally much lower."*

The Transport Agency national NO_2 monitoring network uses diffusion tubes. These consist of a small plastic tube, approximately 7cm long, as shown in figure 3. During sampling, one end is open and the other closed. The closed end contains an absorbent for the gaseous species to be monitored, in this case NO_2. The exposed tubes are analysed in the laboratory.

Measurements are made monthly at each site using diffusion tubes supplied and analysed by Staffordshire County Council Scientific Services (SCC) in the UK.

The monitoring programme is operated by Watercare Services Ltd on behalf of Transport Agency, in accordance with the Transport Agency's Operating Manual[12].

[11] AEA (2008). *Diffusion tubes for ambient NO_2 monitoring: practical guidance for laboratories and users,* prepared by AEA Energy and Environment for the Department for Environment, Food and Rural Affairs and the Devolved Administrations, February 2008.

[12] NZTA (2013b). *Ambient air quality (nitrogen dioxide) monitoring programme – Operating manual 2013/14,* prepared by Watercare Services Ltd and Emission Impossible Ltd for NZ Transport Agency, September 2013.

(a) close up of a passive diffusion tube used in the monitoring

(b) a passive diffusion tube deployed at the central motorway junction, Auckland

Figure 3: Passive samplers used in the Transport Agency national NO_2 monitoring network

3.2 Monitoring sites

3.2.1 Monitoring zones

The Transport Agency's monitoring zones have been established for each main urban area[13] in New Zealand, as well as for Taupo, Otaki, Blenheim, Greymouth and Queenstown. The number of monitoring sites within each zone reflects the risk of being exposed to elevated levels of air pollution arising from vehicles using the state highway network. This is based on the population of urban areas in each zone.

In 2007 and 2008, 53 locations were monitored throughout New Zealand. The Transport Agency expanded the network in 2009 to include background and local road locations and then undertook a further significant expansion in 2010 to improve coverage. In 2013, the national network monitored NO_2 concentrations in 129 locations. Table 1 summarises the number of monitoring sites in each zone.

[13] The Transport Agency's monitoring zones reflect the "urban areas" used by Statistics New Zealand. The urban area classification is designed to identify concentrated urban or semi-urban settlements without the distortions of administrative boundaries. Three types of urban areas are defined – main, secondary and minor – and these are delineated by population. See http://www.stats.govt.nz/Census/2013-census/info-about-2013-census-data/2013-census-definitions-forms/definitions/geographic.aspx for details.

Table 1: The number of monitoring sites in each zone from 2007 to 2013

Monitoring zone	Population in 2013 (000's)	Site type	Number of sites[a]						
			2007	2008	2009	2010	2011	2012	2013
Whangarei	49	SH	1	1	1	1	1	1	1
		Background			1	2	1	1	1
Auckland - Northern	273	SH	3	3	6[b]	5	5	5	5
		Local	1	1	5[b]	5	5	5	5
		Background			1	1	1	1	1
Auckland - Western	205	SH	1	1	5	5	5	4[c]	4
		Local			4	4	4	5[c]	5
		Background			1	1	1	1	1
Auckland - Central	424	SH	6	6	6	6	6	6	6
		Local			5	5	5	5	5
		Background	1	1	1	1	1	1	1
Auckland - Southern	400	SH	4	4	6	6	6	6	6
		Local			3	3	3	3	3
		Background			1	1	1	1	1
Hamilton	169	SH	3	3	3	5	5	5	5
		Local				3	3	3	3
		Background				1	1	1	1
Cambridge	17	SH	1	1	1	1	1	1	1
Te Awamutu	15	SH				1	1	1	1
Taupo	21	SH	1	1	1	1	1	1	1
Tauranga	120	SH	3	3	3	4	4	4	4
		Local				2	2	2	2
		Background				1	1	1	1
Rotorua	53	SH	1	1	1	1	1	1	1
		Background	-	-	-	1	1	1	1
Gisborne	33	SH	1	1	1	1	1	1	1
Napier	57	SH	2	2	2	2	2	2	2
		Background				1	1	1	1
Hastings	64	SH	1	1	1	1	1	1	1
		Background				1	1	1	1
New Plymouth	52	SH	1	1	1	1	1	1	1
		Background				1	1	1	1

Monitoring zone	Population in 2013 (000's)	Site type	Number of sites[a]						
			2007	2008	2009	2010	2011	2012	2013
Wanganui	38	SH	1	1	2	1	1	1	1
Palmerston North	78	SH	1	1	1	3	3	3	3
		Local				1	1	1	1
		Background				1	1	1	1
Otaki	6	SH				1	1	1	1
Kapiti	39	SH	1	1	1	1	1	1	1
Upper Hutt	37	SH				1	1	1	1
		Background				1	1	1	1
Lower Hutt	97	SH	2	2	3	3	3	3	3
		Local				1	1	1	1
		Background				1	1	1	1
Porirua	51	SH	1	1	1	1	1	1	1
		Background							1
Wellington	188	SH	2	2	4	6	5	5	5
		Local				3	3	3	3
		Background				2	2	2	2
Nelson	60	SH	3	3	3	3	3	3	3
		Background				1	1	1	1
Blenheim	29	SH	1	1	1	1	1	1	1
Christchurch	353	SH	3	3	3	6	6	6	6
		Local				4	4	4	4
		Background	1	1	1	2	2	2	2
Greymouth	10	SH	1	1	1	1	1	1	1
Dunedin	112	SH	2	2	2	3	4	4	4
		Local	1	1	1	3	3	2	2
		Background				1	1	1	1
Queenstown	11	SH	1	1	1	1	1	1	1
Invercargill	48	SH	1	1	1	1	1	1	1
		Background				1	1	1	1
Grand Total			**53**	**53**	**86**	**130**	**129**	**128**	**129**

a. The number of sites includes all sites that had data for the current year. Therefore, if a site was relocated to another location in a particular year but both locations have at least one month's data for that year then both sites are counted in this table.
b. AUC004 was a state highway site until the beginning of 2009 when the Northern Gateway Toll Road opened. At this time, its state highway status was revoked and AUC004 then became a local road site.
c. AUC049 was a state highway site until the end of 2011 when the new SH18 Hobsonville deviation was opened. At this time, its state highway status was revoked and AUC049 then became a local road site.

3.2.2 Site selection criteria

Monitoring sites in the Transport Agency's national NO_2 passive monitoring network are classified as:

- *State highway* sites, which are located within 100 metres of the highway being monitored.
- *Local* road sites, which are located within 50 metres of the road being monitored.
- Urban *background* sites, which are located more than 100 metres from a state highway and more than 50 metres from a busy local road.

The actual locations within each zone have been selected based on a number of other considerations as follows:

- Sites are generally within 50 metres of either a school or residential areas to represent exposure to road vehicle emissions in locations that are sensitive to adverse air pollution effects.
- State highway sites are located on sections of the state highway network with the highest traffic flows in the region (typically where the annual average daily traffic (AADT) count is greater than 20,000 vehicles per day) and sections of the state highway network with congestion (based on 'level of service' indicators). These are intended to represent locations where elevated concentrations are most likely to occur.

Several monitoring sites have triplicate passive samplers, which are co-located with regional council continuous monitors to assess the precision and accuracy of results.

3.2.3 Location of monitoring sites

The locations of the monitoring sites are shown in the results maps in section 4 and appendix 2. A description for each site is summarised in table 13 in appendix 1.

Full information on all sites in the national NO_2 network is available in a separate site metadata report[14] and the Transport Related Air Quality Monitoring System (TRAMS) database on the air.nzta.govt.nz website.

3.3 Analysis of results

3.3.1 Ambient standards and guidelines

Relevant health-based standards and guidelines for NO_2 are shown in table 2, covering a range of averaging periods from short-term (1-hour) to long-term (annual) exposure.

New Zealand has 1-hour and 24-hour values for ambient NO_2 concentrations set in the National Environmental Standards[15] (NES) and the Ambient Air Quality Guidelines[16] (AAQG) respectively. The NES ambient standard applies anywhere in a region that is in the open air and where people are likely to be exposed to the contaminant over the relevant averaging period. The regulations are designed to provide a guaranteed minimum level of health protection for New Zealanders. For NO_2 the NES is 200µg/m^3 (1-hour average). There is also an AAQG for NO_2 of 100µg/m^3 as a 24-hour average.

[14] NZTA (2013a). *op. cit*.

[15] MfE (2011). *Resource management (national environmental standards for air quality) regulations 2004, including the 2011 amendments,* Ministry for the Environment, June 2011.

[16] MfE (2002). *Ambient air quality guidelines, 2002 update*, Air quality report no. 32, prepared by the Ministry for the Environment and the Ministry of Health, May 2002.

There are no health-based New Zealand guidelines associated with exposure to NO_2 for periods of time longer than 24 hours. However, the WHO[17] has an annual average guideline for NO_2 of 40µg/m³.

Table 2: NO_2 ambient air quality standards and guidelines

Contaminant	Averaging period	Standard or guideline[18]	Concentration	Annual allowable exceedance
Nitrogen Dioxide	1-hour	NES	200µg/m³	9
	24-hour	AAQG	100µg/m³	-
	Annual	AAQG[19]	30µg/m³	-
	Annual	WHO	40µg/m³	-

3.3.2 Assessment criteria

As mentioned previously, the passive monitoring undertaken measures monthly average NO_2 concentrations but these are not directly comparable to short-term standards and guidelines. However, a 2008 review of regional council monitoring results[20] suggests that any site which exceeds the annual average WHO guideline is also likely to exceed the NES for NO_2. This means that, through careful choice of sampling sites and the use of passive samplers as screening devices, locations where standards and guidelines are most likely to be exceeded due to motor vehicle emissions can be identified.

The WHO Global Update of Air Quality Guidelines report[21] highlights that health effects may occur at levels below this guideline, and recommends that a lower guideline should be used if NO_2 is monitored as an indicator of overall pollution levels. WHO states that:

> *"Evidence from animal toxicological studies indicates that long-term exposure to nitrogen dioxide at concentrations above current ambient concentrations has adverse effects. In population studies, nitrogen dioxide has been associated with adverse health effects even when the annual average nitrogen dioxide concentration complied with the WHO annual guideline value of 40µg/m³. Also, some indoor studies suggest effects on respiratory symptoms among infants at concentrations below 40µg/m³.*
>
> *The present guideline was set to protect the public from effects on health of nitrogen dioxide gas itself. The rationale for this is that, because most abatement methods are specific to nitrogen oxides, they are not designed to control other co-pollutants and may even increase their emissions.* ***If, instead, nitrogen dioxide is monitored as a marker for the concentrations and risks of the complex combustion-generated pollution mixtures, an annual guideline value lower than 40µg/m³ should be used instead****."*

Because the Transport Agency's network is measuring NO_2 as a *"marker for the concentrations and risks of the complex combustion-generated pollution mixtures"* (as highlighted above), it may be appropriate to consider a lower annual guideline. Although the WHO does not specify an appropriate lower annual guideline, this recommendation has been taken into consideration in the development of the Transport

[17] WHO (2006). *op. cit.*

[18] Refer to the glossary for definition of these terms

[19] This is a critical level for protecting ecosystems and is not a health-based guideline.

[20] NIWA (2008). *The determinants of levels of secondary particulate pollution and nitrogen dioxide in urban New Zealand – Part 1*. NIWA report AKL2008-053 prepared for the Foundation for Research, Science and Technology, July 2008

[21] WHO (2006). *op. cit.*

Agency's criteria for assessment of passive monitoring results, which are summarised in table 3 which follows.

Table 3: Transport Agency assessment criteria for annual average NO_2 passive monitoring results

Contaminant	Annual average concentration	Descriptor	Notes
Nitrogen Dioxide	≥40µg/m³	High	Identifies locations where the WHO annual NO_2 guideline is likely to be exceeded and air quality effects of motor vehicles need to be reduced.
	≥30µg/m³	Medium	Identifies locations where air quality is degraded as a result of motor vehicle emissions and may cause adverse effects.

Locations where the concentration measured by passive monitoring exceeds 40µg/m³ (high) and 30µg/m³ (medium) are summarised in section 4.3.

3.3.3 Data analysis

The passive diffusion tubes measure total NO_2 accumulated for a period of one month. Annual averages are calculated and presented in maps and summary tables in the body of this report *for only those sites with a minimum of 75% valid data* (ie at least nine months of results).

Triplicate passive samplers are co-located with regional council continuous NO_2 monitors at several monitoring sites. Annual average results for these sites are calculated as follows depending upon the amount of valid data:

- if *all three* individual triplicate results have *100% valid data*, then average all three results;
- if *all three* individual triplicate results have *at least 75% valid data* and the *same amount of valid data* (eg all three individual triplicate results have 83% valid data), then average all three results;
- if the three individual triplicate results have *varying amounts of valid data* but *at least 75% valid data*, then average the two results with the *highest % valid data*; or
- if *two of three* individual triplicate results have *at least 75% valid data*, then average the two results only.

Annual averages have not been calculated if two of three individual triplicate results have less than 75% valid data, or where all three individual triplicate results have less than 75% valid data.

Appendix 1 (table 13) presents the percentage valid data for all sites but only shows the corresponding annual averages *for those with at least 75% valid data*. Triplicate results are shown as the average of the three samplers.

3.3.4 Quality assurance

The Transport Agency national passive monitoring network has been setup and is operated in general accordance with the UK's Local Air Quality Management Technical Guidance [22], which includes requirements for quality assurance and quality control.

The results from co-located triplicate passive samplers are used to check the precision (or repeatability) of the results. The tubes are all located next to each other and also as close as possible to the sample inlet of the continuous NO_2 analyser. To check the precision of the passive monitoring results the coefficient of variation (CV), also known as the relative standard deviation, is calculated for the triplicate samples each month. The higher the CV value the greater the spread between the triplicate samples. The annual average concentrations measured at these sites are compared to continuous monitors to provide an indication of the accuracy of passive tubes.

The coefficient of variation (CV) is calculated for the triplicate diffusion tubes each month for quality assurance according to:

$$CV = SD/mean*100$$

From the UK's Local Air Quality Management Technical Guidance [23], diffusion tubes are considered to have "good" precision where the CV of duplicates or triplicates based on eight or more individual periods during the year is less than 20%, and the overall average CV of all monitoring periods is less than 10%. Diffusion tubes are considered to have "poor" precision where the CV of four or more individual periods is greater than 20% and/or the average CV is greater than 10%. The distinction between "good" and "poor" precision is an indicator of how well the same measurement can be reproduced.

For the triplicate sites in the Transport Agency's network since 2007, the average CV has been less than 8%[24]. The CV has been less than 20% for 95% of the triplicate samples, indicating that the precision of the passive samplers is good.

[22] DEFRA (2009). *Local air quality management, technical guidance LAQM TG(09),* Department for Environment, Food and Rural Affairs, February 2009.NZTA (2012).

[23] DEFRA (2009). *op. cit.*

[24] This is the average coefficient of variation for all triplicate samples taken between 2007 and 2013.

4. Results

This section summarises the Transport Agency's national NO_2 passive monitoring results from 2007 to 2013. The results are presented as follows:

- Annual averages across the national network by year
- Overall averages by monitoring zone
- Tables of all high (≥40µg/m^3) and medium (30-39.9µg/m^3) locations

4.1 National network results

The annual averages recorded across the national network are presented in figure 4 (2007), figure 5 (2008), figure 6 (2009), figure 7 (2010), figure 8 (2011), figure 9 (2012) and figure 10 (2013).

Tables of full results, including annual and seasonal means, are given in appendix 1 and detailed results maps for each region are included in appendix 2.

