

# NERMN Air Monitoring 2007

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*Working with our communities for a better environment  
E mahi ngatahi e pai ake ai te taiao*



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## Executive Summary

Environment Bay of Plenty monitors air quality as part of its statutory responsibilities under the Resource Management Act 1991 and the Resource Management (National Environmental Standards Relating to Certain Air Pollutants, Dioxins and Other Toxics) Regulations 2004.

This report summarises recorded data and discusses the changes in air quality over time. It also reviews the monitoring programme and includes guidance and recommendations for the future direction of this programme.

Since the beginning of the monitoring programme in 1996 a number of monitoring sites have been established in the region. Some of these are baseline long-term sites, while others are short-term investigative sites. There are currently nine sites in operation, monitoring contaminants like particulate matter (PM<sub>10</sub>), carbon monoxide, sulphur dioxide, nitrogen dioxide and hydrogen sulphide.

Statistical analysis presented in a graphical format show patterns and trends in each set of data. The focus is on particulate matter (PM<sub>10</sub>), as nationally this is the contaminant of greatest interest and concern. However information is presented for all monitored contaminants in each site's discussion section.

The implementation of the National Environmental Standard has seen a change in focus on the location and type of monitoring sites. This new approach is used by Environment Bay of Plenty. An example is the Edmund Road monitoring site in Rotorua which each year consistently records more than 20 exceedances of the standard. Extra investigative sites have been identified for some of the smaller population centres in the region to ensure compliance with the PM<sub>10</sub> standard. To date monitoring data only shows exceedance of the PM<sub>10</sub> standard in the Rotorua Local Air Management Area (LAMA).

Other National Environmental Standard contaminants are also monitored. Monitoring of carbon monoxide and nitrogen dioxide has shown levels well below the standard. Monitoring of sulphur dioxide in the Mt Maunganui industrial area has shown some elevated levels and as a result extra monitoring is being done in this area to better determine the temporal and spatial patterns of this contaminant.

Population and vehicle numbers have both increased during the period of monitoring for most of the main urban centres in the region. The rates of increase vary, with Tauranga being the main centre of growth. The air monitoring data sets are yet to show the direct effects of this growth because of: (1) variations in meteorology (which is the main determinant of contaminant levels experienced by the population), (2) improvements in fuel specifications and vehicles, (3) improvements in the way people heat their homes. As expected there are no discernable trends to date.

Airshed and point source models have been developed, providing a valuable and powerful tool to complement ambient monitoring programmes (e.g. Rotorua LAMA). These models, when validated against recorded data, let us determine ground level concentrations of contaminants at a variety of locations rather than the single point associated with a monitoring site. This provides valuable information for assessment of NES-AQ compliance within the regional airshed and air discharge permit applications by industry. The council should look at developing these airshed models and the required operational skill set in house as the ability to run new scenarios quickly and reliably is dependant on sound emission and meteorological datasets, both of which are in the process of being developed.



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# Chapter 1: Introduction

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## 1.1 Introduction

Environment Bay of Plenty is required to undertake monitoring activities as part of its statutory responsibilities under the Resource Management Act 1991 and the Resource Management (National Environmental Standards Relating to Certain Air Pollutants, Dioxins and Other Toxics) Regulations 2004.

The current Natural Environmental Regional Monitoring Network (NERMN) is based around a regional network of monitoring sites designed for regional state-of-the-environment monitoring, documentation and reporting. Natural environment monitoring determines the overall regional impact of activities on environment quality.

This report will involve the review of the Environment Bay of Plenty Air NERMN programme. It will report on air quality data collected to date, it will also include a review of the monitoring programme and provide guidance and recommendations as to the future direction of this programme.

## 1.2 Requirements of RMA and Regional Plans

The purpose of the Resource Management Act (1991) is to promote sustainable management of natural and physical resources. Environmental monitoring is a specific requirement of the Act. Section 35 directs Regional Councils to *“gather such information, and or undertake or commission such research, and monitor the state of the whole or any part of the environment of its region or district to the extent that is appropriate, as is necessary to carry out effectively its functions under the Act”*.

In December 2003 the Bay of Plenty Regional Air Plan was made operative. The purpose of this plan is to enable Environment Bay of Plenty to promote the sustainable management of the Bay of Plenty air environment. Sustainable management is defined in section 5 of the Act as:

*“Managing the use, development and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural wellbeing and for their health and safety while –*

- (a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
- (b) Safeguarding the life-supporting capacity of air, water, soil and ecosystems; and*
- (c) Avoiding, remedying or mitigating any adverse effects of activities on the environment.”*

Section 5.5 of the Air Plan outlines plan monitoring and review. Information for plan monitoring will be drawn from a range of NERMN monitoring programmes including data collection and the resulting analysis performed and documented in this report.

### 1.3 Report Objectives

This report forms the assessment of the current ambient air quality monitoring programme for the Bay of Plenty region. The *objectives* are briefly outlined below:

- (a) Assess air quality changes in Bay of Plenty between 1997 and the end of 2007 and compare against the National Environmental Standard for Air Quality (NES-AQ).
- (b) To compare current trends with earlier assessments.
- (c) To provide information for a review of the current monitoring programme.

### 1.4 Scope and Structure of Report

Chapter One forms an introduction to the report, outlining the responsibility of Environment Bay of Plenty under the Resource Management Act to monitor the air environment.

Chapter Two discusses the recent National Environmental Standard - Air Quality.

Chapter Three briefly covers the basic meteorological patterns within the Bay of Plenty and how these affect air quality as a result of physical and social responses.

Chapter Four discusses the monitoring methods implemented by Environment Bay of Plenty and provides monitoring site metadata.

Chapter Five presents the results of the Environment Bay of Plenty monitoring programme for the period 1997–2007. This section describes the changes in monitoring results and trends. It also contains discussion on data distribution, diurnal patterns, seasonal trends and relationships with meteorology.

Chapter Six presents the data capture rates.

Chapter Seven discusses future monitoring schedules and equipment requirements.

Chapter Eight discusses recommendations for this air quality monitoring programme.

Chapter Nine summarises the monitoring data trends to date.

## Chapter 2: National Environmental Standards

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### 2.1 Overview

A new Regulation for ambient air quality in New Zealand was promulgated in September 2004, as a National Environmental Standard (NES-AQ) under s43 of the Resource Management Act 1991. The NES-AQ specifies health-based limits for ambient air concentrations of fine particulate (PM<sub>10</sub>), carbon monoxide, nitrogen dioxide, ozone and sulphur dioxide. The Regulation also specifies requirements for monitoring of these pollutants, in the event that the standards are breached. It establishes an air quality management regime, based on controls over the issuing of resource consents in those areas where the limits are exceeded, or likely to be exceeded.

A key element of this control regime is the designation of “airsheds” under subclause 14 of the Regulation. These are to be specified by the Minister for the Environment by a notice in the Gazette. The term “airsheds” is only loosely defined in the Regulation, and it has since been suggested that the term Local Air Management Area (LAMA) gives a better indication of the function and purpose of these areas hence the term LAMA is used.

Regional Councils were invited to nominate specific LAMA’s for their region by 1 July 2005.

### 2.2 Rotorua Local Air Management Area

In response to the Ministry for the Environment’s request to nominate Local Air Management Areas (LAMA), Environment Bay of Plenty has currently designated only one LAMA for the Bay of Plenty region, this is the Rotorua LAMA (New Zealand Gazette, 2005).

The location and extent of this area was initially based on local air quality monitoring data, air emission inventories, air discharge consents, council staff knowledge, geophysical, population and meteorological information. The extent of the LAMA has more recently been qualified by the airshed modelling exercise (Fisher et. al., 2007).

Rotorua has a unique topographic situation whereby the city is located on the southern edge of a caldera basin. Being inland, the city does not have the same ‘flushing’ diurnal wind patterns experienced by the coastal urban centres. The prevailing wind is from the south west resulting in the airmass being moved from the city across the lake.

During winter the basin is prone to ground based radiation inversions and cooling katabatic winds causing a confinement of the air mass above the city. On other occasions during winter, settled conditions associated with post frontal ridging and the outputs from domestic heating result in elevated particulate concentrations.

Home heating for some dwellings in this area is via the geothermal resource, however due to controls to sustain the geothermal field, wood burners/open fires are still a widely used heating option.

The air quality monitoring site at Pererika Street has recorded exceedences (1-6 per year from the nine years of monitoring) of the standard. The site is located on the boundary of a residential area to the south and a main arterial road to the north.

Diurnal analysis of data collected at Pererika Street shows that the values increase in the morning which is likely to be a result of vehicular activity. The levels generally remain elevated during the day and then increase again (excluding summer) in the evening, which would be the result of domestic heating. The same trends can be seen in the carbon monoxide plots for data from this site.

The site at Pererika Street is considered to be a good indicator site for overall air quality in Rotorua. However, with the designation of the Rotorua LAMA, a second site was established in Edmund Road to give a better indication of the possible worst-case impacts from residential heating.

Monitoring results from sites within the LAMA are discussed in more depth in Sections 5.3.1 to 5.3.3.

## Chapter 3: Bay of Plenty Meteorology

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Meteorology forms the single major effect on the dispersion of contaminants from sources and ultimately air quality. The following section summarises patterns in general meteorology parameters (primarily surface wind and ambient air temperature) that effect air quality and the concentration of contaminants within the region.

The weather experienced in the Bay of Plenty, as in other parts of the New Zealand, is influenced by the eastward movement of weather systems and by the bold topography of New Zealand. The Bay of Plenty has a sunny climate, with less wind than most other parts of the country and with considerable rainfall and temperature variability (Quayle, 1974).

### 3.1 Wind data

A range of airstreams affect the Bay of Plenty with differing results on the local meteorology patterns. Wind roses for the main urban areas show a coastal/inland pattern as well as variations on a seasonal timeframe (Figure 3.1).

Below is a brief summary of the main flows impacting on the Bay of Plenty. These flows are normally not present during periods of exceedance of the standard as the increase in turbulence will aid dispersion and often accompanying precipitation acts as a cleaning mechanism. These winds are however often partly responsible for setting up conditions prior to an exceedance event (bringing a colder airmass over the region thus triggering domestic heating) and are definitely responsible for the cessation of these periods of high concentrations.

#### 3.1.1 North to northeast airstreams

Airstreams from the north and north east frequently have long trajectories over the warm ocean to the north of New Zealand, and as a result, the air flowing on to the Bay of Plenty under these conditions is very humid. As the whole region is exposed to the north, these airstreams often produce widespread and heavy rain when the moist air is forced to ascend over rising ground. These airstreams will often result in an increase in background PM<sub>10</sub> concentrations as marine sourced particulate is entrained and carried inland.

### 3.1.2 **West to southwest airstreams**

This is a common situation in New Zealand, occurring most frequently during the spring months, and is particularly exaggerated during El Nino conditions. These airstreams are typically accompanied by the presence of a single or often multiple cold fronts, giving showers chiefly to the western areas. The Bay of Plenty however is sheltered by the Kaimai and Mamaku ranges and as a result only a few showers are experienced in most cases. These typically cooler airstreams during winter often precede the onset of an anticyclone over the country which results in settled weather and potential for exceedances.

### 3.1.3 **South to southeast airstreams**

The area to the east and south of the Bay of Plenty comprises the central high country of the North Island. South to southeast airstreams will normally have released much moisture as rain on the ranges and usually produce fine dry weather over the region. They are normally associated with the leading edges of a high pressure system so during winter they often precede settled weather frequently associated with inversion development and increased domestic heating activity as colder nights prevail.

### 3.1.4 **West to northwest airstreams**

The Coromandel, Kaimai and Mamaku Ranges provide sheltering to much of the Bay of Plenty in west to northwest situations. Because of the sheltering much of the rain that falls in the western Bay of Plenty with this type of situation occurs with the passage of fronts, rather than as a result of orographic effects on the northwesterly flow. As with all of the above mentioned airstreams, these flows will bring 'background' particulate into and through the region. A proposal is being submitted to FRST for a project investigating the quantity of this component of particulate. The data record from the Pongakawa monitoring site (Section 6.3.10) is the council's background site and provides valuable information for a number of investigations.

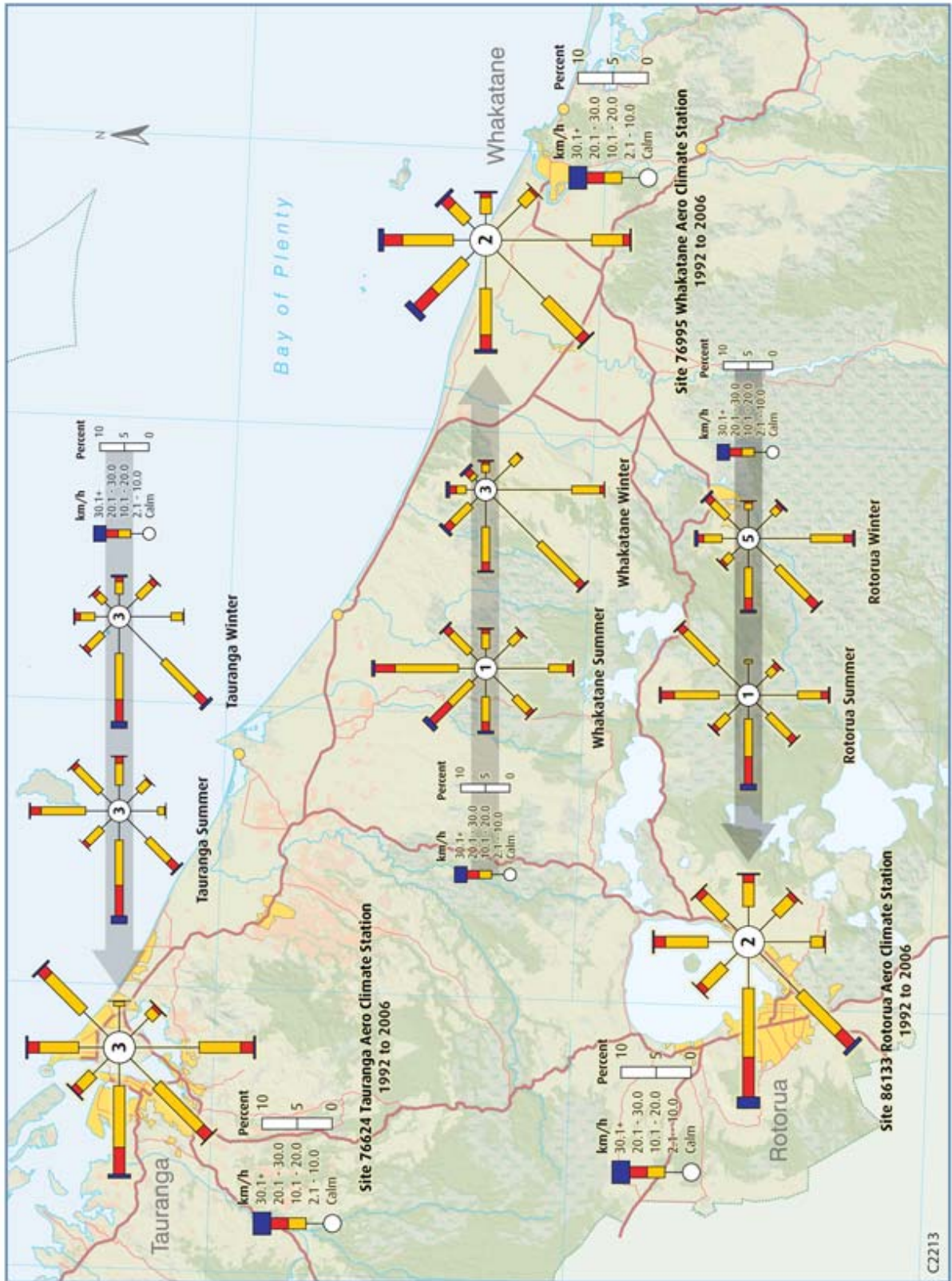


Figure 3.1 Windroses for the Bay of Plenty region (Data source: NIWA Climate Database, 2007)



### 3.2 Air temperature data

Air temperature data is generally negatively correlated with PM<sub>10</sub> concentrations. Recorded exceedance of the PM<sub>10</sub> standard in Rotorua typically occurs during the cooler evenings during the heating season (for Rotorua LAMA - May to September) and combined with other key boundary layer characteristics and a significantly sized source, creates problems that are not normally experienced at the other main urban locations within the region.

Analysis of long term temperature records as part of a recent climate change project show the coldest nights have significantly warmed in the Bay of Plenty since good quality, daily temperature records began in 1940 (Figure 3.2). And the number of cold nights has significantly decreased (Figure 3.3).

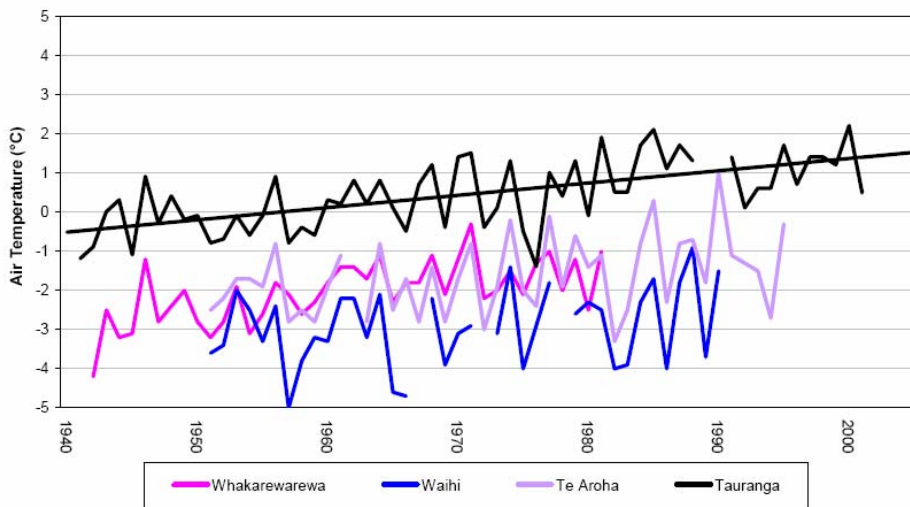


Figure 3.2 Cold nights at four Bay of Plenty stations. (Griffiths et. al., 2003)

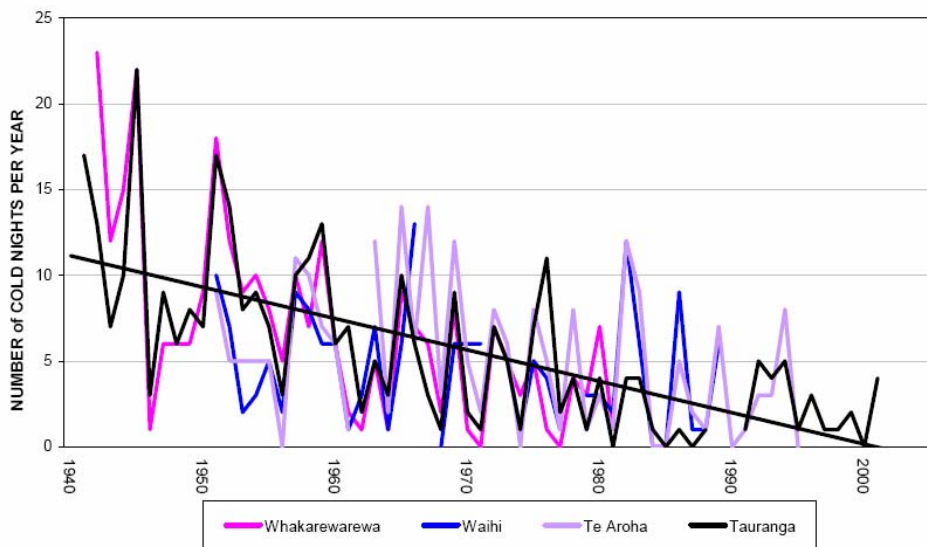


Figure 3.3 Frequency of cold nights at four Bay of Plenty stations. (Griffiths et. al., 2003).

