Monitoring of CO, NO_2, SO_2, ozone, benzene and benzo(a)pyrene in New Zealand

Air Quality Technical Report No. 42

Environet Limited

October 2003

Published in January 2004 by the
Ministry for the Environment
Manatū Mō Te Taiao
PO Box 10-362, Wellington, New Zealand

Air Quality Technical Report 42

This document is available on the Ministry for the Environment's website:
www.mfe.govt.nz

Foreword

Information about the state of New Zealand's air quality is important for estimating potential health effects and determining where emissions should be reduced to improve air quality. This report summarises our current knowledge about the concentrations of **carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ozone (O_3), benzene and benzo(a)pyrene** (BaP) in New Zealand's air.

The results indicate that concentrations of these pollutants are generally low and within guideline values in New Zealand, and in many areas air quality in New Zealand is extremely good. However, there are some urban areas where CO, NO_2, O_3, benzene and BaP reach levels that are high enough to cause adverse health effects. These typically occur in Auckland and Christchurch close to busy roads or where inversion layers trap wintertime pollution from domestic fires. Further analysis of such potential health effects is described in an accompanying report.

I would like to thank you those councils and others who contributed data and commented on this report.

Barry Carbon
Chief Executive
Ministry for the Environment

Acknowledgements

The Ministry would like to thank the following for their contribution of data for the report:

- Paul Baynham, Northland Regional Council
- Karen Roberts, Hawkes Bay Regional Council
- Perry Davy, Wellington Regional Council
- Teresa Aberkane, Environment Canterbury
- Richard Chilton, Kevin Mahon and Peter Day, Auckland Regional Council
- Ross Jones, Environment Waikato
- Gary Bedford, Taranaki Regional Council
- Trevor James, West Coast Regional Council
- Leif Pigott, Otago Regional Council
- Paul Sheldon, Nelson City Council
- Shane Ironmonger, Environment Bay of Plenty.

Contents

List of Tables

List of Figures

Executive Summary

Air quality monitoring for carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ozone (O_3), benzene and benzo(a)pyrene (BaP) has been carried out in a number of locations in New Zealand. This report summarises the results of this monitoring for the years 1992 to 2002 and identifies areas and contaminants of concern. Results are compared to the ambient air quality guidelines and the air quality categories – excellent, good, acceptable, alert, and action (MfE and MoH, 2002).

Air quality monitoring of CO has been carried out in Auckland, Waikato, Hawkes Bay, Bay of Plenty, Wellington, Canterbury, Otago and Nelson. For the majority of the time, concentrations of CO are 'excellent' or 'good' in most of these locations. However, the guideline values are regularly exceeded at the Khyber Pass Road traffic site and at residential monitoring sites in Christchurch. Long-term monitoring for CO at Queen Street in Auckland and St Albans in Christchurch indicates concentrations of this contaminant have decreased between 1992 and 2001.

Concentrations of NO_2 have been monitored in Auckland, Waikato, Hawkes Bay, Wellington, Canterbury and Nelson. In addition, survey type monitoring has been carried out in Taranaki, Bay of Plenty and Otago. For the majority of the time, concentrations of NO_2 are 'excellent' or 'good' in these locations. The main exception is the Khyber Pass Road monitoring site in Auckland, where NO_2 concentrations regularly exceed guideline values. No guideline value exceedences for NO_2 (24-hour average) have been measured at residential air quality monitoring sites.

Ambient air quality monitoring for SO_2 has been carried out in a number of locations within Canterbury, Auckland and Hawkes Bay. In addition, survey type monitoring has been carried out in Taranaki, Bay of Plenty and Otago. Concentrations of SO_2 are 'excellent' or 'good' in most locations. No guideline exceedences for SO_2 were measured during the period of 1992 to 2002.

Air quality monitoring for O_3 has been carried out at a number of locations within Auckland and at two sites on the outskirts of Christchurch. Two exceedences of the eight-hour guideline value occurred at Musick Point in Auckland during October 2002. In other locations, guideline values have not been exceeded, although a large proportion of the data were within the 'acceptable' category and in Auckland up to 15% of the data were in the 'alert' air quality category.