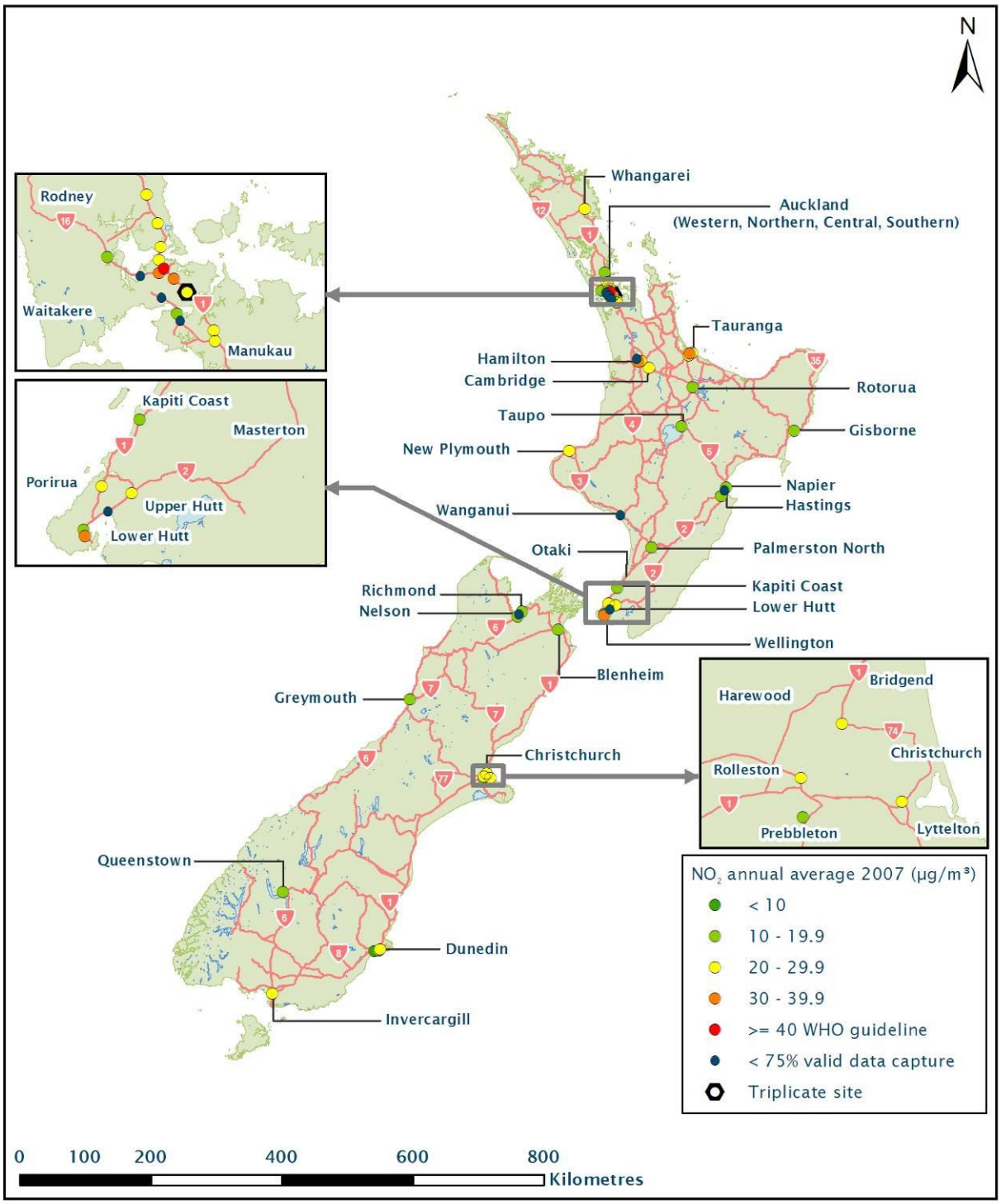

Figure 4: Annual NO_2 averages recorded for the national network in 2007

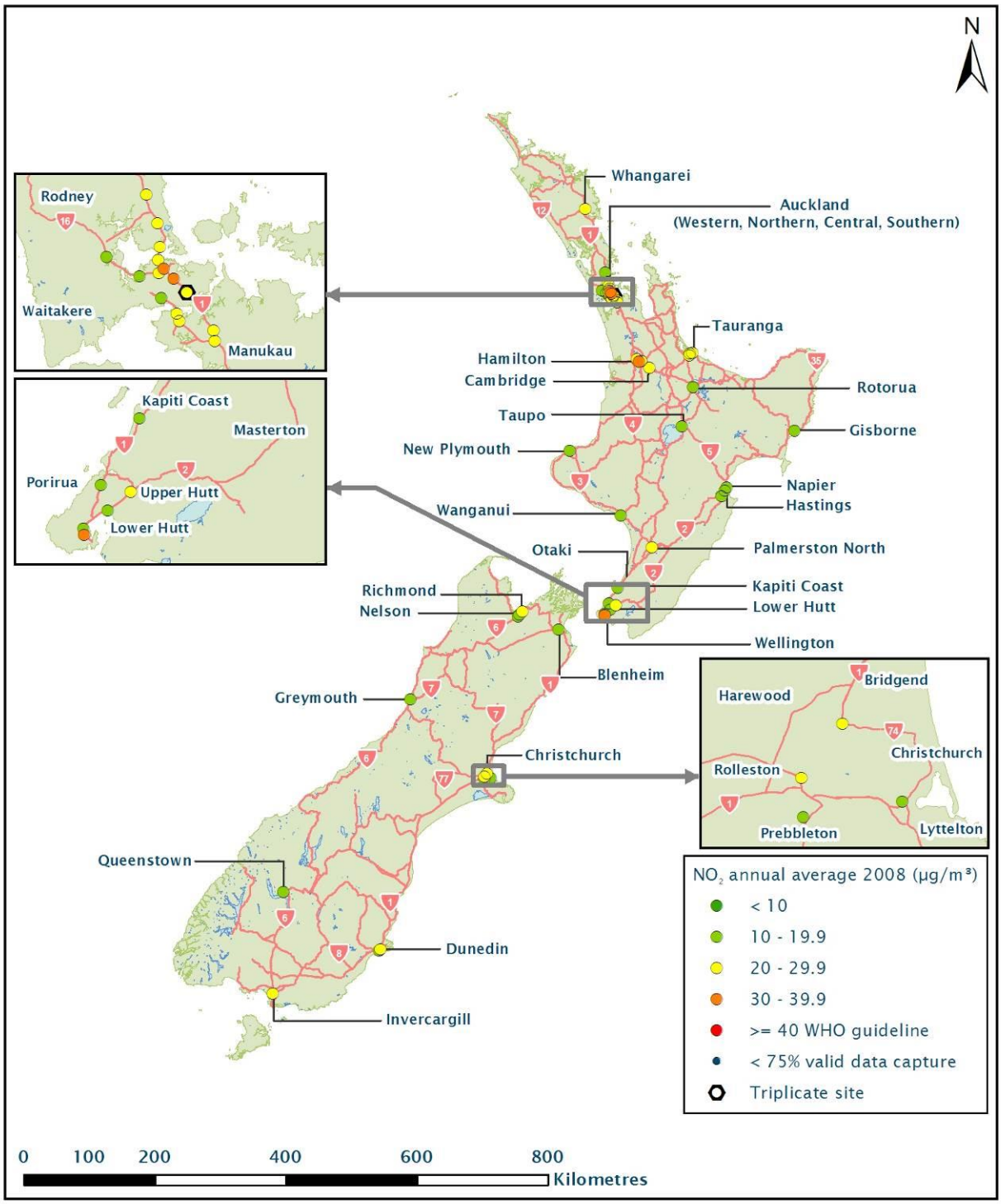

Figure 5: Annual NO_2 averages recorded for the national network in 2008

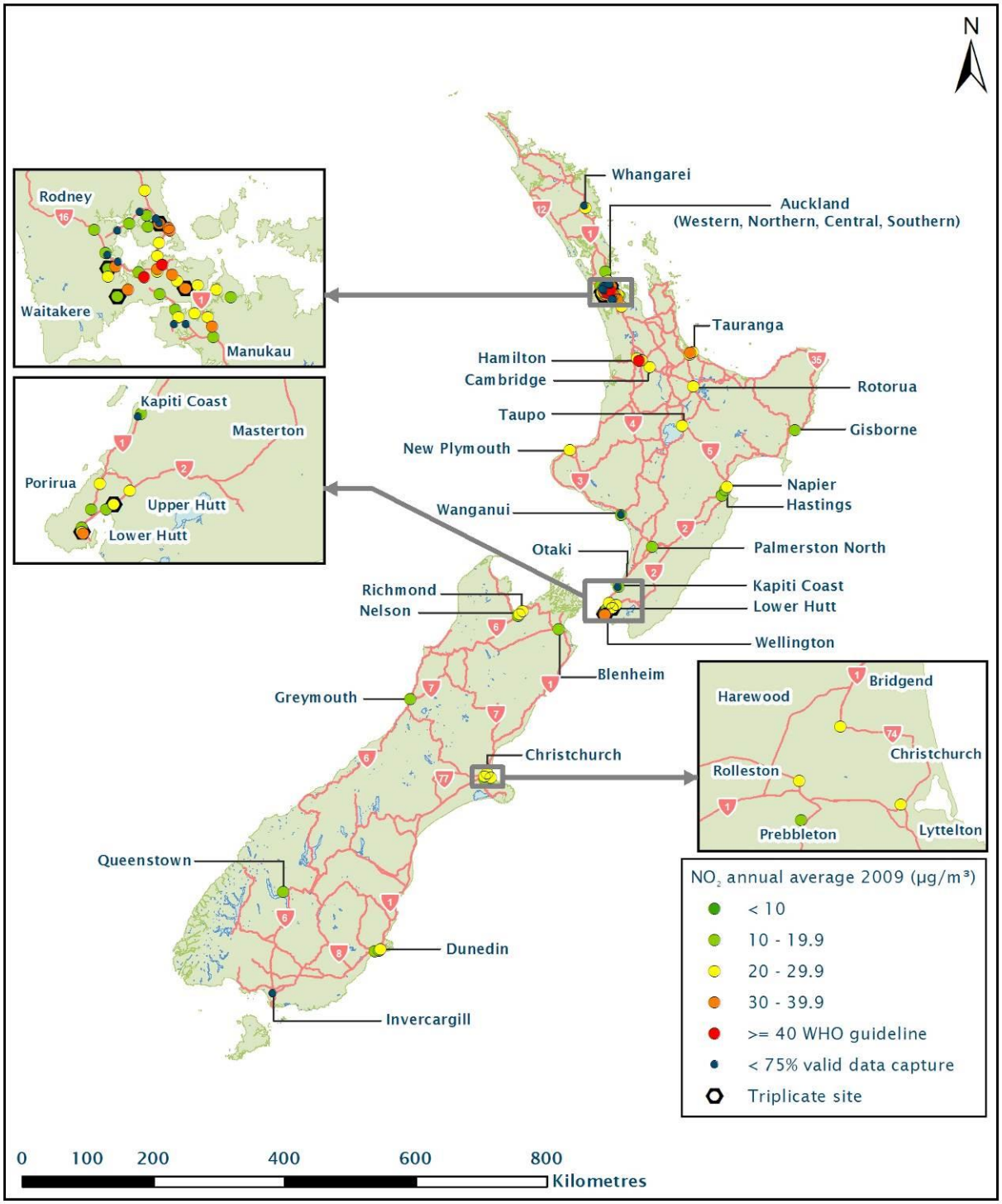

Figure 6: Annual NO_2 averages recorded for the national network in 2009

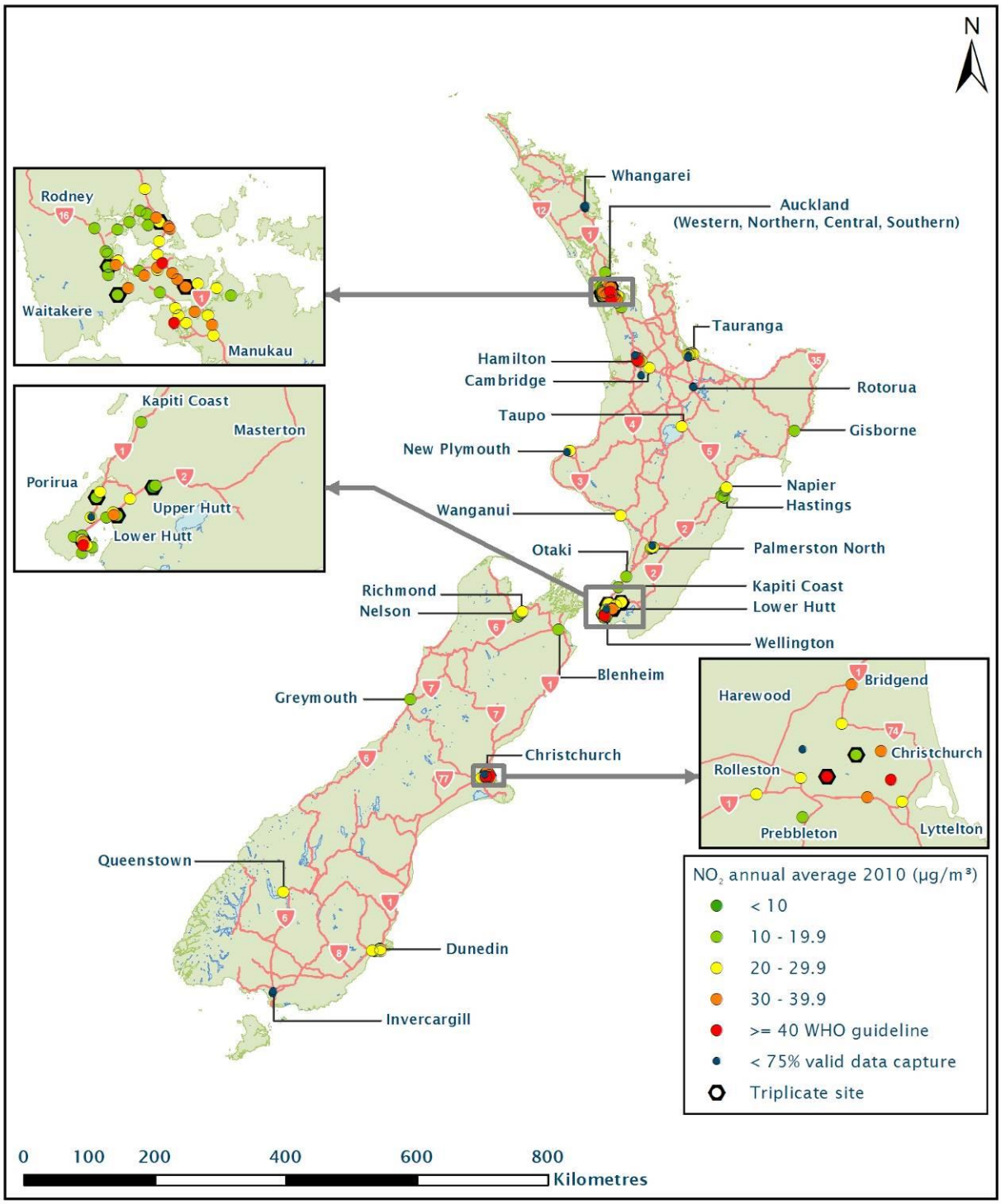

Figure 7: Annual NO_2 averages recorded for the national network in 2010

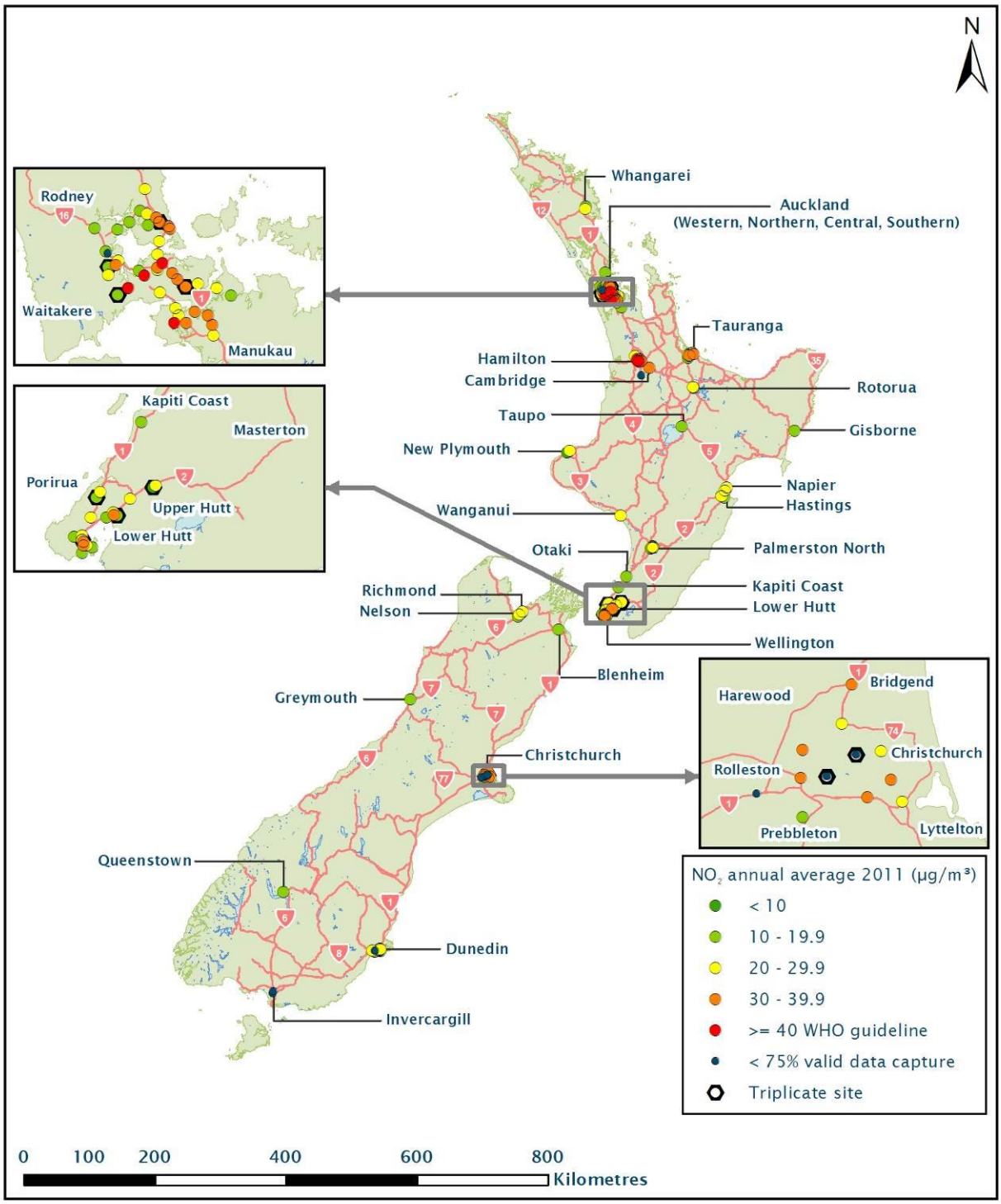

Figure 8: Annual NO_2 averages recorded for the national network in 2011

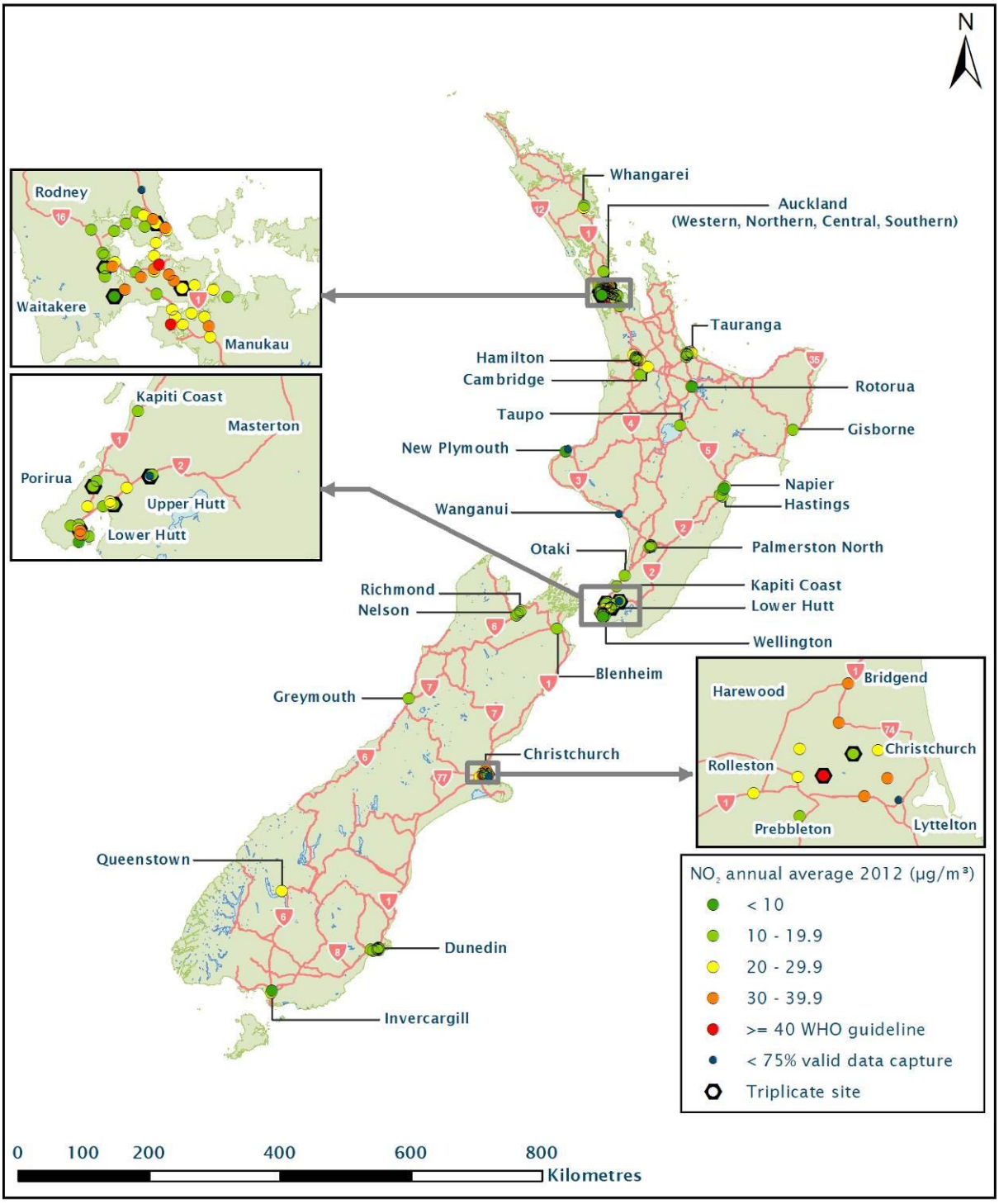

Figure 9: Annual NO_2 averages recorded for the national network in 2012

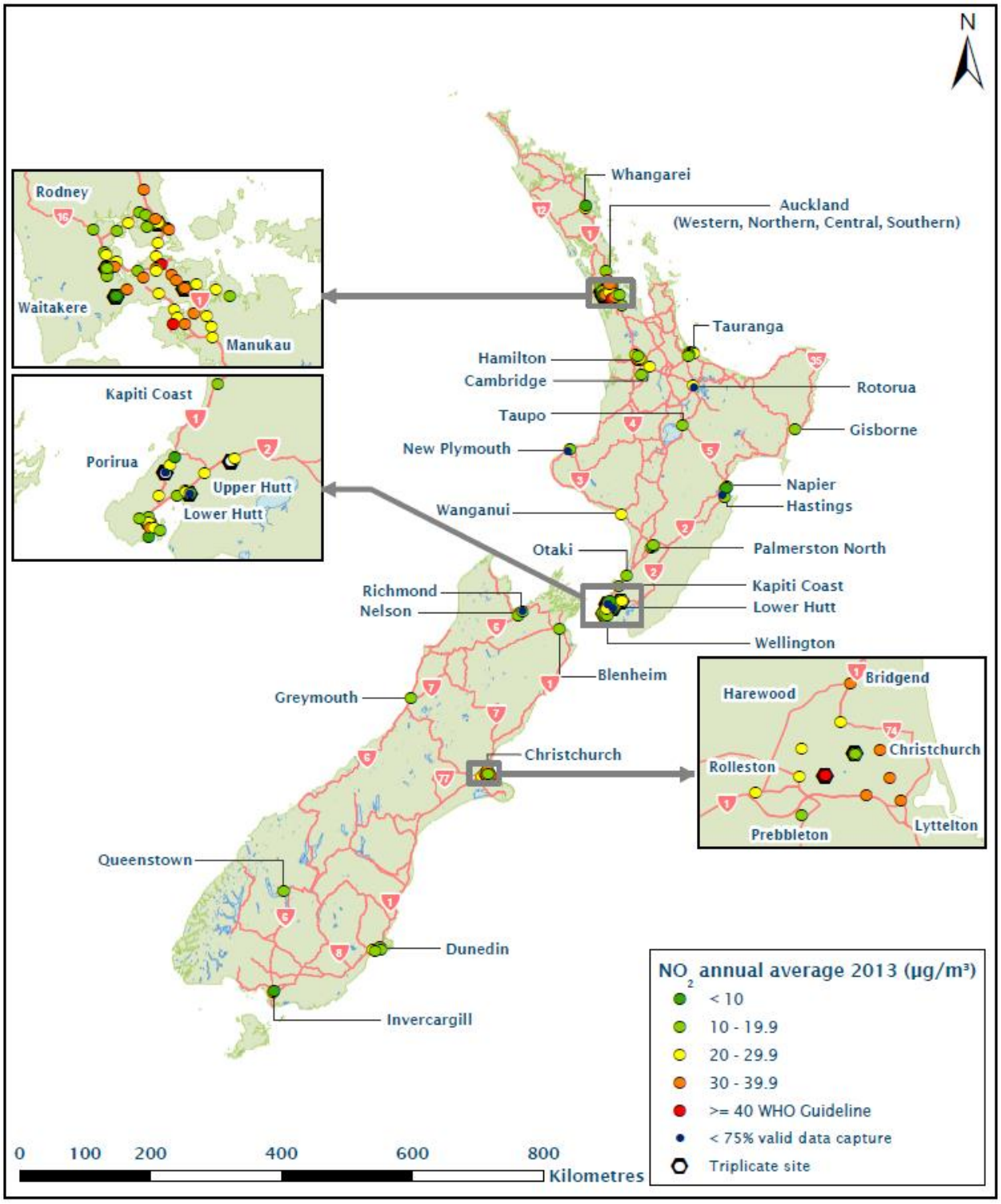

Figure 10: Annual NO_2 averages recorded for the national network in 2013

4.2 Monitoring zone results

Monitoring zones are presented for the North Island and South Island in figures 11 and 12. The maximum, minimum and average of the annual average NO_2 results in each category (state highway, local road and background) are shown for each zone in figures 13 to 42 and indicate the year by year trends since monitoring began in 2007.

Although the number of samplers as well as the distances of each sampler from the roads varies per monitoring zone, these results provide a useful snapshot of the variation in NO_2 concentrations across the country. The results indicate that the monitoring zones with the highest maximum NO_2 concentrations are Auckland Central, Auckland South then Christchurch (post the earthquakes) closely followed by Hamilton.

Results for individual monitoring sites are provided in appendix 1.

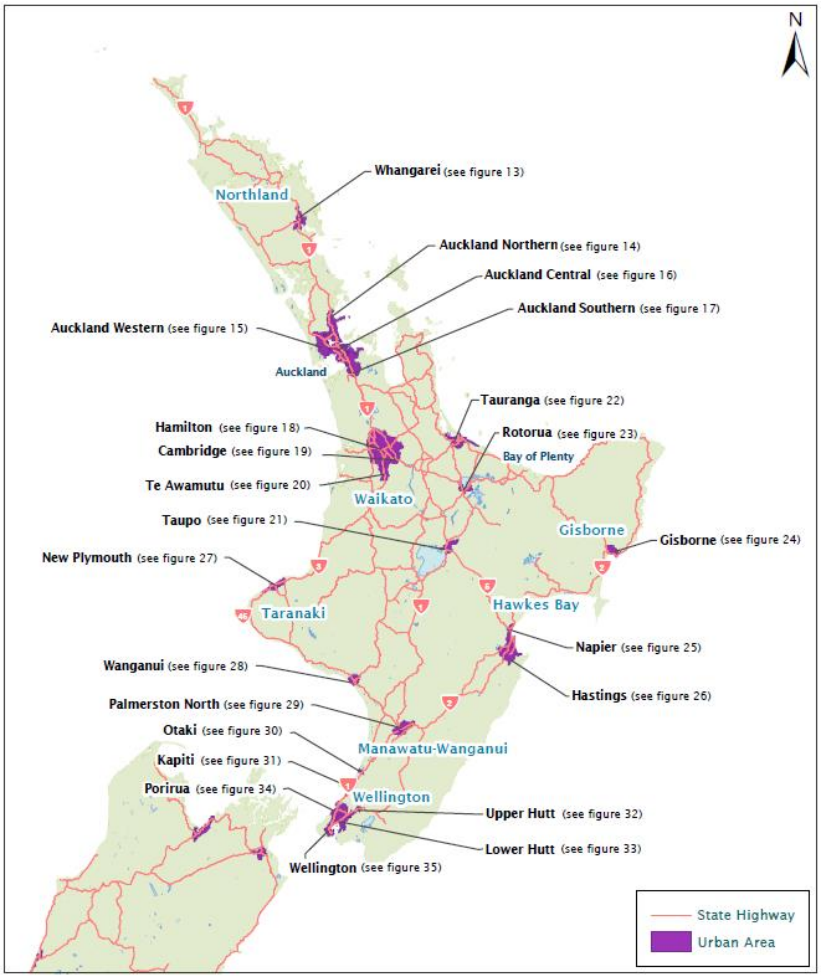

Figure 11: North Island monitoring zones

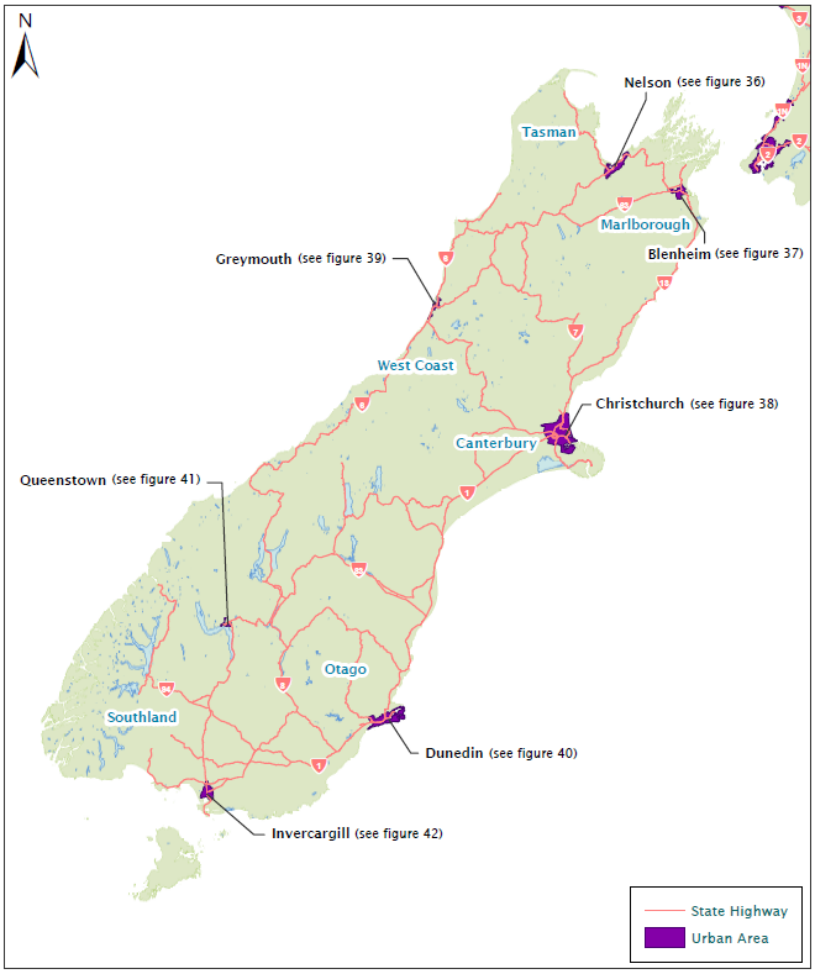

Figure 12: South Island monitoring zones

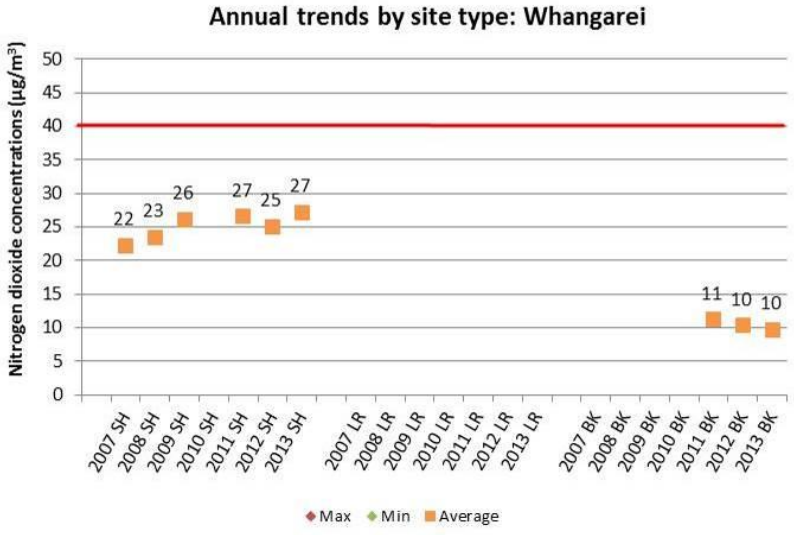

Figure 13: Maximum, minimum and average NO_2 annual values in Whangarei

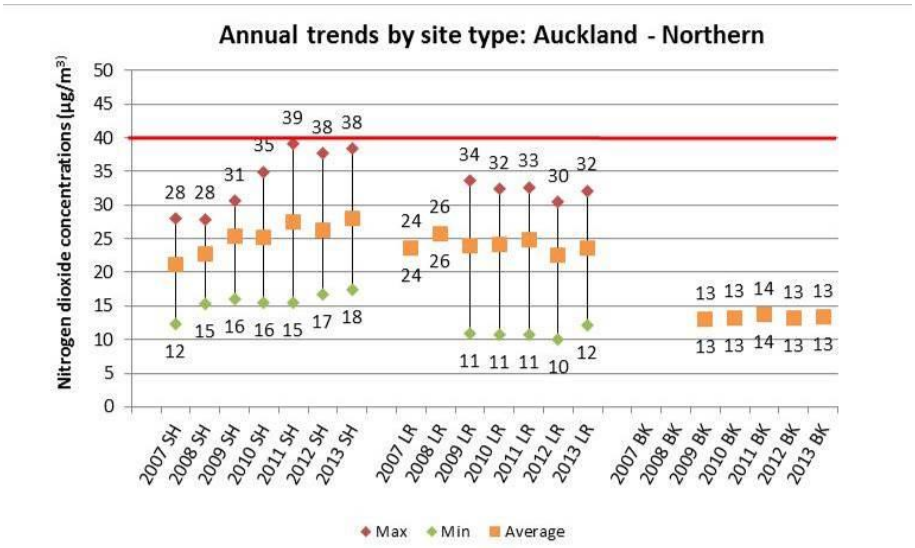

Figure 14: Maximum, minimum and average NO_2 annual values in Auckland – Northern

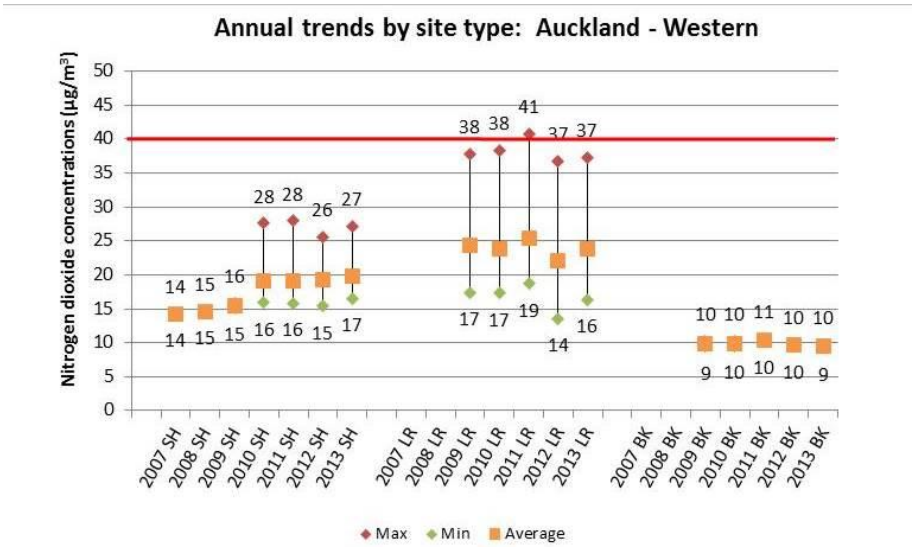

Figure 15: Maximum, minimum and average NO_2 annual values in Auckland – Western

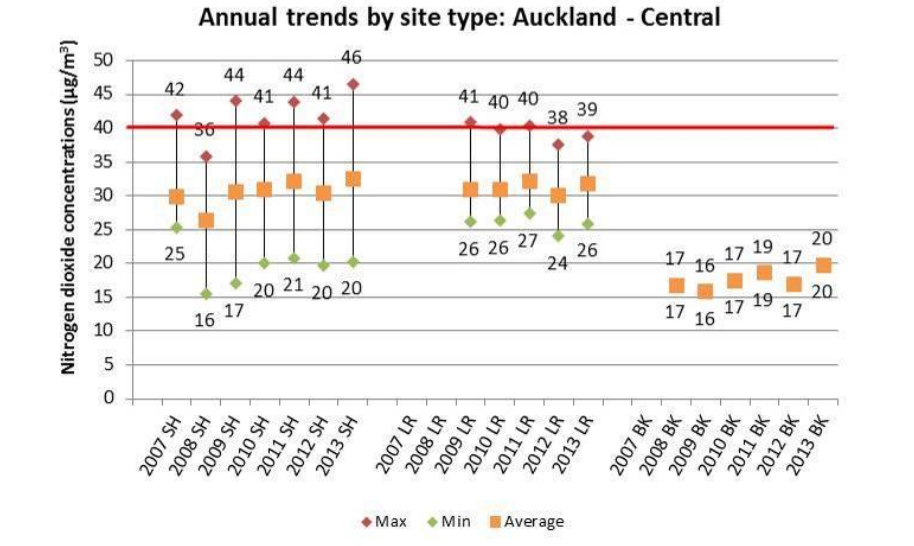

Figure 16: Maximum, minimum and average NO_2 annual values in Auckland - Central

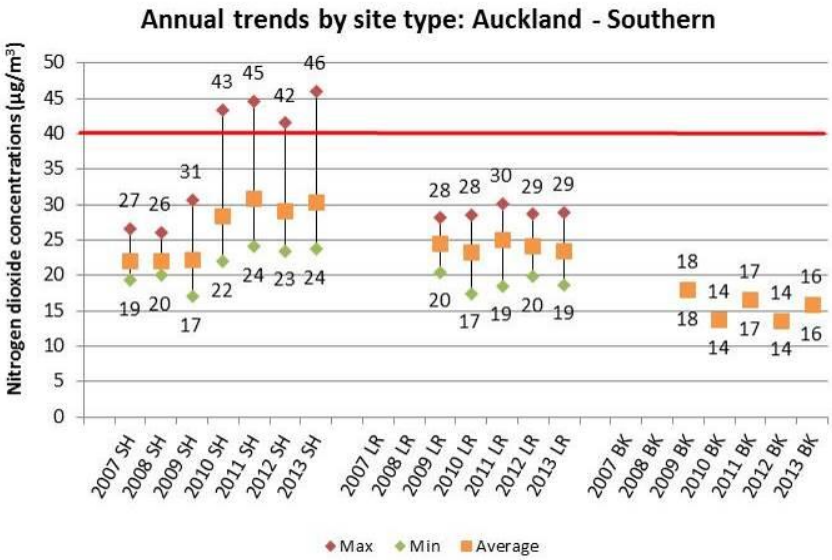

Figure 17: Maximum, minimum and average NO_2 annual values in Auckland - Southern