An understanding of these temperature patterns is important as links through to end user patterns provides additional information about source characteristics. A recent investigation by BRANZ Ltd. (Isaacs et. al., 2005) looking at energy use of New Zealand households highlights this link with heating patterns and ambient temperature (Figure 3.4). As the external temperature drops, the heating energy use increases in most houses and thus resulting negative impacts on air quality become noticeable. There is no doubt that the further south you live, the cooler are the external temperatures before people start to heat. Interestingly the average external temperature in summer for Invercargill is below the threshold for heating in Auckland (Isaacs et. al, 2005).

<b>Regional Council</b>	<b>Start Temp. °C</b>	<b>End Temp. °C</b>
Northland	15.2	15.2
Auckland	15.1	14.7
Bay of Plenty	14.2	14.2
Waikato	13.1	14.5
Gisborne/Hawkes Bay	13.7	13.8
Taranaki/Manawatu-Wanganui	13.7	13.5
Wellington	13.0	12.4
Tasman/Nelson/Marlborough	12.6	13.2
Canterbury	12.3	11.7
Otago/Southland	11.7	13.5

*Figure 3.4 Heating season temperatures. (Isaac et. al., 2005).*

Analysis of the Edmund Road PM<sub>10</sub> and ambient temperature record further highlights this relationship (Figure 3.5). There has been anecdotal evidence that particulate values are related to the day of the week (highlighting the social behavioural link). While it has been detected in the datasets the effect of national sporting events coinciding with higher particulate concentrations, the general weekly pattern is for particulate concentrations to increase once ambient temperature reaches approximately 15°C.

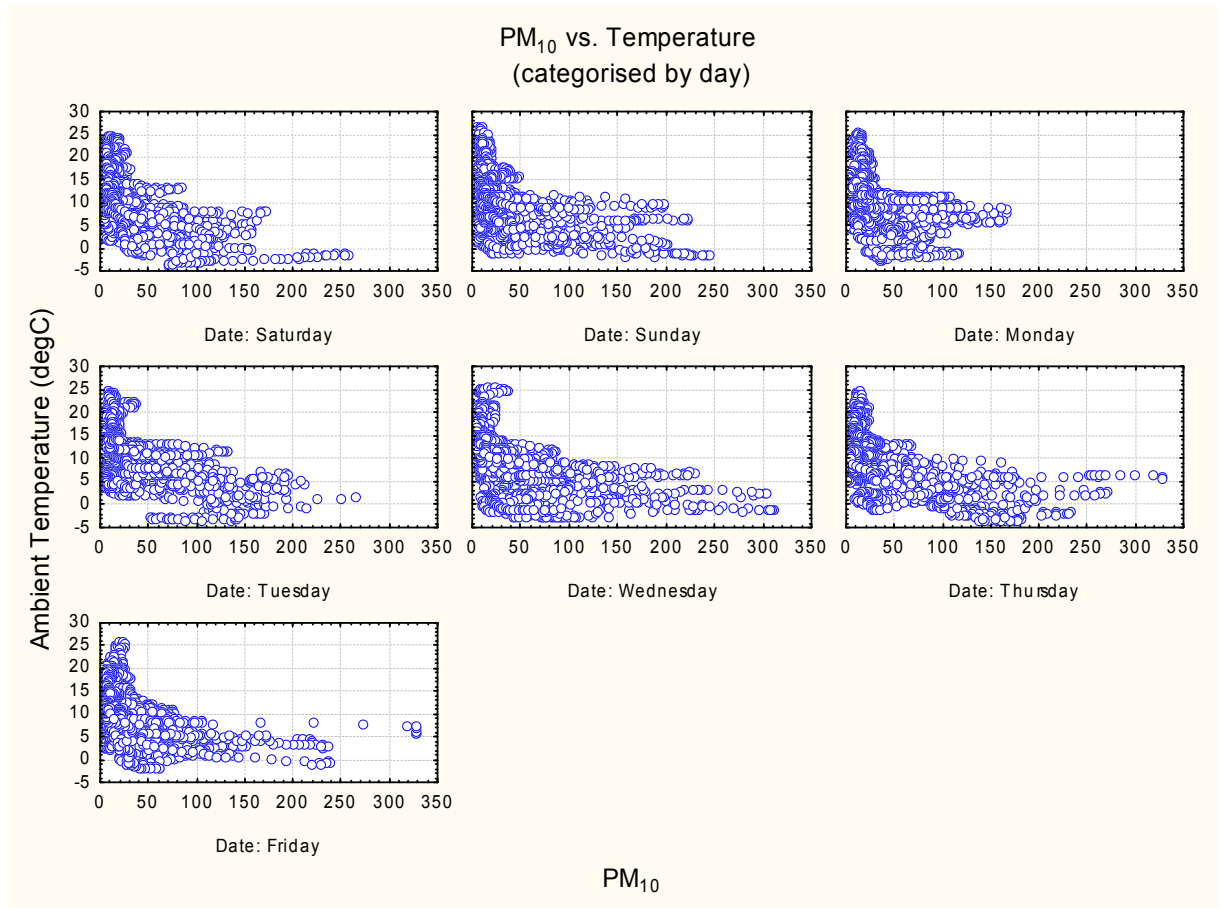


Figure 3.5 Weekday temperature versus particulate relationships for the Edmund Road monitoring site (10 min data).

### 3.3 Mixing height (inversions)

The right combination of the parameters mentioned in the two previous sections gives rise to the development of a surface confined mixing height. The following is a discussion of this phenomenon from the recent modelling investigation for the Rotorua LAMA (Fisher et. al, 2007).

A major cause of high pollution is the occurrence of a winter time inversion over the city. “Inversion” can be a misleading term, with a more correct one being the “mixing depth” – the height to which pollution emitted at the surface can disperse. This phenomenon is well known as the major reason some South Island towns (such as Christchurch) experience very high pollution levels. Model outputs of the day-to-day variation in the mixing depths are shown in Figure 3.6.

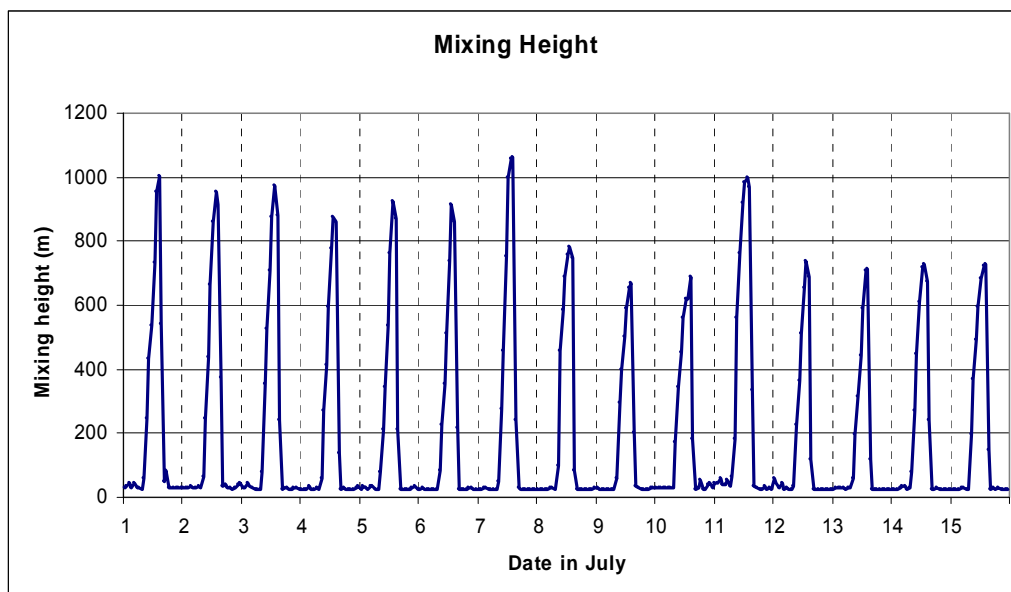


Figure 3.6 Depth of the inversion layer, Rotorua, July 2001 (Fisher et.al, 2007).

The noticeable feature of these results is the regular, rapid, and severe collapse of the mixing layer every afternoon at 3pm to 4pm – just when wood fires are being lit. This ‘inversion’ creates a trap for air pollution on many nights in winter. Its break up in the morning, along with a slight increase in wind speeds, effectively clears the city each day. Without this, a situation could arise where high pollution from the previous night could stay around and lead to very high concentrations (as occurs occasionally in other places).

A more extensive period is shown in Figure 3.7, for the whole of winter. This is shown to illustrate two features of relevance to air pollution occurrences.

There are two periods – in early May, and later in May – where the mixing height is almost never less than 150m. These are likely to be windy periods, where even at night the atmosphere is turbulent and any pollution emissions will be dispersed rapidly.

In contrast there is a period in early June where the opposite occurs – the mixing height rarely exceeds 100m, and is regularly at or below 50m. These are likely to be cool, calm conditions, where pollution emitted does not disperse and can build up to exceedance levels over much of the city.

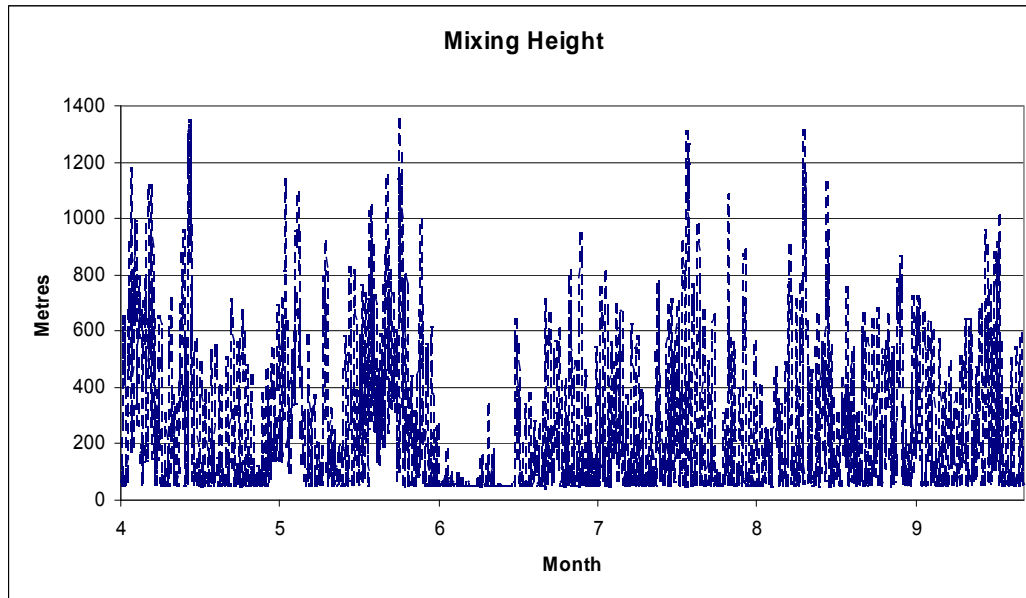


Figure 3.7 Depth of the inversion layer, Rotorua, through winter of 2001 (Fisher et.al, 2007).

Note that some of these inversion features described above may be specific to the particular year of meteorology – 2001. Some features may be slightly different from year to year.

## Chapter 4: Monitoring Methods

### 4.1 Monitoring methods

The MfE good practice guide for air quality monitoring (2000) and the more recent NES-AQ regulations (2004) recommend a set of methodologies for ambient air quality monitoring. These are as shown in Table 4.1 and are implemented in Environment Bay of Plenty's monitoring programme.

*Table 4.1 Monitoring methods used.*

Contaminant	Method
PM <sub>10</sub>	TEOM (with co-location) and FDMS TEOM. United States Code of Federal Regulations, Title 40, Protection of Environment, Volume 2, Part 50, Appendix J, Reference method for the determination of particulate matter as PM <sub>10</sub> in the atmosphere.
CO	Australian Standard AS3580.7.1:1992, Methods for sampling and analysis of ambient air, Determination of carbon monoxide, Direct-reading instrumental method.
SO <sub>2</sub>	Australian Standard AS3580.4.1:1990, Methods for sampling and analysis of ambient air, Determination of sulphur dioxide, Direct-reading instrumental method.
NO <sub>x</sub>	Australian Standard AS3580.5.1:1993, Methods for sampling and analysis of ambient air, Determination of oxides of nitrogen, Chemiluminescence method.
H <sub>2</sub> S	Australian Standard AS3580.4.1:1990, Methods for sampling and analysis of ambient air, Determination of sulphur dioxide, Direct-reading instrumental method.

See Appendix 1 for a full description of the instrumentation and methods used for this monitoring programme.



Table 4.1 Reported monitoring site details

Site Title	Pererika	Otumoetai	Quay Street	Pongakawa	Fenton Street	Te Ngae
Location	Pererika Street, Rotorua	Otumoetai Road, Tauranga	Quay Street, Whakatane	Pongakawa Bush Road	Corner of Fenton and Amohau Streets, Rotorua	Te Ngae Road, Rotorua
Land/site owner	Pukeroa Oruawhata Trust	Otumoetai Primary	Environment Bay of Plenty	Private land owner	Pak n Save	NIWA depot building, Te Ngae Road
Site height above sea level	280 metres (±6m)	65 metres (±6m)	14 metres (±6m)	102 metres (±6m)	288 metres (±6m)	320m
Region	Bay of Plenty	Bay of Plenty	Bay of Plenty	Bay of Plenty	Bay of Plenty	Bay of Plenty
Co-ordinates	U16: 943 353 (NZMG 2794248 6335478)	U14: 8675 8680 (NZMG 2786835 6386414)	W15: 6172 5380 (NZMG 2861724 6353804)	V15: 1732 6349 (NZMG 2817320 6363490)	U16: 9536 3536 (NZMG 2795361 6335365)	V15: 9549 3456 (NZMG 2795488 6334955)
Directions to site	The site is situated on the Pukeroa Oruawhata Trust (ex Telecom Works Depot) property, off Pererika Street, Rotorua.	Travel along Otumoetai Road, Tauranga to the corner of Darragh and Otumoetai Roads. The shed is located in the south eastern corner of the school field.	The site is located on the roof of the Environment Bay of Plenty building in Quay Street. Access is via the air conditioning service entry.	Travel 50 kilometres along ThorntonRoad/SH2 towards Tauranga. Turn left at Pongakawa School Road and travel 1.5km before turning left into Old Coach Road. Travel 1.5 kilometres until; reaching Pongakawa Bush Road then travel 3.9 kilometres before turning left into a gate marked with Dairy Shed number 21565. Park at the milking shed and walk 160m north to the site.	Access the Pak n Save car park from Amohau Street. The caravan is located in the southwest corner of the car park adjacent to the traffic lights.	Located in the NIWA depot building
Contaminant monitored	CO & PM <sub>10</sub> , and H <sub>2</sub> S	CO, PM <sub>10</sub> and NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>10</sub>	CO & PM <sub>10</sub>	H <sub>2</sub> S
Monitoring objectives	Long term CO and PM <sub>10</sub> monitoring in residential area. Assess the levels of H <sub>2</sub> S in a selection of areas throughout Rotorua. Sites will also assist in the monitoring exposure levels of the people in that area.	Long term CO and PM <sub>10</sub> monitoring in residential area. Investigative monitoring of NO <sub>x</sub> .	Ambient particulate levels in Whakatane and assess seasonal variations.	Long term PM10 monitoring in background area.	Commercial setting. Vehicle input monitoring	Assess the levels of H <sub>2</sub> S in areas that are likely to have higher emissions from several directions. Sites will also assist in the monitoring exposure levels of the people in that area.
Site type	Urban PM <sub>10</sub> , H <sub>2</sub> S & CO site	Urban CO, PM <sub>10</sub> and NO <sub>x</sub> site	Urban PM <sub>10</sub> site. Neighbourhood (0.5-4km)	Background PM <sub>10</sub> site	Peak traffic site	H <sub>2</sub> S
Equipment	TEOM, Partisol 2025, ML9830 and ML9850 with thermal oxidiser.	TEOM, Partisol 2025, ML9830 and ML9841	Partisol 2000	Partisol 2025	TEOM, Partisol 2025 and ML9830	ML9850 with thermal oxidiser.
Site topography	The site is located in a large yard with a row of single storey buildings 100m to the south and another group of buildings 250m to the south east. Amohau Street is located 50m to the north. The yard is located on the edge of a residential area.	Situated on a flat area within the Otumoetai suburb, which is an elevated region to the west of Tauranga City.	Located on the roof of the Environment Bay of Plenty Building. Sampling inlet is 2m above the roofline.	Large flat paddock with surrounding rolling countryside	Situated on a flat area on the southeastern corner of the Fenton / Amohau Street intersection.	Situated on a flat area about 360m north of the Rotorua racecourse.
Location and direction of major sources	Residential home heating surrounds the site.	Source direction is 360 degrees. Residential properties in the clockwise arc from 0 to 180 degrees. Otumoetai Road is located in the immediate vicinity in the arc from 181 to 359 degrees.	Situated atop of a building located 60m south of the Whakatane River. 360 degree possible source location.	Rural paddock sources. 360 degrees as possible source direction.	Sources are located predominately to the north and west but due to the caravans proximity to the intersection sources could be described as being from all bearings.	Natural, multiple sources, major source are the Whakarewarewa area to the south and active geothermal area on the lake margins to the northwest.
Planned development of site	Permanent. H <sub>2</sub> S - Semi permanent. Possible relocation to other areas within Rotorua City for concentration mapping.	Permanent	Permanent	Permanent	Short term (1 year), repeatable.	Semi permanent – Possible relocation to other areas within Rotorua City for concentration mapping.