Concentrations of benzene have been monitored in Auckland, Christchurch, Hamilton, Dunedin, Nelson, the Bay of Plenty and on the West Coast. Annual average concentrations have been within the current guideline value of 10 μgm^{-3} (annual average) and 2010 guideline (3.6 μgm^{-3}) at most 'residential' sites. Guideline exceedences have been recorded at Khyber Pass Road in Auckland and at Riccarton Road in Christchurch. However, these were peak traffic sites that are not typically representative of a person's potential annual exposure.

Measurements of BaP have been carried out in Christchurch during 1999. Data show strong correlations with PM_{10} concentrations and indicate that the annual average BaP concentrations are at least 4 ngm^{-3}, more than 10 times the guideline value concentration. Based on these results, it is likely that BaP concentrations also exceed ambient air quality guideline values in areas where elevated PM_{10} concentrations occur as a result of solid fuel burning for domestic home heating.

1 Introduction

This report provides a summary of the results of air quality monitoring of carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ozone (O_3), benzene and benzo(a)pyrene in New Zealand from 1992 to 2002.

Prior to the introduction of the Resource Management Act (RMA) in 1991, air quality monitoring in New Zealand was the responsibility of the then Department of Health. Monitoring at that time was mainly conducted in the larger urban centres of Christchurch and Auckland, although some smoke monitoring was carried out in the smaller towns. Air quality monitoring in Auckland and Christchurch prior to 1991 included CO, NOx, SO_2, lead and particles. Concentrations were typically compared to international guidelines such as those set by the World Health Organisation (WHO).

With the RMA came a shift in the responsibility for air quality to regional councils. Specific requirements under Sections 35 and 30 of the RMA include air quality monitoring and management. As a result, air quality monitoring networks were established and expanded throughout the country during the 1990s.

In 1994, the Ministry for the Environment developed a set of ambient air quality guidelines for key air contaminants in New Zealand (MfE, 1994). These included health related guideline values for CO, PM_{10}, SO_2, NO_2, O_3, hydrogen sulphide (H_2S), and lead. A review of these guideline values and their application was carried out during the late 1990s and a discussion document on this review was released in December 2000 (MfE, 2000). In May 2002, the final updated ambient air quality guideline values were released (MfE and MoH, 2002). This document includes revised guideline values of the contaminants in the 1994 document as well as guideline values for new contaminants including benzene, 1,3 butadiene, formaldehyde, acetaldehyde, benzo(a)pyrene, mercury, chromium and arsenic. The guideline values for contaminants that are discussed in this report are shown in Table 1.2.

The Ministry for the Environment has also established an Environmental Performance Indicators programme to collate and report air quality data. The programme aims to improve the quality, quantity and reporting of air quality monitoring. Through the signing of partnership agreements, councils have agreed to undertake specific monitoring and to provide the data for reporting over a national website. As part of the obligations under the agreements, councils will have the opportunity to comment on this report prior to its release.

The monitoring procedures used by regional councils mostly follow the recommendations outlined in the Ministry's *Good Practice Guide for Air Quality Monitoring and Data Management*. This document includes a description of monitoring methods and data collection and processing protocols for New Zealand. One of the recommended reporting methods for presenting air quality data is the use of air quality categories based on a proportion of the guideline value (Table 1.1). These categories are used to present air quality data. These are generally presented based on air quality monitoring results for each year of monitoring. However, in locations where monitoring was limited to shorter time periods, results have been presented on a monthly basis.

Other data reported includes the number of guideline breaches, the maximum measured concentration, the 99.5 percentile concentration for 24-hour averages and the 99.9 percentile concentration for hourly and eight-hour averages. The number of guideline exceedences has been extrapolated for each year based on the proportion of days or hours monitored. For example, if three guideline value exceedences were measured, but sampling only took place for one half of the year, the estimated number of exceedences would be six. This extrapolation includes an adjustment for seasonal variations. An example of the equation used to estimate the number of exceedences per year for a 24-hour average guideline value is shown in Equation 1.1.