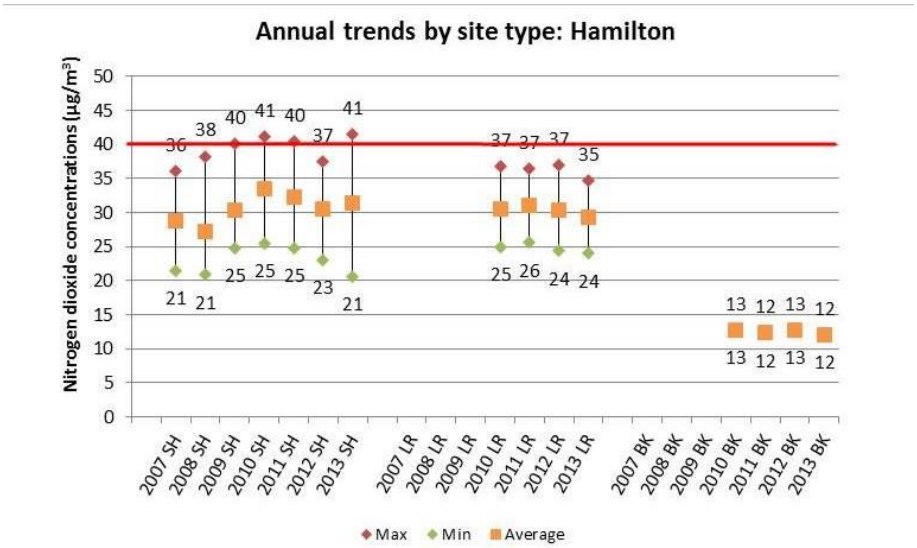

Figure 18: Maximum, minimum and average NO_2 annual values in Hamilton

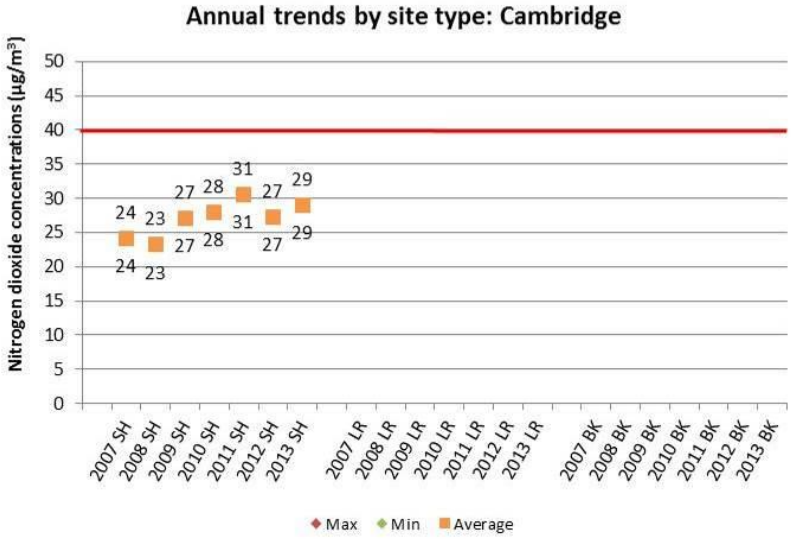

Figure 19: Maximum, minimum and average NO_2 annual values in Cambridge

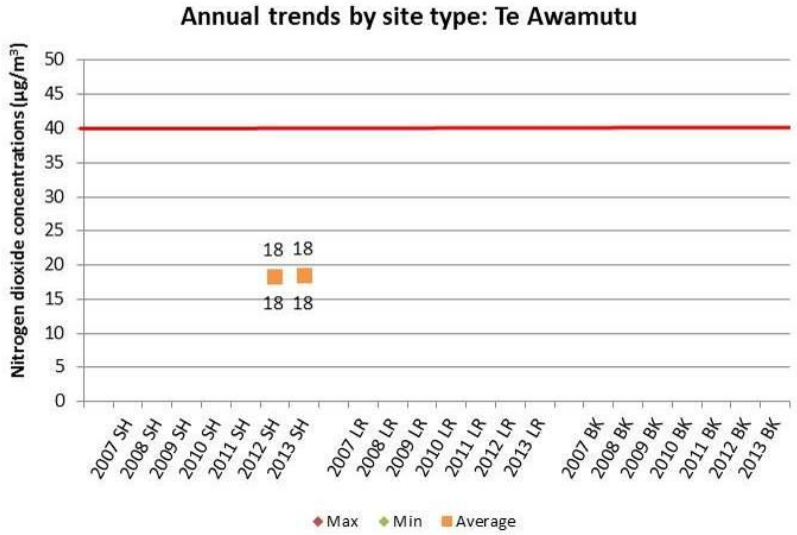

Figure 20: Maximum, minimum and average NO_2 annual values in Te Awamutu

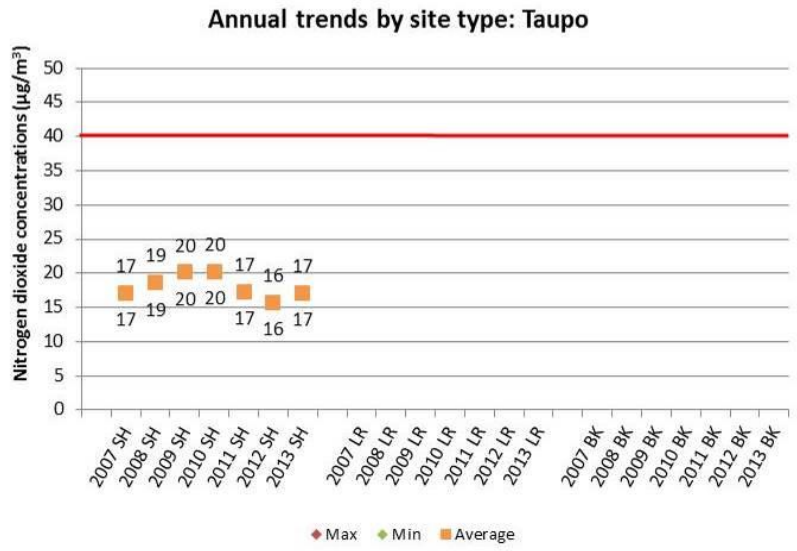

Figure 21: Maximum, minimum and average NO_2 annual values in Taupo

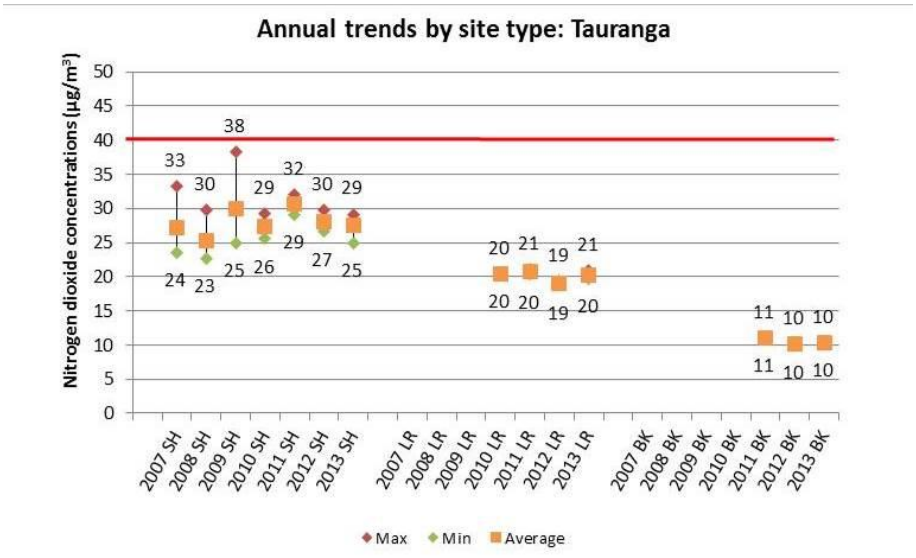

Figure 22: Maximum, minimum and average NO_2 annual values in Tauranga

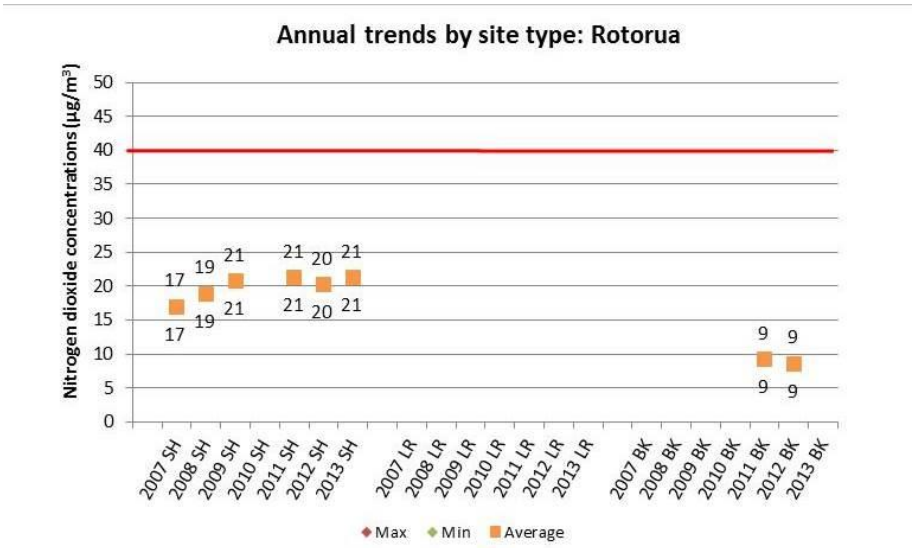

Figure 23: Maximum, minimum and average NO_2 annual values in Rotorua

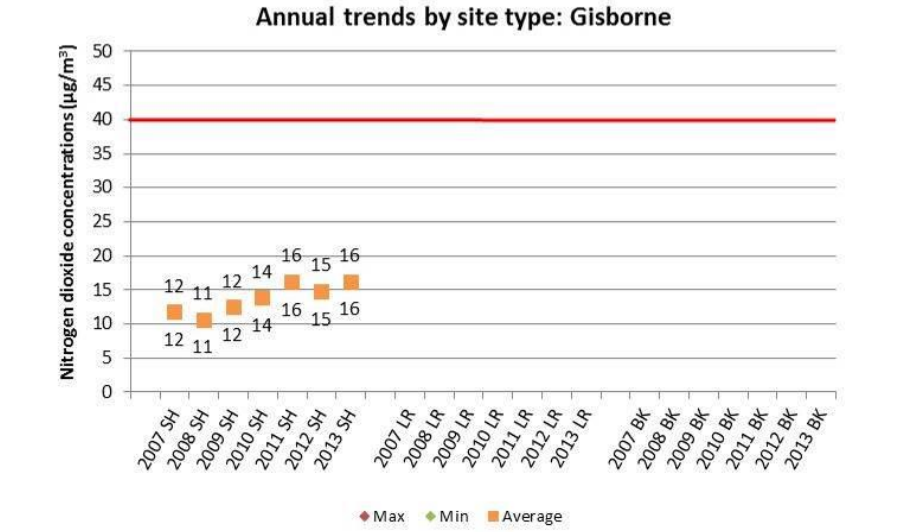

Figure 24: Maximum, minimum and average NO_2 annual values in Gisborne

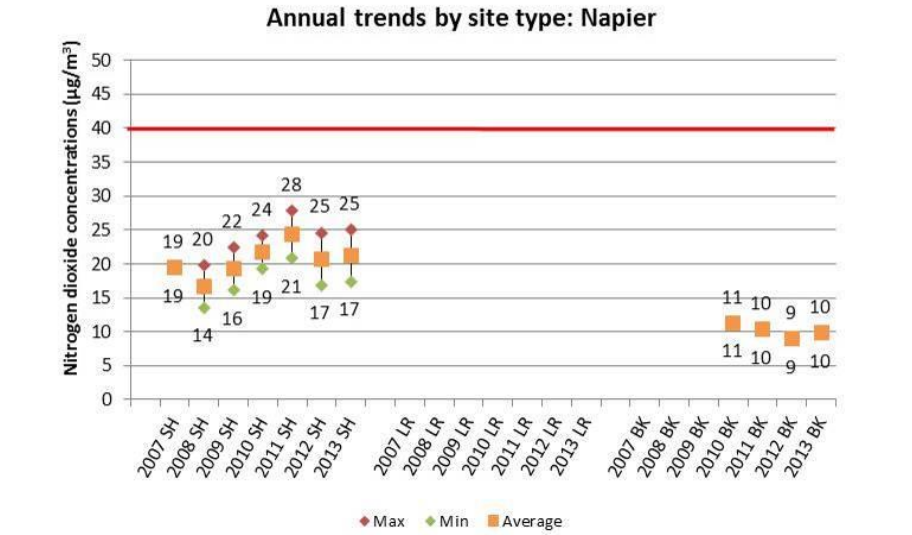

Figure 25: Maximum, minimum and average NO_2 annual values in Napier

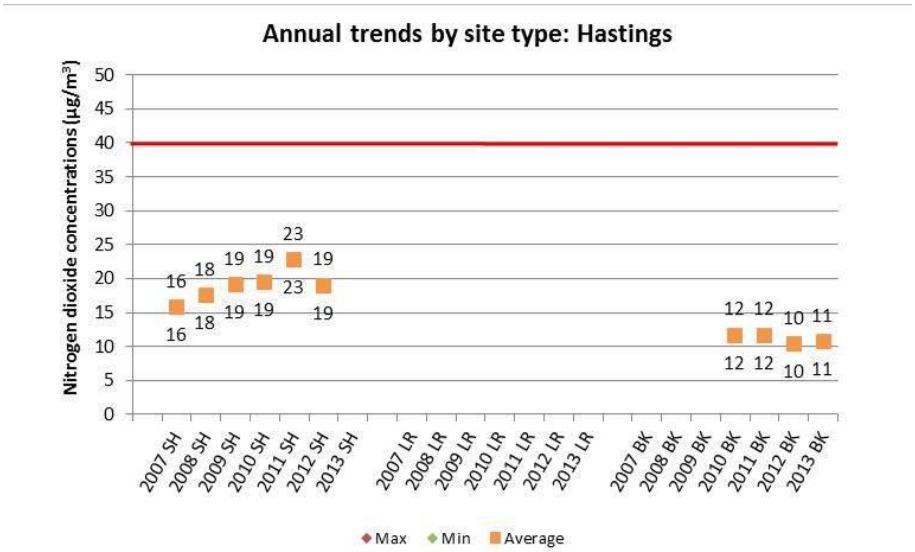

Figure 26: Maximum, minimum and average NO_2 annual values in Hastings

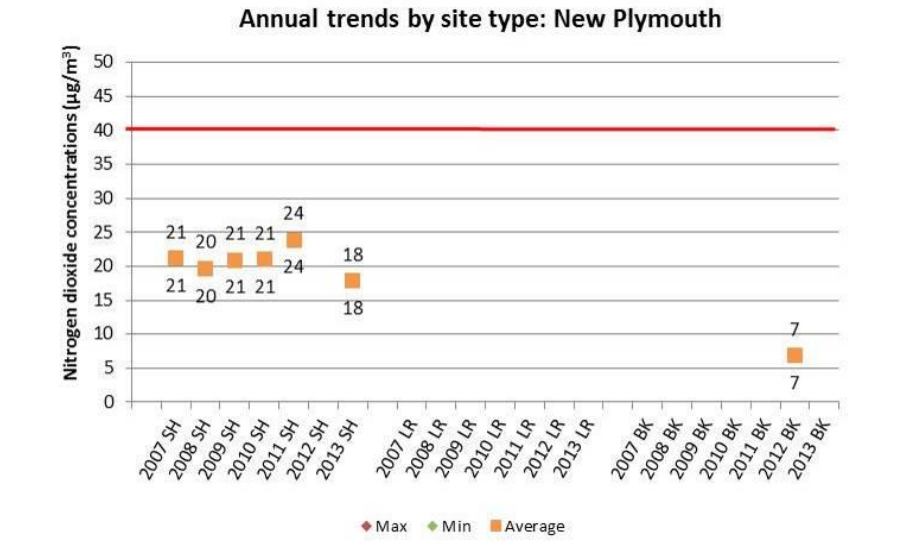

Figure 27: Maximum, minimum and average NO_2 annual values in New Plymouth

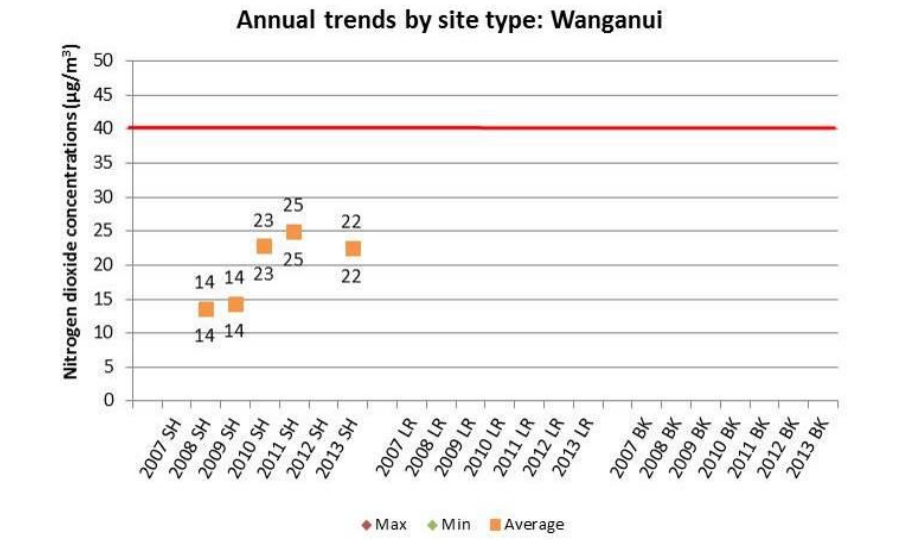

Figure 28: Maximum, minimum and average NO_2 annual values in Wanganui

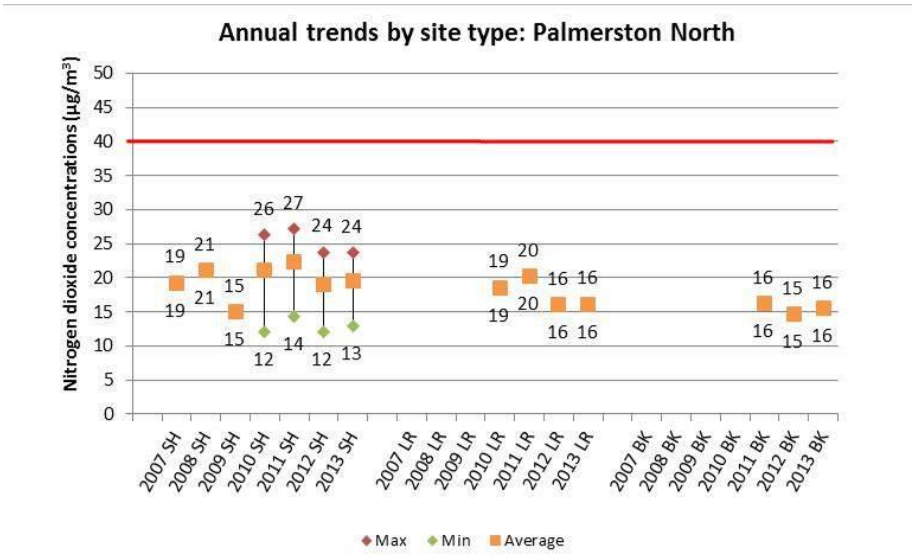

Figure 29: Maximum, minimum and average NO_2 annual values in Palmerston North

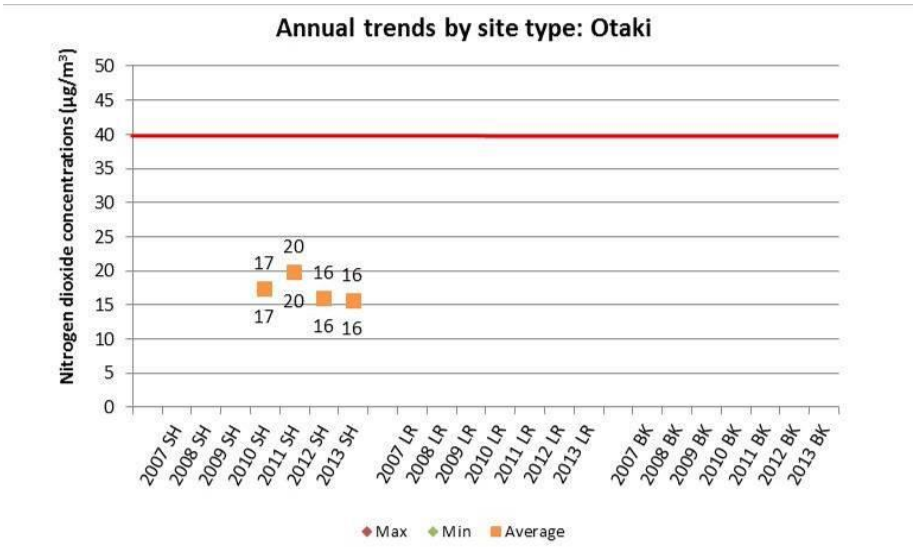

Figure 30: Maximum, minimum and average NO_2 annual values in Otaki

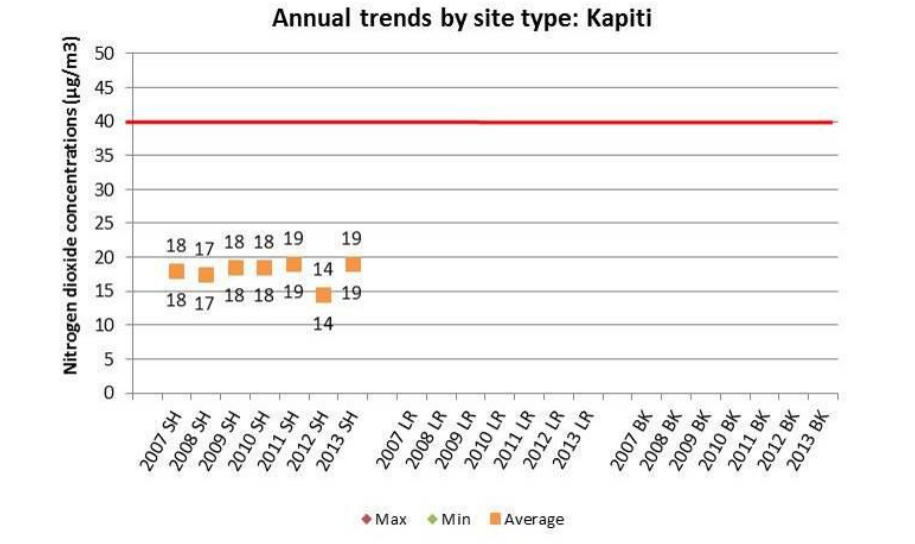

Figure 31: Maximum, minimum and average NO_2 annual values in Kapiti

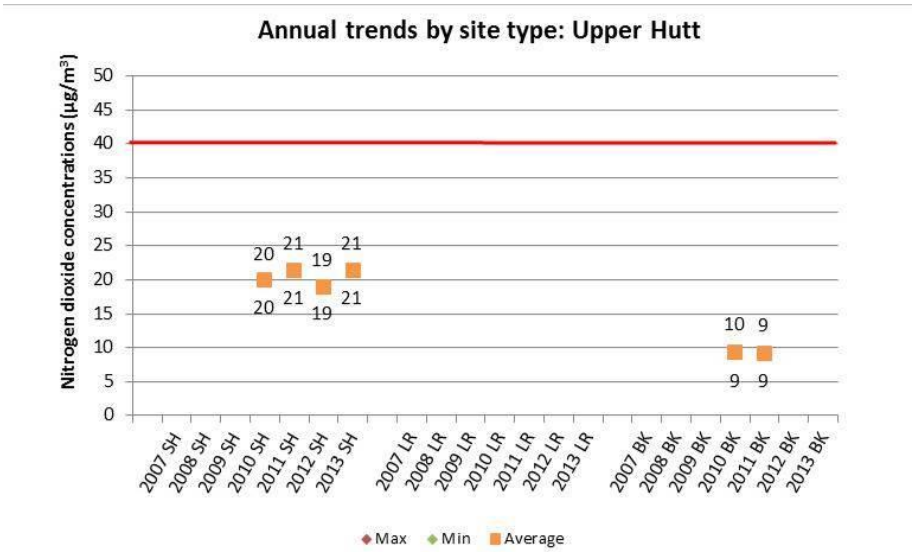

Figure 32: Maximum, minimum and average NO_2 annual values in Upper Hutt

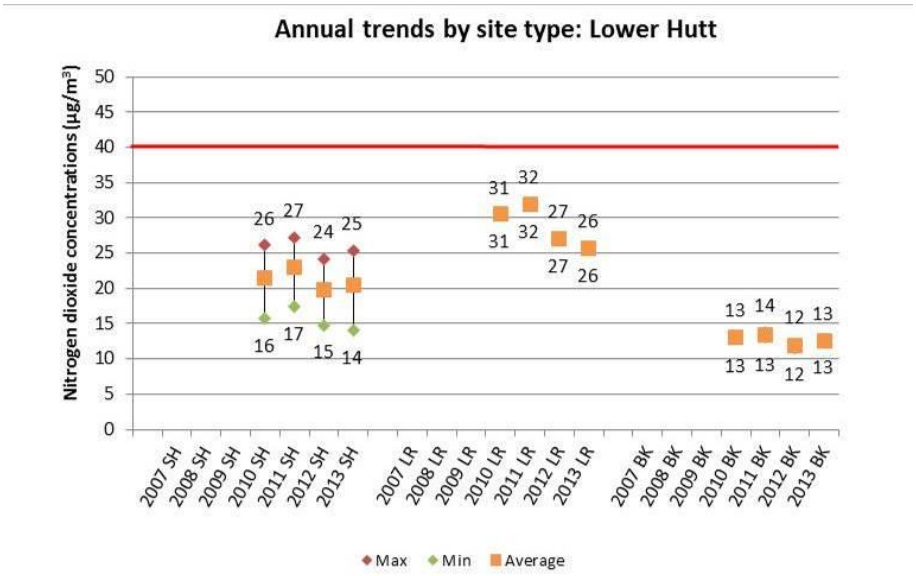

Figure 33: Maximum, minimum and average NO_2 annual values in Lower Hutt

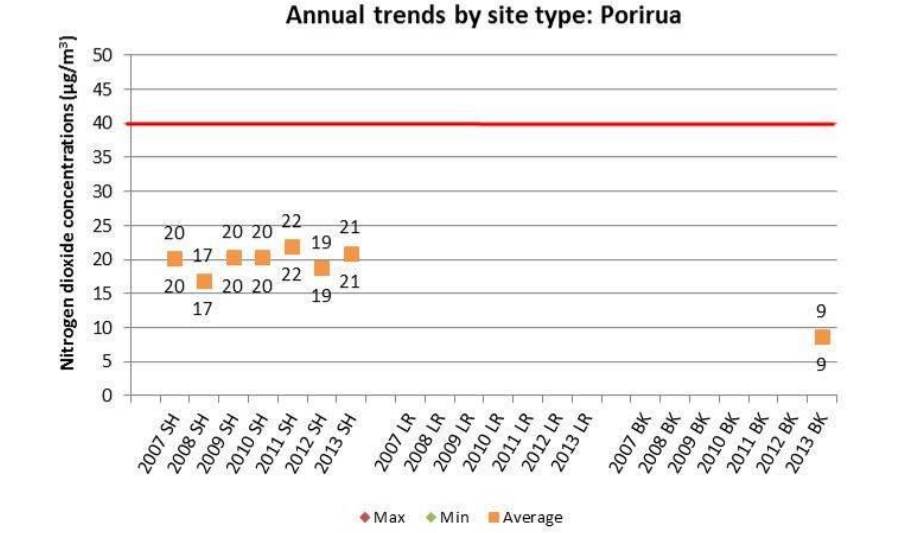

Figure 34: Maximum, minimum and average NO_2 annual values in Porirua

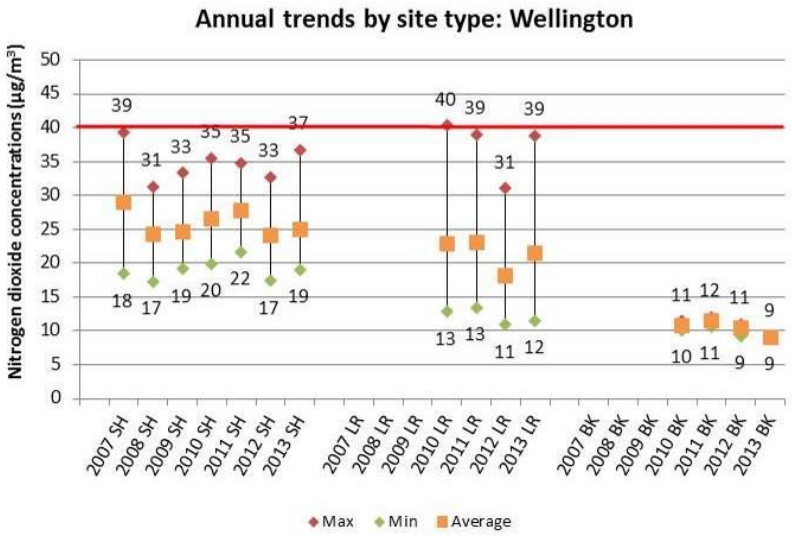

Figure 35: Maximum, minimum and average NO_2 annual values in Wellington

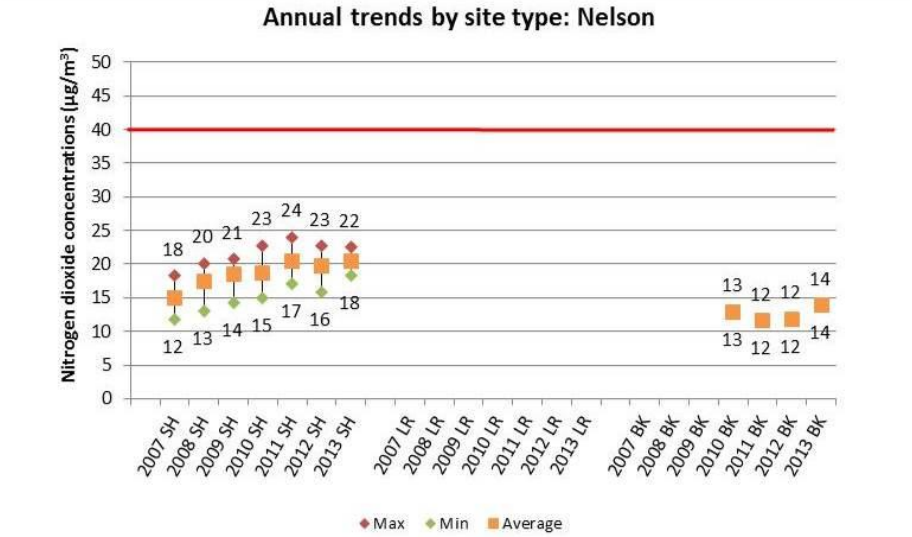

Figure 36: Maximum, minimum and average NO_2 annual values in Nelson

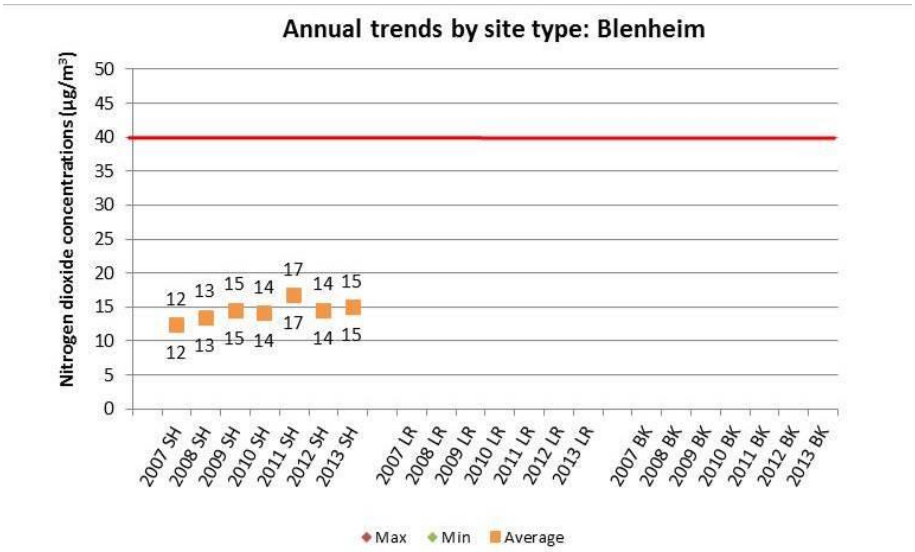

Figure 37: Maximum, minimum and average NO_2 annual values in Blenheim

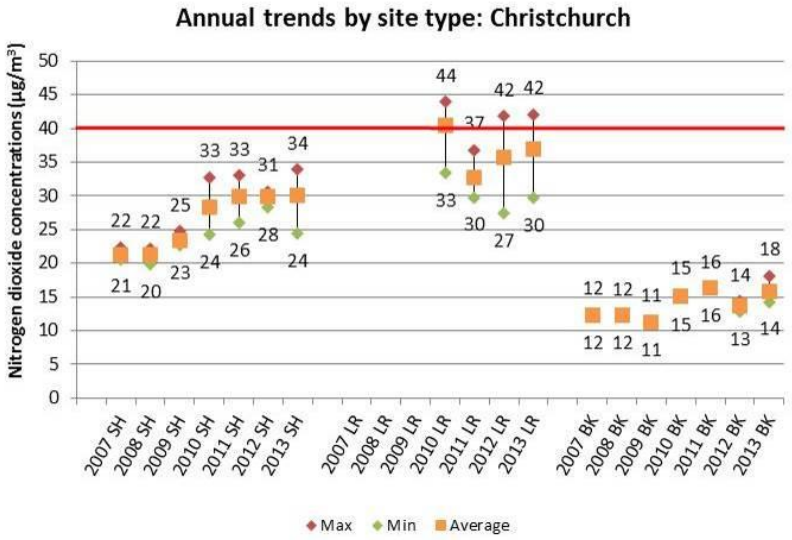

Figure 38: Maximum, minimum and average NO_2 annual values in Christchurch

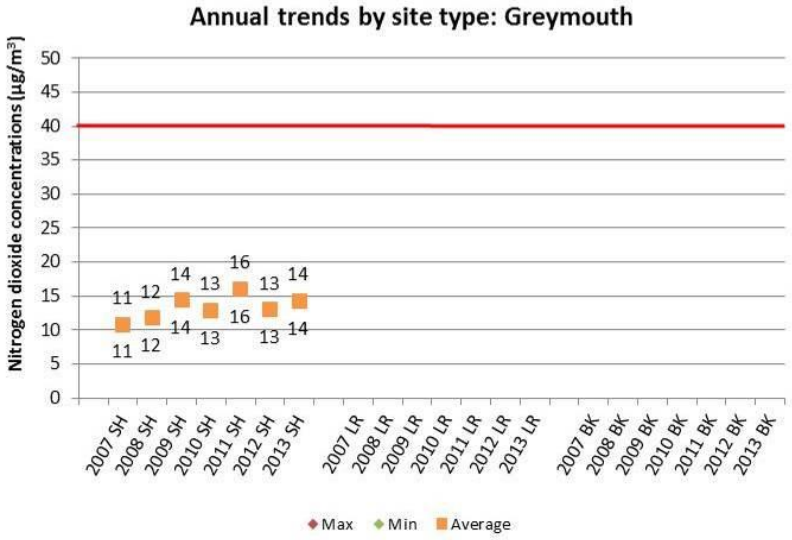

Figure 39: Maximum, minimum and average NO_2 annual values in Greymouth

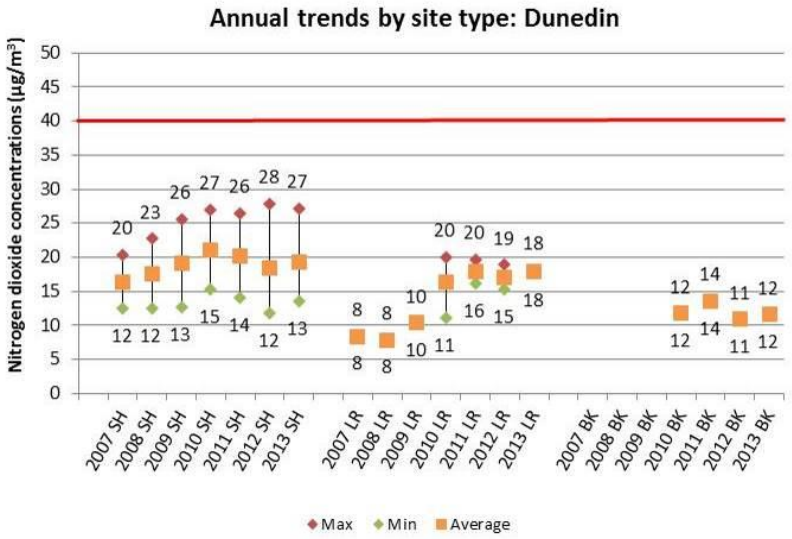

Figure 40: Maximum, minimum and average NO_2 annual values in Dunedin

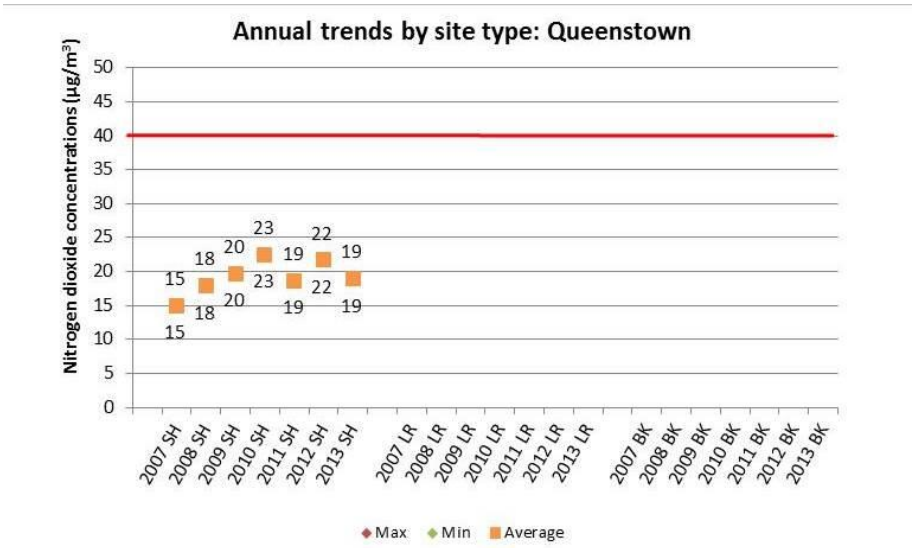

Figure 41: Maximum, minimum and average NO_2 annual values in Queenstown

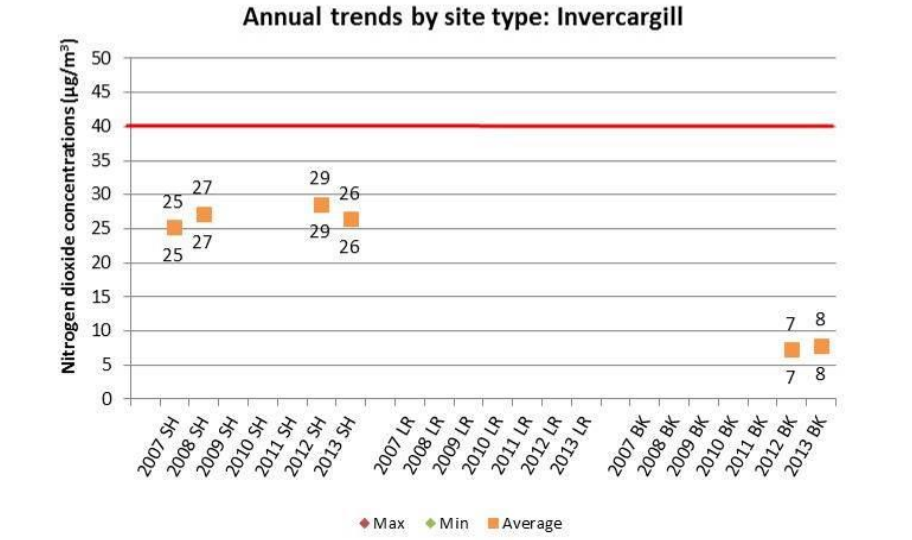

Figure 42: Maximum, minimum and average NO_2 annual values in Invercargill

4.3 High and medium locations

The locations which recorded high (≥40µg/m³) and medium (30-39.9µg/m³) annual average NO_2 concentrations are summarised in table 4 (2007), table 5 (2008), table 6 (2009), table 7 (2010), table 8 (2011), table 9 (2012) and table 10 (2013).

Note: triplicate sites (eg CHR017-019) are reported in the following tables with the average of the three annual values (assuming that each sampler has at least 75% valid data).

Table 4: Locations recording high and medium NO_2 annual average concentrations in 2007

High and medium NO_2 locations in 2007						
Site ID	**Site name**	**Zone**	**Annual NO_2 (µg/m³)**	**Valid data (%)**	**Site type**	**Distance to main road (m)**
High concentrations ≥ 40µg/m³						
AUC009	CMJ / Canada St	Auckland - Central	41.9	100%	State highway	20
Medium concentrations 30-39.9µg/m³						
WEL008	Rugby St / Sussex St	Wellington	39.4	100%	State highway	2
HAM003	Lorne St / Ohaupo Rd	Hamilton	36.1	100%	State highway	1
HAM010	Marsh St / Chapel St	Tauranga	33.3	100%	State highway	2
AUC011	Southern Motorway / Mt Hobson Rd	Auckland - Central	31.0	92%	State highway	10
AUC022	North Western Motorway / Niger St	Auckland - Central	30.0	100%	State highway	32

Table 5: Locations recording high and medium NO_2 annual average concentrations in 2008

High and medium NO_2 locations in 2008						
Site ID	**Site name**	**Zone**	**Annual NO_2 (µg/m³)**	**Valid data (%)**	**Site type**	**Distance to main road (m)**
High concentrations ≥ 40µg/m³						
No sites exceeding 40µg/m³ in 2008						
Medium concentrations 30-39.9µg/m³						
HAM003	Lorne St / Ohaupo Rd	Hamilton	38.3	100%	State highway	1
AUC009	CMJ / Canada St	Auckland - Central	35.8	92%	State highway	20
AUC011	Southern Motorway / Mt Hobson Rd	Auckland - Central	31.3	100%	State highway	10
WEL008	Rugby St / Sussex St	Wellington	31.3	100%	State highway	2

Table 6: Locations recording high and medium NO_2 annual average concentrations in 2009

High and medium NO_2 locations in 2009						
Site ID	**Site name**	**Zone**	**Annual NO_2 ($\mu g/m^3$)**	**Valid data (%)**	**Site type**	**Distance to main road (m)**
High concentrations ≥ 40µg/m³						
AUC009	CMJ / Canada St	Auckland - Central	44.0	92%	State highway	20
AUC060	New North Rd / Mt Albert Rd	Auckland - Central	40.8	75%	Local road	1
HAM003	Lorne St / Ohaupo Rd	Hamilton	40.0	92%	State highway	1
Medium concentrations 30-39.9µg/m³						
HAM010	Marsh St / Chapel St	Tauranga	38.3	92%	State highway	2
AUC063	Great North Rd / Rata St	Auckland - Western	37.8	75%	Local road	1
AUC011	Southern Motorway / Mt Hobson Rd	Auckland - Central	36.9	100%	State highway	10
AUC053	Te Atatu Rd / Edmonton Rd	Auckland - Western	34.8	75%	Local road	3
AUC046	Lake Rd / Esmonde Rd	Auckland – Northern	33.6	75%	Local road	2
WEL008	Rugby St / Sussex St	Wellington	33.3	92%	State highway	2
AUC022	North Western Motorway / Niger St	Auckland - Central	31.6	100%	State highway	32
AUC042	Lake Rd / Service Ln	Auckland – Northern	31.6	75%	Local road	1
AUC018	Southern Motorway / Waimate St	Auckland - Southern	30.7	83%	State highway	60
AUC013 AUC014 AUC015	Southern Motorway / Gavin St (triplicate site)	Auckland - Central	30.4	94%	State highway	100
AUC044 AUC045	Northern Motorway / Wairau Rd (triplicate site)	Auckland – Northern	30.2[25]	75%	State highway	45

[25] This is the average of AUC044 and AUC045 only. The average does not include AUC043 because there was less than 75% valid data for this sampler.

Table 7: Locations recording high and medium NO_2 annual average concentrations in 2010

High and medium NO_2 locations in 2010						
Site ID	**Site name**	**Zone**	**Annual NO_2 ($\mu g/m^3$)**	**Valid data (%)**	**Site type**	**Distance to main road (m)**
High concentrations ≥ 40µg/m³						
AUC068	George Bolt Dr / Kirkbride Rd	Auckland - South	43.3	100%	State highway	2
CHR017 CHR018 CHR019	ECan Riccarton Rd (triplicate site)	Christchurch	42.8	75%	Local road	5
HAM013	Greenwood St / Killarney Rd	Hamilton	41.2	75%	State highway	1
CHR016	Buckleys Rd / Norwich St	Christchurch	40.9	75%	Local road	3
AUC009	CMJ / Canada St	Auckland - Central	40.8	92%	State highway	20
WEL049	Riddiford St / Mein St	Wellington	40.3	83%	Local road	1
Medium concentrations 30-39.9µg/m³						
AUC060	New North Rd / Mt Albert Rd	Auckland - Central	39.9	100%	Local road	1
HAM003	Lorne St / Ohaupo Rd	Hamilton	39.0	92%	State highway	1
AUC063	Great North Rd / Rata St	Auckland - Western	38.3	100%	Local road	1
HAM014	Victoria St / Ulster St	Hamilton	36.8	75%	Local road	1
AUC011	Southern Motorway / Mt Hobson Rd	Auckland - Central	36.7	100%	State highway	10
WEL008	Rugby St / Sussex St	Wellington	35.5	100%	State highway	2
AUC170	Northern Motorway / Tristram Ave	Auckland - Northern	35.0	100%	State highway	5
CHR015	Shirley Rd / North Pde	Christchurch	33.4	75%	Local road	10
AUC053	Te Atatu Rd / Edmonton Rd	Auckland - Western	32.8	100%	Local road	3
CHR014	Brougham St / Waltham Rd	Christchurch	32.8	75%	State highway	12
AUC042	Lake Rd / Service Ln	Auckland – Northern	32.4	100%	Local road	1
AUC022	North Western Motorway / Niger St	Auckland - Central	32.3	100%	State highway	32

High and medium NO_2 locations in 2010						
Site ID	**Site name**	**Zone**	**Annual NO_2 ($\mu g/m^3$)**	**Valid data (%)**	**Site type**	**Distance to main road (m)**
CHR013	Main North Rd / Johns Rd	Christchurch	32.1	75%	State highway	3
AUC061	Great South Rd / Green Ln East	Auckland - Central	31.3	100%	Local road	2
AUC046	Lake Rd / Esmonde Rd	Auckland – Northern	31.0	100%	Local road	2
WEL053	Knights Rd / Bloomfield Tce	Lower Hutt	30.5	83%	Local road	1
AUC071	Mangere Rd / Walmsley Rd	Auckland - Central	30.3	100%	Local road	1
AUC018	Southern Motorway / Waimate St	Auckland - Southern	30.2	100%	State highway	60

Note:

1. A large number of the sites identified as high or medium sites in this table were only commissioned in late 2009 and early 2010 and therefore did not have results available for earlier years. These include:

    - AUC068
    - AUC170
    - CHR013
    - CHR014
    - CHR015
    - CHR016
    - CHR017-019
    - HAM013
    - HAM014
    - WEL049
    - WEL053

Table 8: Locations recording high and medium NO_2 annual average concentrations in 2011

High and medium NO_2 locations in 2011						
Site ID	**Site name**	**Zone**	**Annual NO_2 ($\mu g/m^3$)**	**Valid data (%)**	**Site type**	**Distance to main road (m)**
High concentrations ≥ 40µg/m³						
AUC068	George Bolt Dr / Kirkbride Rd	Auckland - South	44.7	100%	State highway	2
AUC009	CMJ / Canada St	Auckland - Central	43.9	100%	State highway	20
AUC063	Great North Rd / Rata St	Auckland - Western	40.8	100%	Local road	1
HAM003	Lorne St / Ohaupo Rd	Hamilton	40.4	100%	State highway	1
AUC060	New North Rd / Mt Albert Rd	Auckland - Central	40.3	100%	Local road	1
HAM013	Greenwood St / Killarney Rd	Hamilton	40.1	75%	State highway	1
Medium concentrations 30-39.9µg/m³						
AUC170	Northern Motorway / Tristram Ave	Auckland - Northern	39.2	100%	State highway	5
WEL049	Riddiford St / Mein St	Wellington	39.0	92%	Local road	1
AUC011	Southern Motorway / Mt Hobson Rd	Auckland - Central	37.5	92%	State highway	10
CHR016	Buckleys Rd / Norwich St	Christchurch	36.8	75%	Local road	3
HAM014	Victoria St / Ulster St	Hamilton	36.5	100%	Local road	1
AUC053	Te Atatu Rd / Edmonton Rd	Auckland - Western	35.2	100%	Local road	3
WEL008	Rugby St / Sussex St	Wellington	34.8	100%	State highway	2
AUC022	North Western Motorway / Niger St	Auckland - Central	34.1	100%	State highway	32
AUC061	Great South Rd / Green Ln East	Auckland - Central	33.8	100%	Local road	2
AUC018	Southern Motorway / Waimate St	Auckland - Southern	33.1	92%	State highway	60
CHR014	Brougham St / Waltham Rd	Christchurch	33.0	92%	State highway	12
AUC042	Lake Rd / Service Ln	Auckland – Northern	32.7	100%	Local road	1

High and medium NO_2 locations in 2011						
Site ID	**Site name**	**Zone**	**Annual NO_2 ($\mu g/m^3$)**	**Valid data (%)**	**Site type**	**Distance to main road (m)**
HAM007	Fifteenth Ave / Cameron Rd	Tauranga	32.1	92%	State highway	2
HAM018	SH2 / Maunganui Rd	Tauranga	31.9	100%	State highway	2
WEL053	Knights Rd / Bloomfield Tce	Lower Hutt	31.9	92%	Local road	1
CHR013	Main North Rd / Johns Rd	Christchurch	31.7	92%	State highway	3
CHR012	Memorial Ave / Grahams Rd	Christchurch	31.6	83%	Local road	1
AUC046	Lake Rd / Esmonde Rd	Auckland – Northern	31.0	100%	Local road	2
AUC013 AUC014 AUC015	Southern Motorway / Gavin St (triplicate site)	Auckland - Central	30.9	100%	State highway	100
HAM015	Brooklyn Rd / Peachgrove Rd	Hamilton	30.8	100%	Local road	3