Site Title	Marsh Street	Edmund Road	Totara Street	King Street	Church Street	Ti Street	Arawa Street
Location	Corner of Marsh and Chapel Street	cnr of Linton Park Recreational Reserve (adjacent to 51 Edmund Rd), Edmund Road, Rotorua.	cnr Waimarie and Totara street, within Tauranga City Council compound.	Adjacent to Maori Wardens Office, 7a Victoria Ave.	Church Street, Opotiki	Ti Street, Rotorua	Environment Bay of Plenty building, Arawa Street, Rotorua
Land/site owner	District council	Rotorua District Council	Tauranga City Council	Whakatane District Council	Whakatohea Maori Trust	Dimond Industries building	Environment B-O-P
Site height above sea level	5 metres	290 metres	10 metres	10 metres	15 metres	280m	280m
Region	Bay of Plenty	Bay of Plenty	Bay of Plenty	Bay of Plenty	Bay of Plenty	Bay of Plenty	Bay of Plenty
Co-ordinates	U14: 8947 8688 (NZMG 2789471 6386878)	U16: 9185, 3577 (NZMG 2791852 6335771)	U14: 9138, 8838 (NZMG 2791384 6388383)	W15: 5989, 5247 (NZMG 2859898 6352477)	W15: 8623 4632 (NZMG 2886234 6346324)	V15: 9535 3475 (NZMG 2795488 6334925)	U16: 9535 3575 (NZMG 2795262 6335807)
Directions to site	Located at the Marsh / Chapel Street traffic intersection.	Travelling north along Edmund Road, the site is located on the right-hand side in Linton Park Recreational Reserve, adjacent to residential property 51 Edmund Road.	Located at Waimaie/Totara Streets intersection.	Located east of King Street, behind Kopeopeo shops, adjacent to the Maori Wardens Office on the alley-way,	Travel along Bridge Street, Opotiki. Turn left onto Nelson Street, right onto King Street, then left onto Potts Ave. Site is at rear of Whaktohea compound on the right.	Located in the Dimond Industries Building, Ti Street on a mezzanine floor in the workshop.	Located on the second floor of the Environment Bay of Plenty office, Arawa Street, Rotorua.
Contaminant monitored	CO & PM <sub>10</sub>	PM <sub>10</sub>	SO <sub>2</sub>	PM <sub>10</sub>	CO & PM <sub>10</sub>	H <sub>2</sub> S	H <sub>2</sub> S
Monitoring objectives	Assess vehicle emissions at busy intersection in Tauranga.	Long-term residential & commercial PM <sub>10</sub> monitoring.	Assess commercial contribution, and vehicle peak emissions at busy intersection in Mount Maunganui.	Long-term residential area PM <sub>10</sub> Monitoring.	CO and PM10 monitoring in residential area.	Assess the levels of H <sub>2</sub> S in areas that are likely to have higher emissions from several directions. Sites will also assist in the monitoring exposure levels of the people in that area.	Assess the levels of H <sub>2</sub> S in areas that are likely to have higher emissions from several directions. Sites will also assist in the monitoring exposure levels of the people in that area.
Site type	Peak/micro PM <sub>10</sub> & CO site	Residential & Commercial PM <sub>10</sub>	Commercial & Peak Traffic SO <sub>2</sub>	Urban/Commercial PM <sub>10</sub>	Background PM <sub>10</sub> & CO site	H <sub>2</sub> S	H <sub>2</sub> S
Equipment	TEOM, ML9830	TEOM, Partisol 2025	EC9850	FDMS TEOM	TEOM	MDA 7100	MDA 7100
EPI site classification	Type 1(a)	Type 1(a)	Type 1(a)	Type 1(a)	Type 2(a)	Type 2(a)	Type 2(a)
Site topography	Flat land adjacent to the Waikareao estuary (which is located to the west) and rise in elevation to the east.	Situated on gently undulating area within Linton Park Recreational Reserve (Western Heights). Commercial area to the east, and residential surrounding the site.	Flat area with empty paddock to east, busy road running (Totara St) north/south to the west, and surrounded by industrial activity.	Situated on a flat area with a carpark to the north, and surrounding residential and commercial.	Situated on a flat area within the Opotiki township. Commercial areas to the north and east, residential to the south	Situated on a flat area about 500m north of the Rotorua racecourse.	Located in the Rotorua office of Environment B-O-P in Arawa Street.
Location and direction of major sources	The Marsh /Chapel Street intersection is located 5m to the NE.	Residential source direction is 360 degrees, with some commercial source from directional arc 40 degrees to 130 degrees.	Busy road (Totara St) to the west from 190 degrees to 350 degrees, and commercial source direction is 360 degrees.	Residential and commercial source direction is 360 degrees.	Source direction is 360 degrees. Residential properties in the arc from 180 to 360 degrees.	Natural, multiple sources, major source are the Whakarewarewa area to the south and active geothermal area on the lake margins to the northwest.	Natural, multiple sources.
Planned development of site	Short term (1 year), repeatable.	Permanent Site.	Semi-permanent Site.	Permanent Site.	Short term (1 year), repeatable.	Semi permanent – Possible relocation to other areas within Rotorua City for concentration mapping.	Semi permanent – Possible relocation to other areas within Rotorua City for concentration mapping.

## Chapter 5: Monitoring Results

### 5.1 MfE Environmental Performance Indicators (EPI)

Environmental performance indicators (EPI) for air quality are used to measure and report on the state of our air environment.

The air indicators selected (Table 5.1) are 'state' indicators. State indicators provide a picture of the current state of the environment judged by comparing the monitoring results to MfE standard values (Table 5.2).

Table 5.1 Performance Indicators.

Category	Maximum Measured Value	Comment
Excellent	<10% of the standard	Of little concern, if maximum values are less than a tenth of the guideline, average values are likely to be much less.
Good	10 – 33% of the standard	Peak measurements in this range are unlikely to impact air quality.
Acceptable	33 – 66% of the standard	A broad category, where maximum values might be of concern in some sensitive locations but generally at a level which does not warrant dramatic action.
Alert	66 – 100% of the standard	A warning level, which can lead to exceedences if trends are not curbed.
Action	Exceeds the standard	Exceedences of the standard are a cause for concern and warrant action if they exceed the NES-AQ permissible occasions.

Table 5.2 Ministry for the Environment standards.

Contaminant	MfE Standard value	
	Threshold concentration	Permissible excess
Carbon monoxide	10 milligrams per cubic metre expressed as a running 8-hour mean.	One 8-hour period in a 12-month period
Sulphur dioxide	350 micrograms per cubic metre expressed as a 1-hour mean.	9 hours in a 12-month period
	570 micrograms per cubic metre expressed as a 1-hour mean.	Not to be exceeded at any time
PM <sub>10</sub>	50 micrograms per cubic metre expressed as a 24-hour a mean.	One 24-hour period in 12-month period
Nitrogen dioxide	200 micrograms per cubic metre expressed as a 1-hour mean.	9 hours in a 12-month period
Hydrogen sulphide <sup>a</sup>	7 micrograms per cubic metre expressed as a 1-hour mean.	-

*a – value is based on an odour nuisance level and is a guideline value (MfE, 2002).*

## 5.2 Quality Assurance

All monitoring sites are operated by Environment Bay of Plenty. The operation of these sites is undertaken in accordance with the Environmental Data Services Field Practice Manual (1998), MfE (2000) and MfE (2002) guidance documents. Operation includes maintenance of the site and instrumentation and calibration of the monitoring equipment.

The Environmental Data Services Air Quality Office Practice Manual (1999) outlines procedures for the provision of quality assured data.

As a form of external audit on the instrument operation an inspection programme is conducted using Ecotech Pty Ltd on an initial 12 month routine for the first 3 years of this monitoring programme. This inspection programme has now been extended to 18 months. Ecotech is an ISO 9001 and NATA accredited company. Reports from Ecotech provide calibration, service results and comments regarding the operation of the site and instrumentation.

## 5.3 Monitoring Results

The results reported in this section are from the air monitoring sites listed in Section 4. For the purpose of this report the data will be reported in relation to the MfE standards, however where the contaminant is not covered by the standards then the MfE guidelines will be used for comparison.

Each results report contains a description of the site location, discussion on the data trends, a location map often containing census 2006 heating results and traffic count information, and finally a page containing graphical analysis (with a PM<sub>10</sub> focus) which is linked to the earlier discussion page.

### 5.3.1 Pererika Street, Rotorua.

**Name:** Pererika.

**Location:** 15 Pererika Street, Rotorua.

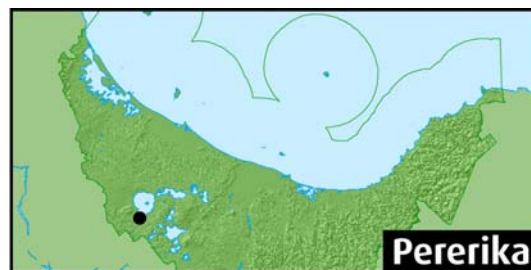
**Site Type:** Residential/traffic.

**Contaminants:** PM<sub>10</sub> and CO.

**Meteorology:** Yes, 10m.

**Elevation:** 280m.

**Monitoring Period:** 1998 to present.



#### Location:

This site is impacted by two main anthropogenic sources. The Amohau Street roadway (AADT (annual average daily total) ~14,000) 20m to the north and the largely residential area several hundred metres to the south (Figure 5.1). Immediately to the south is a sealed yard and reserve land. Immediately to the east is the Rotorua Boys High School, with large sport fields and a gas fired central heating system. The developed area to the north east is largely occupied by businesses, with a significant geothermal heating (“other fuels”) profile.

#### PM<sub>10</sub>:

For the majority of time the PM<sub>10</sub> values are measured in the ‘Good’ air quality category. However during the winter months, air quality reduces into the ‘Acceptable’ and ‘Alert’ categories. For less than one percent of the time the air quality is within the ‘Action’ category. Occasional exceedances of the PM<sub>10</sub> NES-AQ do occur at this site during the winter months. On average 2.3 exceedances have occurred per year with a maximum number of 6 recorded in 1998. This seasonal increase is reflected in the concentration and diurnal plots, with winter time being the time of elevated concentrations.

On a daily scale the winter time plot shows the dominating effect of domestic heating sources, with a noticeable increase in the morning on top of the traffic contribution and then a 4 fold increase on summer time levels being recorded during the evening as emissions from woodburners impact the site. The source patterns are reflected in recent emission inventory and modelling investigations for the Rotorua LAMA.

The concentration roses also show this seasonal pattern. The winter rose shows higher values and a predominance of these higher values from the south west quadrant which lines up well with the residential area in that quadrant. The impact from the north is less pronounced. During summer the concentrations are lower and equally spread, with the exception of the north component which has slightly higher results and reflects the traffic influence during this time.

#### CO:

Carbon monoxide values recorded at Pererika Street, exhibit the same trends as the PM<sub>10</sub> record, with a pronounced increase during the winter months. The MfE standard was not exceeded at this site. Values are higher than at the Otumoetai monitoring site in Tauranga, which could be due to differences in local meteorological conditions, vehicle densities, and the proximity to Amohau Street, which is 20 metres to the north of this site. The wind roses from Rotorua Airport show the prevailing wind for this area is from the southwest quarter (see Section 3) suggesting that CO emissions from vehicles often get transported away from the sampling inlet.

The seasonal diurnal data for Pererika shows the influence of vehicle produced CO in the time period from 07:00 to 10:00 for all seasons (although autumn and winter are more predominant). Levels are generally depressed during the day (probably the result of wind conditions causing increased mixing) with noticeable increases from 17:00 particularly in the autumn and winter months where domestic heating would be a significant producer of carbon monoxide.

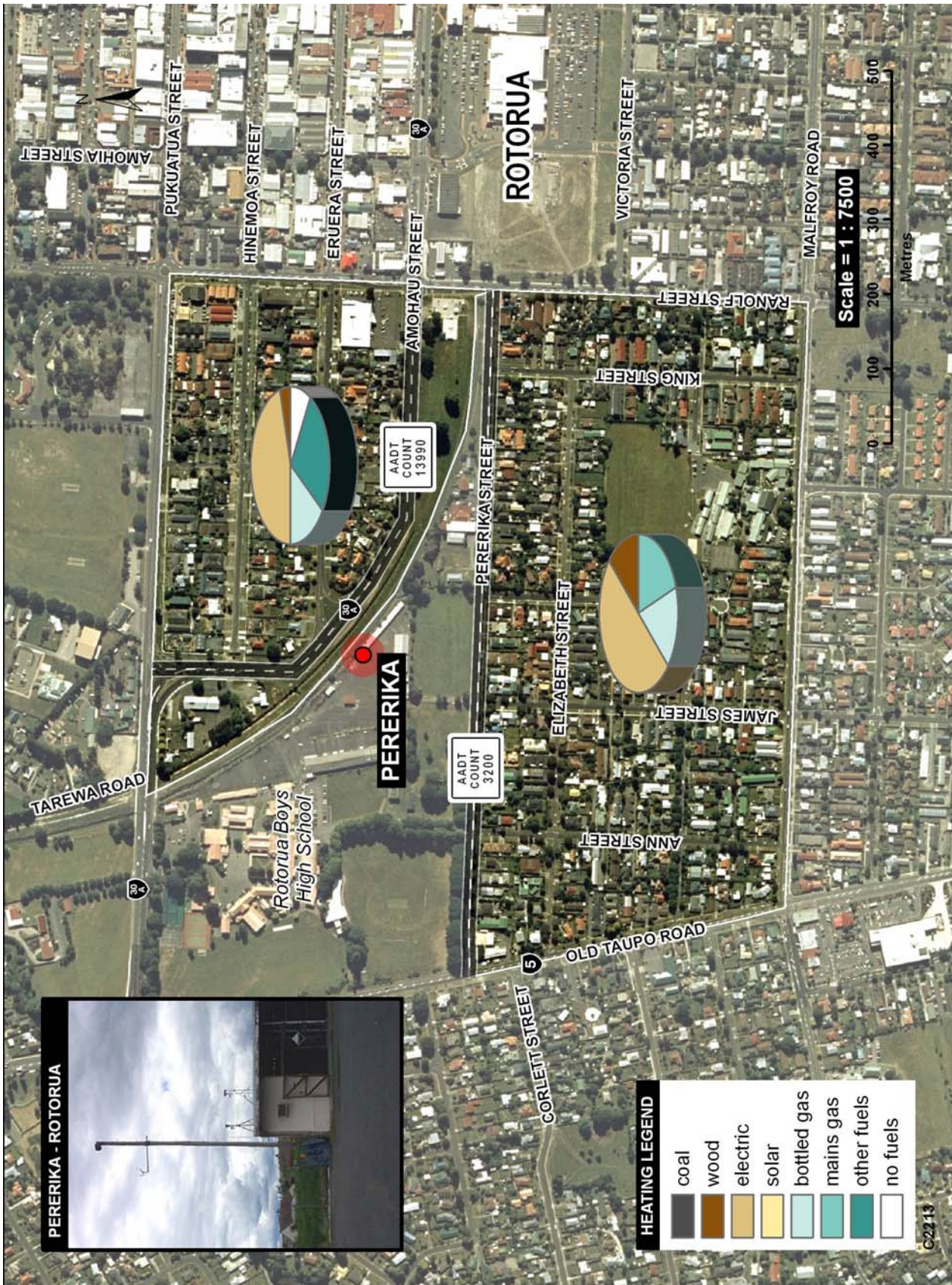


Figure 5.1 Pererika site location map.

PERERIKA MONITORING SITE (Data 1998 – 2007).	Environmental Performance Indicator (PM10)	<p>                     ■ Action (100+%)                      ■ Alert (66-100%)                      ■ Acceptable (33-66%)                      ■ Good (10-33%)                      ■ Excellent (&lt;10%)                 </p>	
	PM10 Concentrations ( $\mu\text{g}/\text{m}^3$ )	<p>                     ■ Maximum                      ■ Average                 </p>	
	Diurnal and Distribution	<p>                     — Autumn — Winter — Spring — Summer                 </p>	<p>                     PM<sub>10</sub> (24hr)                 </p>
	Seasonal Concentration Rose. (10_min data)	<p> <b>Summer</b>                      (calm 5% of the time)                 </p> <p> <b>Winter</b>                      (calm 10% of the time)                 </p> <p>                     PM<sub>10</sub> (<math>\mu\text{g}/\text{m}^3</math>)    Percent                 </p> <p>                     100.1+                      50.1-100.0                      20.1-50.0                      0.1-20.0                 </p> <p>                     10                      5                      0                 </p>	

### 5.3.2 Fenton Street, Rotorua.

**Name:** Fenton.

**Location:** Fenton/Amohau Street, Rotorua.

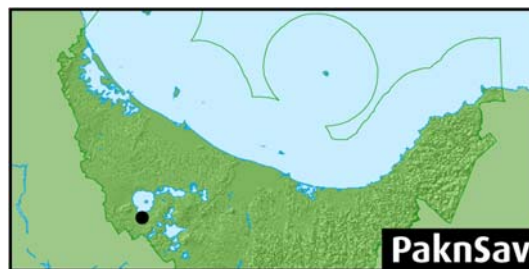
**Site Type:** Peak traffic.

**Contaminants:** PM<sub>10</sub> and CO.

**Meteorology:** Yes, 6m.

**Elevation:** 288m.

**Monitoring Period:** 1999, 2004 – 2007.



#### Location:

This site is located on the corner of the busiest intersection in Rotorua (PaknSave carpark) with entry traffic into the city arriving on SH30A from the east coupled with a significant north/south volume of ~10,000 AADT on Fenton Street (Figure 5.2). Both roadways are within 5m of the sampling equipment. The closest significant residential area is 300m to the southwest, with a heating type profile dominated by electricity. Geothermal energy (other fuels) is also utilised within this area as a means of dwelling heating.

#### PM<sub>10</sub>:

Two periods of monitoring have been undertaken at this site. Both show a level of air quality in the 'Good' to 'Acceptable' categories with roughly a 60:40 split respectively. The seasonal pattern for maximum 24 hour concentration is uniformly distributed with all values falling between 20 and 40µg/m<sup>3</sup>; a maximum value recorded during December is possibly the result of increased traffic volumes during the Christmas holiday period.

Seasonal diurnal patterns are reasonably consistent with a concentration build up in the morning associated with increasing traffic volumes as the population commutes to work. Levels then plateau at an elevated level during the day as traffic volumes stabilise. A build up toward 17:00 is also evident as commuters return home. Interestingly the winter profile has the characteristic elevated evening values as a result of domestic heating emissions even though the site is somewhat removed from dense residential development. This migration of particulate matter is highlighted in the recent modelling report (see Fisher et. al., 2007). This movement of particulate is further emphasized by the winter concentration rose, which signals a source in the southwest quadrant, the summer rose shows higher concentration to the north with aligns well with the traffic source.