Equation 1.1: No. > guideline (May–August) x [123/days monitored (May–August)] + No. > guideline (January–April, September–December) x [242/days monitored (January–April, September–December)]

Table 1.1: Ministry for the Environment's air quality categories

Category	Measured value	Comment
Excellent	Less than 10% of the guideline	Of little concern: if maximum values are less than a 10th of the guideline, average values are likely to be much less
Good	Between 10% and 33% of the guideline	Peak measurements in this range are unlikely to affect air quality
Acceptable	Between 33% and 66% of the guideline	A broad category, where maximum values might be of concern in some sensitive locations but generally they are at a level which does not warrant urgent action
Alert	Between 66% and 100% of the guideline	This is a warning level, which can lead to exceedences if trends are not curbed
Action	Exceeds the guideline value	Exceedences of the guideline are a cause for concern and warrant action, particularly if they occur on a regular basis

Table 1.2: Summary of the ambient air quality guidelines for contaminants discussed in this report

Contaminant	2002 guideline values[a]	
	Concentration	Averaging period
Carbon monoxide	30 mg m^{-3} 10 mg m^{-3}	One-hour Eight-hour
Nitrogen dioxide	200 µg m^{-3} 100 µg m^{-3}	One-hour 24-hour
Sulphur dioxide[b]	350 µg m^{-3} 120 µg m^{-3}	One-hour 24-hour
Ozone	150 µg m^{-3} 100 µg m^{-3}	One-hour Eight-hour
Benzene (year 2002) Benzene (year 2010)	10 µg m^{-3} 3.6 µg m^{-3}	Annual Annual
Benzo(a)pyrene)	0.0003 µg m^{-3}	Annual

Source: MfE and MoH, 2002

Notes:

[a] All values apply to the gas measured at standard conditions of temperature (0°C) and pressure (1 atmosphere).[b] The sulphur dioxide guideline values do not apply to sulphur acid mist.

Each section in this report provides a brief description of the recommended monitoring methods for that contaminant, followed by sections outlining the state or concentrations in each region where monitoring is carried out.

1.1 Air quality monitoring in New Zealand

The number of air quality monitoring sites and the range of contaminants monitored in New Zealand has expanded over the last decade. While suspended particulate (PM_{10}) is the priority contaminant for air quality monitoring in most regions, measurements of other contaminants such as CO and NO_2 are also common. In Auckland, extensive monitoring has also been carried out for O_3 and in Christchurch, concentrations of SO_2 are also routinely measured. Concentrations of benzene and benzo(a)pyrene have been measured in some locations in recent years, although this monitoring tends to be for a shorter term, rather than continuous sampling. A summary of the air quality monitoring sites within New Zealand and the contaminants that have been measured is provided in Appendix One.

2 Carbon monoxide (CO)

Concentrations of carbon monoxide have been measured in a number of urban centres in New Zealand. Results of this monitoring are compared to the following ambient air quality guideline values for New Zealand:

- 30 mgm^{-3} (one-hour average)
- 10 mgm^{-3} (eight-hour average).

The recommended monitoring method for carbon monoxide in New Zealand is AS3580.7.1 – 1992. This method specifies infra-red absorption. Unless stated otherwise, all data presented in this section are based on monitoring methods that comply with AS3580.7.1 – 1992. This method is the recommended in both the *Good Practice Guide for Air Quality Monitoring and Data Management* (MfE, 2000) and the *Ambient Air Quality Guidelines* (MfE and MoH, 2002).

2.1 Auckland region

Carbon monoxide concentrations have been measured at nine sites in the Auckland region since 1992. The longest record of data is for Queen Street, for which data are available from 1992 to 2000 (Tisdalls site) and from 1998 to 2001 (carpark site). The summary data for CO monitoring in Auckland is shown in Table 2.1. The percentage of measured one-hour and eight-hour average CO concentrations within air quality categories at each site is shown in the graphs in Sections 2.1.1 to 2.1.7. Site classifications for the different areas are as follows:

- Queen Street — Traffic peak
- Takapuna — Residential peak
- Khyber Pass — Traffic peak
- Hobson Street — Traffic peak
- Henderson — Residential peak
- Dominion Road — Traffic peak
- Pakuranga — Residential peak
- Manurewa — Residential neighbourhood

Descriptions of the site classifications are on page 32 of the *Good Practice Guide to Air Quality Monitoring and Data Management* (Ministry for the Environment, 2000). In general, the first descriptor relates to the most likely sources of pollution and the second refers to the spatial area covered by the monitoring site. The latter is described in the *Australian Standard – Ambient air – Guide for the siting of air sampling units* (AS 2922, 1987).