AUC043 AUC044 AUC045	Northern Motorway / Wairau Rd (triplicate site)	Auckland – Northern	30.6	100%	Local road	20
HAM004	Victoria St / Queen St	Cambridge	30.6	100%	State highway	1
AUC069	Bairds Rd / Otara Rd	Auckland - Southern	30.2	100%	Local road	10
HAM001	Cambridge Rd / Morrinsville Rd	Hamilton	30.1	100%	State highway	3
AUC071	Mangere Rd / Walmsley Rd	Auckland - Central	30.0	100%	Local road	1
CHR003	Yaldhurst Rd / Curletts Rd	Christchurch	30.0	92%	State highway	5

Table 9: Locations recording high and medium NO_2 annual average concentrations in 2012

High and medium NO_2 locations in 2012						
Site ID	**Site name**	**Zone**	**Annual NO_2 ($\mu g/m^3$)**	**Valid data (%)**	**Site type**	**Distance to main road (m)**
High concentrations ≥ 40µg/m³						
AUC068	George Bolt Dr / Kirkbride Rd	Auckland - South	41.5	100%	State highway	2
CHR017 CHR018 CHR019	ECan Riccarton Rd (triplicate site)	Christchurch	41.4	100%	Local road	5
AUC009	CMJ / Canada St	Auckland - Central	41.3	100%	State highway	20
Medium concentrations 30-39.9µg/m³						
AUC170	Northern Motorway / Tristram Ave	Auckland - Northern	37.7	100%	State highway	5
AUC060	New North Rd / Mt Albert Rd	Auckland - Central	37.6	100%	Local road	1
HAM003	Lorne St / Ohaupo Rd	Hamilton	37.5	100%	State highway	1
HAM014	Victoria St / Ulster St	Hamilton	37.0	92%	Local road	1
AUC063	Great North Rd / Rata St	Auckland - Western	36.8	100%	Local road	1
HAM013	Greenwood St / Killarney Rd	Hamilton	36.8	100%	State highway	1
AUC011	Southern Motorway / Mt Hobson Rd	Auckland - Central	36.3	100%	State highway	10
CHR016	Buckleys Rd / Norwich St	Christchurch	33.6	100%	Local road	3
WEL008	Rugby St / Sussex St	Wellington	32.7	100%	State highway	2
AUC061	Great South Rd / Green Ln East	Auckland - Central	31.8	100%	Local road	2
AUC053	Te Atatu Rd / Edmonton Rd	Auckland - Western	31.7	100%	Local road	3
AUC022	North Western Motorway / Niger St	Auckland - Central	31.4	100%	State highway	32
WEL049	Riddiford St / Mein St	Wellington	31.0	100%	Local road	1
CHR002	Main North Rd / Queen Elizabeth II Dr	Christchurch	30.7	100%	State highway	2
CHR014	Brougham St / Waltham Rd	Christchurch	30.6	83%	State highway	12

High and medium NO_2 locations in 2012						
Site ID	**Site name**	**Zone**	**Annual NO_2 ($\mu g/m^3$)**	**Valid data (%)**	**Site type**	**Distance to main road (m)**
AUC042	Lake Rd / Service Ln	Auckland – Northern	30.5	100%	Local road	1
CHR013	Main North Rd / Johns Rd	Christchurch	30.4	100%	State highway	3

Table 10: Locations recording high and medium NO_2 annual average concentrations in 2013

High and medium NO_2 locations in 2013						
Site ID	**Site name**	**Zone**	**Annual NO_2 ($\mu g/m^3$)**	**Valid data (%)**	**Site type**	**Distance to main road (m)**
High concentrations ≥ 40µg/m³						
AUC009	CMJ / Canada St	Auckland - Central	46.5	100%	State highway	20
AUC068	George Bolt Dr / Kirkbride Rd	Auckland - South	46.0	100%	State highway	2
CHR017 CHR018 CHR019	ECan Riccarton Rd (triplicate site)	Christchurch	41.6	94%	Local road	5
HAM013	Greenwood St / Killarney Rd	Hamilton	41.4	100%	State highway	1
Medium concentrations 30-39.9µg/m³						
AUC060	New North Rd / Mt Albert Rd	Auckland - Central	38.8	100%	Local road	1
WEL049	Riddiford St / Mein St	Wellington	38.8	100%	Local road	1
AUC170	Northern Motorway / Tristram Ave	Auckland - Northern	38.5	100%	State highway	5
HAM003	Lorne St / Ohaupo Rd	Hamilton	38.4	100%	State highway	1
AUC011	Southern Motorway / Mt Hobson Rd	Auckland - Central	38.0	92%	State highway	10
AUC063	Great North Rd / Rata St	Auckland - Western	37.4	100%	Local road	1
WEL008	Rugby St / Sussex St	Wellington	36.7	100%	State highway	2
HAM014	Victoria St / Ulster St	Hamilton	34.8	92%	Local road	1
AUC053	Te Atatu Rd / Edmonton Rd	Auckland - Western	34.2	92%	Local road	3
CHR013	Main North Rd / Johns Rd	Christchurch	33.9	92%	State highway	3
CHR014	Brougham St / Waltham Rd	Christchurch	33.7	75%	State highway	12
CHR016	Buckleys Rd / Norwich St	Christchurch	33.6	83%	Local road	3
AUC071	Mangere Rd / Walmsley Rd	Auckland - Central	32.6	100%	Local road	1
AUC046	Lake Rd / Esmonde Rd	Auckland - Northern	32.2	100%	Local road	2

High and medium NO_2 locations in 2013						
Site ID	**Site name**	**Zone**	**Annual NO_2 ($\mu g/m^3$)**	**Valid data (%)**	**Site type**	**Distance to main road (m)**
CHR006	Rutherford St / Ferry Rd	Christchurch	32.0	83%	State highway	5
AUC061	Great South Rd / Green Ln East	Auckland - Central	31.9	100%	Local road	2
AUC005	Northern Motorway / Fairview Ave	Auckland - Northern	31.9	75%	Local road	2
HAM001	Cambridge Rd / Morrinsville Rd	Hamilton	31.8	100%	State highway	240
AUC022	North Western Motorway / Niger St	Auckland - Central	31.7	100%	State highway	32
AUC013 AUC014 AUC015	Southern Motorway / Gavin St (triplicate site)	Auckland - Central	31.7	100%	State highway	210
AUC067	South Western Motorway / Massey Rd	Auckland - Southern	30.8	100%	State highway	85
AUC042	Lake Rd / Service Ln	Auckland – Northern	30.6	100%	Local road	1

5. Trends

This section summarises the trends in the Transport Agency national NO_2 passive monitoring results from 2007 to 2013. The results are presented as follows:

- Annual trends
- Seasonal variation
- Comparison of continuous and passive monitoring methods

5.1 Annual trends from 2007 to 2013

The percentage change in measured annual averages between 2007 and 2013 has been calculated for the 40 sites that have been operating since 2007, where valid data was at least 75% for both 2007 and 2013 (see appendix 1- table 13). The majority of these sites (88%) show an increase in measured NO_2 annual averages between 2007 and 2013, with half of the sites recording increases of 20% or more.

Across all of the monitored sites with complete data records (36 in total), annual average NO_2 concentrations in 2013 are 19% higher on average than in 2007 but have only recorded a 4% increase on average between 2010 and 2013. This slowing may reflect the impact of improvements in vehicle technology counteracting some of the growth in vehicle travel or may be as a result of the state of the economy influencing vehicle movements or both.

A review of longer term regional council monitoring data from Auckland, Wellington and Christchurch[26] concluded that trends in NO_2 concentrations are not clear, with many sites reporting static or upward trends in annual mean concentrations. The review found that the Takapuna and Penrose motorway sites (which are both located near State Highway 1) operated by the Auckland Council (AC) display upward trends in NO_2 despite downward trends in NO_x. The authors conclude that the increase in NO_2 concentration may be due to increased congestion as well as changes in the vehicle fleet. While modern vehicles generally have lower emissions than older vehicles, the proportion of NO_x emissions that are emitted directly from the exhaust as NO_2 may be increasing.

5.2 Seasonal variation

NO_2 concentrations vary seasonally, with higher concentrations being observed during winter. This is more likely to be as a result of the poor dispersion conditions which occur during winter (eg temperature inversions and calms) rather than the influence of domestic fires which are generally low emitters of NO_2 relative to motor vehicles. It is possible that NO_2 concentrations may also be affected by background ozone concentrations (which are higher during winter than in summer[27]) but this effect is likely to be minor.

Seasonal variation is illustrated for two typical Transport Agency passive monitoring sites in figure 43.

Seasonal averages, as well as the ratios of concentrations in winter (June, July and August) compared to summer (December, January and February) are provided in appendix 1 (table 15). The ratio is calculated for all national network sites with valid summer and winter averages (ie with data for at least two out the three months for each season).

For the majority of sites, the ratio averages at around 2, indicating that NO_2 concentration in winter is typically double the summer concentration. However, there is variation in the extent of seasonal variation across sites and there is no clear pattern. The average ratio across all sites in 2007 to 2013 was 1.8.

[26] NIWA (2008). *op. cit.*

[27] ARC (2007). *Nitrogen dioxide in air in the Auckland region*. Auckland Regional Council technical publication no. 346, December 2007

Interestingly, in 2013 the average ratio increased to 1.8 from 1.5 in 2012, meaning the difference between the summer and winter averages was more pronounced than the previous year.

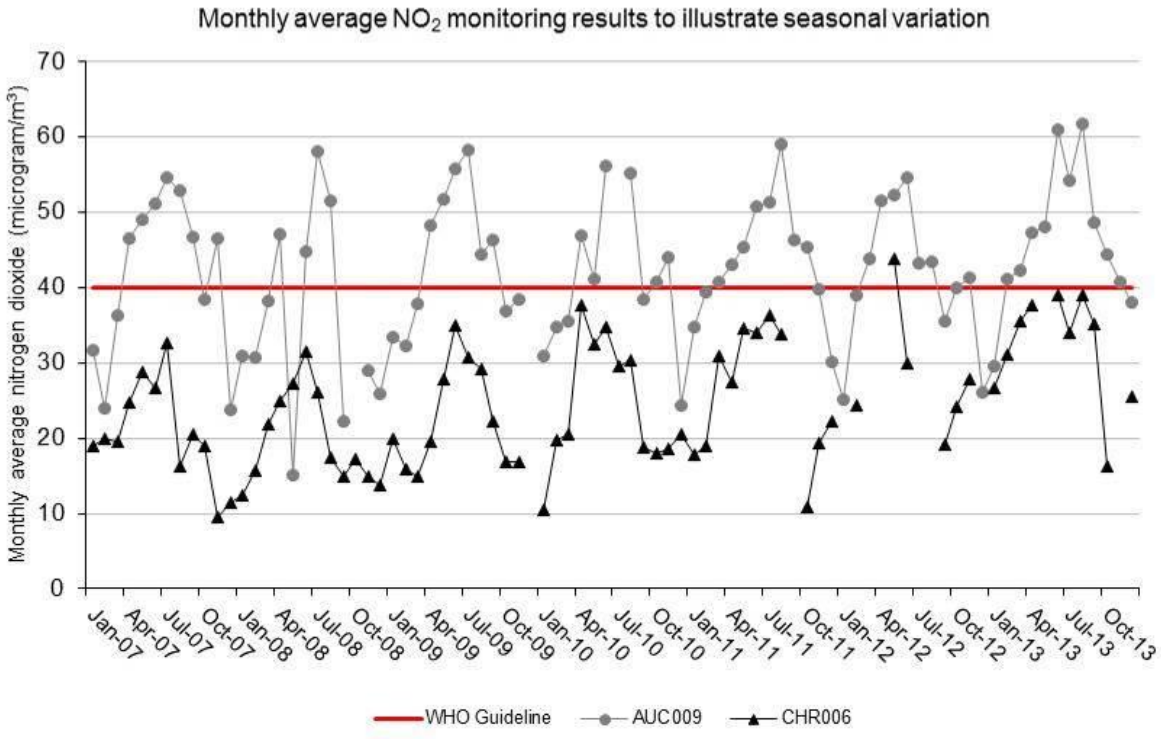

Figure 43: Seasonal variation in monthly average NO_2 concentration for two sites[28]

5.3 Comparison of passive and continuous methods

The results from passive samplers are not directly comparable with those of continuous monitors because the measurement techniques are different.

The first site in the national network to have NO_2 passive diffusion tubes (in triplicate) co-located with a continuous NO_2 monitor was the Auckland Council[29] (AC) site at Penrose in Auckland (AUC013-015). This site was first established in 2007. Five more co-located sites were added in 2009, with a further expansion in 2010. Seven monitoring sites in the Transport Agency's network were co-located with regional council continuous NO_2 monitors in 2013.

Table 11 compares the annual NO_2 averages calculated from continuous monitors with those from the co-located passive diffusion tubes for sites where a *full* year of passive monitoring data is available (ie those sites which recorded 100% valid data).

Note: In the following table, an * is used to indicate that the value shown is an average of only two triplicate results.

[28] The WHO NO_2 guideline is an annual guideline and is not directly comparable to monthly concentrations.

[29] Established originally by Ministry for the Environment

Table 11: Comparison of continuous and passive monitoring results at the co-located sites

Site ID	Co-located site name	Year	Annual average (µg/m³)		Percentage difference
			Continuous [30]	Average of the triplicate tubes	
AUC013-015	MfE/AC Penrose	2007	24.0	27.1	+13%
		2008	23.7	23.9	+1%
		2009	23.1	29.2*	+26%
		2010	22.8	29.8	+31%
		2011	23.7	30.9	+30%
		2012	18.8	28.8	+53%
		2013	19.5	31.7	+63%
AUC043-045	AC Takapuna	2010	21.5	27.0	+26%
		2011	20.0	30.6	+53%
		2012	19.4	27.6	+42%
		2013	20.2	29.5	+46%
AUC054-056	AC Henderson	2010	12.7	17.5	+38%
		2011	12.3	18.8	+53%
		2012	12.8	17.8	+39%
		2013	11.8	17.3	+47%
AUC057-059	AC Glen Eden	2010	7.8	9.9	+27%
		2011	7.8	10.4	+33%
		2012	9.6	9.7	+1%
		2013	7.4	9.5	+29%
WEL028-030	GWRC Melling Station	2009	18.4	23.4*	+27%
WEL031-033	GWRC Corner V	2009	27.5	25.3	-8%
		2010	25.8	27.5	+7%
		2011	24.3	29.5*	+21%
		2012	20.1	25.6	+27%
		2013	19.4	25.8	+33%
WEL034-036	GWRC Duncan Park	2010	8.1	10.9	+35%
		2011	8.2	11.6*	+41%
WEL054-056	GWRC Birch Lane	2011	10.6	13.1*	+24%
WEL058-060	GWRC Savage Park	2011	7.0	9.1	+30%
CHR017-019	ECan Riccarton Rd	2012	38.0	41.4	+9%
		2013	38.0	41.6	+9%
CHR020-022	ECan Coles Pl	2012	11.0	14.0*	+27%
		2013	12.0	15.0	+25%

The results for Penrose are illustrated in more detail in figure 44, which shows that the passive samplers generally follow the trends for the continuous monitor but do not match exactly, especially at higher NO_2 concentrations.