#### CO:

Due to the site location on the corner of Fenton and Amohau Streets the carbon monoxide values are noticeably higher than at the Pererika site. Daily data does not have the characteristic morning and evening peaks recorded at Pererika. Instead a typical daily profile shows an increase in CO beginning at about 06:00, which then peaks in the late afternoon and drops away after 20:00 when traffic levels will begin to decrease and the workforce retires for the day. The recession rate post 17:00 is less dramatic than the morning increases. This indicates that the site is much more strongly dominated by traffic impacts, and that vehicle movements are much more consistent throughout the day.

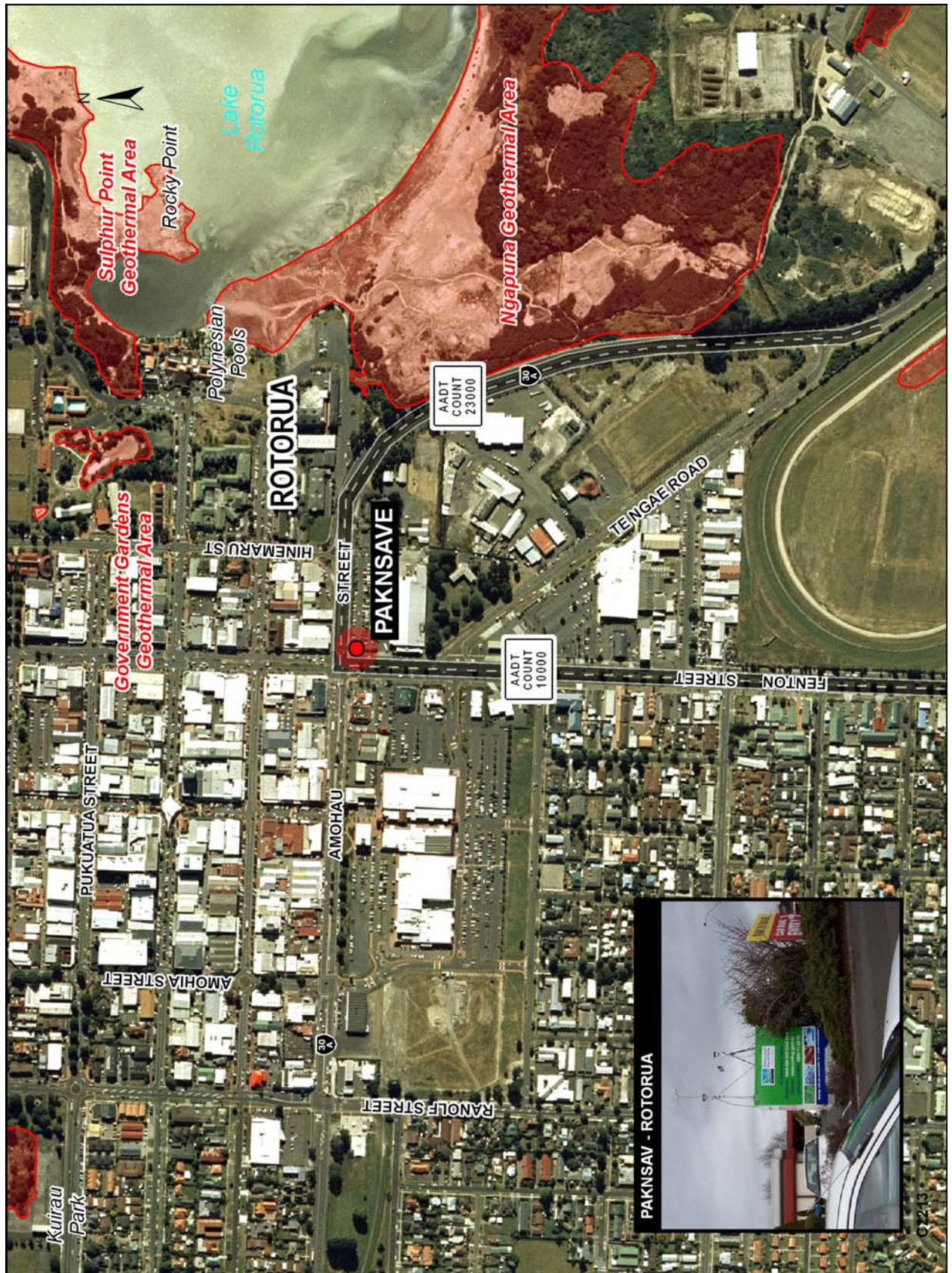


Figure 5.2 Fenton site location map.



FENTON MONITORING SITE (Data 1999, 2004 – 2006).	Environmental Performance Indicator (PM10)	<p>Stacked bar chart showing Environmental Performance Indicator (PM10) for years 1999, 2004, 2005, and 2006. The y-axis represents percentage from 0% to 100%. The legend indicates five performance levels: Excellent (&lt;10%), Good (10-33%), Acceptable (33-66%), Alert (66-100%), and Action (100+%).</p> <table border="1"> <thead> <tr> <th>Year</th> <th>Excellent (&lt;10%)</th> <th>Good (10-33%)</th> <th>Acceptable (33-66%)</th> <th>Alert (66-100%)</th> <th>Action (100+%)</th> </tr> </thead> <tbody> <tr> <td>1999</td> <td>0%</td> <td>63%</td> <td>37%</td> <td>0%</td> <td>0%</td> </tr> <tr> <td>2004</td> <td>2%</td> <td>61%</td> <td>37%</td> <td>0%</td> <td>0%</td> </tr> <tr> <td>2005</td> <td>0%</td> <td>58%</td> <td>42%</td> <td>0%</td> <td>0%</td> </tr> <tr> <td>2006</td> <td>0%</td> <td>69%</td> <td>31%</td> <td>0%</td> <td>0%</td> </tr> </tbody> </table>	Year	Excellent (<10%)	Good (10-33%)	Acceptable (33-66%)	Alert (66-100%)	Action (100+%)	1999	0%	63%	37%	0%	0%	2004	2%	61%	37%	0%	0%	2005	0%	58%	42%	0%	0%	2006	0%	69%	31%	0%	0%
	Year	Excellent (<10%)	Good (10-33%)	Acceptable (33-66%)	Alert (66-100%)	Action (100+%)																										
	1999	0%	63%	37%	0%	0%																										
	2004	2%	61%	37%	0%	0%																										
2005	0%	58%	42%	0%	0%																											
2006	0%	69%	31%	0%	0%																											
PM10 Concentograph ( $\mu\text{g}/\text{m}^3$ )	<p>Radar chart showing PM10 Concentograph by month from January to December. The chart displays Maximum (red line) and Average (green line) values for each month. The radial axis represents concentration in <math>\mu\text{g}/\text{m}^3</math>, ranging from 0 to 120.</p>																															
Diurnal and Distribution	<p>Two line graphs: one showing diurnal distribution of PM10 by season (Autumn, Winter, Spring, Summer) and another showing cumulative distribution of PM10 (24hr).</p>																															
Seasonal Concentration Rose. (10 min data)	<p>Seasonal Concentration Rose diagrams for Summer and Winter, showing wind direction and PM10 concentration levels. The Summer diagram is labeled "(calm 2% of the time)" and the Winter diagram is labeled "(calm 5% of the time)". A legend indicates PM10 (<math>\mu\text{g}/\text{m}^3</math>) and Percent scales.</p>																															

### 5.3.3 Edmund Road, Rotorua.

**Name:** Edmund.

**Location:** 49 Edmund Road, Rotorua.

**Site Type:** Residential.

**Contaminants:** PM<sub>10</sub>.

**Meteorology:** Yes, 6m.

**Elevation:** 290m.

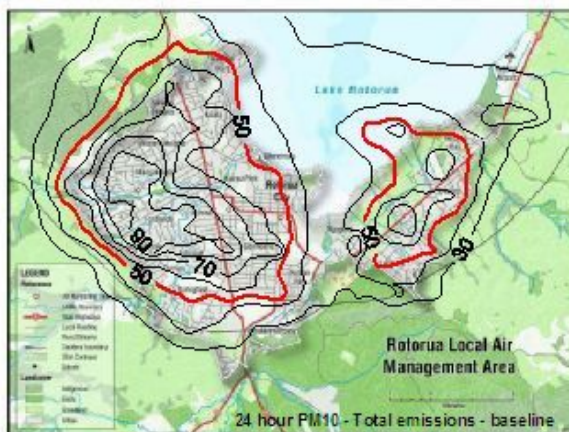
**Monitoring Period:** 2006 – present.



#### Location:

This site is located close to Edmund Road, which is a main residential road linking the Western suburbs (Figure 5.3). The site is surrounded by dense residential areas although the area immediately to the south of the site is punctuated by a small stream and associated reserve land. The site is more elevated than the other two Rotorua sites as the land rises to the base of Mt Ngongotaha. This elevation difference between this area and lake edge promotes light drainage flows under settled conditions. The effect of this meteorological phenomenon is highlighted in the recent airshed modelling exercise although the scale of its effect on particulate movement is only minor.

The modelling exercise also confirmed that the location of this site meets the NES-AQ requirement of 'worst case' monitoring location (see figure below).



#### PM<sub>10</sub>:

The period of record at this monitoring site is only short with records beginning in March 2006. The results to date however show a large number of exceedances (24 for 2006) of the standard during the 'heating season' (determined by survey (Iremonger & Graham, 2006) as starting in April and finishing in September). For over 80% of the time the air quality is of an 'Acceptable' or better quality. The maximum recorded 24hr concentration is 116µg/m<sup>3</sup> and the strong seasonal pattern is shown in the following concentograph. The same seasonal pattern is shown in the diurnal dataset with the summer trace showing the very slight influence of traffic. The spring trace shows the final effect of the heating season as concentrations increase in the early evening. Autumn has a bimodal pattern with evening domestic heating emissions now being recorded with a morning peak as residents relight their fires. The winter trace shows the full effect of domestic heating with a marked peak present in the morning followed by a return to base levels during 12:00 to 16:00 as the emissions reduce, turbulence develops and mixing occurs. This situation reverses quickly around 17:00 as fires are lit and concentrations continue to increase as the mixing height reduces and stability in the lower airmass occurs.

The concentration rose is only for a limited dataset due to meteorological instrument issues, it does however cover the period of most interest. Points of note are, i) the significant amount of time calm conditions prevail (36%); ii) the highest concentrations come from the western quadrant, which contains the densest housing and is upslope; iii) and the even characteristics for the remaining sections of the compass which reflects the relatively homogenous nature of the emission source.

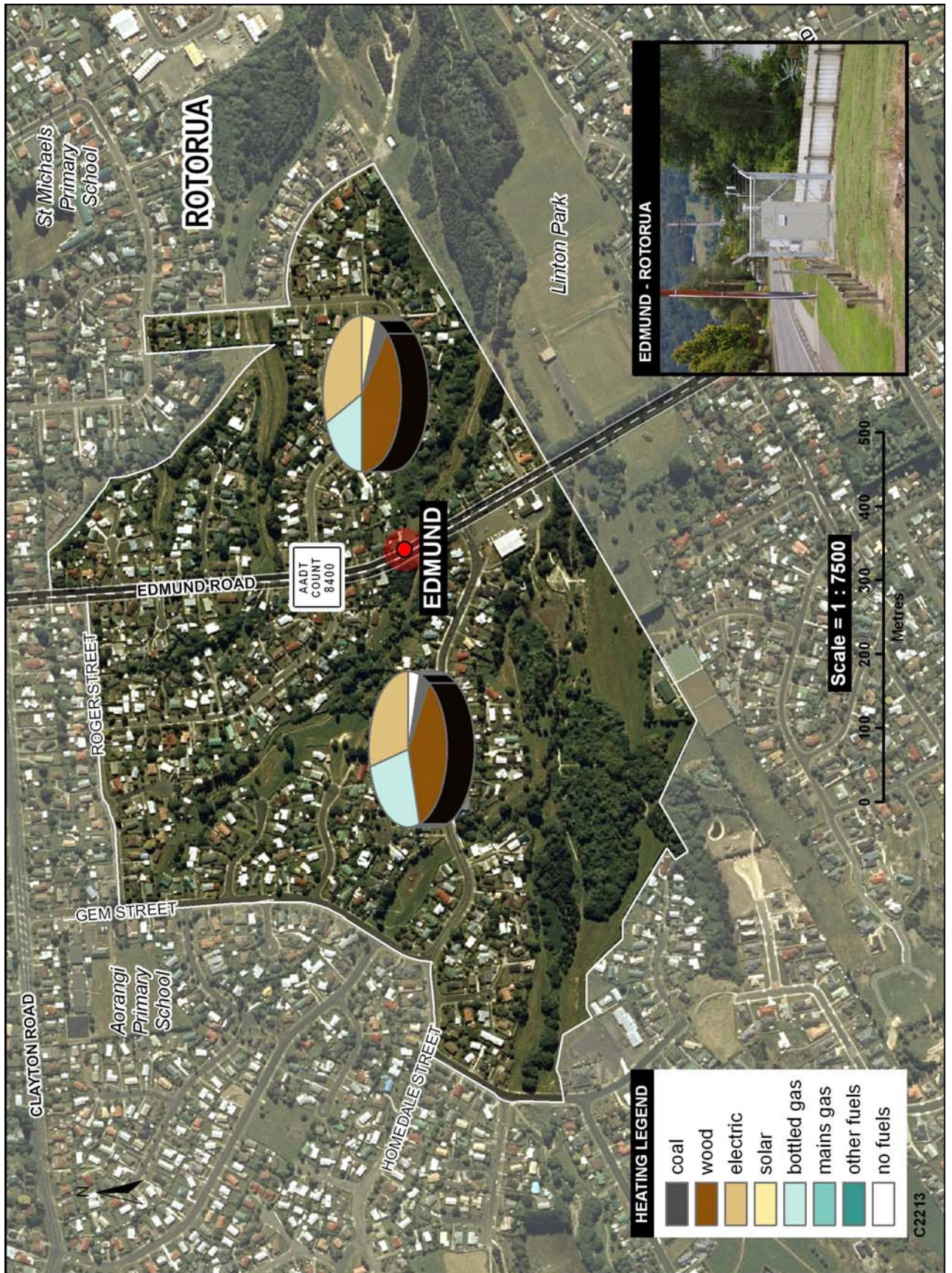


Figure 5.3 Edmund site location map.

EDMUND MONITORING SITE (Data 2006 & 2007).	Environmental Performance Indicator (PM10)	<p>Stacked bar chart showing Environmental Performance Indicator (PM10) for 2006 and 2007. The Y-axis represents the percentage of time in each category, ranging from 0% to 100%. The X-axis shows the years 2006 and 2007. The legend indicates the following categories:</p> <ul style="list-style-type: none"> <li>Action (100+%)</li> <li>Alert (66-100%)</li> <li>Acceptable (33-66%)</li> <li>Good (10-33%)</li> <li>Excellent (&lt;10%)</li> </ul>
	PM10 Concentrations ( $\mu\text{g}/\text{m}^3$ )	<p>Radar chart showing PM10 Concentrations by month for 2006 and 2007. The Y-axis represents concentration in <math>\mu\text{g}/\text{m}^3</math>, ranging from 0 to 120. The X-axis shows the months from January to December. The legend indicates the following categories:</p> <ul style="list-style-type: none"> <li>Maximum</li> <li>Average</li> </ul>
	Diurnal and Distribution	<p>Two line graphs showing Diurnal and Distribution of PM10. The left graph shows PM10 concentration (<math>\mu\text{g}/\text{m}^3</math>) over 24 hours for Autumn, Winter, Spring, and Summer. The right graph shows the cumulative distribution of PM10 concentrations over 24 hours.</p>
	Seasonal Concentration Rose (10 min. data)	<p>Seasonal Concentration Rose for Feb - August 2006. The rose shows the distribution of PM10 concentrations by direction and season. The chart is titled "Feb - August 2006 (calm 36% of the time)".</p>

### 5.3.4 Arawa Street, Rotorua.

**Name:** Arawa.

**Location:** 1059&1125 Arawa Street, Rotorua.

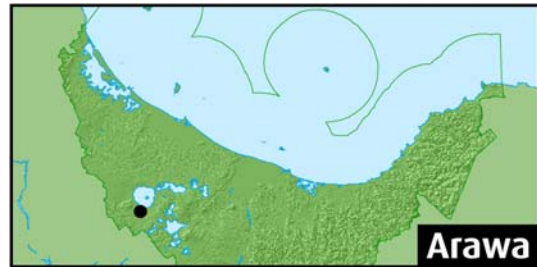
**Site Type:** Commercial.

**Contaminants:** H<sub>2</sub>S.

**Meteorology:** No.

**Elevation:** 280m.

**Monitoring Period:** 1998 – 2005.



#### **Location:**

The site is located in close proximity to several significant geothermal zones within the downtown Rotorua area, the Government Garden and Sulphur Point geothermal areas are located within 300m east of the site (Figure 5.4).

#### **Background:**

Dr Bruce Graham (2007) has recently summarised H<sub>2</sub>S in geothermal areas. The following paragraphs outline some of these findings.

It has been recognised for many years (Thom et al, 1976) that the concentrations of hydrogen sulphide in geothermal areas, such as Rotorua, are often well above levels that would be classified as unacceptable by most general air quality criteria. Routine monitoring by the Bay of Plenty Regional Council has been undertaken at several sites in the city. Annual average concentrations are between 75 and 150 µg/m<sup>3</sup> (Iremonger, 2004) and yet, there are no obvious signs of concern amongst residents regarding the possible effects — in fact, some consider the geothermal environment to be healthier than elsewhere. (Daily Post, May 2007).

The potential for adverse health effects in Rotorua has been examined in a number of population-based studies, using official cancer registry, mortality (death) and morbidity (illness) data (Bates et. al, 1997, 1998, 2002). These studies have found evidence of significant increases in the incidence of a range of illnesses among Rotorua residents, when compared to the rest of the population of New Zealand. These include the following: nasal cancers, cerebrovascular disease, diseases of the arteries, arterioles, and capillaries, and eye disorders. The data was adjusted for variations in ethnicity and age, but it was not possible to adjust for other possible confounders such as smoking, lifestyle and socio-economic factors.

More recent work by Durand and Wilson (2006) has reported similar findings for an increased incidence of non-infectious respiratory diseases, based on 11 years of hospital admission data. In this case, the effects were shown to be related to the area of residence within Rotorua but, once again, no allowance was able to be made for possible confounding factors.