Table 2.1: Summary data for CO monitoring in Auckland

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
One-hour average CO concentrations Queen Street (Tisdalls)										
% valid data	100%	81%	100%	96%	97%	100%	69%	21%	42%	
Hours > 30 mgm^{-3}	0	0	0	5	0	0	0	0	0	
Days > guideline	0	0	0	2	0	0	0	0	0	
99.9 %ile mgm^{-3}	15	17	16	16	16	11	11	15	15	
Maximum mgm^{-3}	22	19	22	89	24	15	15	17	16	
Eight-hour average CO concentrations Queen Street (Tisdalls)										
% valid data	100%	81%	100%	95%	97%	100%	69%	21%	42%	
Hours > 10 mgm^{-3}	56	126	107	31	37	0	0	0	0	
Days > guideline	8	10	1	2	4	0	0	0	0	
99.9 %ile mgm^{-3}	12	13	10	23	12	8	7	8	9	
Maximum mgm^{-3}	14	14	10	30	16	9	9	8	9	
One-hour average CO concentrations Queen Street (carpark)										
% valid data							24%	96%	87%	90%
Hours > 30 mgm^{-3}							0	2	0	0
Days > guideline							0	1	0	0
99.9 %ile mgm^{-3}							18	22	18	15
Maximum mgm^{-3}							18	38	21	19
Eight-hour average CO concentrations Queen Street (carpark)										
% valid data							24%	96%	87%	89%
Hours > 10 mgm^{-3}							30	54	11	11
Days > guideline							12	10	3	3
99.9 %ile mgm^{-3}							11	17	10	11
Maximum mgm^{-3}							11	25	11	12
One-hour average CO concentrations (Takapuna)										
% valid data				43%	59%	91%	85%	71%		32%
Hours > 30 mgm^{-3}				0	0	0	0	0		0
99.9 %ile mgm^{-3}				12	11	11	10	11		4
Maximum mgm^{-3}				16	17	17	14	14		6
Eight-hour average CO concentrations (Takapuna)										
% valid data				43%	59%	91%	85%	71%		32%
Hours > 10 mgm^{-3}				0	0	0	0	0		0
99.9 %ile mgm^{-3}				6	7	8	6	8		3
Maximum mgm^{-3}				7	9	9	7	9		4
One-hour average CO concentrations (Khyber Pass)										
% valid data					13%	91%	89%	97%	76%	94%
Hours > 30 mgm^{-3}					0	0	0	0	0	0
99.9 %ile mgm^{-3}					13	19	17	16	13	13
Maximum mgm^{-3}					14	22	19	18	18	15

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Eight-hour average CO concentrations (Khyber Pass)										
% valid data					13%	91%	89%	97%	75%	94%
Hours > 10 mgm^{-3}					15	188	110	57	0	0
Days > guideline					8	51	31	21	0	0
99.9 %ile mgm^{-3}					10	13	12	11	9	8
Maximum mgm^{-3}					11	14	14	11	10	9
One-hour average CO concentrations (Hobson)										
% valid data					31%	100%	77%	99%	25%	
Hours > 30 mgm^{-3}					0	0	0	0	0	
99.9 %ile mgm^{-3}					7	13	13	13	8	
Maximum mgm^{-3}					9	19	19	19	8	
Eight-hour average CO concentrations (Hobson)										
% valid data					31%	100%	77%	100%	25%	
Hours > 10 mgm^{-3}					0	0	0	3	0	
Days > guideline					0	0	0	2	0	
99.9 %ile mgm^{-3}					5	8	9	9	5	
Maximum mgm^{-3}					5	9	10	11	5	
One-hour average CO concentrations (Dominion Road, 1995 and 1996, and Henderson)										
% valid data				96%	11%		55%	99%	100%	99%
Hours > 30 mgm^{-3}				11	0		0	0	0	0
Days > guideline				1	0		0	0	0	0
99.9 %ile mgm^{-3}				15	5		7	7	5	5
Maximum mgm^{-3}				73	6		8	11	8	20
Eight-hour average CO concentrations (Dominion Road, 1995 and 1996, and Henderson)										
% valid data				95%	11%		55%	99%	100%	99%
Hours > 10 mgm^{-3}				3	0		0	0	0	0
Days > guideline				1	0		0	0	0	0
99.9 %ile mgm^{-3}				7	3		4	4	3	3
Maximum mgm^{-3}				14	3		4	4	3	5
One-hour average CO concentrations (Manurewa, 1996 and 1997, and Pakuranga)										
% valid data					78%	20%	44%	86%	69%	99%
Hours > 30 mgm^{-3}					0	0	0	0	0	0
99.9 %ile mgm^{-3}					11	6	10	11	5	11
Maximum mgm^{-3}					14	8	13	12	6	22
Eight-hour average CO concentrations (Manurewa, 1996 and 1997, and Pakuranga)										
% valid data					78%	20%	44%	86%	69%	99%
Hours > 10 mgm^{-3}					0	0	0	0	0	0
99.9 %ile mgm^{-3}					6	3	8	8	4	7
Maximum mgm^{-3}					8	3	8	10	4	9