[30] Continuous monitoring data for the AUC sites have been provided by Auckland Council, for the WEL sites by Greater Wellington Regional Council, and for the CHR sites from Environment Canterbury.

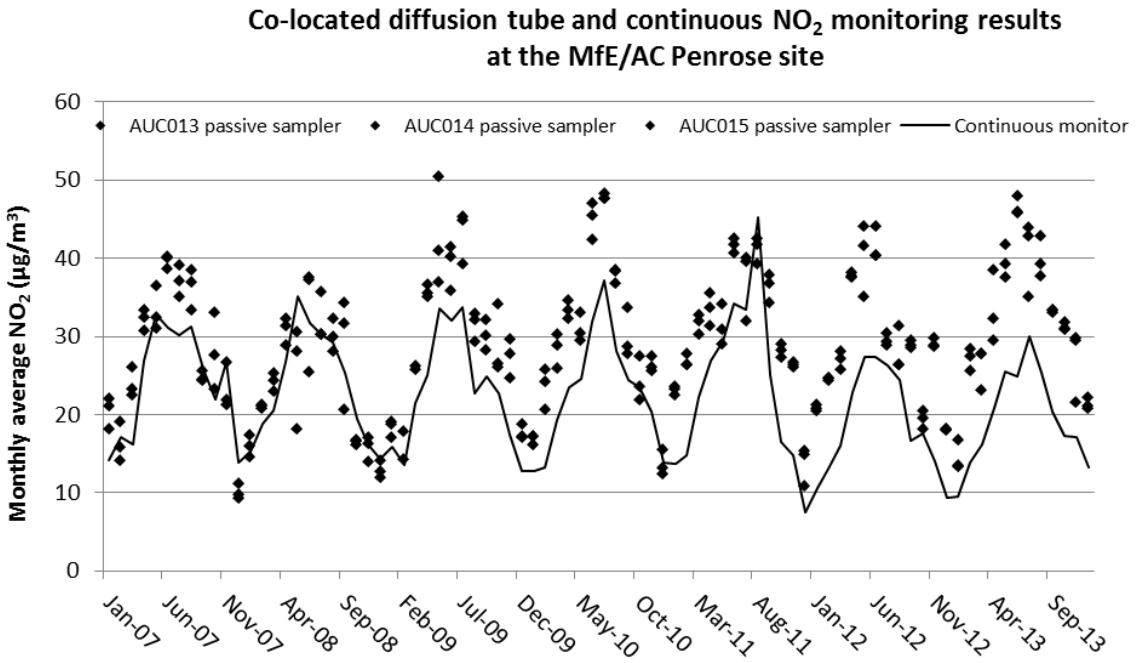

Figure 44: Comparison of passive monitoring (triplicate results) and continuous monitoring results at Penrose in Auckland

These results show that the passive monitoring results are typically higher than the corresponding continuous data. This is in contrast to a comparison undertaken by ARC[31], which found that passive monitoring results were usually lower than the corresponding continuous data (on average 17% lower at Penrose).

In the UK, a bias adjustment factor is used to adjust passive monitoring results to make them directly comparable with the results gained from continuous monitoring methods. This standard formula, taken from the UK's *Local air quality management technical guidance*[32], is shown below:

$$\text{Bias adjustment factor} = \frac{\text{Instrumental } NO_2 \text{ Average}}{\text{Passive } NO_2 \text{ Average}}$$

The Transport Agency results shown in table 11 together with the ARC findings suggest that the relationship between passive and continuous monitoring results is not consistent. Consequently, the application of adjustment factors is not recommended until further investigation can be undertaken.

In this report, the values from passive samplers are presented *without any adjustment* in order to maintain consistency among the passive data. Because of differences in the methodology, the passive results would not be expected to *exactly* match those measured using a continuous analyser. However, data from both methods would be expected to demonstrate a *similar pattern* in the temporal and spatial distributions[33].

The Transport Agency will continue to undertake comparisons of the two monitoring methods and will investigate the use of statistical tools to estimate uncertainties. The relationship between NO_2 and other pollutants measured at these sites will also be investigated to provide an indication of whether NO_2 concentrations and trends are providing a good proxy for overall vehicle pollution.

[31] ARC (2007). *op. cit.*

[32] DEFRA (2009). *op. cit.*

[33] ARC (2007). *op. cit.*

6. Description of high NO_2 sites

Since 2007, nine of the Transport Agency's national network sites have recorded high annual average NO_2 concentrations, ie values greater than or equal to 40µg/m^3, as shown in table 12. The sites are listed based on their annual averages in 2013. As can be seen, all of these sites have consistently recorded high or medium readings since they were installed.

In these locations, the WHO annual NO_2 guideline is likely[34] to be exceeded and the air quality effects of motor vehicle emissions need to be reduced.

These sites are described briefly in the following sections.

Table 12: Summary of the annual averages recorded at all "high" sites since 2007

Site ID	Site name	Annual average (µg/m^3)							Commissioned
		2013	2012	2011	2010	2009	2008	2007	
AUC009	CMJ / Canada St	46.5	41.3	43.9	40.8	44.0	35.8	41.9	Jan-2007
AUC068	George Bolt Dr / Kirkbride Rd	46.0	41.5	44.7	43.3	-			Jul-2009
CHR017 CHR018 CHR019	ECan Riccarton Rd (triplicate site)	41.6*	41.4*	<75% data	42.8*				Apr-2010
HAM013	Greenwood St / Killarney Rd	41.4	36.8	40.1	41.2				Apr-2010
AUC060	New North Rd / Mt Albert Rd	38.8	37.6	40.3	39.9	40.8			Apr-2009
WEL049	Riddiford St / Mein St	38.8	31.0	39.0	40.3				Mar-2010
HAM003	Lorne St / Ohaupo Rd	38.4	37.5	40.4	39.0	40.0	38.3	36.1	Jan-2007
CHR016	Buckleys Rd / Norwich St	37.5	33.6	36.8	40.9				Apr-2010
AUC063	Great North Rd / Rata St	37.4	36.8	40.8	38.3	37.8			Apr-2009

Note: In the above table, the high values are shaded to distinguish them from the medium values. An * is used to indicate that the value shown is an average of the results for the ECan Riccarton Road triplicate site.

[34] If continuous monitoring was to be undertaken rather than passive sampling which is indicative only.

6.1 Central Motorway Junction / Canada Street (AUC009)

Figure 45: Location of AUC009 monitoring site

AUC009 is a state highway site and is located at Canada Street, Newton near the Central Motorway (Spaghetti) Junction in Auckland (see figure 45). The site was commissioned in January 2007.

The average annual NO_2 concentrations recorded at site AUC009 were 41.9µg/m³ in 2007, 35.8µg/m³ in 2008, 44.0µg/m³ in 2009, 40.8µg/m³ in 2010, 43.9µg/m³ in 2011, 41.3µg/m³ in 2012 and 46.5µg/m³ in 2013.

Monitoring of traffic using the state highway network in this area shows that AUC009 is impacted by very high traffic volumes. The combined annual average daily traffic flow (AADT) on the motorways in the Central Motorway Junction beneath the Upper Queen Street over bridge in 2013 was approximately 150,000, of which just over 4% were heavy vehicles (Transport Agency data).

The Transport Agency has a number of projects which are expected to reduce NO_2 concentrations at the AUC009 site in future as a result of improved traffic flows in and around the Central Motorway Junction. These include:

- SH1 Victoria Park Tunnel, which was completed in April 2012 (http://www.nzta.govt.nz/projects/victoria-park-tunnel/)
- SH1 Newmarket Connection: Viaduct Replacement Project, which was completed in March 2013 (http://www.nzta.govt.nz/projects/newmarketconnection/)

Completion of the Western Ring Route improvements in 2017 will also significantly improve the network efficiency of the state highway and local road network in Auckland, including the operation of the Central Motorway Junction. The ring route will provide an alternative north-south route that will bypass the CBD and is expected to reduce congestion and transport-related air pollution in the vicinity of site AUC009 (http://www.nzta.govt.nz/projects/wrr/).

6.2 George Bolt Drive / Kirkbride Road (AUC068)

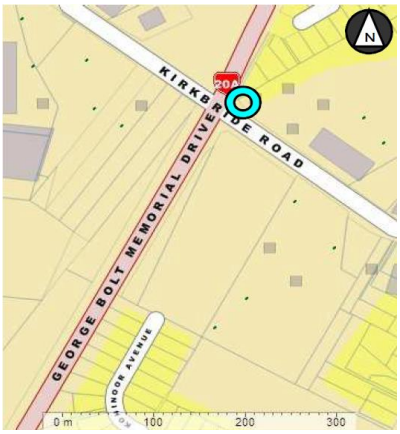

Figure 46: Location of AUC068 monitoring site

AUC068 is a state highway site and is located on SH20A (the major route to the Auckland Airport) at the intersection of George Bolt Memorial Drive and Kirkbride Road in Mangere (see figure 46). The site was commissioned in July 2009.

The average annual NO_2 concentrations recorded at site AUC068 were 43.3µg/m³ in 2010, 44.7µg/m³ in 2011, 41.5µg/m³ in 2012 and 46.0µg/m³ in 2013.

The annual average daily traffic flow (AADT) on George Bolt Memorial Drive in 2013 was approximately 40,000, of which around 6.5% were heavy vehicles (Transport Agency data). For Kirkbride Road, Auckland Transport traffic count data from 2013 indicate that the AADT in the vicinity of the site is approximately 18,000. The combined monitoring suggests that AUC068 is impacted by high traffic volumes (in the order of nearly 60,000 vehicles per day on average).

The Transport Agency has secured $140M of Government funding to upgrade SH20A. The state highway will be upgraded with a new motorway interchange at the Kirkbride Road intersection (see http://www.nzta.govt.nz/projects/sh20a-to-airport/). In addition to grade separation, the project will involve:

- Provision for future bus shoulder lanes
- Relocation of cycleway facilities from SH20A onto the local road network

Construction is scheduled to commence in early 2015 and will take two years to complete. Concentrations at AUC068 are expected to reduce following completion.

6.3 ECan Riccarton Road Triplicate Site (CHR017-019)

Figure 47: Location of CHR017-019 monitoring site

CHR017-019 is a local road site and is located in the retail area of Riccarton Road (approximately 30 metres east of the Westfield Riccarton Mall) in Riccarton, Christchurch (see figure 47). The site was commissioned in April 2010 with the passive samplers installed in triplicate and is co-located with the Environment Canterbury continuous air quality monitoring site.

The average annual NO_2 concentration recorded at site CHR017-019 was 42.8µg/m^3 in 2010, 41.4µg/m^3 in 2012 and 41.6µg/m^3 in 2013. Insufficient (less than 75% valid) data were collected in 2011 (due to the series of earthquakes that have affected the city since September 2010) and so no annual average was available for 2011. However, a review of the 2011 results suggests that the annual average concentration in 2011 would have been at least as high as 2010 if the site had not been disrupted.

Christchurch City Council traffic data indicates that this location is impacted by nearly 27,000 vehicles per day on average. However, typical traffic patterns in the area have been severely disrupted as a result of earthquake damage altering the routes that people are able or need to travel on. In addition, since the February 2011 earthquake, the Riccarton Mall has become the de facto primary retail centre in Christchurch.

Although there are significant transport works programmes underway (see http://www.tfc.govt.nz/ and http://www.ccc.govt.nz/cityleisure/projectstoimprovechristchurch/transport/AAC/index.aspx), it will be some time before the roading network is functioning 'normally' in Christchurch. In the meantime, slow moving and congested traffic will likely continue to adversely affect air quality near the CHR017-019 site in the short-to-medium term.

6.4 Greenwood Street / Killarney Road (HAM013)

Figure 48: Location of HAM013 monitoring site

HAM013 is a state highway site and is located on the junction of Greenwood Street (SH1) and Killarney Road in Frankton, Hamilton (see figure 48). The site was commissioned in April 2010.

The average annual NO_2 concentrations recorded at site HAM013 were 41.2µg/m³ in 2010, 40.1µg/m³ in 2011, 36.8µg/m³ in 2012 and 41.4µg/m³ in 2013.

This site is close to a busy junction where there is a lot of congested traffic (including heavy goods vehicles). The Transport Agency's data for 2013 show that the AADT on Greenwood Street in the vicinity was around 27,680 vehicles per day, with a heavy vehicle contribution of 13%. Hamilton City Council data for 2013 indicate that Killarney Road is subject to around 13,000 vehicles per day on average.

There are a number of projects which may help to reduce transport-related air pollution in the vicinity of site HAM013 in the medium-to-long term, including:

- The Waikato Expressway project, which is being completed in stages (some sections are already open) and is due to be fully open in 2019. (http://www.nzta.govt.nz/projects/waikato-expressway/)
- The Southern Links project, which is still at an early stage of development. Decisions and recommendations were issued in early 2014 to future-proof the $600m Southern Links transport network but progression to construction stage could be 10-15 years away. (http://www.nzta.govt.nz/projects/southern-links/)

6.5 New North Road / Mt Albert Road (AUC060)

Figure 49: Location of AUC060 monitoring site

AUC060 is a local road site and is located on the intersection of Mt Albert Road and New North Road in Mt Albert, Auckland (see figure 49). The site was commissioned in April 2009.

The average annual NO_2 concentrations recorded at site AUC060 were 40.8µg/m³ in 2009, 39.9µg/m³ in 2010, 40.3µg/m³ in 2011, 37.6µg/m³ in 2012 and 38.8µg/m³ in 2013.

This site is close to a local road intersection where there is a lot of congested traffic. Auckland Transport traffic count data from 2012 indicate that the AADT in the vicinity of the site on Mt Albert Road is approximately 13,600, and on New North Road approximately 20,000.

Completion of the Western Ring Route improvements in 2017 will significantly improve the network efficiency of the state highway and local road network in Auckland. The ring route will provide an alternative north-south route that will bypass the CBD. It will also take pressure off local roads, such as New North Road, helping to reduce congestion and transport-related air pollution in the vicinity of site AUC060 (http://www.nzta.govt.nz/projects/wrr/).

6.6 Riddiford Street / Mein Road (WEL049)

Figure 50: Location of WEL049 monitoring site

WEL049 is a local road site and is located on the corner of the Riddiford Street and Hall Street intersection in Newtown, Wellington (see figure 50). The site was commissioned in March 2010.

The average annual NO_2 concentrations recorded at site WEL049 were 40.3µg/m³ in 2010, 39.0µg/m³ in 2011, 31.0µg/m³ in 2012 and 38.8µg/m³ in 2013.

This site is close to a busy intersection, a few metres up the road from a bus stop and across from Wellington Hospital and Newtown School. Wellington City Council traffic count data from 2014 indicate that the AADT in the vicinity of the site is approximately 23,250.

There are a number of projects in development which are expected to help reduce NO_2 concentrations in the vicinity of the WEL049 site in the short to medium term as follows:

- The local Wellington councils have a number of planned projects designed to improve the Adelaide Road transport corridor for walking, cycling, and public transport (http://wellington.govt.nz/your-council/projects/adelaide-road and http://www.gw.govt.nz/it-s-agreed-bus-rapid-transit-for-wellington-s-public-transport-spine/)
- The National War Memorial and Underpass project (http://www.nzta.govt.nz/projects/memorial-park/index.html), the Basin Bridge project (http://www.nzta.govt.nz/projects/basin-bridge/index.html) and the Inner City Bypass Improvements project (http://www.nzta.govt.nz/projects/inner-city-bypass-improvements/index.html) all of which form part of the wider Tunnel to Tunnel (T2T) Project (http://www.nzta.govt.nz/projects/tunnel-to-tunnel/index.html). The T2T project is intended to improve east-west traffic movements on the

state highway network between Ngauranga and the Airport and well as facilitate the public transport improvements mentioned above that have been proposed by the Regional Council.

- In 2014 a Board of Inquiry declined planning approval for the Transport Agency to enable construction of the Basin Bridge. The Transport Agency has appealed the decision (http://www.nzta.govt.nz/about/media/releases/3657/news.html). The outcome of the appeal will have an impact on the direction and timing of the wider T2T project, GWRC's projects as well as the adjoining Mount Victoria Tunnel Duplication project (http://www.nzta.govt.nz/projects/mt-vic-duplication/), which includes duplicating the tunnel, widening Ruahine Street and Wellington Road, walking and cycling improvements.

6.7 Lorne Street / Ohaupo Road (HAM003)

Figure 51: Location of HAM003 monitoring site

HAM003 is a state highway site and is located on the junction of Lorne Street (SH1) and Ohaupo Road (SH3) in Melville, Hamilton (see figure 51). The site was commissioned in January 2007.

The average annual NO_2 concentrations recorded at site HAM003 were 36.1µg/m³ in 2007, 38.3µg/m³ in 2008, 40.0µg/m³ in 2009, 39.0µg/m³ in 2010, 40.3µg/m³ in 2011, 37.5µg/m³ in 2012, and 38.4µg/m³ in 2013.

This site is close to a busy junction where there is a lot of congested traffic (including heavy goods vehicles). The Transport Agency data for 2013 show that:

- Lorne Street recorded an AADT of approximately 13,240 with around 9% being heavy vehicles.
- Kahikatea Drive recorded an AADT of approximately 19,150 with around 9% being heavy vehicles.
- Ohaupo Road recorded an AADT of approximately 24,810 with around 8% heavy vehicles.

There are a number of projects which may help to reduce transport-related air pollution in the vicinity of site HAM003 in the medium to long term, including:

- The Waikato Expressway project, which is being completed in stages (some sections are already open) and is due to be fully open in 2019. (http://www.nzta.govt.nz/projects/waikato-expressway/)

- The Southern Links project, which is still at an early stage of development. Decisions and recommendations were issued in early 2014 to future-proof the $600m Southern Links transport network but progression to construction stage could be 10-15 years away. (http://www.nzta.govt.nz/projects/southern-links/)

There are also a number of upgrades being considered for the following intersections in the vicinity:

- SH1/SH3
- SH1/Normandy Road and SH1/Cobham Road
- SH1/SH26

6.8 Buckleys Road / Norwich Street (CHR016)

Figure 52: Location of CHR016 monitoring site

CHR016 is a local road site and is located in the Eastgate retail area of Buckleys Road (opposite Norwich Street) in Linwood, Christchurch (see figure 52). The site was commissioned in March 2010.

The average annual NO_2 concentrations recorded at site CHR016 were 40.9µg/m³ in 2010, 36.8µg/m³ in 2011, 33.6µg/m³ in 2012 and 37.5µg/m³ in 2013.

This site is on a busy road in a suburb that adjoins Avonside (one of the worst affected suburbs following the September 2010, February 2011 and June 2011 earthquakes in Christchurch). Christchurch City Council traffic data indicates that this location is typically impacted by approximately 27,000 vehicles per day on average. However, typical traffic patterns in Christchurch have been severely disrupted due to damage to infrastructure altering the routes that people are able or need to travel on.

Around half of all Christchurch's streets and roads suffered some level of damage in the 22 February 2011 earthquake. More than 50,000 individual road surface defects have been recorded across the city – this covers anything from a hump in the road to more major damage. The Transport Agency is working closely with the Canterbury Earthquake Recovery Authority (CERA) to repair and replace earthquake damaged roading infrastructure in the city.

Although there are significant transport works programmes underway (see http://www.tfc.govt.nz/ and http://www.ccc.govt.nz/cityleisure/projectstoimprovechristchurch/transport/AAC/index.aspx), it will be

some time before the roading network is functioning 'normally' in Christchurch. In the meantime, slow moving and congested traffic will likely continue to adversely affect air quality near the CHR016 site in the short to medium term.

6.9 Great North Road / Rata Street (AUC063)

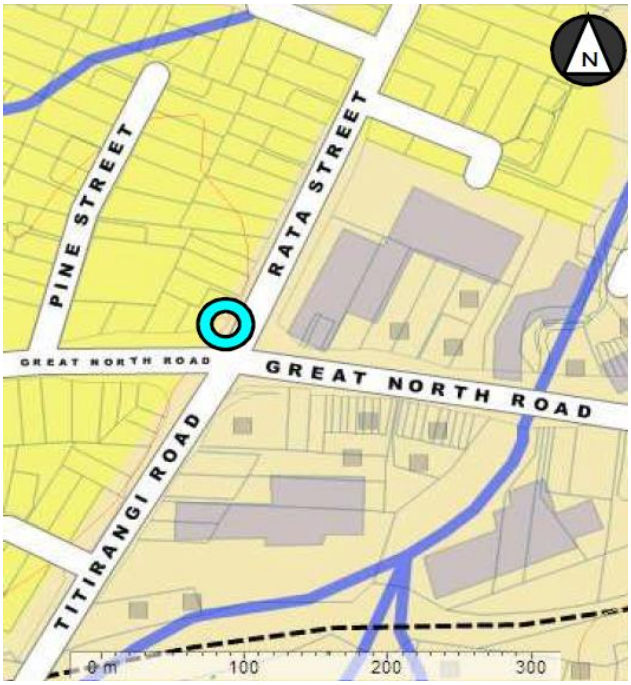

Figure 53: Location of AUC063 monitoring site

AUC063 is a local road site and is located on the intersection of Great North Road and Rata Street in New Lynn, Auckland (see figure 53). The site was commissioned in April 2009.

The average annual NO_2 concentrations recorded at site AUC063 were 37.8µg/m^3 in 2009, 38.3µg/m^3 in 2010, 40.8µg/m^3 in 2011, 36.8µg/m3 in 2012 and 37.4µg/m^3 in 2013.

This site is at a major local road intersection where there is a lot of congested traffic. Auckland Transport traffic count data from 2012 indicate that the AADT in the vicinity of the site on Great North Road is approximately 39,000, and on Rata Street approximately 33,000.

Completion of the Western Ring Route improvements in 2017 will significantly improve the network efficiency of the state highway and local road network in Auckland. The ring route will provide an alternative north-south route that will bypass the CBD. It will also take pressure off local roads, such as Great North Road, helping to reduce congestion and transport-related air pollution in the vicinity of site AUC009 (http://www.nzta.govt.nz/projects/wrr/).

7. Conclusions

7.1 High concentration sites

High NO_2 sites are defined as those where the annual average NO_2 concentration measured by passive samplers exceeds 40µg/m^3.

Over the years 2007 to 2013, nine national network sites have recorded high annual average NO_2 concentrations, with one of these (AUC009) recording high readings in every year except 2008.

For 2013, the following four sites were classified as high sites:

- AUC009 - a state highway site at the central motorway junction in Auckland.
- AUC068 - a state highway site near the intersection of Kirkbride Road and George Bolt Memorial Drive on the way to Auckland airport.
- CHR017-019 - a local road site on Riccarton Road[35] in Christchurch.
- HAM013 – a state highway site at the intersection of Greenwood Street and Killarney Road in Hamilton

In all of the high locations the WHO annual NO_2 guideline is likely to be exceeded, and the air quality effects of motor vehicle emissions need to be reduced.

For the majority of the high sites, the Transport Agency and other agencies have a number of planned projects that will improve traffic flow and air quality at these sites. However, some of these are in the very early stages and are not scheduled for completion in the short term (within three years) so concentrations at some sites may remain elevated for the foreseeable future. Other factors such as changes over time to the vehicle fleet and vehicle emission standards as well as the extent to which different transport modes are used will also influence, to a greater or lesser extent, air quality at these high concentration sites.

7.2 Medium concentration sites

Medium NO_2 sites are defined as those where the annual average NO_2 concentration measured by passive samplers exceeds 30µg/m^3 but is less than 40µg/m^3. In these locations air quality is likely to be degraded as a result of motor vehicle emissions and may cause adverse effects but not to the potential extent of the high sites.

Since 2007, more than 30 national network sites have recorded medium annual average NO_2 concentrations.

In 2013, 22 sites were classified as medium sites. These sites are located near busy local roads and state highways in Auckland, Hamilton, Wellington, and Christchurch.

[35] This location is a triplicate site where the passive samplers are co-located with a continuous monitor operated by Environment Canterbury.

7.3 Trends from 2007 to 2013

Forty sites have valid data records which enable trends between 2007 and 2013 to be investigated. The majority of these sites (88%) show an increase in measured NO_2 annual averages between 2007 and 2013, with half the sites recording increases of 20% or more.

Across all of the monitored sites with complete data records (36 in total), annual average NO_2 concentrations in 2013 are 19% higher on average than in 2007 but have only recorded a 4% increase on average between 2010 and 2013. This slowing may reflect the impact of improvements in vehicle technology counteracting some of the growth in vehicle travel or may be as a result of the state of the economy influencing vehicle movements or both.

7.4 Seasonal variation

NO_2 concentrations vary seasonally, with higher concentrations being observed during winter. For most sites, the average NO_2 concentration in winter (June to August) is typically double that in summer (December to February).

7.5 Comparison of continuous and passive methods

Seven monitoring sites in the Transport Agency network were co-located with regional council continuous NO_2 monitors in 2013. Passive monitoring results are typically higher than the corresponding continuous data. However, the relationship between the passive and continuous monitoring data has not been consistent to date so results are presented without any adjustment in this report.

Quality assurance of the passive monitoring network has been undertaken using triplicate passive samplers, also at ten sites. A comparison of the triplicate data shows that the precision (repeatability) of the passive samplers is good, with an average coefficient of variation of less than 8%.

7.6 Future work

In recent years, the development of the passive sampling network by the Transport Agency has been largely in increasing the *quantity of sites* to improve the coverage and representativeness of the results. The wealth of data now available provides an opportunity for any future development to now focus on enhancing the *value of the results*, by using the information to better understand how the Transport Agency can contribute to a reduction in adverse air quality effects from land transport and specifically by:

- Undertaking air quality investigations for any Transport Agency national network state highway passive monitoring sites where the annual average NO_2 concentration measured by passive samplers exceeds 40µg/m^3.
- Assessing the feasibility of measuring traffic volume, speed, and percentage of heavy vehicles in close proximity to key Transport Agency national NO_2 passive monitoring network sites. The highest priority will be monitoring of these parameters where the annual average NO_2 concentration measured by passive samplers exceeds the medium threshold (30µg/m^3).
- Investigating the relationship between continuous and passive NO_2 monitoring results and evaluate the suitability of statistical tools for developing appropriate correlation factors and establishing uncertainties.

- Investigating the relationship between continuous and passive NO_2 monitoring results and other pollutants measured at co-located sites to provide an indication of whether NO_2 concentrations and trends are providing a good proxy for overall vehicle pollution.

Annual data are uploaded annually into the Transport Related Air Quality Monitoring System (TRAMS) database, after receiving the last analysis report for December of the previous year. Annual and seasonal averages, together with links to the site metadata files as PDFs, can be viewed and accessed using either SpatialViewer (https://spatialviewer.nzta.govt.nz/) or via the Monitoring tab under the Transport and Air Quality website (http://air.nzta.govt.nz/transport-related-air-quality-monitoring-data).

8. References

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9. Glossary

Terms	Description
AADT	Annual average daily traffic
AAQG	Ambient Air Quality Guidelines
AC	Auckland Council (prior to 1 November 2010 known as Auckland Regional Council)
ARC	Auckland Regional Council (since 1 November 2010 known as Auckland Council)
Background site	A monitoring site which is located more than 100 metres from a state highway and more than 50 metres from a busy local road.
Co-located site	Co-location is a procedure used in air quality monitoring where two or more monitors or samplers are installed in the same location so the measurements can be compared. For example, co-locating a passive sampler with a continuous monitor at the same site.
Continuous monitoring	Air quality monitoring undertaken by continuously collecting and measuring airborne gases or particles using a vacuum source in order to (usually) demonstrate compliance with an applicable regulation, eg a chemiluminescent NO_2 analyser
CV	Coefficient of variation, a normalized measure of dispersion of a probability distribution defined as the ratio of the standard deviation to the mean
DEFRA	UK Department for Environment, Food and Rural Affairs
ECan	Environment Canterbury
GWRC	Greater Wellington Regional Council
Local road	A road with an AADT>20,000 or which is known hot spot for traffic congestion
Local road site	A monitoring site which is located within 50 metres of a busy local road.
MfE	Ministry for the Environment
NES	National Environmental Standards for Air Quality
NO_2	Nitrogen dioxide, a type of air pollutant
NO_x	Nitrogen oxides, the collective term for air pollutants containing a mixture of nitrogen and oxygen
NZTA/ Transport Agency	The New Zealand Transport Agency is a Road Controlling Authority and the agency responsible for the building and operation of New Zealand's state highway network, amongst other duties, since July 2008. Previously state highways were managed by Transit New Zealand).
Passive monitoring	Air quality monitoring undertaken by collecting airborne gases through a diffusion barrier onto a sorbent medium without the use of a vacuum source, eg diffusion tubes
$PM_{2.5}$	Fine particles less than 2.5 micrometres in diameter, a type of air pollutant
PM_{10}	Particles less than 10 micrometres in diameter, a type of air pollutant
SH	State highway
SH site	A monitoring site which is located within 100 metres of a state highway.
Summer	Defined for the purpose of calculating a seasonal "summer" average as December (of the previous year), January and February

Triplicate site	A site where three passive samplers are installed next to each other to check the precision (or repeatability) of the results. The results are used to calculate the coefficient of variation (CV) which indicates the accuracy of the samplers.
µg/m^3	Unit used to express air pollution concentrations, in this case a microgram of pollutant per cubic metre of air
Valid data	Data that have been through a process to remove any values that do not reflect actual conditions being monitored. For example, if a sampler is damaged or vandalised during the monitoring period then the result is declared invalid and cannot be used to calculate any seasonal or annual averages covering that period
% valid data	The minimum is set at 75% for the purpose of calculating an average for a monitoring period. For annual averages, at least nine months must have valid reading. For seasonal average all three months must have a valid reading (as two out of three is 67% which is below the 75% threshold).
WHO	World Health Organisation
Winter	Defined for the purpose of calculating a seasonal “winter” average as June, July and August

Appendix 1: Tables

This appendix presents detailed results as follows:

- Table 13 is a summary of site metadata for all sites that were operational between 2007 and 2013.
- Table 14 is a summary of annual average NO_2 concentrations for all sites for 2007 to 2013. Note: the *percentage change between 2007 and 2013 is only calculated for sites with at least 75% valid data* in 2007 and 2013.
- Table 15 compares the annual and seasonal averages (winter and summer) for 2008 to 2013. Note: *annual averages are only calculated for years with at least 75% valid data* (ie nine out of 12 months) and *seasonal averages are only calculated for periods with at least 66% valid data* (ie two out of three months).