The above studies are about to be followed up by a much more intensive community-based investigation funded by the (US) National Institutes of Health (Bates, 2005). This work will involve detailed health assessments on a sample of about 1800 Rotorua residents, and exposure monitoring, over a period of five years.

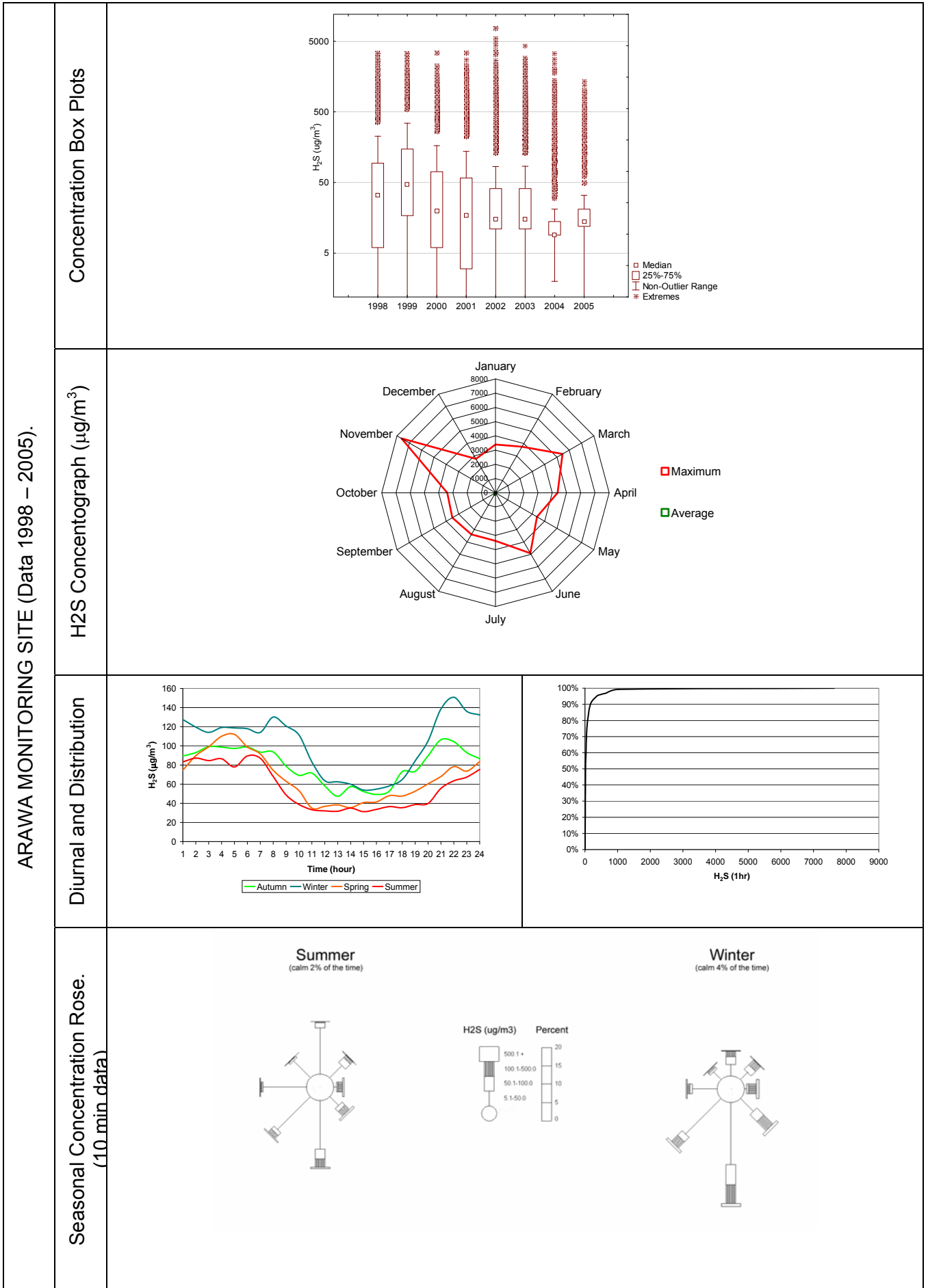
#### **H<sub>2</sub>S:**

The one hour average values calculated from the record at Arawa Street are several orders of magnitude greater than the current MfE guideline for H<sub>2</sub>S of 7µg/m<sup>3</sup>, which is based on a nuisance level (smell), rather than a health effect level.

The diurnal pattern of concentration is closely linked with windspeed trends, with lower concentrations recorded during periods of mixing. On average winter time has the higher concentrations as a result of greater calm periods.



Figure 5.4 Arawa site location map.





### 5.3.5 Ti Street, Rotorua.

**Name:** Ti.

**Location:** 12 Ti Street, Rotorua.

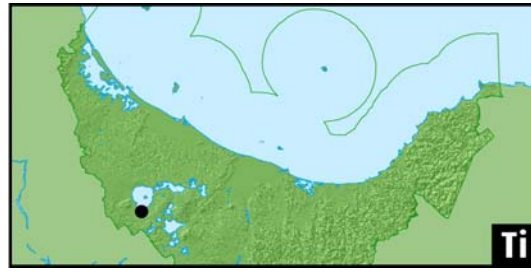
**Site Type:** Commercial.

**Contaminants:** H<sub>2</sub>S.

**Meteorology:** No.

**Elevation:** 280m.

**Monitoring Period:** 1998 – 2005.

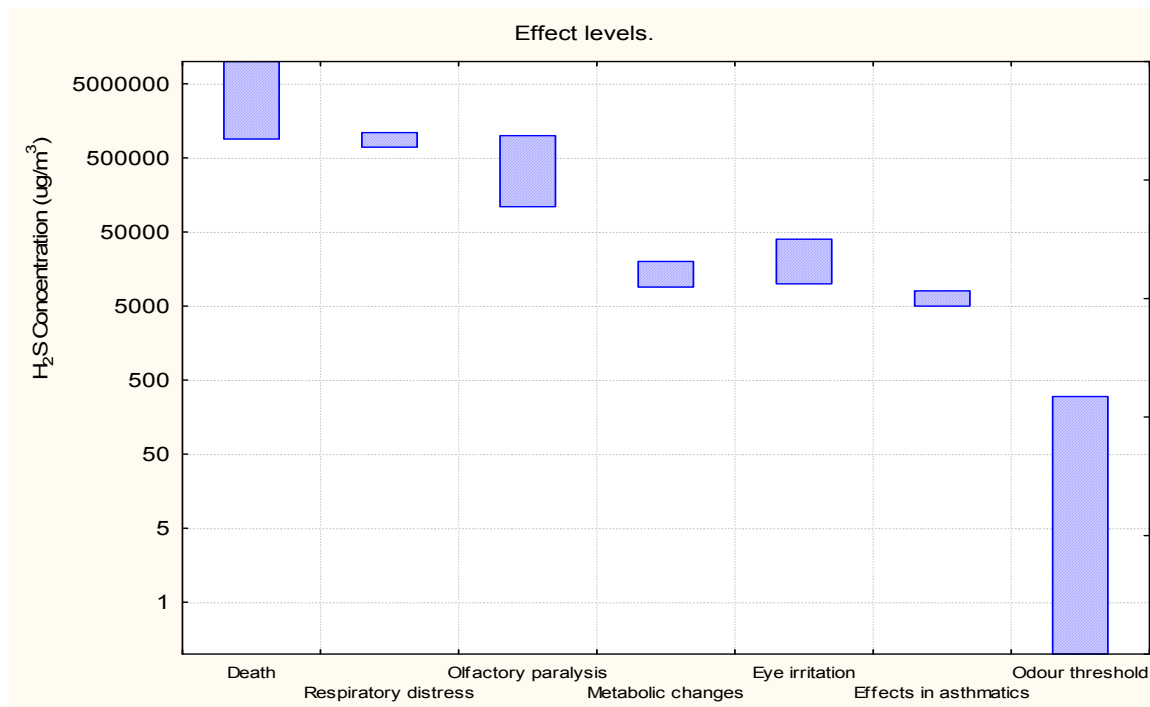


#### Location:

Located midway along Ti Street and 300m west of the extensive Ngapuna Geothermal Area and 300m northwest of the Arawa Park Racecourse Geothermal Area (Figure 5.5).

#### Background:

The current MfE guideline for H<sub>2</sub>S is 7µg/m<sup>3</sup>, which is based on a nuisance level (smell), rather than a health effect level. The figure below summarises additional health thresholds (Graham, 2007).



The average value for the period of record to date is 144µg/m<sup>3</sup>, which is approximately double the value for Arawa Street (80µg/m<sup>3</sup>). However the peak values have been higher at Arawa Street. This difference is believed to be due to differences in location and localised wind patterns.

It appears that Ti Street is impacted by multiple sources arising from a number of different directions, whereas Arawa Street has fewer sources releasing H<sub>2</sub>S from fewer directions with respect to the monitor. Thus, Ti Street is being impacted almost continuously regardless of wind direction, whereas the Arawa Street monitor only responds when the wind is in certain directions. However, the levels at Arawa Street are generally higher, either because the monitor is closer to the sources and/or the sources are stronger.

Similar diurnal patterns are recorded at this site when compared with Arawa Street. Localised wind patterns have an effect on measured concentrations.



Figure 5.5 Ti site location map.

TI MONITORING SITE (Data 1998 – 2005).	<p style="text-align: center;"><b>Concentration Box Plots</b></p>									
	<p style="text-align: center;"><b>H2S Concentograph (<math>\mu\text{g}/\text{m}^3</math>)</b></p>									
	<p style="text-align: center;"><b>Diurnal and Distribution</b></p>									
	<p style="text-align: center;"><b>Seasonal Concentration Rose. (10 min. data)</b></p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p><b>Summer</b> (calm 2% of the time)</p> </div> <div style="text-align: center;"> <p><b>Winter</b> (calm 4% of the time)</p> </div> </div> <div style="text-align: center; margin-top: 10px;"> <p><b>H2S (<math>\mu\text{g}/\text{m}^3</math>) Percent</b></p> <table border="1"> <tr> <td>500.1 +</td> <td>20</td> </tr> <tr> <td>100.1-500.0</td> <td>15</td> </tr> <tr> <td>50.1-100.0</td> <td>10</td> </tr> <tr> <td>5.1-50.0</td> <td>5</td> </tr> <tr> <td>Calm</td> <td>0</td> </tr> </table> </div>	500.1 +	20	100.1-500.0	15	50.1-100.0	10	5.1-50.0	5	Calm
500.1 +	20									
100.1-500.0	15									
50.1-100.0	10									
5.1-50.0	5									
Calm	0									

### 5.3.6 Otumoetai Road, Tauranga.

**Name:** Otumoetai.

**Location:** 236 Otumoetai Road, Tauranga.

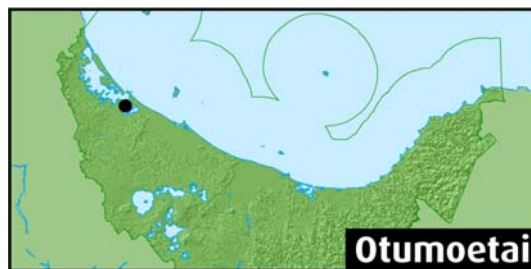
**Site Type:** Residential.

**Contaminants:** PM<sub>10</sub>, CO and NO<sub>x</sub>.

**Meteorology:** Yes, 6m.

**Elevation:** 65m.

**Monitoring Period:** 1998 – present.



#### Location:

Like Pererika this site is impacted by two main anthropogenic sources. The Otumoetai Road roadway (AADT ~10,000) 20m to the east and residential areas in all direction for at least 700m.

Immediately to the north is the Otumoetai Primary School, with associated sport fields. Census heating data shows a dominance of electricity followed equally by bottled gas and woodburners (Figure 5.6).

#### PM<sub>10</sub>:

For the majority of time the PM<sub>10</sub> values are measured in the 'Good' air quality category (>70% of the record). However during the winter months, air quality can reduce and fall into the 'Acceptable' category. During the nine years of monitoring air quality has never been within the 'Action' category. This seasonal increase is reflected in the diurnal plots, with winter time being the time of elevated concentrations.

On a daily scale the winter time plot shows the dominating effect of domestic heating sources, with a noticeable increase in the morning on top of the traffic contribution and then an increase on summer time levels being recorded during the evening as emissions from woodburners impact the site. The source patterns are reflected in recent emission inventory and modelling investigations for the Rotorua LAMA. The diurnal plot also shows elevated levels for summer during the day which could be the result of the daily sea breeze transporting marine derived particles across the area.

The concentration roses also show this seasonal pattern. The winter rose shows the prevailing south westerly wind effect. Otherwise concentrations are evenly distributed. The summer rose shows the effect of the sea breeze.

#### CO:

Carbon monoxide values recorded at this site exhibit the same trends as the PM<sub>10</sub> record, with a pronounced increase visible during the winter months. The MfE standard is not exceeded at this site. Values are lower than at the other long-term residential monitoring site (Pererika), which is due to differences in local meteorological conditions and vehicle densities. The wind roses from Tauranga Airport show the prevailing wind for this area is from the southwest quarter (see Section 3) suggesting that CO emissions from vehicles may often get transported away from the sampling inlet.

Levels are generally depressed during the day (probably the result of wind conditions causing increased mixing) with noticeable increases from 17:00 particularly in the autumn and winter months where domestic heating would be a significant producer of carbon monoxide.

#### NO<sub>x</sub>:

Monitoring shows average values of 8µg/m<sup>3</sup> (1 hour) for the 2 years of record. Data values fall within the 'Excellent' category 92% of the time. The standard has not been exceeded at this site. The maximum recorded value (89µg/m<sup>3</sup>) is less than half of the NES-AQ (200µg/m<sup>3</sup>).

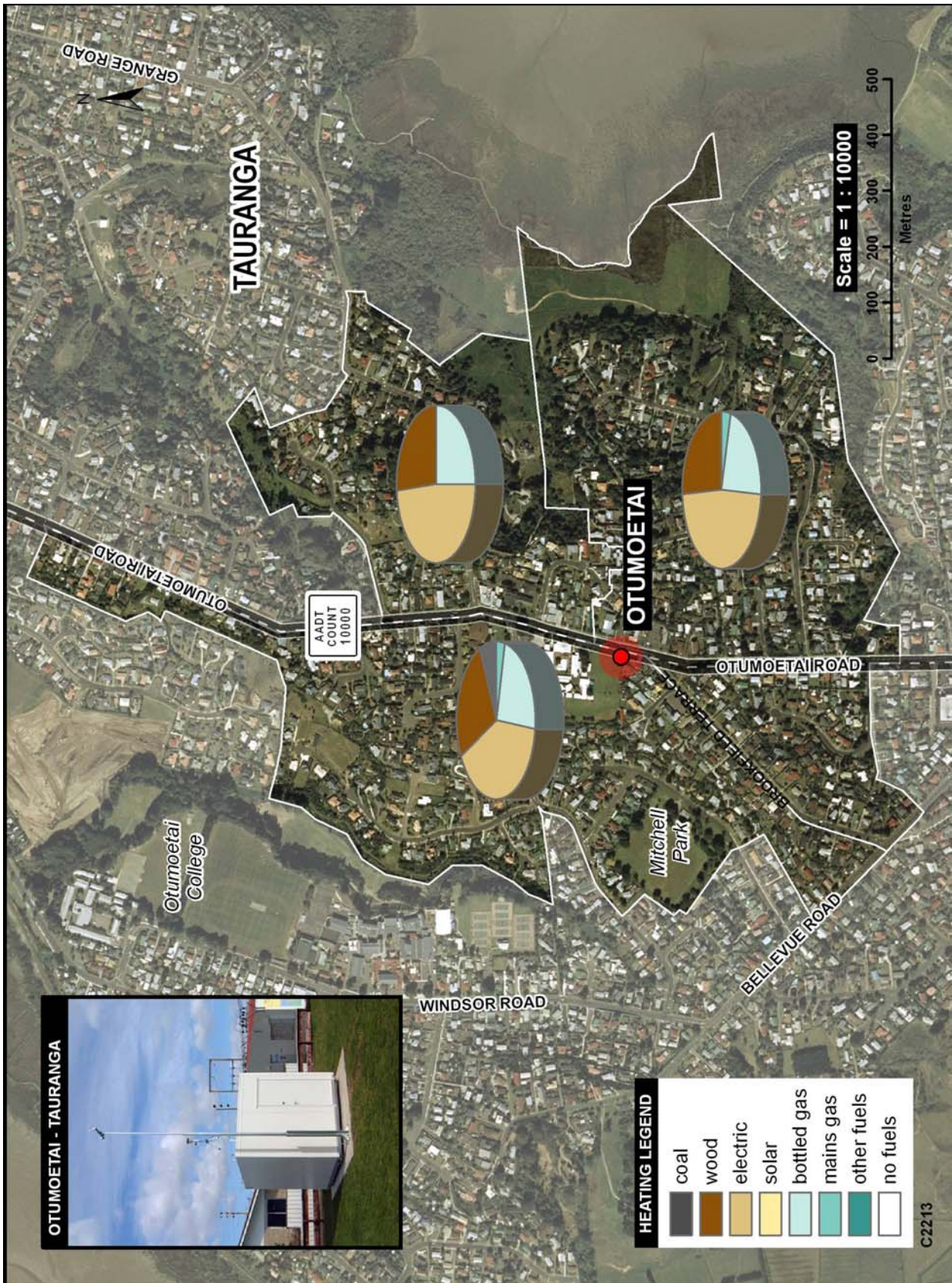


Figure 5.6 Otumoetai site location map.

OTUMOETA MONITORING SITE (Data 1998 – 2007).	Environmental Performance Indicator (PM10)	<p>Stacked bar chart showing Environmental Performance Indicator (PM10) from 1998 to 2007. The Y-axis represents the percentage of time (0% to 100%). The X-axis represents the years (1998 to 2007). The legend indicates the following categories:</p> <ul style="list-style-type: none"> <li>Action (100+%)</li> <li>Alert (66-100%)</li> <li>Acceptable (33-66%)</li> <li>Good (10-33%)</li> <li>Excellent (&lt;10%)</li> </ul>
	PM10 Concentrations ( $\mu\text{g}/\text{m}^3$ )	<p>Radar chart showing PM10 Concentrations by month (January to December). The radial axis represents concentration in <math>\mu\text{g}/\text{m}^3</math> (0 to 120). The legend indicates:</p> <ul style="list-style-type: none"> <li>Maximum (Red line)</li> <li>Average (Green line)</li> </ul>
	Diurnal and Distribution	<p>Diurnal and Distribution graphs. The left graph shows <math>\text{PM}_{10}</math> (<math>\mu\text{g}/\text{m}^3</math>) vs Time (hour) for Autumn, Winter, Spring, and Summer. The right graph shows the cumulative distribution of <math>\text{PM}_{10}</math> (24hr) from 0 to 40 <math>\mu\text{g}/\text{m}^3</math>.</p>
	Seasonal Concentration Rose (10_min data)	<p>Seasonal Concentration Rose diagrams for Summer (calm 18% of the time) and Winter (calm 15% of the time). The legend indicates:</p> <ul style="list-style-type: none"> <li>PM10 (<math>\mu\text{g}/\text{m}^3</math>): 100 1+, 50.1-100.0, 20.1-50.0, 0.2-20.0</li> <li>Percent: 10, 5, 0</li> </ul>

### 5.3.7 Totara Street, Tauranga.

**Name:** Totara.

**Location:** 185 Totara Street, Tauranga.

**Site Type:** Commercial/Industrial.

**Contaminants:** SO<sub>2</sub>.

**Meteorology:** Yes, 6m.

**Elevation:** 10m.

**Monitoring Period:** part of 2005 – present.



#### Location:

This site is bounded immediately to the west by Totara Street which has an AADT of approximately 10,000. Hewletts Road, ~300m to the south has an AADT of ~25,000. These flows are predicted to increase as improvement to Hewletts Road are finalised and the second Mt Maunganui/Tauranga harbour bridge is commissioned. This site is impacted by a number of sources (industrial and various forms of transport combustion). These sources surround the site for within a minimum of 500m in all directions (Figure 5.7). The open coastline is 1.5km to the northeast at its closest point and the harbour/land interface is located 500m to the west and south of the monitoring site. This topographic setting results in complex meteorological patterns as temperature variation creates and drives localised air mass circulation.

#### SO<sub>2</sub>:

For the majority of time the SO<sub>2</sub> values fall in the “Excellent” category. However during the summer and autumn months, exceedances of the 350µg/m<sup>3</sup> and 570µg/m<sup>3</sup> standard have been recorded. In 2006, 21 exceedances of the lower standard were recorded, with 3 occasions when the second standard was exceeded (with a maximum of 674µg/m<sup>3</sup> being measured).

This seasonal increase is reflected in the diurnal plots, with the autumn and summer time traces showing peaks and elevated levels. The concentograph shows this seasonal pattern. Analysis of the 10 minute SO<sub>2</sub> data and onsite meteorology shows a build up of higher concentrations in the southwest quadrant which is impacted by industry and traffic. Values diminish in the arc from north to southeast.

SO<sub>2</sub> and wind direction (10min. values)  
Totara Street monitoring station.

2 March 2006 - 7 February 2007

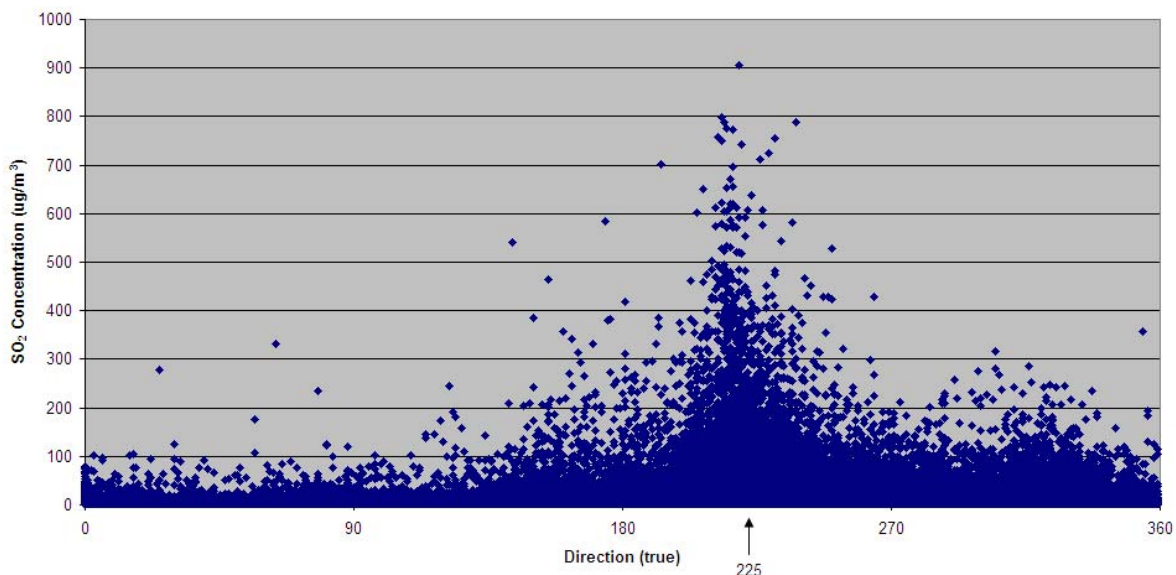


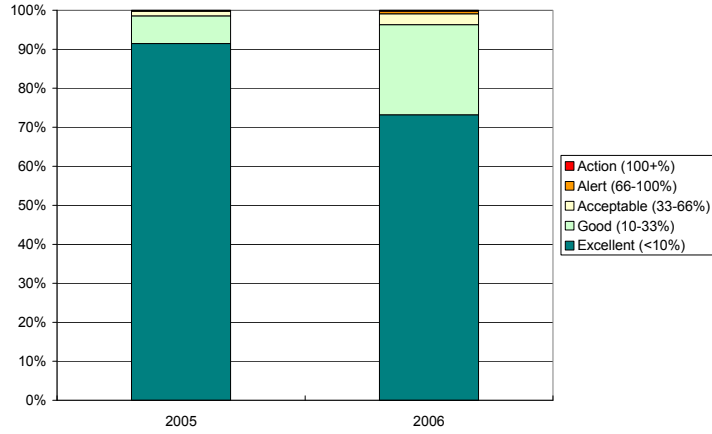


Figure 5.7 Totara site location map.

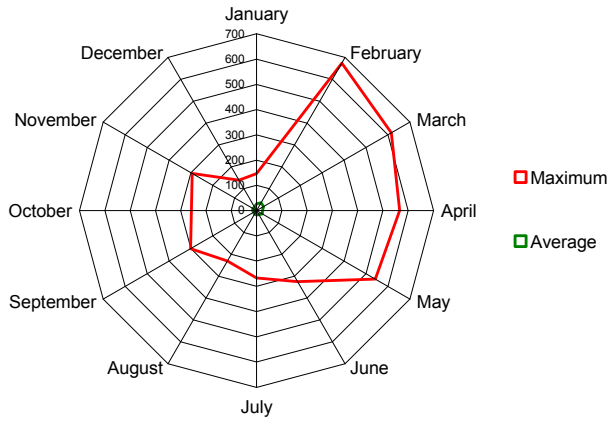


TOTARA MONITORING SITE (Data 2005 – 2006).

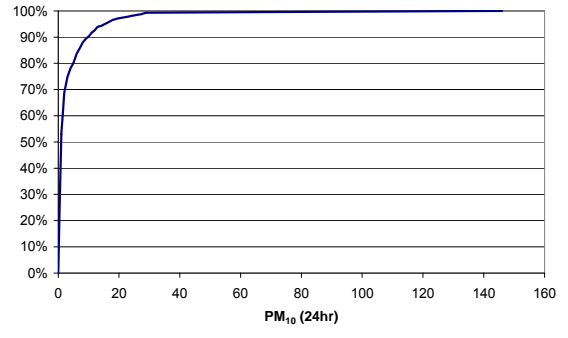
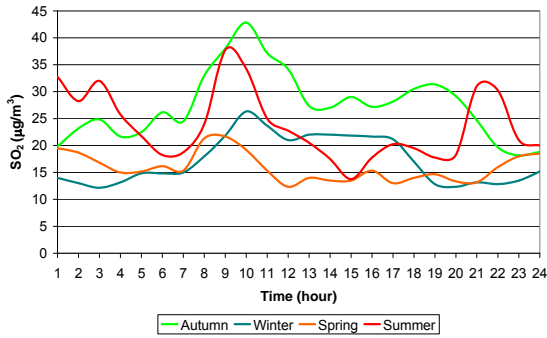
Environmental Performance Indicator



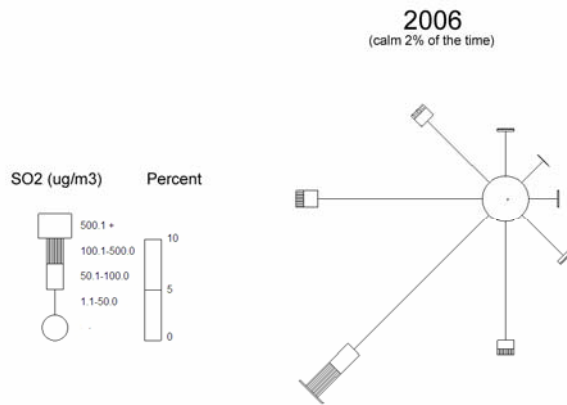
Concentograph ( $\mu\text{g}/\text{m}^3$ )



Diurnal and Distribution



Seasonal Concentration Rose. (10 min. data)



### 5.3.8 Marsh Street, Tauranga.

**Name:** Marsh.

**Location:** Marsh/Chapel Street, Tauranga.

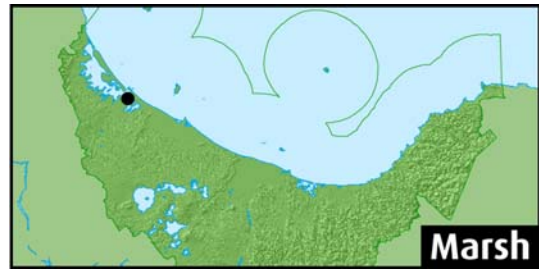
**Site Type:** Peak traffic.

**Contaminants:** PM<sub>10</sub> and CO.

**Meteorology:** No.

**Elevation:** 5m.

**Monitoring Period:** 2000 – 2003.



#### **Location:**

This site is located at a busy Tauranga intersection servicing traffic to and from Mount Maunganui and also bypass traffic along the Waikareao Expressway (Figure 5.8). The amount of heavy diesel traffic type at this site would be less than at the Fenton Street site in Rotorua but still significant. The site will also be influenced by sea breezes, particularly during the summer months. The positioning of the site would also result in the movement of ambient air away from the sample inlet during the predominant wind (south westerly).

#### **PM<sub>10</sub>:**

For the majority of the time (>95%), data values fall into the “Acceptable” to “Good” categories. The concentograph shows no dominant annual trends.

The diurnal plot shows the expected morning increase associated with traffic flow. The levels remain elevated throughout the day and begin to decrease in the late afternoon. Prominent peaks in the autumn and winter plots could be linked to calmer atmospheric conditions on the cooler mornings. Sea breezes (evident in the summer concentration rose) would result in further mixing of the air mass but also means that sea spray could be present, a component of which falls into the PM<sub>10</sub> size fraction.

Due to the proximity of this site in the intersection, within 5m of the roadway, the concentration roses show a generally even distribution of particulate values.

#### **CO:**

Due to the site location on the corner of Marsh and Chapel Streets the carbon monoxide values are noticeably higher than the two residential sites (Otumoetai and Pererika). Diurnal data does not have the characteristic morning and evening peaks recorded at the other residential CO sites. Instead a typical daily profile shows an increase in CO beginning at about 06:00, which then peaks in the late afternoon and drops away after 20:00. This indicates that the site is more strongly dominated by traffic impacts, and that vehicle movements are much more consistent throughout the day. Patterns and values are similar to those recorded at the Fenton Street site. Maximum recorded values are still below the MfE standard.



Figure 5.8 Marsh site location map.

MARSH MONITORING SITE (Data 2000 – 2003).	Environmental Performance Indicator (PM10)	<p>Stacked bar chart showing Environmental Performance Indicator (PM10) from 2000 to 2003. The y-axis represents percentage from 0% to 100%. The legend includes: Action (100+%), Alert (66-100%), Acceptable (33-66%), Good (10-33%), and Excellent (&lt;10%).</p>
	PM10 Concentrations ( $\mu\text{g}/\text{m}^3$ )	<p>Radar chart showing PM10 Concentrations by month from January to December. The chart shows Maximum and Average values for each month.</p>
	Diurnal and Distribution	<p>Two line graphs showing diurnal and distribution of PM10. The left graph shows PM10 concentration over 24 hours for Autumn, Winter, Spring, and Summer. The right graph shows the cumulative distribution of PM10 over 24 hours.</p>
	Seasonal Concentration Rose. (10 min data)	<p>Two wind roses showing seasonal concentration roses for Summer and Winter. The Summer rose is labeled '(calm 2% of the time)' and the Winter rose is labeled '(calm 2% of the time)'. A legend shows PM10 concentration ranges and corresponding percentages.</p>

### 5.3.9 Quay Street, Whakatane.

**Name:** Quay.

**Location:** 5 Quay Street, Whakatane.

**Site Type:** Commercial/Residential.

**Contaminants:** PM<sub>10</sub>.

**Meteorology:** No.

**Elevation:** 14m.

**Monitoring Period:** 1998 – 2005.



#### Location:

The site was located in the Environment Bay of Plenty, Quay Street premises, and for the entirety of the monitoring period was mounted on the headquarters roof top. The Wairaka subdivision is located within 500m to the east (Figure 5.9) otherwise the next nearest domestic residential area is several kilometres to the west. The domestic source from this direction is partly sheltered by the headland punctuating The Strand.

#### PM<sub>10</sub>:

The monitor at Quay Street is the same as the Pongakawa sampler but with only one inlet. Two exceedances have been recorded at this site during the 8 years of monitoring, one each in 1998 and 2001. Higher 24-hour and annual values have been recorded at Quay Street when compared with the Pongakawa site. A 24-hour maximum of 56.9  $\mu\text{g}/\text{m}^3$  (in December) has been recorded with a full record average of 13.8  $\mu\text{g}/\text{m}^3$ . Generally the quality of air in this locale is 'Acceptable' or better, with most of the time (~70%) it being of a "Good" quality. There is a trend that this category has increased over the period of monitoring which is probably the effect of meteorology rather than variations in the significant sources.

Salt spray is an issue at this site with the sample filters showing signs of salt staining. No particular increase in the winter months is evident at this site. Residential areas of Whakatane might however show signs of increases in the winter months as a result of more domestic fires operating. The current site is near a smaller area of residential housing but is less likely to pick up the effects of domestic fires at its current location.

This limitation has been addressed with the Quay site being decommissioned and in mid 2006 a new TEOM FDMS site being installed in King Street, Whakatane, central to the residential area. Early results (see graph below) already show a dominant seasonal pattern with increases in concentrations being recorded in winter months. To date no exceedances have been recorded at this new location.

PM<sub>10</sub> @ King Street, Whakatane.

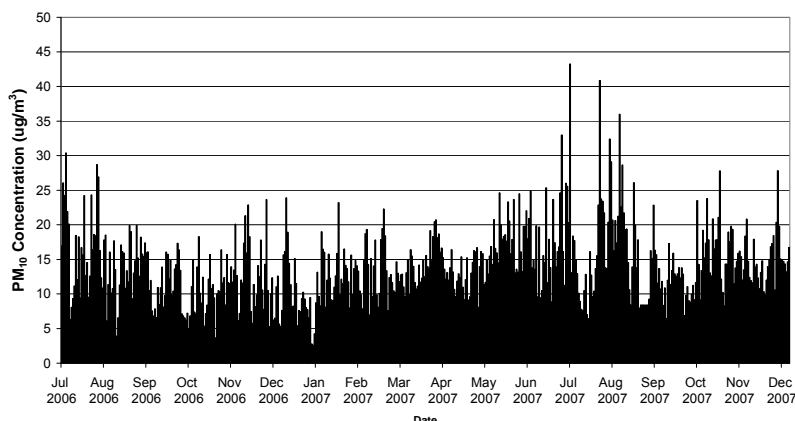




Figure 5.9 Quay site location map.

QUAY MONITORING SITE (Data 1998 – 2005).	Environmental Performance Indicator (PM10)	<table border="1"> <caption>Estimated Environmental Performance Indicator (PM10) Data (1998-2005)</caption> <thead> <tr> <th>Year</th> <th>Excellent (&lt;10%)</th> <th>Good (10-33%)</th> <th>Acceptable (33-66%)</th> <th>Alert (66-100%)</th> <th>Action (100+%)</th> </tr> </thead> <tbody> <tr> <td>1998</td> <td>0%</td> <td>41%</td> <td>51%</td> <td>2%</td> <td>4%</td> </tr> <tr> <td>1999</td> <td>5%</td> <td>61%</td> <td>28%</td> <td>6%</td> <td>0%</td> </tr> <tr> <td>2000</td> <td>4%</td> <td>62%</td> <td>28%</td> <td>6%</td> <td>0%</td> </tr> <tr> <td>2001</td> <td>5%</td> <td>68%</td> <td>23%</td> <td>4%</td> <td>0%</td> </tr> <tr> <td>2002</td> <td>8%</td> <td>68%</td> <td>20%</td> <td>4%</td> <td>0%</td> </tr> <tr> <td>2003</td> <td>5%</td> <td>73%</td> <td>18%</td> <td>4%</td> <td>0%</td> </tr> <tr> <td>2004</td> <td>5%</td> <td>77%</td> <td>14%</td> <td>4%</td> <td>0%</td> </tr> <tr> <td>2005</td> <td>7%</td> <td>76%</td> <td>14%</td> <td>4%</td> <td>0%</td> </tr> </tbody> </table>		Year	Excellent (<10%)	Good (10-33%)	Acceptable (33-66%)	Alert (66-100%)	Action (100+%)	1998	0%	41%	51%	2%	4%	1999	5%	61%	28%	6%	0%	2000	4%	62%	28%	6%	0%	2001	5%	68%	23%	4%	0%	2002	8%	68%	20%	4%	0%	2003	5%	73%	18%	4%	0%	2004	5%	77%	14%	4%	0%	2005	7%	76%	14%	4%	0%
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PM10 Concentration ( $\mu\text{g}/\text{m}^3$ )	<table border="1"> <caption>Estimated Monthly PM10 Concentrations (<math>\mu\text{g}/\text{m}^3</math>)</caption> <thead> <tr> <th>Month</th> <th>Maximum (<math>\mu\text{g}/\text{m}^3</math>)</th> <th>Average (<math>\mu\text{g}/\text{m}^3</math>)</th> </tr> </thead> <tbody> <tr><td>January</td><td>45</td><td>25</td></tr> <tr><td>February</td><td>40</td><td>20</td></tr> <tr><td>March</td><td>35</td><td>15</td></tr> <tr><td>April</td><td>30</td><td>10</td></tr> <tr><td>May</td><td>25</td><td>10</td></tr> <tr><td>June</td><td>20</td><td>10</td></tr> <tr><td>July</td><td>15</td><td>10</td></tr> <tr><td>August</td><td>15</td><td>10</td></tr> <tr><td>September</td><td>20</td><td>10</td></tr> <tr><td>October</td><td>25</td><td>10</td></tr> <tr><td>November</td><td>30</td><td>10</td></tr> <tr><td>December</td><td>35</td><td>10</td></tr> </tbody> </table>		Month	Maximum ( $\mu\text{g}/\text{m}^3$ )	Average ( $\mu\text{g}/\text{m}^3$ )	January	45	25	February	40	20	March	35	15	April	30	10	May	25	10	June	20	10	July	15	10	August	15	10	September	20	10	October	25	10	November	30	10	December	35	10																
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Diurnal and Distribution	No diurnal plot is available due to daily sampling. <table border="1"> <caption>Estimated PM10 (24hr) CDF Data</caption> <thead> <tr> <th>PM10 (<math>\mu\text{g}/\text{m}^3</math>)</th> <th>Percentage</th> </tr> </thead> <tbody> <tr><td>0</td><td>0%</td></tr> <tr><td>5</td><td>10%</td></tr> <tr><td>10</td><td>30%</td></tr> <tr><td>15</td><td>60%</td></tr> <tr><td>20</td><td>85%</td></tr> <tr><td>25</td><td>95%</td></tr> <tr><td>30</td><td>98%</td></tr> <tr><td>40</td><td>100%</td></tr> <tr><td>60</td><td>100%</td></tr> </tbody> </table>		PM10 ( $\mu\text{g}/\text{m}^3$ )	Percentage	0	0%	5	10%	10	30%	15	60%	20	85%	25	95%	30	98%	40	100%	60	100%																																			
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Seasonal Concentration Rose	No wind rose plot is available due to daily sampling.																																																								

### 5.3.10 Pongakawa

**Name:** Pongakawa.

**Location:** 3.9km up Pongakawa Bush Road.

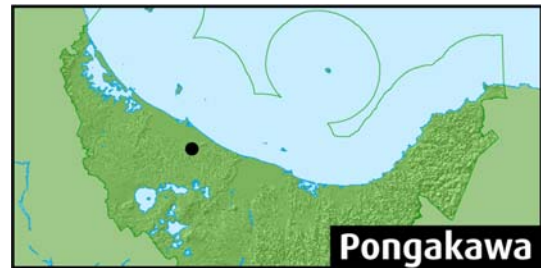
**Site Type:** Background.