Table 13: Summary of metadata for the Transport Agency's national ambient NO_2 monitoring network

Site metadata summary * = triplicate site										
Monitoring zone	Site ID	Site name	Area	NZTM easting	NZTM northing	Distance to sensitive receptor (m)	Site type	State highway	Distance to SH (m)	Distance to local road (m)
Whangarei	AUC001	Western Hills Dr / Selwyn Ave	Woodhill	1718908	6046054	10	SH	1	1	350
	AUC038	Huia St (relocated to AUC171)	Whau Valley	1717812	6048753	10	Background	1	880	95
	AUC171	Korau Rd (relocated from AUC038)	Tikipunga	1720175	6049513	5	Background	1	1535	80
Auckland - Northern	AUC004	Grand Dr / Tauranga Pl	Orewa	1750060	5949364	50	Local[a]	1	1220	1
	AUC005	Northern Motorway / Fairview Ave	Albany	1753063	5935161	120	Local	1	160	2
	AUC006	Northern Motorway / Curry Ln (relocated to AUC170)	Westlake	1755497	5928947	25	SH	1	5	35
	AUC007	Northern Motorway / Sulphur Beach Rd	Northcote	1756065	5923935	5	SH	1	11	610
	AUC039	Albany Highway / Ashby Pl	Unsworth Heights	1752018	5930500	8	SH	18	60	330
	AUC040	Upper Harbour Dr / William Pitcher Pl	Greenhithe	1749755	5928069	15	SH	18	12	270
	AUC041	Glenfield Rd / Sunset Rd	Glenfield	1753390	5929775	5	Local	18	1115	1
	AUC042	Lake Rd / Service Ln	Takapuna	1758078	5927136	5	Local	1	1590	1
	AUC043* AUC044* AUC045*	Northern Motorway / Wairau Rd (AC Takapuna) * = triplicate site	Takapuna	1756069	5928070	50	SH	1	50	45
	AUC046	Lake Rd / Esmonde Rd	Takapuna	1758428	5926591	5	Local	1	1425	2
	AUC047	Woodcote Dr	Marlborough	1753696	5927375	10	Background	1	2530	60
	AUC170	Northern Motorway /Tristram Ave (relocated from AUC006)	Westlake	1755482	5928973	25	SH	1	5	5

Site metadata summary * = triplicate site										
Monitoring zone	Site ID	Site name	Area	NZTM easting	NZTM northing	Distance to sensitive receptor (m)	Site type	State highway	Distance to SH (m)	Distance to local road (m)
Auckland - Western	AUC020	North Western Mway / Cedar Heights Ave	Massey East	1744601	5921792	10	SH	16	90	170
	AUC048	North Western Motorway / Te Atatu Rd	Te Atatu	1747262	5919849	40	SH	16	2	2
	AUC049	Hobsonville Rd / Carnegie Cres	Hobsonville	1747244	5926410	5	Local[b]	18	280	10
	AUC050	SH16 / Kennedys Rd	Whenuapai	1742258	5926703	7	SH	16	4	155
	AUC051	North Western Motorway / Taitapu St	Massey East	1745021	5921302	8	SH	16	70	195
	AUC052	Henderson Valley Rd / Hickory Ave	Henderson	1745187	5916791	15	Local	16	3450	5
	AUC053	Te Atatu Rd / Edmonton Rd	Te Atatu South	1746835	5918811	5	Local	16	930	3
	AUC054* AUC055* AUC056*	Lincoln Rd / Henderson Intermediate (AC Henderson) * = triplicate site	Henderson	1745143	5918530	20	Local	16	2095	7
	AUC057* AUC058* AUC059*	Meadowvale Rd / Ceramco Park (AC Glen Eden) * = triplicate site	Glen Eden	1747149	5912480	10	Background	16	6160	250
	AUC063	Great North Rd / Rata St	New Lynn	1749443	5913945	3	Local	20	4140	10
Auckland - Central	AUC008	Northern Motorway / St Mary's Bay Rd	St Mary's Bay	1755662	5921138	10	SH	1	70	280
	AUC009	CMJ / Canada St	Newton	1756811	5919276	20	SH	1	20	130
	AUC011	Southern Motorway / Mt Hobson Rd	Remuera	1758969	5917106	10	SH	1	10	390
	AUC013* AUC014* AUC015*	Southern Motorway / Gavin St (AC Penrose) * = triplicate site	Penrose	1761757	5914171	45	SH	1	100	210
	AUC021	Waterbank Cres	Waterview	1751684	5917742	10	Background	16	150	260

Site metadata summary * = triplicate site										
Monitoring zone	Site ID	Site name	Area	NZTM easting	NZTM northing	Distance to sensitive receptor (m)	Site type	State highway	Distance to SH (m)	Distance to local road (m)
	AUC022	North Western Motorway / Niger St	Arch Hill	1755717	5918398	10	SH	16	32	110
	AUC025	Hugh Watt Dr / Melrose Rd	Hillsborough	1756246	5912958	5	SH	20	40	215
	AUC060	New North Rd / Mount Albert Rd	Mt Albert	1752882	5916590	3	Local	16	1515	1
	AUC061	Great South Rd / Green Ln East	Greenlane	1759925	5915778	8	Local	1	255	2
	AUC062	Ellerslie Panmure Hway / Mountain Rd	Panmure	1764307	5914946	10	Local	1	2300	3
	AUC064	Sandringham Rd / Kowhai Intermediate (MfE Kingsland)	Kingsland	1755692	5917809	2	Local	16	470	4
	AUC071	Mangere Rd / Walmsley Rd	Otahuhu	1763685	5908918	3	Local	1	1670	1
Auckland - Southern	AUC018	Southern Motorway / Waimate St	Flat Bush	1767463	5906047	20	SH	1	60	250
	AUC019	Southern Motorway / Liggett Dr	Manukau	1767713	5903803	10	SH	1	100	60
	AUC026	South Western Motorway / Hastie Ave	Mangere Bridge	1759570	5909661	5	SH	20	25	270
	AUC027	South Western Motorway / Ashmore Pl	Mangere	1760189	5908083	5	SH	20	20	490
	AUC067	South Western Motorway / Massey Rd	Mangere East	1761844	5906521	6	SH	20	20	85
	AUC068	George Bolt Dr / Kirkbride Rd	Mangere	1759293	5906550	10	SH	20A	2	2
	AUC069	Bairds Rd / Otara Rd	Otara	1766535	5908095	5	Local	1	605	10
	AUC070	Dominion Rd / Settlement Rd	Papakura	1774740	5896065	25	Local	1	3440	5
	AUC072	Pakuranga Rd / Bell Reserve (AC Pakuranga)	Pakuranga	1768412	5913942	5	Local	1	4320	3
	AUC073	Oakridge Way (AC Botany)	Botany	1771370	5912359	10	Background	1	7040	250
Hamilton	HAM001	Cambridge Rd / Morrinsville Rd	Hillcrest	1804416	5813725	40	SH	1	3	240

Site metadata summary * = triplicate site										
Monitoring zone	Site ID	Site name	Area	NZTM easting	NZTM northing	Distance to sensitive receptor (m)	Site type	State highway	Distance to SH (m)	Distance to local road (m)
	HAM002	Avalon Dr / Grandview Rd	Nawton	1797762	5816739	40	SH	1	3	20
	HAM003	Lorne St / Ohaupo Rd	Melville	1800756	5813015	2	SH	1 & 3	1	5
	HAM012	Te Rapa Rd / Ann Michele St	Pukete	1795724	5821363	8	SH	1	4	910
	HAM013	Greenwood St / Killarney Rd	Frankton	1799056	5814544	10	SH	1	1	1
	HAM014	Victoria St / Ulster St	Beerescourt	1799295	5817333	31	Local	1	1670	1
	HAM015	Brooklyn Rod / Peachgrove Rd	Claudelands	1801984	5816917	20	Local	1	3400	3
	HAM016	Bridge St / Cobham Dr	Hamilton West	1801223	5814608	7	Local	1	1190	1
	HAM017	Seamer Pl	St Andrews	1798688	5819138	10	Background	1	1665	93
Cambridge	HAM004	Victoria St / Queen St	Cambridge	1816991	5803351	15	SH	1	1	30
Te Awamutu	HAM022	Ohaupo Rd / Albert Park Dr	Te Awamutu	1804490	5790839	5	SH	3	1	80
Taupo	HAM005	Tongariro St / Norman Smith St	Taupo	1866997	5714268	60	SH	1	2	5
Tauranga	HAM007	Fifteenth Ave / Cameron Rd	Tauranga South	1878044	5822402	45	SH	2A	2	2
	HAM008	Maunganui Rd / Golf Rd	Mt Maunganui	1882910	5826562	30	SH	2	2	30
	HAM010	Marsh St / Chapel St	Tauranga	1879269	5825395	60	SH	2	2	2
	HAM018	SH2 / Maunganui Rd	Te Maunga	1884544	5824456	50	SH	2	2	810
	HAM019	Bellevue Rd / Otumoetai Rd	Brookfield	1876492	5823919	20	Local	2	1040	2
	HAM020	Cameron Rd / Twentythird Ave	Gate Pa	1877026	5821388	15	Local	2	1090	3
	HAM021	Seaforth Gr	Greerton	1875811	5819200	5	Background	29	360	280
Rotorua	HAM006	Old Taupo Rd / Pukuatua St	Rotorua	1883582	5774041	40	SH	30A & 5	3	40

Site metadata summary * = triplicate site										
Monitoring zone	Site ID	Site name	Area	NZTM easting	NZTM northing	Distance to sensitive receptor (m)	Site type	State highway	Distance to SH (m)	Distance to local road (m)
	HAM023	Lightheart St	Glenholme	1884716	5772827	10	Background	5	880	170
Gisborne	NAP001	Wainui Rd / Craig Rd	Gisborne	2038946	5707152	5	SH	35	2	190
Napier	NAP002	Napier Hastings Motorway / Meeanee Rd	Jervoistown	1931872	5616278	40	SH	50	3	2
	NAP003	Hyderabad Rd / Georges Dr	Marewa	1935474	5620994	10	SH	2	3	70
	NAP006	Hastie Pl	Onekawa	1934262	5618615	15	Background	50	800	600
Hastings	NAP004	Napier Hastings Motorway / Omahu Rd	Woolwich	1927501	5607387	180	SH	50A	20	10
	NAP005	Amanda Pl	Mayfair	1931267	5605429	15	Background	2	230	100
New Plymouth	WAN001	Northgate / Paynters Ave	Fitzroy	1695561	5676854	50	SH	3	1	140
	WAN009	Benbow Pl	Westown	1691914	5674457	5	Background	45	1360	240
Wanganui	WAN002	London St / Grey St (relocated to WAN010)	Wanganui	1773681	5578142	50	SH	3	1	70
	WAN010	London St / Grey St (relocated from WAN002)	Wanganui	1773776	5578231	10	SH	3	1	60
Palmerston North	WAN004	Rangitikei St / Featherston St	Palmerston Nth Central	1821340	5530133	20	SH	3	1	1
	WAN005	Pioneer Hwy / Maxwells Line	Awapuni	1818864	5527893	30	SH	56	1	35
	WAN006	Main St / Ruahine St	Terrace End	1823226	5530270	40	SH	3	1	10
	WAN007	Pitt St / Ferguson St	West End	1821556	5528890	20	Local	3	920	1
	WAN008	Tyndall St	Roslyn	1822113	5531385	5	Background	3	1250	100
Otaki	WEL061	State Highway 1 / Mill Rd	Otaki	1782095	5485605	15	SH	1	3	5

Site metadata summary * = triplicate site										
Monitoring zone	Site ID	Site name	Area	NZTM easting	NZTM northing	Distance to sensitive receptor (m)	Site type	State highway	Distance to SH (m)	Distance to local road (m)
Kapiti	WEL004	Ihakara Street (relocated to WEL063)	Paraparaumu	1768605	5467998	20	SH	1	3	610
	WEL063	Main Rd South / Rimutaka St (relocated from WEL004)	Paraparaumu	1769627	5469035	20	SH	1	5	680
Upper Hutt	WEL057	River Rd / Totara Park Rd	Clouston Park	1774749	5446335	20	SH	2	2	5
	WEL058* WEL059* WEL060*	GWRC Savage Park * = triplicate site	Upper Hutt	1773803	5445683	21	Background	2	600	69
Lower Hutt	WEL002	Western Hutt Rd / Manor Park Rd	Manor Park	1765598	5441729	180	SH	2	1	485
	WEL003	Western Hutt Rd / Riddlers Cres	Petone	1757206	5435187	8	SH	2	40	150
	WEL028* WEL029* WEL030*	Western Hutt Rd / Block Rd (GWRC Melling Station) * = triplicate site	Boulcott	1759881	5436960	5	SH	2	10	50
	WEL052	Western Hutt Rd / Pharazyn St	Boulcott	1759667	5436831	12	SH	2	15	185
	WEL053	Knights Rd / Bloomfield Tce	Lower Hutt	1759934	5436058	20	Local	2	828	1
	WEL054* WEL055* WEL056*	GWRC Birch Lane * = triplicate site	Waterloo	1761034	5435864	8	Background	2	1595	100
Porirua	WEL005	Johnsonville Porirua Mway / Titahi Bay Rd	Porirua	1754930	5444242	30	SH	1	50	5
	WEL072	Naver Pl	Papakowhai	1756584	6008686	9	Background	1	305	1380

Site metadata summary * = triplicate site										
Monitoring zone	Site ID	Site name	Area	NZTM easting	NZTM northing	Distance to sensitive receptor (m)	Site type	State highway	Distance to SH (m)	Distance to local road (m)
Wellington	WEL007	Wellington Urban Motorway / Bolton St	Lambton	1748501	5428612	15	SH	1	30	175
	WEL008	Rugby St / Sussex St	Mt Cook	1748917	5426328	15	SH	1	2	95
	WEL027	Johnsonville Porirua Mway / Helston Rd (relocated to WEL064)	Johnsonville	1751754	5435077	5	SH	1	100	5
	WEL031* WEL032* WEL033*	Vivian St / Victoria St (GWRC Corner V) * = triplicate site	Te Aro	1748455	5427079	15	SH	1	7	5
	WEL034* WEL035* WEL036*	GWRC Duncan Park * = triplicate site	Linden	1753584	5442139	18	Background	1	585	60
	WEL047	Karori Rd / Campbell St	Karori	1745617	5428203	10	Local	1	2895	1
	WEL048	Thames St	Island Bay	1748544	5422507	1	Background	1	2870	150
	WEL049	Riddiford St / Mein St	Newtown	1748907	5425194	15	Local	1	1090	1
	WEL050	Wellington Rd / Hamilton Rd	Kilbirnie	1750102	5425039	2	SH	1	4	195
	WEL051	Miramar Ave / Hobart St	MIramar	1752043	5424476	3	Local	1	575	4
	WEL064	Johnsonville Porirua Mway / Helston Rd (relocated from WEL027)	Johnsonville	1751625	5435095	7	SH	1	7	5
Nelson	WEL009	Haven Rd / Queen Elizabeth II Dr	Nelson	1623243	5431540	40	SH	6	3	10
	WEL010	Whakatu Dr / Songer St	Stoke	1618638	5427252	10	SH	6	10	125
	WEL011	Richmond Deviation / Melia Pl	Richmond	1616187	5424131	10	SH	6	60	420
	WEL062	Totara St	Toi Toi	1622565	5429808	10	Background	6	1335	90

Site metadata summary * = triplicate site										
Monitoring zone	Site ID	Site name	Area	NZTM easting	NZTM northing	Distance to sensitive receptor (m)	Site type	State highway	Distance to SH (m)	Distance to local road (m)
Blenheim	WEL012	Nelson St / McLauchlan St	Blenheim	1678828	5404333	20	SH	6	3	390
Christchurch	CHR002	Main North Rd / Queen Elizabeth II Dr	Redwood	1569019	5185272	30	SH	74	2	40
	CHR003	Yaldhurst Rd / Curletts Rd	Riccarton	1565126	5180169	30	SH	73	5	5
	CHR004	Nash Rd	Hilmorton	1565311	5176435	60	Background	75	440	715
	CHR006	Rutherford St / Ferry Rd	Woolston	1574752	5177873	20	SH	74A	12	5
	CHR011	Main South Rd / Parker St	Hornby	1560924	5178620	15	SH	1	10	5
	CHR012	Memorial Ave / Grahams Rd	Burnside	1565320	5182825	10	Local	1	2195	1
	CHR013	Main North Rd / Johns Rd	Belfast	1569958	5189023	6	SH	74 & 1	3	1695
	CHR014	Brougham St / Waltham St	Waltham	1571458	5178310	8	SH	73	12	5
	CHR015	Shirley Rd / North Pde	Shirley	1572768	5182715	12	Local	74	2005	10
	CHR016	Buckleys Rd / Norwich St	Linwood	1573683	5179994	7	Local	73	2150	3
	CHR017* CHR018* CHR019*	ECan Riccarton Rd * = triplicate site	Riccarton	1567570	5180276	50	Local	73	1900	5
	CHR020* CHR021* CHR022*	ECan Coles Pl * = triplicate site	St Albans	1570393	5182343	40	Background	74	2545	155
Greymouth	CHR001	Tainui St / School Lane	Greymouth	1452575	5298043	13	SH	6	1	175

Site metadata summary * = triplicate site										
Monitoring zone	Site ID	Site name	Area	NZTM easting	NZTM northing	Distance to sensitive receptor (m)	Site type	State highway	Distance to SH (m)	Distance to local road (m)
Dunedin	DUN001	Cumberland St / Hanover St	Dunedin	1406666	4917299	30	SH	1	2	195
	DUN002	Dunedin Southern Motorway / Barnes Dr	Caversham	1404335	4914580	5	SH	1	40	150
	DUN003	Dunedin Southern Motorway / Old Brighton Rd (relocated to DUN011)	Fairfield	1397755	4913692	10	Local	1	150	2
	DUN006	Quarry Rd / Gladstone Rd	Mosgiel Rd	1394721	4915218	30	SH	87	1	80
	DUN007	Durham St	Mornington	1404084	4915951	3	Background	1	1470	50
	DUN008	Stuart St / Strathmore Cres	Roslyn	1405367	4917609	5	Local	1	1310	10
	DUN009	Anderson Bay Rd / Bay View Rd	South Dunedin	1406779	4914351	20	Local	1	1215	2
	DUN011	Dunedin Southern Motorway / Old Brighton Rd (relocated from DUN003)	Fairfield	1397812	4913605	125	SH	1	60	3
Queenstown	DUN004	Stanley St / Sydney St	Queenstown	1258576	5004222	100	SH	6A	3	455
Invercargill	DUN005	Dee St / Don St	Invercargill	1242407	4849734	5	SH	6	1	265
	DUN010	Terrace St	Rosedale	1243428	4852255	10	Background	6	1130	50

a. AUC004 was a state highway site until the beginning of 2009 when the Northern Gateway Toll Road opened. At this time, its state highway status was revoked and AUC004 then became a local road site.

b. AUC049 was a state highway site until the end of 2011 when the new SH18 Hobsonville deviation was opened. At this time, its state highway status was revoked and AUC049 then became a local road site.

Table 14: Summary of annual averages from the Transport Agency's national ambient NO_2 monitoring network

Annual average summary * = triplicate average - = less than 75% valid data																	
Annual NO_2 (µg/m³)																	
Monitoring zone	**Site ID**	**2007**	% valid data	**2008**	% valid data	**2009**	% valid data	**2010**	% valid data	**2011**	% valid data	**2012**	% valid data	**2013**	% valid data	**% change 2007 - 2013**	**% change 2010 - 2013**
Whangarei	AUC001	22.2	92%	23.4	100%	26.1	83%	-	42%	26.5	92%	25.1	92%	27.2	83%	22%	
	AUC038					-	25%	-	17%								
	AUC171							-	33%	11.2	92%	10.3	92%	9.7	83%		
Auckland – Northern	AUC004	12.3	100%	15.4	92%	10.9	100%	10.8	92%	10.7	100%	10.0	83%	12.2	75%	-1%	13%
	AUC005	23.7	92%	25.8	100%	28.1	100%	28.4	83%	29.5	100%	-	58%	31.9	75%	35%	12%
	AUC006	28.0	100%	27.9	100%	-	42%										
	AUC007	23.3	100%	25.0	100%	25.1	92%	28.5	100%	28.8	100%	28.2	100%	27.7	100%	19%	-3%
	AUC039					-	67%	16.1	100%	17.0	100%	16.7	100%	17.5	100%		9%
	AUC040					16.0	75%	15.5	100%	15.4	92%	18.5	100%	19.9	100%		28%
	AUC041					15.8	75%	18.6	100%	20.2	100%	20.1	92%	19.3	100%		4%
	AUC042					31.6	75%	32.4	100%	32.7	100%	30.5	100%	30.6	100%		-6%
	AUC043 AUC044 AUC045					30.2*	75%	27.0*	100%	30.6*	100%	27.6*	100%	29.5	94%		9%
	AUC046					33.6	75%	31.0	100%	31.0	100%	29.3	100%	32.2	100%		4%
	AUC047					13.0	75%	13.2	100%	13.7	100%	13.2	100%	13.3	100%		1%
	AUC170					-	50%	35.0	100%	39.2	100%	37.7	100%	38.5	100%		10%
Auckland – Western	AUC020	14.3	92%	14.7	100%	15.9	100%	16.6	100%	16.2	100%	16.0	100%	17.5	100%	23%	5%
	AUC048					-	67%	27.6	92%	28.0	100%	25.6	100%	27.2	100%		-1%
	AUC049					-	50%	16.0	100%	15.9	100%	13.6	100%	16.7	83%		4%

Annual average summary * = triplicate average - = less than 75% valid data																	
Annual NO_2 (µg/m^3)																	
Monitoring zone	Site ID	2007	% valid data	2008	% valid data	2009	% valid data	2010	% valid data	2011	% valid data	2012	% valid data	2013	% valid data	% change 2007 - 2013	% change 2010 - 2013
	AUC050					15.2	75%	16.3	100%	16.2	100%	15.4	100%	16.6	100%		2%
	AUC051					-	67%	19.1	100%	-	67%	19.9	100%	21.4	92%		12%
	AUC052					20.7	75%	19.8	100%	20.4	100%	19.3	100%	19.6	92%		-1%
	AUC053					34.8	75%	32.8	100%	35.2	100%	31.7	92%	34.2	92%		4%
	AUC054 AUC055 AUC056					17.6*	75%	17.5*	100%	18.8*	100%	17.8*	100%	17.3	97%		-1%
	AUC057 AUC058 AUC059					9.9*	75%	9.9*	100%	10.4*	100%	9.7*	100%	9.5	97%		-4%
	AUC063					37.8	75%	38.3	100%	40.8	100%	36.8	100%	37.4	100%		-3%
Auckland - Central	AUC008	25.3	100%	26.6	100%	23.9	100%	27.6	100%	28.3	100%	28.5	100%	28.3	100%	12%	3%
	AUC009	41.9	100%	35.8	92%	44.0	92%	40.8	92%	43.9	100%	41.3	100%	46.5	100%	11%	14%
	AUC011	31.0	92%	31.3	100%	36.9	100%	36.7	100%	37.5	92%	36.3	100%	38.0	92%	23%	4%
	AUC013 AUC014 AUC015	27.1*	100%	23.9*	100%	29.2*	100%	29.8*	100%	30.9*	100%	28.8*	100%	31.7	100%	17%	6%
	AUC021	-	67%	16.8	100%	15.8	100%	17.4	92%	18.6	100%	16.9	100%	19.7	100%		13%
	AUC022	30.0	100%	29.4	100%	31.6	100%	32.3	100%	34.1	100%	31.4	100%	31.7	100%	6%	-2%
	AUC025	-	67%	15.5	100%	17.1	100%	20.0	92%	20.8	100%	19.6	100%	20.3	100%		2%
	AUC060					40.8	75%	39.9	100%	40.3	100%	37.6	100%	38.8	100%		-3%
	AUC061					29.4	75%	31.3	100%	33.8	100%	31.8	100%	31.9	100%		2%
	AUC062					28.1	75%	26.3	100%	27.4	100%	27.6	100%	29.4	100%		12%
	AUC064					26.2	75%	26.9	75%	29.6	83%	24.1	100%	25.9	100%		-4%
	AUC071					29.6	75%	30.3	100%	30.0	100%	29.2	100%	32.6	100%		8%
Auckland - Southern	AUC018	26.5	75%	26.0	83%	30.7	83%	30.2	100%	33.1	92%	29.9	100%	29.3	83%	10%	-3%
	AUC019	20.1	100%	21.2	92%	19.6	100%	23.0	100%	24.1	100%	23.4	100%	23.8	100%	18%	3%

Annual average summary * = triplicate average - = less than 75% valid data																	
Annual NO_2 (µg/m^3)																	
Monitoring zone	Site ID	2007	% valid data	2008	% valid data	2009	% valid data	2010	% valid data	2011	% valid data	2012	% valid data	2013	% valid data	% change 2007 - 2013	% change 2010 - 2013
	AUC026	19.3	92%	20.0	100%	17.0	100%	22.0	100%	25.0	100%	25.0	92%	23.7	100%	23%	8%
	AUC027	-	67%	21.1	100%	21.7	100%	25.5	83%	28.2	92%	26.4	100%	28.1	92%		10%
	AUC067					-	50%	26.4	100%	29.9	100%	27.9	100%	30.8	100%		17%
	AUC068					-	50%	43.3	100%	44.7	100%	41.5	100%	46.0	100%		6%
	AUC069					28.1	75%	28.5	100%	30.2	100%	28.6	100%	29.0	100%		2%
	AUC070					20.5	75%	17.5	92%	18.5	92%	19.8	83%	18.7	100%		7%
	AUC072					24.7	75%	24.0	100%	26.1	100%	24.0	100%	22.7	100%		-5%
	AUC073					17.9	75%	13.8	100%	16.5	100%	13.6	100%	15.8	100%		15%
Hamilton	HAM001	21.4	100%	22.6	92%	26.3	92%	28.4	92%	30.1	100%	29.4	100%	30.2	100%	41%	6%
	HAM002	-	50%	20.9	100%	24.7	92%	25.4	92%	26.2	100%	25.8	100%	26.4	100%		4%
	HAM003	36.1	100%	38.3	100%	40.0	92%	39.0	92%	40.4	100%	37.5	100%	38.4	100%	6%	-2%
	HAM012							-	50%	24.8	100%	23.1	100%	20.6	100%		
	HAM013							41.2	75%	40.1	100%	36.8	100%	41.4	100%		1%
	HAM014							36.8	75%	36.5	100%	37.0	92%	34.8	92%		-6%
	HAM015							29.5	75%	30.8	100%	29.6	100%	28.9	100%		-2%
	HAM016							25.0	75%	25.6	92%	24.4	100%	24.0	100%		-4%
	HAM017							12.8	75%	12.3	100%	12.8	75%	12.1	100%		-6%
Cambridge	HAM004	24.1	100%	23.2	100%	27.0	92%	27.9	92%	30.6	100%	27.3	100%	29.0	100%	20%	4%
Te Awamutu	HAM022							-	50%	-	58%	18.3	83%	18.5	75%		
Taupo	HAM005	17.2	100%	18.6	100%	20.2	100%	20.3	100%	17.3	75%	15.8	100%	17.1	100%	0%	-15%
Tauranga	HAM007	24.7	100%	23.1	100%	27.0	100%	28.5	92%	32.1	92%	29.1	100%	29.2	100%	18%	2%
	HAM008	23.5	92%	22.6	92%	24.9	100%	25.6	100%	29.1	92%	29.8	100%	28.8	100%	22%	13%
	HAM010	33.3	100%	29.8	100%	38.3	92%	25.9	92%	29.6	92%	26.7	100%	27.4	100%	-18%	6%
	HAM018							29.2	75%	31.9	100%	26.6	100%	24.9	75%		-15%
	HAM019							20.4	75%	21.0	100%	19.3	100%	20.9	100%		2%
	HAM020							-	58%	20.3	100%	18.8	100%	19.7	100%		

Annual average summary * = triplicate average - = less than 75% valid data																	
Annual NO_2 ($\mu g/m^3$)																	
Monitoring zone	Site ID	2007	% valid data	2008	% valid data	2009	% valid data	2010	% valid data	2011	% valid data	2012	% valid data	2013	% valid data	% change 2007 - 2013	% change 2010 - 2013
	HAM021							-	67%	11.1	100%	10.1	83%	10.3	100%		
Rotorua	HAM006	17.0	83%	18.9	100%	20.7	92%	-	50%	21.2	83%	20.2	100%	21.3	75%	25%	
	HAM023							-	58%	9.2	83%	8.6	100%	-	58%		
Gisborne	NAP001	11.7	92%	10.6	92%	12.4	100%	13.8	100%	16.1	100%	14.7	100%	16.2	100%	38%	17%
Napier	NAP002	-	67%	13.5	100%	16.1	100%	19.2	92%	20.8	83%	16.9	92%	17.4	83%		-9%
	NAP003	19.4	83%	19.8	100%	22.4	100%	24.1	100%	27.8	83%	24.6	100%	25.0	92%	29%	4%
	NAP006							11.3	75%	10.3	100%	8.9	100%	9.8	83%		-14%
Hastings	NAP004	15.8	83%	17.5	100%	19.1	100%	19.5	100%	22.8	100%	19.0	100%	-	67%		
	NAP005							11.7	75%	12.0	100%	10.4	100%	10.7	83%		-8%
New Plymouth	WAN001	21.2	83%	19.6	92%	20.9	92%	21.0	83%	23.9	100%	-	25%	17.9	75%	-16%	-15%
	WAN009							-	67%	9.7	100%	6.8	100%	-	58%		
Wanganui	WAN002	-	50%	13.6	100%	14.3	75%										
	WAN010					-	17%	22.7	100%	24.9	92%	-	67%	22.4	100%		-1%
Palmerston North	WAN004	19.3	100%	21.1	100%	15.1	100%	25.1	92%	25.4	92%	21.5	100%	22.3	100%	16%	-11%
	WAN005							12.2	75%	14.3	92%	12.0	100%	12.9	100%		6%
	WAN006							26.3	75%	27.1	100%	23.8	92%	23.7	100%		-10%
	WAN007							18.6	75%	20.2	100%	16.0	100%	16.2	100%		-13%
	WAN008							-	67%	16.2	100%	14.6	100%	15.5	100%		
Otaki	WEL061							17.4	83%	19.7	92%	16.0	100%	15.6	92%		-10%
Kapiti	WEL004	17.9	100%	17.3	100%												
	WEL063					18.4	100%	18.5	92%	19.0	92%	14.4	100%	18.9	100%		2%
Upper Hutt	WEL057							19.9	83%	21.4	100%	19.0	100%	21.4	100%		7%
	WEL058 WEL059 WEL060							9.3*	83%	9.1*	100%	-	33%				