**Contaminants:** PM<sub>10</sub>.

**Meteorology:** No.

**Elevation:** 102m.

**Monitoring Period:** 1998 – present.



#### Location:

The site is located in a grass paddock on a dairy farm and is termed 'background' (Figure 5.10). Levels at this site would be expected to be lower than a commercial or industrial site. The original instrument worked on a non-continuous principle, which required field staff to change filters on a nine day rotation. There were three sampling inlets at the site and the sample regime works on a three day interval. This instrument has been superseded with a Sequential Partisol and monitoring is now on a 2 day interval coupled with monthly site visits and filter exchanges.

#### PM<sub>10</sub>:

As expected, values recorded at this site predominantly fall in the "Excellent" and "Good" categories. With "Excellent" being met approximately 20% of the time.

An annual trend is evident as expected general dust production is negatively correlated with pasture growth and rainfall, thus resulting in increases in PM<sub>10</sub> results in the summer months. This pattern is shown by plotted annual maximums on the concentograph.

A full period average of 9.9µg/m<sup>3</sup> has been calculated and the 24-hour maximum to date is 49.1 µg/m<sup>3</sup> (December 2001). No exceedences have been recorded since sampling started.

At both a regional and national level this is an important monitoring site, as quantification of the regional background component is vital for the planning and assessment of cost-effective emission reduction strategies for LAMA investigations, and for establishing baselines for resource consents relating to new discharges.



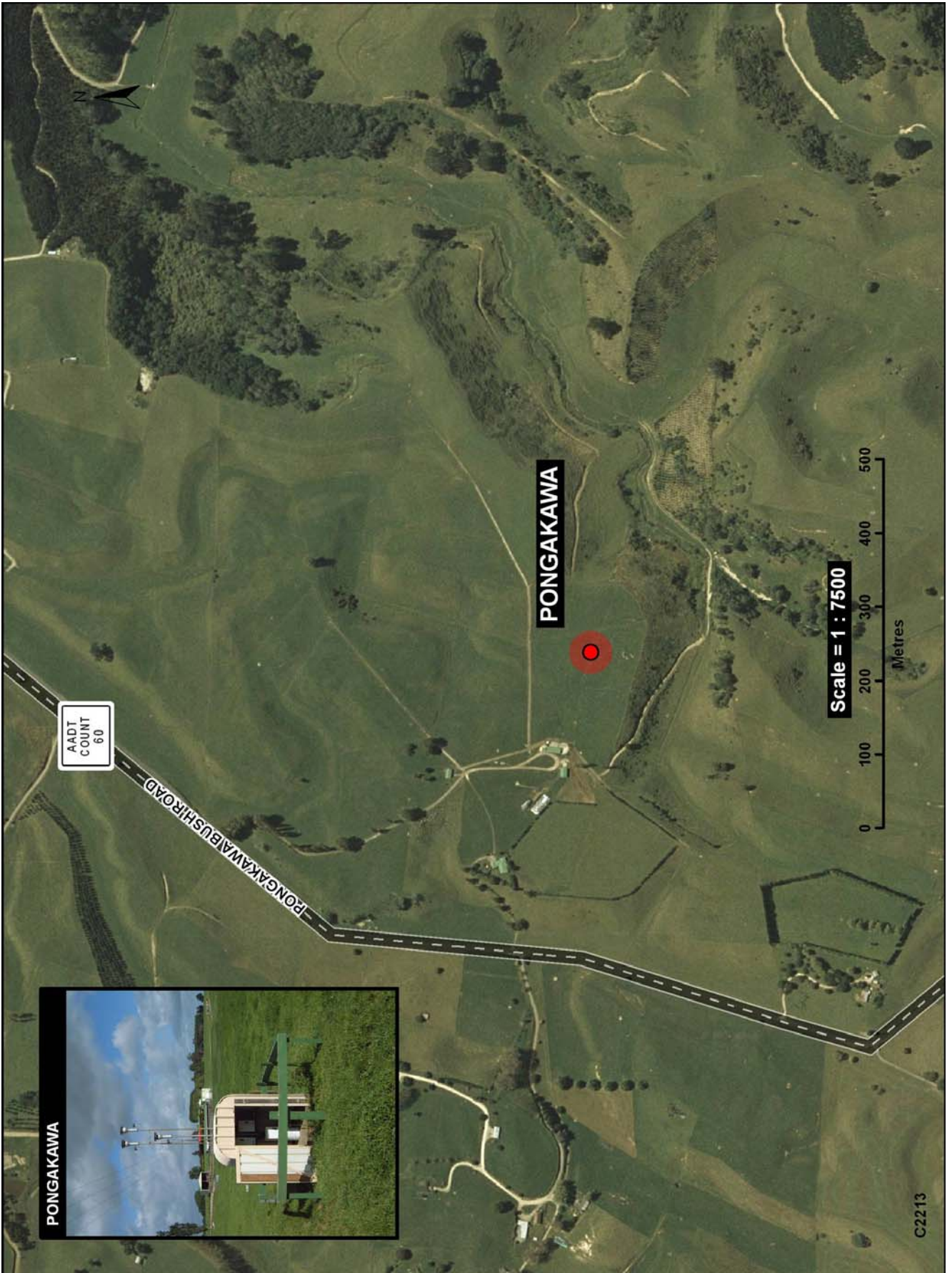


Figure 5.10 Pongakawa site location map.

PONGAKAWA MONITORING SITE (Data 1998 – 2007).	Environmental Performance Indicator (PM10)	<p>Stacked bar chart showing Environmental Performance Indicator (PM10) from 1998 to 2007. The Y-axis represents the percentage of days (0% to 100%). The X-axis represents the years. The legend indicates five categories: Excellent (&lt;10%), Good (10-33%), Acceptable (33-66%), Alert (66-100%), and Action (100+%).</p> <table border="1"> <thead> <tr> <th>Year</th> <th>Excellent (&lt;10%)</th> <th>Good (10-33%)</th> <th>Acceptable (33-66%)</th> <th>Alert (66-100%)</th> <th>Action (100+%)</th> </tr> </thead> <tbody> <tr><td>1998</td><td>21%</td><td>52%</td><td>27%</td><td>0%</td><td>0%</td></tr> <tr><td>1999</td><td>11%</td><td>75%</td><td>14%</td><td>0%</td><td>0%</td></tr> <tr><td>2000</td><td>4%</td><td>73%</td><td>23%</td><td>0%</td><td>0%</td></tr> <tr><td>2001</td><td>17%</td><td>65%</td><td>18%</td><td>0%</td><td>0%</td></tr> <tr><td>2002</td><td>17%</td><td>76%</td><td>7%</td><td>0%</td><td>0%</td></tr> <tr><td>2003</td><td>30%</td><td>65%</td><td>5%</td><td>0%</td><td>0%</td></tr> <tr><td>2004</td><td>13%</td><td>82%</td><td>5%</td><td>0%</td><td>0%</td></tr> <tr><td>2005</td><td>27%</td><td>65%</td><td>8%</td><td>0%</td><td>0%</td></tr> <tr><td>2006</td><td>17%</td><td>72%</td><td>11%</td><td>0%</td><td>0%</td></tr> <tr><td>2007</td><td>18%</td><td>77%</td><td>5%</td><td>0%</td><td>0%</td></tr> </tbody> </table>	Year	Excellent (<10%)	Good (10-33%)	Acceptable (33-66%)	Alert (66-100%)	Action (100+%)	1998	21%	52%	27%	0%	0%	1999	11%	75%	14%	0%	0%	2000	4%	73%	23%	0%	0%	2001	17%	65%	18%	0%	0%	2002	17%	76%	7%	0%	0%	2003	30%	65%	5%	0%	0%	2004	13%	82%	5%	0%	0%	2005	27%	65%	8%	0%	0%	2006	17%	72%	11%	0%	0%	2007	18%	77%	5%	0%	0%
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PM10 Concentrations ( $\mu\text{g}/\text{m}^3$ )	<p>Radar chart showing PM10 Concentrations by month from January to December. The chart displays Maximum (red line) and Average (green line) values for each month. The Y-axis represents concentration in <math>\mu\text{g}/\text{m}^3</math> (0 to 120).</p> <table border="1"> <thead> <tr> <th>Month</th> <th>Maximum (<math>\mu\text{g}/\text{m}^3</math>)</th> <th>Average (<math>\mu\text{g}/\text{m}^3</math>)</th> </tr> </thead> <tbody> <tr><td>January</td><td>40</td><td>20</td></tr> <tr><td>February</td><td>40</td><td>20</td></tr> <tr><td>March</td><td>40</td><td>20</td></tr> <tr><td>April</td><td>40</td><td>20</td></tr> <tr><td>May</td><td>40</td><td>20</td></tr> <tr><td>June</td><td>40</td><td>20</td></tr> <tr><td>July</td><td>40</td><td>20</td></tr> <tr><td>August</td><td>40</td><td>20</td></tr> <tr><td>September</td><td>40</td><td>20</td></tr> <tr><td>October</td><td>40</td><td>20</td></tr> <tr><td>November</td><td>40</td><td>20</td></tr> <tr><td>December</td><td>40</td><td>20</td></tr> </tbody> </table>	Month	Maximum ( $\mu\text{g}/\text{m}^3$ )	Average ( $\mu\text{g}/\text{m}^3$ )	January	40	20	February	40	20	March	40	20	April	40	20	May	40	20	June	40	20	July	40	20	August	40	20	September	40	20	October	40	20	November	40	20	December	40	20																												
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Diurnal and Distribution	<p>No diurnal plot is available due to daily sampling.</p> <p>Cumulative distribution function (CDF) plot for PM10 (24hr). The X-axis is PM10 (24hr) concentration (0 to 60) and the Y-axis is the percentage of days (0% to 100%).</p>																																																																			
Seasonal Concentration Rose	<p>No wind rose plot is available due to daily sampling.</p>																																																																			

### 5.3.11 Church Street, Opotiki.

**Name:** Church.

**Location:** Church Street, Opotiki.

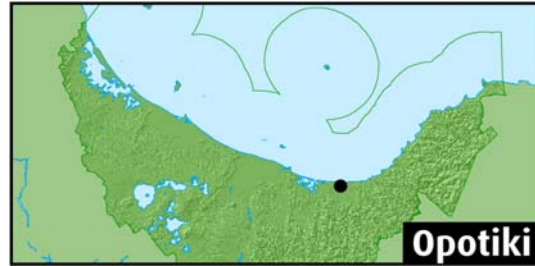
**Site Type:** Commercial/residential.

**Contaminants:** PM<sub>10</sub> & CO.

**Meteorology:** No.

**Elevation:** 15m.

**Monitoring Period:** 2002-2004.



#### **Location:**

This site is located behind the main commercial buildings in Church Street. The closest residential housing is 150m to the southwest. Church Street is located 50m to the east (Figure 5.11). The coastline is 1.5km to the north. Drainage flows in a northward direction would be present from both the Otara and Waioeka river catchments to the south under suitable conditions. Sea breezes would dominate the daily wind patterns during the summer months.

#### **PM<sub>10</sub>:**

Fine particulate levels at this site are 95% of the time "Acceptable" or better. The concentration shows no strong seasonal pattern with monthly maximum concentrations of 40µg/m<sup>3</sup> being common for several periods. The diurnal plots also show a common pattern between seasons, with increases in the early morning being common and elevated levels during the day for spring and summer (sea breeze effect). The autumn and winter traces show the expected evening peak as the sampling detects emissions from nearby domestic heating sources. No exceedance of the standard was recorded at this site. The primary source of measured emissions would be from residential and commercial activities, with a traffic influence in the morning when atmospheric conditions will generally be calm.

#### **CO:**

Measured data shows only low levels of CO are present for the period of record at this site.

The near coastal location of this site and the low levels of vehicular activity have resulted in low values being recorded for this site. Residential areas to the south of the site would have contributed to the seasonal winter increase. Wood fires are a common source of heating in this area.



Figure 5.11 Church site location map.

CHURCH MONITORING SITE (Data 2002 – 2004).	Environmental Performance Indicator (PM10)		
	PM10 Concentrations ( $\mu\text{g}/\text{m}^3$ )		
	Diurnal and Distribution		
	Seasonal Concentration Rose. (10 min data)		

## 5.4 **New sites in 2007**

To improve the councils understanding of PM<sub>10</sub> levels in smaller urban developments and also the spatial extent within the Rotorua LAMA several new sites were installed in 2007. A sequential Partisol has been installed within the grounds of Kawerau North School to determine domestic heating contribution during winter and possible industry contributions during summer as sea breezes dominate meteorological patterns.

A new site within the Rotorua LAMA was established within the eastern area of the city at Ngapuna to determine PM<sub>10</sub> contributions from both domestic and industrial sources.



## Chapter 6: Data Capture Rates

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### 6.1 Data capture rates

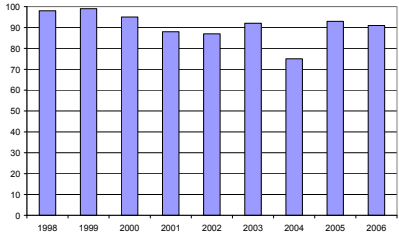
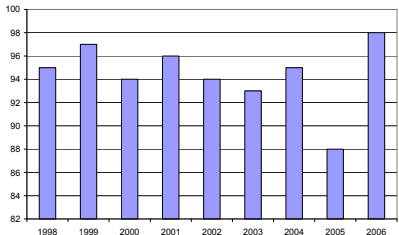
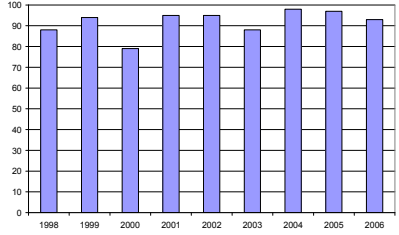
Data capture rate for all sites are listed in Table 7.1. The larger losses at the sites are normally the result of instrument failure, which then requires parts to be sourced from overseas or in some cases the instrument has to be returned to the supplier for servicing (Australia).

Annual data capture totals are plotted for several of the long term sites. No strong negative trend is evident which would suggest instrumentation or staff training issues. The early H<sub>2</sub>S instruments have recorded the lowest data capture rates, which is a result of the method of operation (tape jamming, tape expiry).

Automatic calibrations programmed for the gas analysers have not been included in the calculation of these capture rates.



Table 7.1 Data capture rates.

Site	Type		Capture rate
Otumoetai Road, Tauranga	PM <sub>10</sub>		91
	CO		83
Marsh Street, Tauranga	PM <sub>10</sub>		93
	CO		95
Pererika Street, Rotorua	PM <sub>10</sub>		94
	CO		88
Fenton Street, Rotorua	PM <sub>10</sub>		98
	CO		91
Church Street, Opotiki	PM <sub>10</sub>		98
	CO		96
Pongakawa	PM <sub>10</sub>		96
Quay Street, Whakatane	PM <sub>10</sub>		96
Arawa Street, Rotorua	H <sub>2</sub> S		88
Edmund Road	PM <sub>10</sub>		99
Totara Street	SO <sub>2</sub>		88
Ti Street, Rotorua	H <sub>2</sub> S		82

## Chapter 7: Future Equipment Resources

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This section is designed to provide guidance to the Environmental Data Service section for required monitoring equipment. It combines the requirements of the NES-AQ and the existing NERMN air quality monitoring programme.

Any new monitoring equipment should meet the specification requirements of the NES-AQ.

The current monthly site visit programme coupled with the improvements in telemetry has resulted in a field maintenance programme that is meeting the requirements of the NERMN. The recent data capture calculations suggest that some of the instruments are in a state where replacement is required and this is currently being implemented through the equipment replacement strategy.

Regular 18-month service visits by the equipment suppliers should continue, these audits serve as an additional quality check on the operation and state of the instruments.

### 7.1 Particulate matter (PM<sub>10</sub>)

Results from the co-location particulate monitoring show that during the cooler months recorded values from the TEOM are lower than expected. This is caused by particulate material being “lost” as the sample moves through the TEOM due to the instruments operating temperature. This issue has been well documented both nationally and internationally.

As recommended by the National Environmental Standards for Air Quality (2005) Environment Bay of Plenty has ensured a correction factor has been determined for each TEOM by way of a co-located gravimetric method.