Annual average summary * = triplicate average - = less than 75% valid data																	
Annual NO_2 (µg/m^3)																	
Monitoring zone	**Site ID**	**2007**	% valid data	**2008**	% valid data	**2009**	% valid data	**2010**	% valid data	**2011**	% valid data	**2012**	% valid data	**2013**	% valid data	**% change 2007 - 2013**	**% change 2010 - 2013**
Lower Hutt	WEL002	22.1	100%	21.5	100%	23.5	83%	26.1	92%	27.3	100%	24.3	83%	25.4	100%	15%	-3%
	WEL003	-	67%	13.8	100%	14.4	100%	15.7	100%	17.4	92%	14.8	83%	14.1	100%		-10%
	WEL028 WEL029 WEL030					23.4*	100%										
	WEL052							22.6	83%	24.2	100%	20.5	92%	21.8	100%		-4%
	WEL053							30.5	83%	31.9	92%	27.1	100%	25.7	100%		-16%
	WEL054 WEL055 WEL056							13.0*	83%	13.1*	100%	11.7*	100%	12.6	39%		-3%
Porirua	WEL005	20.1	75%	16.8	75%	20.2	100%	20.2	92%	21.8	100%	18.7	100%	20.9	100%	4%	3%
	WEL072													8.6	100%		
Wellington	WEL007	18.5	83%	17.3	100%	19.2	100%	19.9	100%	21.7	92%	17.4	92%	19.0	100%	3%	-4%
	WEL008	39.4	100%	31.3	100%	33.3	92%	35.5	100%	34.8	100%	32.7	100%	36.7	100%	-7%	3%
	WEL027					19.2	100%	-	17%								
	WEL031 WEL032 WEL033					25.3*	100%	27.5*	100%	29.5*	100%	25.6*	100%	25.8	100%		-6%
	WEL034 WEL035 WEL036							10.9*	100%	11.6*	100%	10.8*	83%	-	14%		
	WEL047							12.8	83%	13.4	100%	10.9	92%	11.6	100%		-10%
	WEL048							10.1	83%	10.6	100%	9.3	92%	9.1	92%		-10%
	WEL049							40.3	83%	39.0	92%	31.0	100%	38.8	100%		-4%
	WEL050							22.9	83%	23.6	92%	19.2	100%	20.8	92%		-9%

Annual average summary * = triplicate average - = less than 75% valid data																	
Annual NO_2 ($\mu g/m^3$)																	
Monitoring zone	Site ID	2007	% valid data	2008	% valid data	2009	% valid data	2010	% valid data	2011	% valid data	2012	% valid data	2013	% valid data	% change 2007 - 2013	% change 2010 - 2013
	WEL051							15.5	83%	16.9	100%	12.6	100%	14.0	100%		-10%
	WEL064							25.1	83%	26.1	100%	22.6	100%	20.9	100%		-17%
Nelson	WEL009	18.3	100%	20.2	83%	20.8	100%	22.8	92%	24.0	83%	22.7	75%	-	42%		
	WEL010	-	58%	19.0	92%	20.2	100%	18.3	92%	20.1	92%	20.5	100%	22.5	92%		23%
	WEL011	11.8	92%	13.0	92%	14.3	100%	15.1	100%	17.2	100%	15.9	83%	18.4	83%	56%	22%
	WEL062							12.9	75%	11.6	75%	11.9	100%	13.9	83%		8%
Blenheim	WEL012	12.3	100%	13.4	100%	14.5	92%	14.1	100%	16.7	100%	14.5	92%	14.9	92%	21%	6%
Christchurch	CHR002	21.0	100%	22.2	100%	23.0	92%	26.8	100%	29.0	100%	30.7	100%	28.9	92%	37%	8%
	CHR003	22.3	100%	21.7	100%	24.8	100%	26.9	100%	30.0	92%	29.8	92%	24.4	75%	9%	-9%
	CHR004	12.3	100%	12.2	100%	11.3	92%	15.0	92%	16.3	100%	14.4	100%	18.1	92%	48%	21%
	CHR006	20.7	100%	19.8	100%	22.6	92%	24.3	100%	26.0	92%	-	50%	32.0	83%	55%	32%
	CHR011							27.6	75%	-	50%	28.3	92%	27.3	92%		-1%
	CHR012							-	67%	31.6	83%	28.7	100%	29.6	92%		
	CHR013							32.1	75%	31.7	92%	30.4	100%	33.9	92%		6%
	CHR014							32.8	75%	33.0	92%	30.6	83%	33.7	75%		3%
	CHR015							33.4	75%	29.8	92%	27.4	100%	29.9	92%		-10%
	CHR016							40.9	75%	36.8	75%	33.6	100%	37.5	83%		-8%
	CHR017 CHR018 CHR019							42.8*	75%	-	67%	41.4*	100%	41.6	94%		-3%
	CHR020 CHR021 CHR022							15.2*	75%	-	64%	14.0*	100%	15.0	94%		-1%
Greymouth	CHR001	10.8	100%	11.7	100%	14.4	92%	12.9	100%	16.0	92%	13.0	100%	14.3	100%	32%	11%
Dunedin	DUN001	20.3	100%	22.7	100%	25.6	92%	27.0	100%	26.4	100%	27.9	100%	27.1	100%	33%	0%
	DUN002	12.5	83%	12.4	100%	12.7	100%	15.3	100%	19.2	100%	15.0	100%	15.6	100%	25%	2%

Annual average summary * = triplicate average - = less than 75% valid data																	
Annual NO_2 (µg/m^3)																	
Monitoring zone	**Site ID**	**2007**	% valid data	**2008**	% valid data	**2009**	% valid data	**2010**	% valid data	**2011**	% valid data	**2012**	% valid data	**2013**	% valid data	**% change 2007 - 2013**	**% change 2010 - 2013**
	DUN003	8.4	83%	7.9	100%	10.3	100%	11.1	92%	-	25%						
	DUN006							20.6	75%	20.8	92%	19.3	100%	20.7	100%		0%
	DUN007							11.8	75%	13.6	100%	10.9	100%	11.6	100%		-2%
	DUN008							17.9	75%	16.2	92%	15.2	100%	17.7	100%		-1%
	DUN009							20.0	75%	19.7	100%	18.9	100%	18.1	100%		-10%
	DUN011									14.1	75%	11.8	100%	13.5	100%		
Queenstown	DUN004	15.0	92%	17.9	92%	19.8	83%	22.5	92%	18.7	75%	21.7	83%	18.9	92%	26%	-16%
Invercargill	DUN005	25.1	92%	27.1	100%	-	67%	-	67%	-	42%	28.5	92%	26.3	83%	5%	
	DUN010							-	67%	-	42%	7.1	100%	27.1	100%	33%	0%

Table 15: Summary of seasonal averages from the Transport Agency's national ambient NO_2 monitoring network*

Seasonal average summary * = triplicate average - = indicates insufficient data to calculate an average ratio																
Monitoring zone	Site ID	2009			2010			2011			2012			2013		
		Summer (Dec08 – Feb09)	Winter (Jun09 – Aug09)	Ratio Winter / Summer	Summer (Dec09 – Feb10)	Winter (Jun10 – Aug10)	Ratio Winter / Summer	Summer (Dec10 – Feb11)	Winter (Jun11 – Aug11)	Ratio Winter/ Summer	Summer (Dec11 – Feb12)	Winter (Jun12 – Aug12)	Ratio Winter/ Summer	Summer (Dec12 – Feb13)	Winter (Jun13 – Aug13)	Ratio Winter/ Summer
Whangarei	AUC001	18.6	34.2	1.8	-			19.0	30.3	1.6	19.6	30.8	1.6	16.0	35.3	2.2
	AUC038		3.4		-	-	-									
	AUC171							6.3	16.4	2.6	6.3	12.6	2.0	6.1	13.7	2.2
Auckland - Northern	AUC004	10.3	16.6	1.6	10.5	12.5	1.2	8.5	12.1	1.4	9.1	12.3	1.3		12.1	
	AUC005	18.3	35.8	2.0	22.7	33.7	1.5	20.9	36.0	1.7	23.9	32.9	1.4	-	42.3	-
	AUC006	19.3														
	AUC007	24.7	28.1	1.1	21.5	34.5	1.6	24.0	30.2	1.3	25.2	32.1	1.3	23.2	35.4	1.5
	AUC039		16.9		11.8	22.5	1.9	12.1	20.5	1.7	12.9	21.9	1.7	12.4	22.8	1.8
	AUC040		18.6		11.5	21.7	1.9	9.8	19.1	2.0	12.8	22.9	1.8	12.8	26.9	2.1
	AUC041		19.4		12.9	23.6	1.8	14.9	21.5	1.4	17.5	25.8	1.5	15.8	23.8	1.5
	AUC042		37.2		23.5	45.2	1.9	23.9	37.4	1.6	25.1	36.0	1.4	22.3	38.6	1.7
	AUC043 AUC044 AUC045	-	35.7*	-	21.2*	39.1*	1.8*	19.2*	40.2*	2.1*	21.4*	34.0*	1.6*	16.4*	40.2*	2.4*
	AUC046		38.3		24.8	46.9	1.9	21.7	40.4	1.9	19.8	35.8	1.8	19.3	44.5	2.3
	AUC047		16.6		8.9	20.0	2.2	9.7	17.6	1.8	9.9	17.3	1.8	8.3	18.2	2.2
	AUC170		43.1		27.7	48.8	1.8	23.9	43.9	1.8	32.4	46.1	1.4	23.1	49.0	2.1

Seasonal average summary * = triplicate average - = indicates insufficient data to calculate an average ratio																	
Monitoring zone	Site ID	2009			2010			2011			2012			2013			
		Summer (Dec08 – Feb09)	Winter (Jun09 – Aug09)	Ratio Winter / Summer	Summer (Dec09 – Feb10)	Winter (Jun10 – Aug10)	Ratio Winter / Summer	Summer (Dec10 – Feb11)	Winter (Jun11 – Aug11)	Ratio Winter/ Summer	Summer (Dec11 – Feb12)	Winter (Jun12 – Aug12)	Ratio Winter/ Summer	Summer (Dec12 – Feb13)	Winter (Jun13 – Aug13)	Ratio Winter/ Summer	
Auckland – Western	AUC020	10.8	18.7	1.7	12.2	24.1	2.0	10.9	21.2	1.9	11.4	19.5	1.7	12.1	23.6	2.0	
	AUC048		36.0		22.8	39.0	1.7	18.0	39.4	2.2	19.3	28.0	1.5	17.2	35.9	2.1	
	AUC049		17.3		11.7	20.9	1.8	11.9	20.3	1.7	9.4	18.2	1.9	10.1	22.2	2.2	
	AUC050		18.4		13.2	20.7	1.6	13.0	17.7	1.4	10.5	21.7	2.1	13.6	21.1	1.6	
	AUC051		19.1		11.8	28.2	2.4	11.6	27.5	2.4	14.1	23.9	1.7	15.1	27.0	1.8	
	AUC052		26.6		14.9	28.9	1.9	13.9	22.6	1.6	14.4	24.7	1.7	14.5	22.4	1.5	
	AUC053		40.2		25.0	45.9	1.8	22.0	43.5	2.0	26.5	37.8	1.4	20.7	44.9	2.2	
	AUC054 AUC055 AUC056	-	23.0*	-	13.0*	23.9*	1.8*	13.8*	21.4*	1.6*	14.9*	22.6*	1.5*	12.5*	22.7*	1.8*	
	AUC057 AUC058 AUC059	-	12.8*	-	7.0*	14.2*	2.0*	6.6*	12.1*	1.8*	8.2*	12.9*	1.6*	5.9*	13.5*	2.3*	
	AUC063		42.1		36.1	48.4	1.3	33.9	44.8	1.3	30.6	40.8	1.3	31.3	43.2	1.4	
Auckland – Central	AUC008	20.4	33.7	1.7	20.5	34.6	1.7	22.2	30.2	1.4	25.0	34.1	1.4	24.6	32.3	1.3	
	AUC009	30.5	52.8	1.7	34.7	55.7	1.6	32.9	53.7	1.6	31.4	47.1	1.5	32.3	59.1	1.8	
	AUC011	27.0	44.3	1.6	29.3	50.3	1.7	25.9	48.2	1.9	23.8	42.1	1.8	26.6	50.8	1.9	
	AUC013 AUC014 AUC015	15.6*	37.9*	2.4*	22.5*	43.6*	1.9*	21.2*	40.0*	1.9*	19.7*	33.0*	1.7*	19.9*	42.3*	2.1*	

Seasonal average summary * = triplicate average - = indicates insufficient data to calculate an average ratio																
Monitoring zone	Site ID	2009			2010			2011			2012			2013		
		Summer (Dec08 – Feb09)	Winter (Jun09 – Aug09)	Ratio Winter / Summer	Summer (Dec09 – Feb10)	Winter (Jun10 – Aug10)	Ratio Winter / Summer	Summer (Dec10 – Feb11)	Winter (Jun11 – Aug11)	Ratio Winter/ Summer	Summer (Dec11 – Feb12)	Winter (Jun12 – Aug12)	Ratio Winter/ Summer	Summer (Dec12 – Feb13)	Winter (Jun13 – Aug13)	Ratio Winter/ Summer
	AUC021	12.3	19.5	1.6	13.7	23.3	1.7	12.1	21.5	1.8	13.3	22.4	1.7	13.5	23.9	1.8
	AUC022	24.2	40.8	1.7	25.7	42.4	1.6	24.0	40.9	1.7	24.9	36.9	1.5	23.8	40.9	1.7
	AUC025	10.3	25.6	2.5	13.8	26.3	1.9	12.3	24.9	2.0	15.5	27.2	1.8	14.4	25.9	1.8
	AUC060		45.4		35.2	48.2	1.4	30.6	46.4	1.5	31.2	41.7	1.3	29.6	45.8	1.5
	AUC061		32.0		22.4	43.2	1.9	23.4	38.8	1.7	26.6	38.0	1.4	20.3	42.9	2.1
	AUC062		32.8		22.0	35.9	1.6	19.4	36.2	1.9	19.7	33.2	1.7	16.7	39.9	2.4
	AUC064		32.2		18.7	38.1	2.0	24.3	34.3	1.4	20.3	31.8	1.6	15.7	33.9	2.2
	AUC071		33.3		24.5	37.9	1.5	22.2	36.4	1.6	21.6	35.7	1.7	23.6	43.2	1.8
Auckland - Southern	AUC018	21.9	33.1	1.5	25.0	41.1	1.6	24.0	43.6	1.8	22.8	32.9	1.4	21.5	36.3	1.7
	AUC019	14.0	25.9	1.8	15.8	30.6	1.9	15.3	29.4	1.9	19.8	31.0	1.6	15.7	34.0	2.2
	AUC026	12.9	24.2	1.9	14.9	28.5	1.9	16.2	28.0	1.7	20.3	30.2	1.5	21.3	30.8	1.4
	AUC027	16.0	25.9	1.6	20.3	37.2	1.8	18.9	35.9	1.9	20.1	33.1	1.6	19.6	34.8	1.8
	AUC067		31.1		19.6	36.7	1.9	18.5	37.2	2.0	22.0	33.9	1.5	19.5	38.3	2.0
	AUC068		47.8		39.1	57.6	1.5	36.0	49.6	1.4	36.1	46.9	1.3	36.6	56.5	1.5
	AUC069		33.1		22.4	37.0	1.7	20.9	37.4	1.8	23.8	34.8	1.5	20.9	38.0	1.8
	AUC070		24.7		14.0	25.8	1.8	13.6	24.7	1.8	14.1	20.2	1.4	12.8	23.8	1.9
	AUC072		27.8		19.1	31.6	1.7	18.5	35.6	1.9	17.4	27.2	1.6	16.7	31.3	1.9
	AUC073		23.1		10.4	22.4	2.2	9.6	25.4	2.7	9.7	17.5	1.8	8.5	21.5	2.5

Seasonal average summary * = triplicate average - = indicates insufficient data to calculate an average ratio																
Monitoring zone	Site ID	2009			2010			2011			2012			2013		
		Summer (Dec08 – Feb09)	Winter (Jun09 – Aug09)	Ratio Winter / Summer	Summer (Dec09 – Feb10)	Winter (Jun10 – Aug10)	Ratio Winter / Summer	Summer (Dec10 – Feb11)	Winter (Jun11 – Aug11)	Ratio Winter/ Summer	Summer (Dec11 – Feb12)	Winter (Jun12 – Aug12)	Ratio Winter/ Summer	Summer (Dec12 – Feb13)	Winter (Jun13 – Aug13)	Ratio Winter/ Summer
Hamilton	HAM001	19.2	27.7	1.4	24.3	36.2	1.5	23.5	29.8	1.3	27.0	33.1	1.2	24.3	32.9	1.4
	HAM002	15.2	29.0	1.9	19.2	35.1	1.8	21.5	29.1	1.4	18.2	30.3	1.7	18.6	33.8	1.8
	HAM003	32.5	43.6	1.3	32.2	44.7	1.4	33.4	42.7	1.3	32.9	39.6	1.2	32.0	44.5	1.4
	HAM012					-		19.8	28.3	1.4	20.2	27.3	1.3	14.4	27.5	1.9
	HAM013					47.3		33.2	47.1	1.4	29.4	41.8	1.4	30.7	51.7	1.7
	HAM014					44.4		26.7	40.5	1.5	30.7	41.8	1.4	31.4	43.0	1.4
	HAM015					34.8		26.9	34.6	1.3	23.1	34.3	1.5	26.2	32.4	1.2
	HAM016					31.3		18.9	31.0	1.6	19.6	31.1	1.6	16.6	32.5	2.0
	HAM017					18.7		8.2	16.4	2.0	8.2	14.5	1.8	8.1	17.3	2.1
Cambridge	HAM004	18.7	31.6	1.7	23.0	35.6	1.5	23.5	33.6	1.4	25.7	30.0	1.2	23.1	32.4	1.4
Te Awamutu	HAM022					-		10.7	21.6	2.0	13.9	19.4	1.4	14.1	23.1	1.6
Taupo	HAM005	14.7	23.9	1.6	19.4	27.6	1.4	13.8	-		13.8	18.9	1.4	14.3	20.9	1.5
Tauranga	HAM007	18.4	33.6	1.8	21.3	37.5	1.8	22.6	36.1	1.6	24.1	33.5	1.4	20.4	36.7	1.8
	HAM008	17.4	34.0	2.0	16.4	37.4	2.3	20.4	35.2	1.7	21.1	35.2	1.7	21.7	35.1	1.6
	HAM010	26.5	51.4	1.9	20.4	34.4	1.7	22.6	33.9	1.5	23.6	28.3	1.2	21.6	33.3	1.5
	HAM018					34.6		23.8	33.8	1.4	24.5	29.3	1.2	22.8	-	-
	HAM019					24.4		14.2	26.0	1.8	14.6	25.2	1.7	15.4	26.3	1.7
	HAM020					26.3		14.8	24.0	1.6	15.3	22.8	1.5	13.4	26.2	2.0

Seasonal average summary * = triplicate average - = indicates insufficient data to calculate an average ratio																	
Monitoring zone	Site ID	2009			2010			2011			2012			2013			
		Summer (Dec08 – Feb09)	Winter (Jun09 – Aug09)	Ratio Winter / Summer	Summer (Dec09 – Feb10)	Winter (Jun10 – Aug10)	Ratio Winter / Summer	Summer (Dec10 – Feb11)	Winter (Jun11 – Aug11)	Ratio Winter/ Summer	Summer (Dec11 – Feb12)	Winter (Jun12 – Aug12)	Ratio Winter/ Summer	Summer (Dec12 – Feb13)	Winter (Jun13 – Aug13)	Ratio Winter/ Summer	
	HAM021					12.9		8.1	13.1	1.6	9.5	11.1	1.2	7.8	13.1	1.7	
Rotorua	HAM006	12.2	26.4	2.2	16.5			15.3	27.4	1.8	16.7	27.1	1.6	9.9	27.0	2.7	
	HAM023					-		6.1	11.7	1.9	7.0	12.9	1.8	4.9	10.2	2.1	
Gisborne	NAP001	9.5	15.2	1.6	10.9	16.4	1.5	11.9	20.4	1.7	12.0	18.4	1.5	11.0	19.2	1.8	
Napier	NAP002	10.2	20.7	2.0	12.5	26.2	2.1	14.6	24.4	1.7	14.3	22.1	1.5	12.9	23.6	1.8	
	NAP003	20.5	28.6	1.4	21.5	32.0	1.5	19.1	31.7	1.7	22.2	29.7	1.3	23.4	31.7	1.4	
	NAP006					15.9		6.2	14.0	2.3	6.8	11.5	1.7	7.0	14.9	2.1	
Hastings	NAP004	15.1	23.8	1.6	17.4	23.5	1.4	16.9	25.2	1.5	18.8	23.7	1.3	-	27.7	-	
	NAP005					15.5		6.4	17.4	2.7	7.7	12.9	1.7	7.2	16.2	2.2	
New Plymouth	WAN001	14.6	25.2	1.7	18.9	21.9	1.2	17.1	24.4	1.4	19.8				19.9		
	WAN009					11.8		6.8	14.1	2.1	6.9	7.1	1.0	-	10.0	-	
Wanganui	WAN002	9.4	15.5	1.6													
	WAN010				20.1	28.5	1.4	18.6	28.1	1.5	18.6	-	-	16.7	27.6	1.6	
Palmerston North	WAN004	13.3	19.5	1.5	12.6	33.2	2.6	19.5	34.5	1.8	16.8	26.3	1.6	14.9	28.1	1.9	
	WAN005					16.3		8.5	22.0	2.6	10.0	15.9	1.6	6.5	16.0	2.4	
	WAN006					35.5		20.7	29.7	1.4	20.1	28.6	1.4	16.7	31.0	1.9	
	WAN007					24.0		13.3	29.2	2.2	12.4	21.2	1.7	9.0	22.2	2.5	
	WAN008					17.3		11.5	21.7	1.9	11.6	16.3	1.4	10.5	18.6	1.8	

Seasonal average summary * = triplicate average - = indicates insufficient data to calculate an average ratio																
Monitoring zone	Site ID	2009			2010			2011			2012			2013		
		Summer (Dec08 – Feb09)	Winter (Jun09 – Aug09)	Ratio Winter / Summer	Summer (Dec09 – Feb10)	Winter (Jun10 – Aug10)	Ratio Winter / Summer	Summer (Dec10 – Feb11)	Winter (Jun11 – Aug11)	Ratio Winter/ Summer	Summer (Dec11 – Feb12)	Winter (Jun12 – Aug12)	Ratio Winter/ Summer	Summer (Dec12 – Feb13)	Winter (Jun13 – Aug13)	Ratio Winter/ Summer
Otaki	WEL061					23.5		14.0	22.0	1.6	12.8	18.0	1.4	12.8	19.8	1.6
Kapiti	WEL004															
	WEL063	14.7	22.3	1.5	16.6	23.6	1.4	15.2	22.2	1.5	12.6	14.7	1.2	14.0	23.7	1.7
Upper Hutt	WEL057					23.9		14.4	26.4	1.8	17.2	20.7	1.2	19.2	24.5	1.3
	WEL058 WEL059 WEL060					13.8*		5.1*	13.0*	2.5*	5.6*					
Lower Hutt	WEL002	15.2	-	-	20.3	35.0	1.7	18.3	34.8	1.9	19.5			21.0	32.3	1.5
	WEL003	8.3	23.6	2.8	10.6	23.9	2.3	10.2	20.2	2.0	13.1	16.8	1.3	10.4	20.9	2.0
	WEL028 WEL029 WEL030	13.0*	32.3*	2.5*												
	WEL052					29.1		13.5	30.5	2.3	17.0	24.9	1.5	16.1	31.7	2.0
	WEL053					38.7		21.5	37.0	1.7	30.4	29.0	1.0	17.5	33.2	1.9
	WEL054 WEL055 WEL056					18.3*		8.1*	17.0*	2.1*	9.8*	15.6*	1.6*	7.3*	20.1*	2.4*
Porirua	WEL005	13.7	28.8	2.1	16.9	26.3	1.6	15.1	24.7	1.6	16.9	19.3	1.1	17.0	24.6	1.4
	WEL072														12.8	

Seasonal average summary * = triplicate average - = indicates insufficient data to calculate an average ratio																
Monitoring zone	Site ID	2009			2010			2011			2012			2013		
		Summer (Dec08 – Feb09)	Winter (Jun09 – Aug09)	Ratio Winter / Summer	Summer (Dec09 – Feb10)	Winter (Jun10 – Aug10)	Ratio Winter / Summer	Summer (Dec10 – Feb11)	Winter (Jun11 – Aug11)	Ratio Winter/ Summer	Summer (Dec11 – Feb12)	Winter (Jun12 – Aug12)	Ratio Winter/ Summer	Summer (Dec12 – Feb13)	Winter (Jun13 – Aug13)	Ratio Winter/ Summer
Wellington	WEL007	12.1	27.3	2.3	17.1	26.9	1.6	15.1	24.7	1.6	16.1	17.9	1.1	15.0	24.4	1.6
	WEL008	25.3	46.0	1.8	29.9	45.9	1.5	30.6	40.2	1.3	27.7	34.8	1.3	30.0	42.7	1.4
	WEL027	13.2	26.1	2.0	15.9											
	WEL031 WEL032 WEL033	17.7*	34.0	1.9*	21.0*	38.4*	1.8*	20.1*	36.0*	1.8*	21.0*	31.8*	1.5*	17.8*	33.5*	1.9*
	WEL034 WEL035 WEL036				8.2*	15.6*	1.9*	8.1*	14.4*	1.8*	8.4*	12.9*	1.5*	-		
	WEL047					16.5		9.8	16.6	1.7	9.4	11.5	1.2	8.1	14.6	1.8
	WEL048					13.8		7.9	12.3	1.6	7.2	11.5	1.6	8.5	11.0	1.3
	WEL049					49.8		32.2	46.1	1.4	28.7	29.3	1.0	33.8	46.9	1.4
	WEL050					30.5		16.5	25.8	1.6	16.9	19.0	1.1	18.2	27.1	1.5
	WEL051					18.2		12.8	18.3	1.4	11.7	14.2	1.2	12.6	17.2	1.4
	WEL064					33.9		17.2	32.1	1.9	19.7	26.1	1.3	18.2	22.6	1.2
Nelson	WEL009	12.7	27.9	2.2	21.0	26.0	1.2	18.9	27.0	1.4	-	23.5	-	-	-	-
	WEL010	13.6	27.6	2.0	18.7	25.7	1.4	12.7	25.8	2.0	15.1	24.5	1.6	13.9	26.6	1.9
	WEL011	8.8	19.4	2.2	12.8	20.2	1.6	9.5	21.5	2.3	12.2	20.7	1.7	12.1	22.9	1.9
	WEL062					16.0		7.9	16.8	2.1	8.9	16.3	1.8	7.5	20.5	2.7
Blenheim	WEL012	7.8	18.3	2.4	11.2	19.3	1.7	12.3	19.7	1.6	11.2	16.8	1.5	9.8	19.5	2.0

Seasonal average summary * = triplicate average - = indicates insufficient data to calculate an average ratio																
Monitoring zone	Site ID	2009			2010			2011			2012			2013		
		Summer (Dec08 – Feb09)	Winter (Jun09 – Aug09)	Ratio Winter / Summer	Summer (Dec09 – Feb10)	Winter (Jun10 – Aug10)	Ratio Winter / Summer	Summer (Dec10 – Feb11)	Winter (Jun11 – Aug11)	Ratio Winter/ Summer	Summer (Dec11 – Feb12)	Winter (Jun12 – Aug12)	Ratio Winter/ Summer	Summer (Dec12 – Feb13)	Winter (Jun13 – Aug13)	Ratio Winter/ Summer
Christchurch	CHR002	17.2	32.9	1.9	22.0	31.4	1.4	21.2	40.4	1.9	23.8	36.2	1.5	23.8	36.6	1.5
	CHR003	13.2	40.7	3.1	16.7	38.5	2.3	18.8	39.8	2.1	28.3	38.3	1.4	18.3	26.6	1.5
	CHR004	8.9	13.4	1.5	8.7	18.6	2.1	8.4	24.3	2.9	10.2	17.9	1.8	10.5	27.2	2.6
	CHR006	16.5	31.6	1.9	15.7	31.5	2.0	19.1	34.7	1.8	23.3	-		28.9	37.4	1.3
	CHR011					36.4		19.3	-		-	35.6		18.1	35.9	2.0
	CHR012					35.9		28.1	36.0	1.3	23.0	34.0	1.5	21.1	36.4	1.7
	CHR013					36.0		22.6	42.6	1.9	21.5	39.1	1.8	23.2	45.9	2.0
	CHR014					39.8		25.8	40.8	1.6	27.2	37.2	1.4	20.1	40.8	2.0
	CHR015					40.6		22.4	42.2	1.9	21.0	30.3	1.4	21.0	39.5	1.9
	CHR016					49.6		31.9	40.9	1.3	24.2	42.7	1.8	21.4	45.3	2.1
	CHR017 CHR018 CHR019					46.9*		34.5*	46.8*	1.4*	37.4*	47.3*	1.3*	35.1*	47.1*	1.3*
	CHR020 CHR021 CHR022					21.1*		7.9*	23.5*	3.0*	9.6*	19.8*	2.1*	8.6*	21.5*	2.5*
Greymouth	CHR001	9.1	19.7	2.2	11.7	14.3	1.2	9.5	18.6	2.0	10.0	14.6	1.5	9.4	24.1	2.6

Seasonal average summary * = triplicate average - = indicates insufficient data to calculate an average ratio																
Monitoring zone	Site ID	2009			2010			2011			2012			2013		
		Summer (Dec08 – Feb09)	Winter (Jun09 – Aug09)	Ratio Winter / Summer	Summer (Dec09 – Feb10)	Winter (Jun10 – Aug10)	Ratio Winter / Summer	Summer (Dec10 – Feb11)	Winter (Jun11 – Aug11)	Ratio Winter/ Summer	Summer (Dec11 – Feb12)	Winter (Jun12 – Aug12)	Ratio Winter/ Summer	Summer (Dec12 – Feb13)	Winter (Jun13 – Aug13)	Ratio Winter/ Summer
Dunedin	DUN001	17.3	33.5	1.9	18.6	35.4	1.9	18.2	29.1	1.6	22.7	33.4	1.5	21.1	28.5	1.3
	DUN002	9.5	18.6	2.0	10.9	19.8	1.8	12.0	23.4	1.9	11.7	18.7	1.6	12.4	16.5	1.3
	DUN003	8.6	11.9	1.4	7.2	12.8	1.8	8.3								
	DUN006					26.7		14.5	24.0	1.7	14.6	22.7	1.6	14.9	22.4	1.5
	DUN007					14.2		8.3	16.8	2.0	8.9	13.5	1.5	9.5	14.6	1.5
	DUN008					20.4		12.9	18.8	1.4	13.0	17.3	1.3	15.1	22.0	1.5
	DUN009					25.4		12.9	22.7	1.8	14.1	24.1	1.7	14.0	20.6	1.5
	DUN011								14.3		10.3	13.4	1.3	10.7	18.5	1.7
Queenstown	DUN004	17.4	-	-	13.1	33.3	2.6	16.3	-	-	-	26.8	-	13.3	19.1	1.4
Invercargill	DUN005	22.2	35.6	1.6		40.9		-	-	-	20.6	33.5	1.6		32.7	
	DUN010					11.1		13.4			5.4	9.6	1.8	5.0	12.3	2.5

* Refer to air.nzta.govt.nz for 2008 summer/winter averages and ratios.

Appendix 2: Maps

This appendix includes maps of annual averages of passive NO_2 samples. The legend for each circle is:

Red	NO_2 values ≥40µg/m^3	a high level signaling likely breach of the WHO annual NO_2 guideline
Orange	NO_2 values of 30-39.9µg/m^3	a medium level signaling degraded air quality and possible adverse effects
Yellow	NO_2 values of 20-29.9µg/m^3	
Green	NO_2 values of 10-19.9µg/m^3	
Dark green	NO_2 values <10µg/m^3	

Maps are provided of the NO_2 annual averages for each monitoring zone as follows:

- Figure 54: Whangarei and Auckland for 2013
- Figure 55: Auckland for 2013
- Figure 56: Hamilton, Cambridge, Tauranga, Rotorua and Taupo for 2013
- Figure 57: Gisborne, Napier, Hastings, New Plymouth, Wanganui and Palmerston North for 2013
- Figure 58: Kapiti, Wellington, Nelson and Blenheim for 2013
- Figure 59: Christchurch and Greymouth for 2013
- Figure 60: Dunedin, Queenstown and Invercargill for 2013

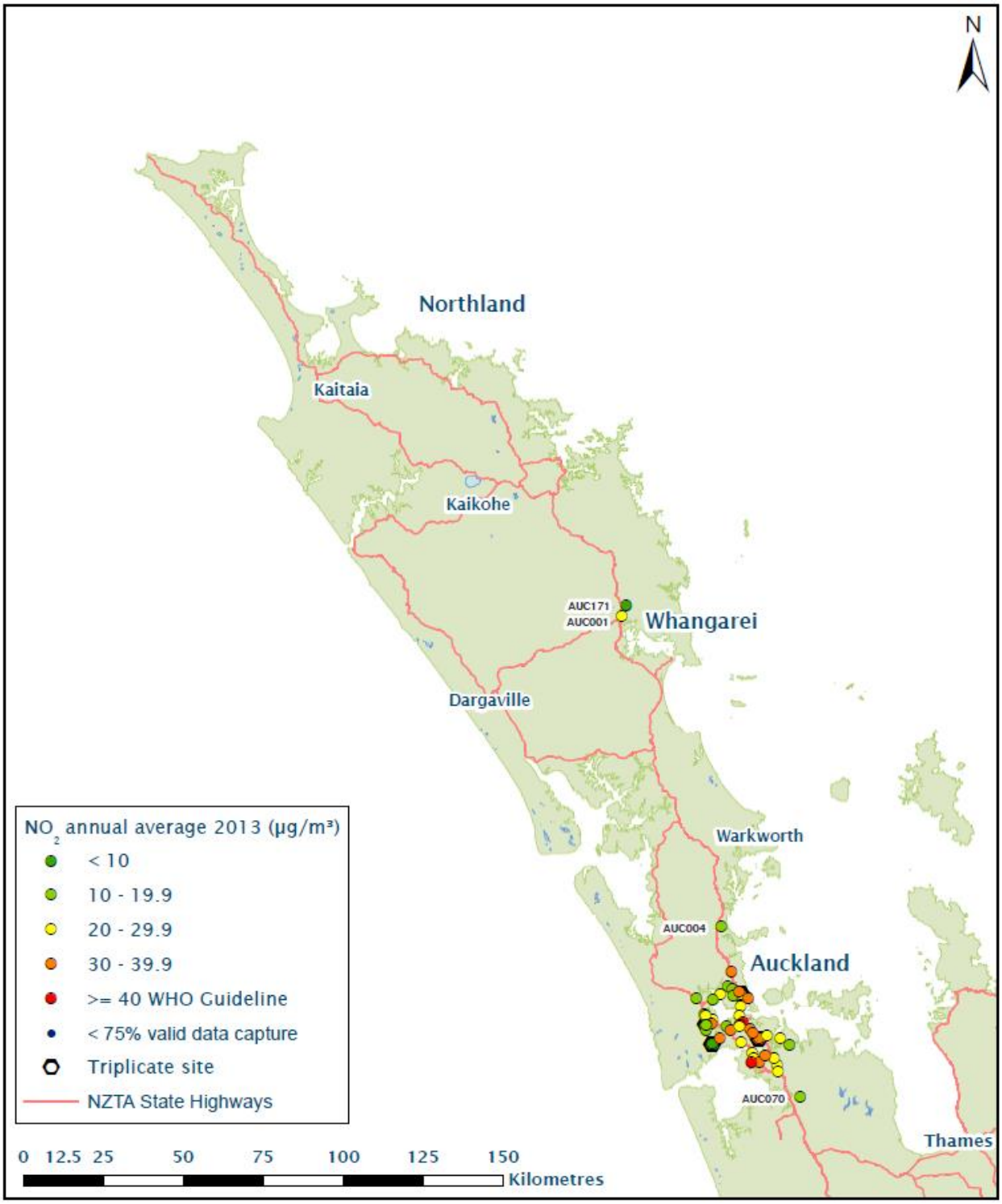

Figure 54: Map of Whangarei and Auckland annual NO_2 averages for 2013

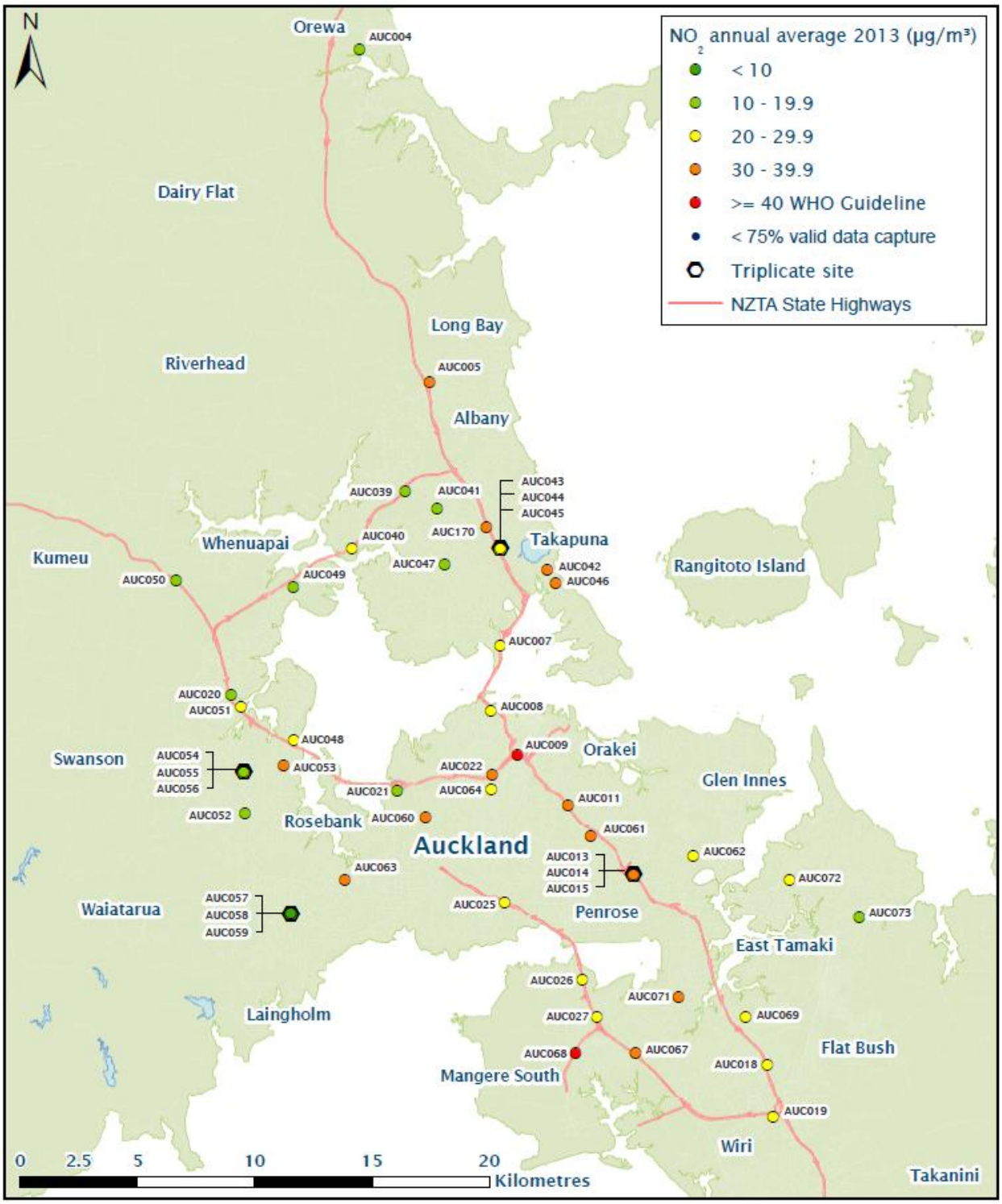

Figure 55: Map of Auckland annual NO_2 averages for 2013

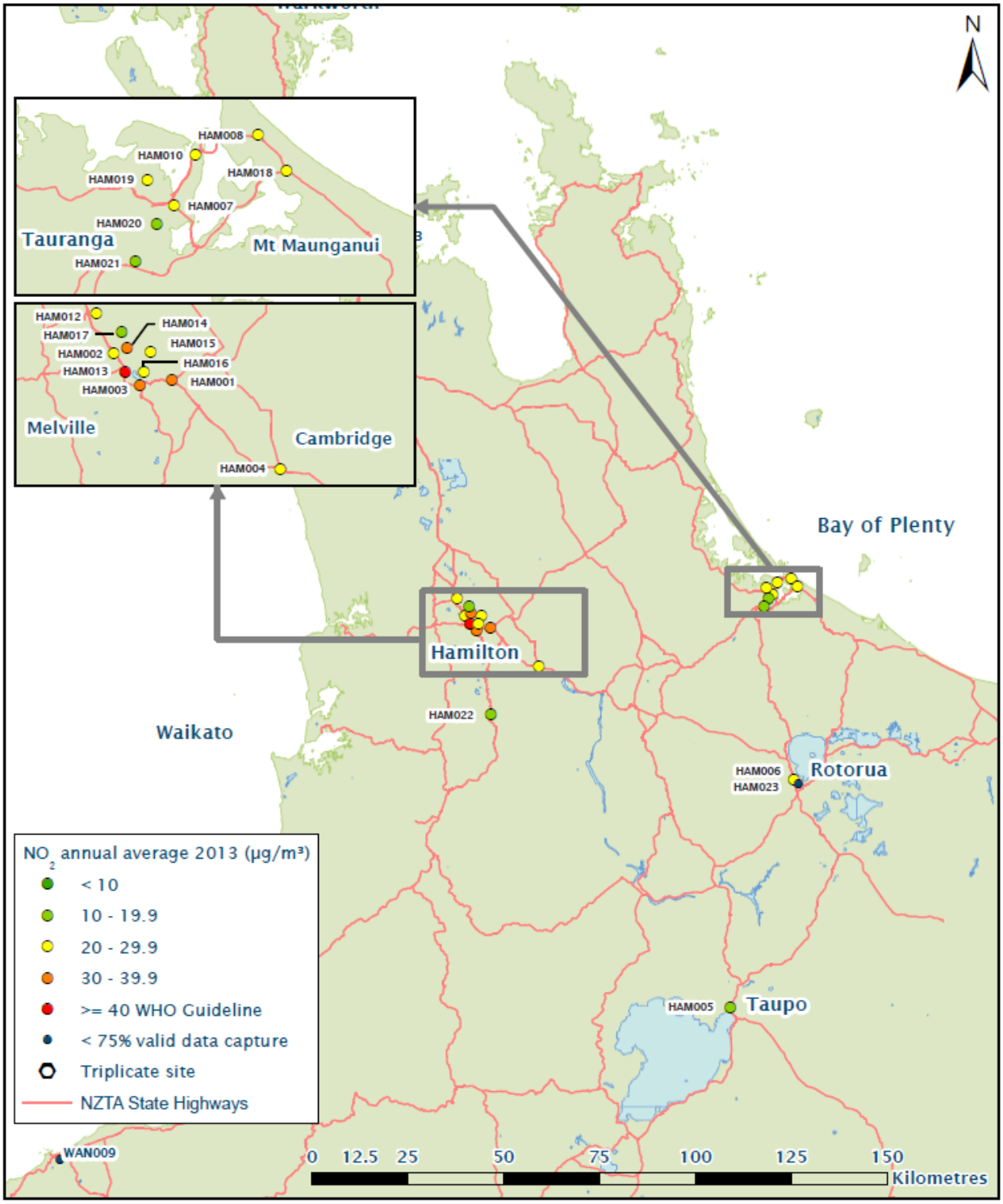

Figure 56: Map of Hamilton, Cambridge, Tauranga, Rotorua and Taupo annual NO_2 averages for 2013

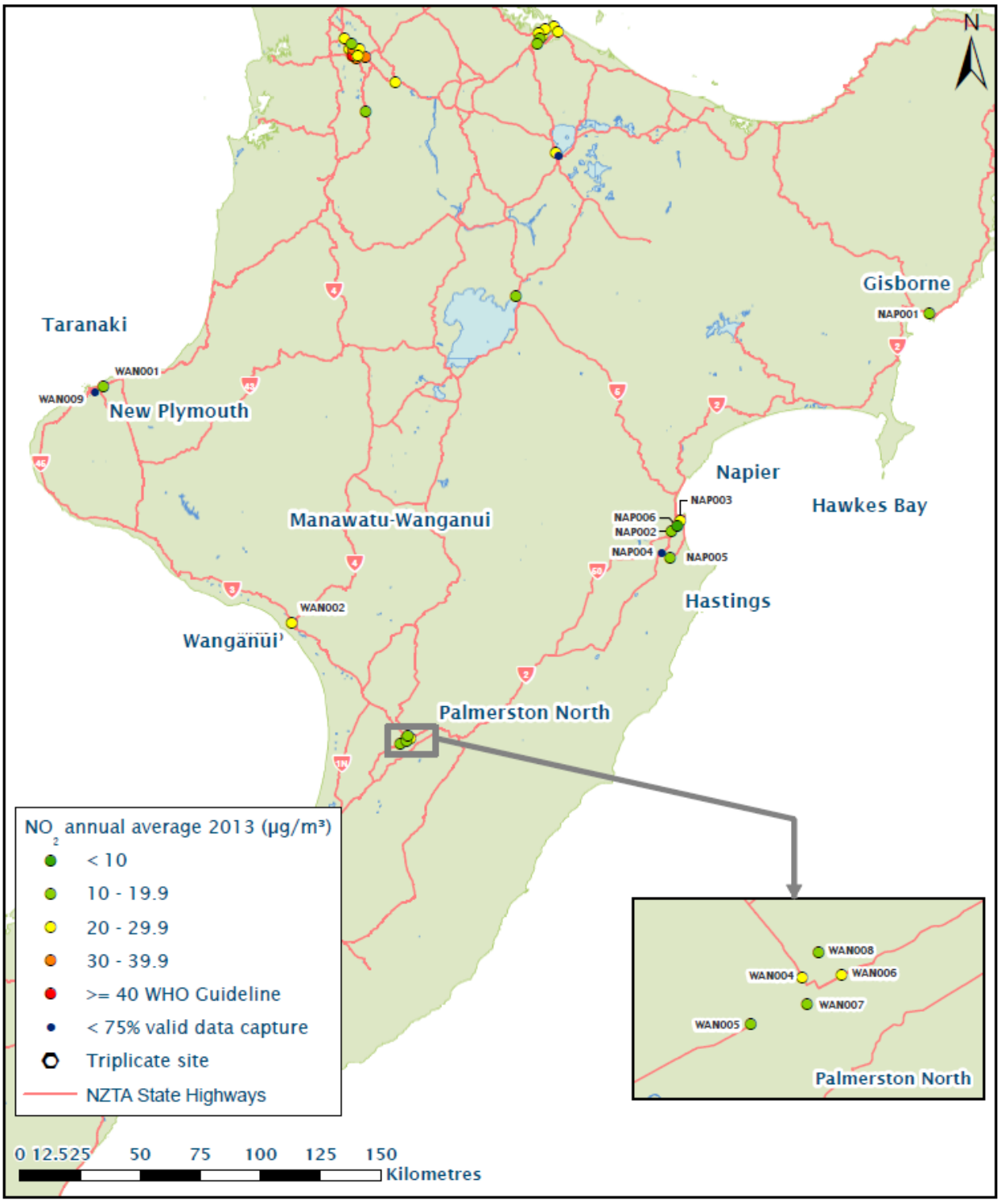

Figure 57: Map of Gisborne, Napier, Hastings, New Plymouth, Wanganui and Palmerston North annual NO_2 averages for 2013

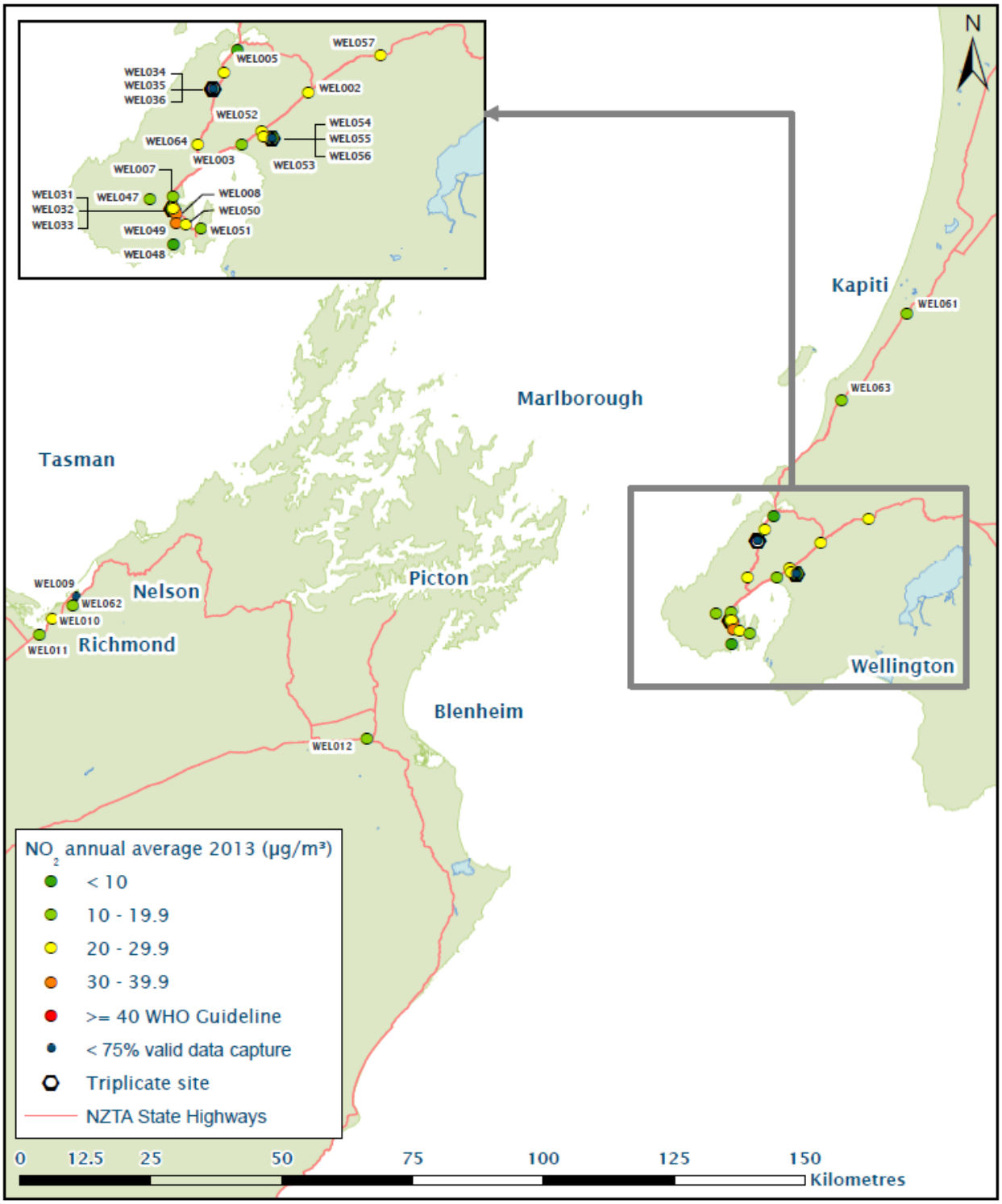

Figure 58: Map of Kapiti, Wellington, Nelson and Blenheim annual NO_2 averages for 2013

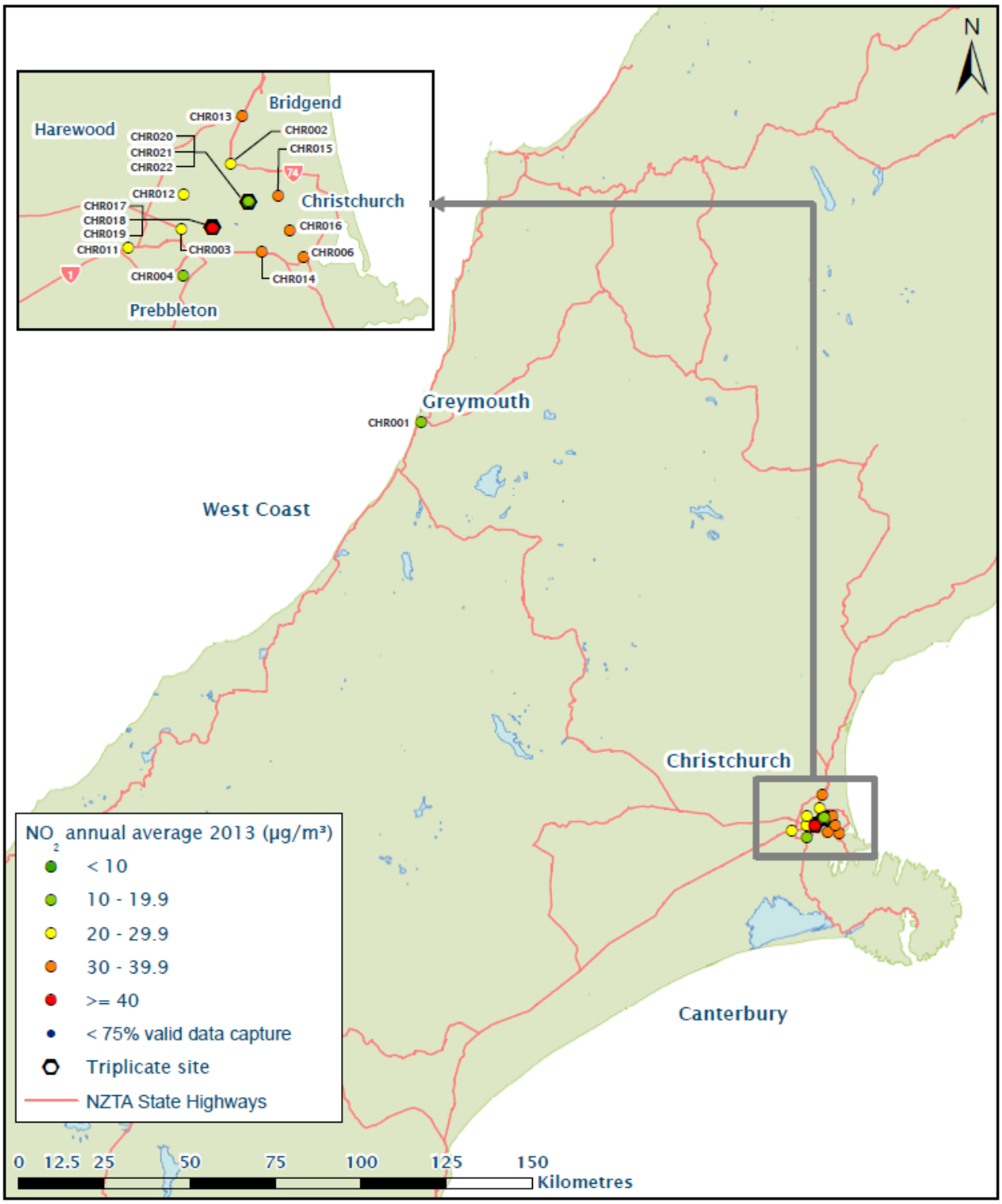

Figure 59: Map of Christchurch and Greymouth annual NO_2 averages for 2013

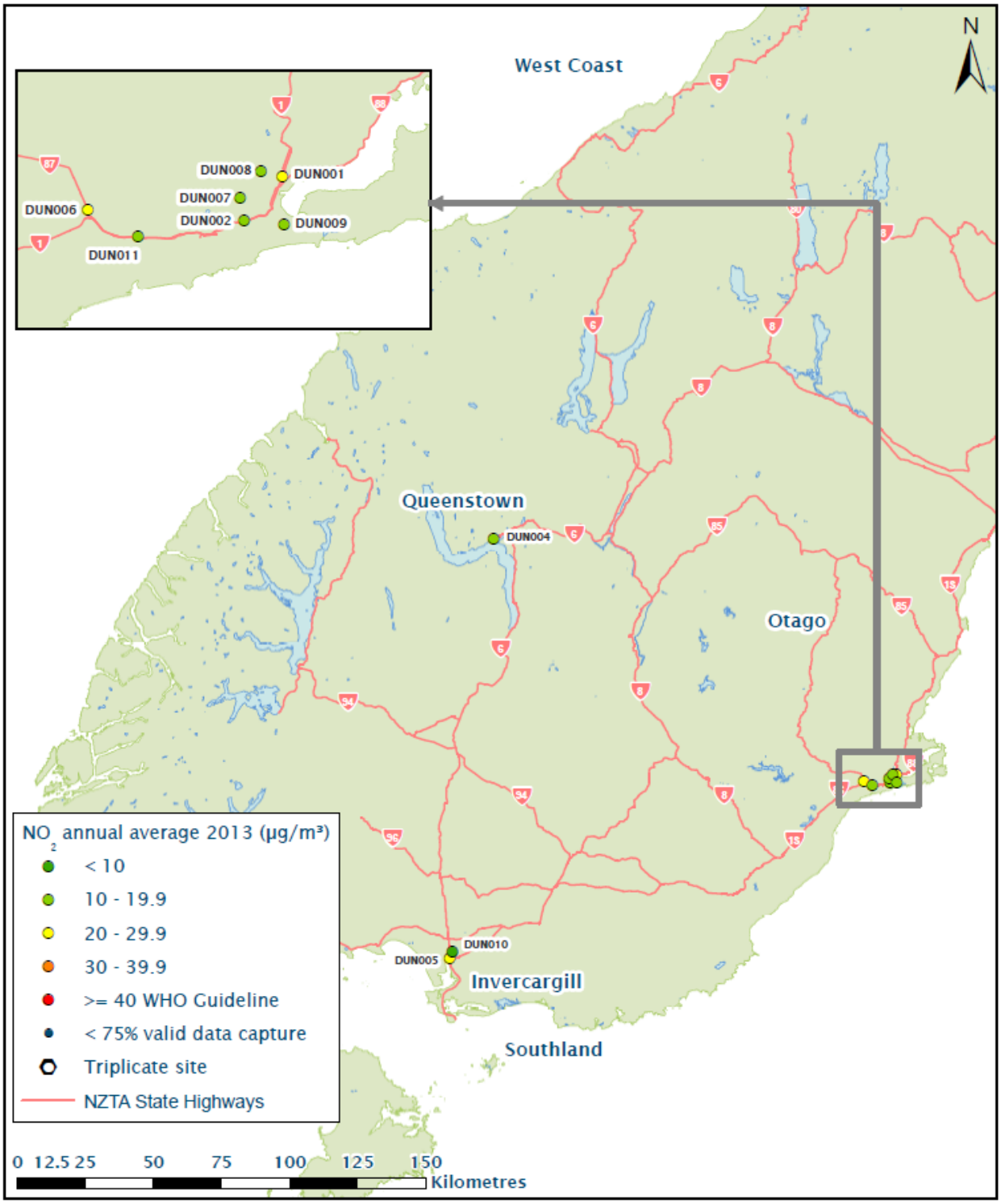

Figure 60: Map of Dunedin, Queenstown and Invercargill annual NO_2 averages for 2013