This methodology has proved to be labour intensive and as a result when the standard TEOM's come up for replacement a more time efficient method should be investigated. The first batch of TEOM's (3) was purchased in 1996/97 and will be due for replacement within the next two years.

### 7.2 Carbon Monoxide

These instruments are now approaching the end of their life. The CO monitoring results show no areas of concern within the region. The suggested approach is to maintain two of the three analysers with required consumable parts. This will allow for one long term reference site to be maintained and one instrument available for peak site monitoring (however it would be surprising to find a location within our region which would exceed the standard as even the busiest urban streets/roads in Auckland fail to exceed this standard).

The performance of these analysers should continue to be annually reviewed.

### 7.3 **Sulphur dioxide**

UV fluorescence is the required and implemented method for this contaminant. Currently 3 sites are in operation in the Mt Maunganui area (2007). The additional two instruments are only part of a short term investigation into industrial generated SO<sub>2</sub>. Proposed consent conditions for this industry will require monitoring to be undertaken by the consent holder and will free up the two ex-H<sub>2</sub>S instruments from Rotorua.

### 7.4 **Nitrogen dioxide**

The current equipment is the required method and is performing well. Monitoring should now focus on the new location in Pererika Street, Rotorua.

### 7.5 **Hydrogen sulphide**

UV fluorescence analysers are used for this monitoring (the required method). However due to demands for this type of analyser for other monitoring within the region (SO<sub>2</sub>) the H<sub>2</sub>S programme is currently on hold. This is only a temporary cessation and the H<sub>2</sub>S monitoring should continue as soon as practicable.

## Chapter 8: Monitoring recommendations

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Environment Bay of Plenty is required to undertake monitoring activities as part of its statutory responsibilities under the Resource Management Act, 1991 and the NES-AQ, 2004. The Air Natural Environmental Regional Monitoring Network (Air NERMN) is based around a regional network of air quality monitoring sites designed for regional state-of-the environment monitoring, documentation and reporting. Natural environment monitoring determines the overall regional impact of activities on environment quality.

This monitoring recommendation (schedule) is for the period of 5 years, although annual NES-AQ reporting will provide updates and possible new directions for some of the monitoring. This schedule was first proposed in 1996 and reviewed and extended in 2003.

This section is designed to provide guidance to the Environmental Data Service section for required monitoring. It combines the requirements of the NES-AQ and the existing NERMN air quality monitoring programme.

### 8.1 Proposed NES-AQ investigations

In addition to the Rotorua LAMA, five areas have been designated as requiring investigative PM<sub>10</sub> monitoring, based on limited monitoring and inventory data (Iremonger, 2005):

- (a) Tauranga/Mt Maunganui
- (b) Ngongotaha
- (c) Kawerau
- (d) Whakatane
- (e) Te Puke

Since the proposal in 2005 monitoring has been undertaken at several of these sites, the timing and continuation of monitoring will be discussed in the following section.

### 8.2 Particulate matter (PM<sub>10</sub>)

Long term monitoring sites at Pererika and Otumoetai should continue to be operated, as the 10 years of record already collected at these two sites provides the basis for valuable trend detection. Pererika is within the Rotorua LAMA and therefore important in the management of this airshed. Otumoetai is in a general area which is projected to experience accelerated growth in the decades to come.

The site at Pongakawa is important as an indicator of background concentrations within the region. This is an important contribution when determining strategies for LAMA's and assessing air discharge consent applications. It will also be an important data set in the proposed national background PM<sub>10</sub> project (proposed by NIWA with FRST funding) which Environment Bay of Plenty has expressed interest in being part of.

The Whakatane monitoring site (King Street) should be maintained as this is located in the middle of the third largest urban area in the region. It has a significant industry on the northwest boundary of the urban area and therefore ongoing monitoring of PM<sub>10</sub> is important for detecting the contribution from a variety of sources.

The newly installed Morland Fox Park site (equipment supplied by MfE) is part of the NES-AQ programme, the suburb where the analyser is located has been identified as 'worst case' for domestic heating emissions for Tauranga City, this site will be key in determining whether a LAMA needs to exist in this area of the city.

Edmund and Ngapuna sites should be continued as they are part of the current Rotorua LAMA monitoring programme. They will be key sites in monitoring the success of the Action Plan, and will provide direction if the strategies require modification.

Kawerau will be monitored until May 2008; this is part of the NES-AQ investigation programme. The future of the site will depend on the results of the 1 year of sampling. If no significant levels are determined then this site will be moved to Ngongotaha for a period of 1 year. If the NES-AQ standard is breached a new continuous PM<sub>10</sub> monitor will need to be installed.

The final site that requires PM<sub>10</sub> monitoring is TePuke; this will follow the deployment at Ngongotaha or occur earlier if other equipment becomes available. The period of monitoring at TePuke should be the same as that for Ngongotaha - for a period of 1 year, with daily sampling for May to September inclusive and every second day for the remaining non-winter periods.

### 8.3 Carbon monoxide

CO monitoring can be down scaled due to the recorded results to date. One site should be maintained at Otumoetai and one in the caravan which is currently at Ngapuna. This arrangement will keep track of the long term trends in the urban area with the greatest population and growth. And also give the flexibility with the caravan to monitor in peak traffic sites if required or assess impacts of new roadway developments (e.g. Rotorua – Victoria Street expressway).

Pererika CO monitoring can be discontinued.

### 8.4 Sulphur dioxide

Due to industry contributions, the monitoring at the Totara Street site should be continued, the extent of the monitoring within this industrial/commercial area should be continued for the time being. There will possibly be requirements for industry within the area to also contribute to this monitoring programme as part of their resource consent. This development should be closely monitored and this section of the monitoring programme adjusted accordingly. In the meantime the SO<sub>2</sub> monitoring at the two additional monitors (Hull and Maru) should be reviewed annually, as these two sites were part of the H<sub>2</sub>S programme in Rotorua.

## 8.5 Nitrogen dioxide

The levels of NO<sub>x</sub> at Otumoetai indicate no continuation in monitoring is required at this site. The analyser can now be moved to Pererika.

## 8.6 Hydrogen sulphide

The H<sub>2</sub>S programme is currently postponed due to SO<sub>2</sub> monitoring requirements in Mt Maunganui. This H<sub>2</sub>S programme should be reinitiated as soon as practicable, with the TeNgae site being continued and a new site (near or at the hospital) determined for the second analyser. This H<sub>2</sub>S monitoring and historical work will be beneficial for the internationally funded H<sub>2</sub>S long term exposure study (2007-2011).

## 8.7 Volatile organic compounds

Five years has now passed since the first passive sampling programme for these contaminants. It is now time to repeat this annual monitoring (start in the next financial year), but with only benzene being measured. This will provide a guide as to levels prior to the step down in the MfE guideline value in 2010 (currently 10µg/m<sup>3</sup> (annual average) to 3.6µg/m<sup>3</sup> to be achieved by 2010).

## 8.8 Meteorology

Basic meteorological parameters (wind speed, direction) should be recorded at each of the air quality monitoring sites. As a surrogate, nearby monitoring sites of other agencies (e.g. NIWA) can suffice if within several kilometres. This additional information provides more value to the primary dataset in determining causes of elevated concentrations and long term source contributions.

SODAR (sound detection and ranging) data should also be collected at a number of key sites within the region, these being Mt Maunganui, Rotorua, Kawerau and Whakatane. This data (boundary layer stability and mixing height) is required in airshed modelling assessments and is often difficult to determine accurately from theoretical methods. NIWA offers this service and is currently preparing quotes for this work.

## 8.9 Modelling

The development of airshed and point source models has provided a valuable and powerful tool to complement ambient monitoring programmes. These models when validated against recorded data provide the ability to determine ground level concentrations of contaminants at a variety of locations rather than the single point associated with a monitoring site. This ability provides valuable information to staff for assessing NES-AQ compliance within the regional airshed and air discharge permit applications by industry.

This model application has worked successfully in the Rotorua LAMA science programme (Fisher, 2007). The model was also used to investigate emission reduction scenarios which provide guidance to the Action Plan initiatives.

The council should look at developing these models and the required operational skill set in house as the ability to run new scenarios quickly and reliably is dependant on sound emission and meteorological datasets, both of which are in the process of being developed.

## Chapter 9: Contaminant summary

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### 9.1 **Particulate matter (PM<sub>10</sub>)**

Particulate matter is an issue in Rotorua and steps have been undertaken to address this problem. Regional investigative monitoring (coupled with the long-term monitoring) should continue to be undertaken in order to identify any other 'hotspots' within the region and to comply with NES-AQ requirements. Adverse health effects from particulate exposure are now better understood and thus this contaminant should be the main focus of monitoring schedules for the next 5 year period. Improvements in monitoring equipment should also be investigated to ensure high capture rates are maintained.

### 9.2 **Carbon monoxide**

Monitoring results for CO are well below the National Environmental Standard but a need for continuing vigilance around areas impacted by traffic and/or residential combustion remains, because of the potential for continuing increases in emissions due to increased growth.

### 9.3 **Sulphur dioxide**

Due to the exceedances recorded to date in the Mt Maunganui industrial/port area monitoring should continue at the Totara Street site. For the time being the monitoring should also continue at the two other SO<sub>2</sub> sites in this area until consent conditions have been finalised for a major industrial source. This will improve the understanding of the ambient levels of this contaminant, and will add value to any further investigative work required in this area.

### 9.4 **Nitrogen dioxide**

Two years of monitoring next to Otumoetai Road in Tauranga has shown this contaminant is not of concern in this type of location. A proposed monitoring period of two years at Pererika Street, which has high traffic volumes, is now required to finish the monitoring of this contaminant.



## 9.5 Hydrogen sulphide

Concerns about possible health effects will only be resolved through long term health studies and these will continue to need supporting ambient data. No trends are discernable which reflects the nature of the geothermal source and the effects of meteorology within the Rotorua urban area.

## Chapter 10: References

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## Appendices

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*Appendix 1 ..... Monitoring Equipment*



## Appendix 1

### Monitoring Equipment

The following is a brief summary of the monitoring equipment used for this NERMN programme.

#### SO<sub>2</sub> Analyser

Environment Bay of Plenty uses an EC9850 sulfur dioxide (SO<sub>2</sub>) analyzer which is an ultraviolet (UV) fluorescence spectrometer designed to continuously measure low concentrations of SO<sub>2</sub> in ambient air. The 9850 analyzer comprises an optical sensor assembly, an analog electronic signal preprocessor module, microprocessor-based control and computation electronics, and a pneumatic system that samples ambient air by point monitoring.

The EC9850 sulfur dioxide analyzer is based on classical fluorescence spectroscopy principles. Sulfur dioxide exhibits a strong ultraviolet absorption spectrum between 200 and 240 nm. Absorption of photons at these wavelengths results in the emission of fluorescence photons at wavelengths between approximately 300 and 400 nm. The amount of fluorescence emitted is directly proportional to the SO<sub>2</sub> concentration. These characteristics are exploited by the 9850 SO<sub>2</sub> analyzer.

UV radiation at 214 nm from a zinc discharge lamp is separated from the other wavelengths in the zinc spectrum by a UV bandpass filter. The 214 nm radiation is focused into the fluorescence cell where it interacts with SO<sub>2</sub> molecules in the beam path. The resulting fluorescence is emitted uniformly in all directions. A portion of the fluorescence; i.e., that emitted perpendicularly to the excitation beam, is collected and focused onto a photomultiplier tube. A reference detector monitors the emission from the zinc lamp and is used to correct for fluctuations in lamp intensity.

The 9850 analyzer uses the advanced digital Kalman filter. This filter provides the best possible compromise between response time and noise reduction for the type of signal and noise present in ambient air analyzers and their application.

The EC9850 A series has a built in charcoal scrubber that provides SO<sub>2</sub>-free zero air to the analyzer, the instrument is designed to monitor the fluorescence background signal by periodically sampling SO<sub>2</sub> scrubbed air. This results in the virtual elimination of zero drift.

#### H<sub>2</sub>S Analyser

Environment Bay of Plenty uses an EC9850 sulfur dioxide (SO<sub>2</sub>) analyzer as described above with the inclusion of the thermal oxidiser. The oxidiser converts the H<sub>2</sub>S to SO<sub>2</sub>.

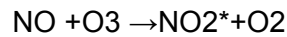
#### NO<sub>x</sub> Analyser

Environment Bay of Plenty uses an EC9841 nitrogen oxides analyzer which uses gas-phase chemilluminescence detection to perform continuous analysis of nitric oxide (NO), total oxides of nitrogen (NO<sub>x</sub>), and nitrogen dioxide (NO<sub>2</sub>). The 9841 analyzer design represents an advance in nitrogen oxides analysis technology achieved by using adaptive microprocessor control of a single measurement channel.

The instrument consists of a pneumatic system, a NO<sub>2</sub>-to-NO converter (molycon), a reaction cell, detector (PMT), and processing electronics. With an auto-zero routine that allows the analyzer to periodically check and correct for background illumination, the 9841 virtually eliminates zero drift.

The EC9841 analyzer uses gas-phase chemiluminescence detection to perform continuous analysis of nitric oxide (NO), total oxides of nitrogen (NO<sub>x</sub>), and nitrogen dioxide (NO<sub>2</sub>). The EC9841 design represents an advance in nitrogen oxides analysis technology achieved primarily by using adaptive microprocessor control of a single measurement channel. The instrument consists of a pneumatic system, an NO<sub>2</sub>-to-NO converter (molycon), a reaction cell, detector (PMT), and processing electronics.

The analysis of nitrogen oxides by chemiluminescence is generally acknowledged to be the best direct measurement technique. The method is based on the luminescence from an activated molecular NO<sub>2</sub> species produced by the reaction between NO and O<sub>3</sub> in an evacuated chamber. The NO molecules react with ozone to form the activated species NO<sub>2</sub>\* according to the reaction mechanism:



As the activated species NO<sub>2</sub>\* reverts to a lower energy state, it emits broad-band radiation from 500 to 3000 nm, with a maximum intensity at approximately 1100 nm. Since one NO molecule is required to form one NO<sub>2</sub>\* molecule, the intensity of the chemiluminescent reaction is directly proportional to the NO concentration in the sample. The PMT current is then directly proportional to the chemiluminescence intensity.

In order to measure the zero offset of the instrument, a background measurement is performed every 70 seconds by diverting the sample flow from the reaction cell to the cell bypass line. This measurement is electronically subtracted from all subsequent measurements to achieve very stable measurements.

### **Carbon Monoxide Analyser**

Environment Bay of Plenty uses a ML9830 Carbon Monoxide analyser manufactured by Monitor Labs, USA.

Carbon monoxide absorbs infrared radiation (IR) at wavelengths near 4.7 microns; therefore, the presence and the amount of CO can be determined by the amount of absorption of the IR. The EC9830 analyzer uses gas filter correlation to compare the detailed IR absorption spectrum between the measured gas and other gases present in the sample being analyzed. A highly concentrated sample of the measured gas, i.e., CO is the filter for IR transmitted through the analyzer, thus gas filter correlation.

The process further defined consists of radiation from the IR source encountering a gas filter wheel alternating between CO, N<sub>2</sub>, and a mask. The radiation passes through a multiple pass measurement cell where the sample gas absorption process occurs, then through a narrow-band-pass filter to limit absorption to optical wavelengths of interest for CO absorption, after which it encounters the IR detector where the amount of absorption is measured.

The N<sub>2</sub> filter in the gas filter correlation wheel is transparent to IR and yields a measure beam that can be absorbed by CO in the measurement cell. The CO filter in the wheel yields a beam that cannot be further attenuated by the CO in the measurement cell, thus it is a reference beam. The mask creates a signal used to determine the strength of the other two signals.

The CO concentration in the measurement cell absorbs the measure beam and does not absorb the reference beam, modulating the IR radiation, or detector input signal between the gas filters. Other gases absorb the reference and measure beams equally and thus do not cause modulation of the detector signal. Using this method, the system responds specifically to CO.

### **Tapered Element Oscillating Microbalance (TEOM)**

Environment Bay of Plenty uses two different PM<sub>10</sub> measuring systems in its monitoring programme. This is to get a balance between the use of high cost/high complexity systems versus the need to cover many sites. The TEOM analysers provide continuous data but are more expensive than the Partisol analysers. The Partisol analysers are manually operated and record only one data point for a 24-hour period whereas the TEOM records continuously and provides an analysis of the variations throughout each day.

Environment Bay of Plenty uses the Tapered Element Oscillating Microbalance (TEOM) Series 1400A ambient particulate monitor manufactured by Rupprecht and Patashnick. More recently these instrument have been replaced with FDMS TEOM units.

The instrument operates by drawing an ambient sample stream through a 10 micron pre-filter head so that only particles sized less than this are measured. They then pass through a filter, which is 'weighed', every two seconds. The difference between the filters current 'weight' and the filters initial 'weight' gives the total mass of the collected particulate matter.

Next the mass rate is calculated by taking the increase in the total mass between the current reading and the immediately preceding one and expressing this as a mass rate in µg/sec. Finally, the mass concentration in µg/m<sup>3</sup> is computed by dividing the mass rate by the flow rate.

The proposed monitoring method is US 40 CFR Part 50, Appendix J, or an equivalent method. Where a tapered elemental oscillating microbalance (TEOM®) is used, it should be co-located with another sampling method, such as a high-volume sampler, to determine an appropriate conversion factor (MfE, 2003). The TEOM has USEPA equivalency certification.

### **Partisol Particulate Sampler**

Environment Bay of Plenty uses the Partisol Model 2000, air sampler manufactured by Rupprecht and Patashnick.

The Partisol Sampler is set up to collect particulate matter on a standard 47 mm Pallflex filter for 24-hour periods from midnight to midnight. The filters used in this procedure are conditioned and weighed before exposure, and then conditioned and weighed again after use to determine the mass of particulate collected during the 24-hour exposure period. Weighing is undertaken on a semi-micro balance with a resolution of 0.00001g. The Partisol hardware stores the data relevant to each 24-hour collection period in its internal data logger for viewing and retrieval. Such information includes the total volume of air passed through the filter, total collection time, average temperature and average pressure during the collection period.

The proposed monitoring method is US 40 CFR Part 50, Appendix J, or an equivalent method (MfE, 2003). The Partisol has USEPA equivalency certification.



## **Sequential Partisol Particulate Sampler**

Environment Bay of Plenty uses the Sequential Partisol Model 2025, air sampler manufactured by Rupprecht and Patashnick.

The principle of operation for this instrument is similar to that of the Partisol 2000, the main difference between the two samplers is the 2025 can store-sample-store up to 16 47mm filters. This sampler has been co-located with one of the TEOM instruments to determine a conversion factor.

The proposed monitoring method is US 40 CFR Part 50, Appendix J, or an equivalent method (MfE, 2003). The Partisol 2025 has USEPA equivalency certification.