								2000	2001	2002
One-hour average CO concentrations (Manukau)										
% valid data								29%	92%	53%
Hours > 30 mgm^{-3}								0	0	0
99.9 %ile mgm^{-3}								7	10	9
Maximum mgm^{-3}								8	15	13
Eight-hour average CO concentrations (Manukau)										
% valid data								29%	92%	53%
Hours > 10 mgm^{-3}								0	0	0
99.9 %ile mgm^{-3}								3	6	5
Maximum mgm^{-3}								4	7	5

2.1.1 Queen Street

Air quality monitoring data for CO for the years 1992 to 2000 at the Queen Street (Tisdalls) site are shown in Figure 2.1. While hourly average concentrations are typically within the 'excellent' or 'good' categories, eight-hour average concentrations are regularly in the 'acceptable' category and a small proportion of data are within the 'alert' category for most years. The eight-hour average guideline value was exceeded during the years 1992 to 1996 inclusive at the Queen Street site but was not exceeded from 1997 to 2000. The one-hour average guideline value was exceeded at this site during 1995 and reached a maximum concentration of 89 mgm^{-3}.

A second air quality monitoring site was established in Queen Street in 1998 (carpark site). Figure 2.2 shows the percentage of measured concentrations at this site within the air quality categories. This shows a similar trend, with the majority of the one-hour average concentrations within the 'excellent' and 'good' categories but with some eight-hour average concentrations of concern. For each of these years, between 1% and 4% of the eight-hour average data were greater than 66% of the guideline value, with a small number of guideline value exceedences occurring at this site during each of these years.

Figure 2.1: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories at Queen Street (Tisdalls), Auckland

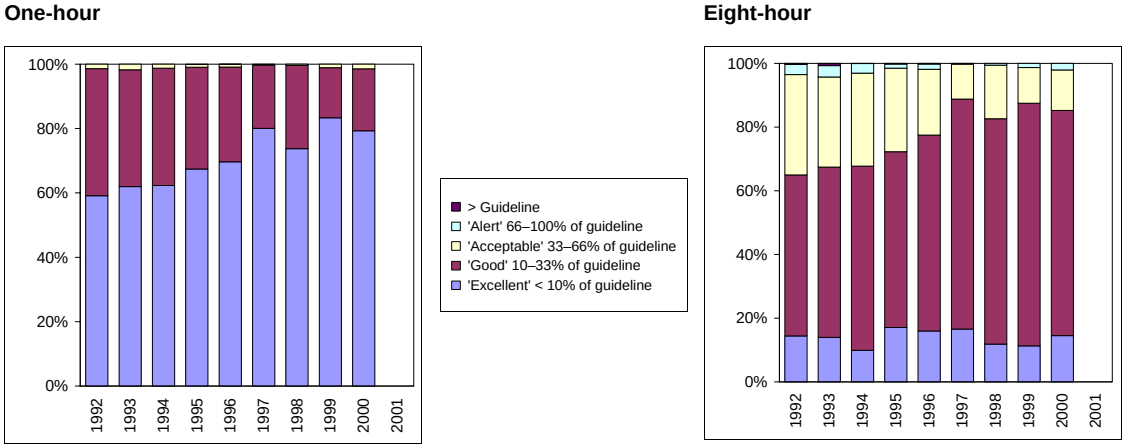
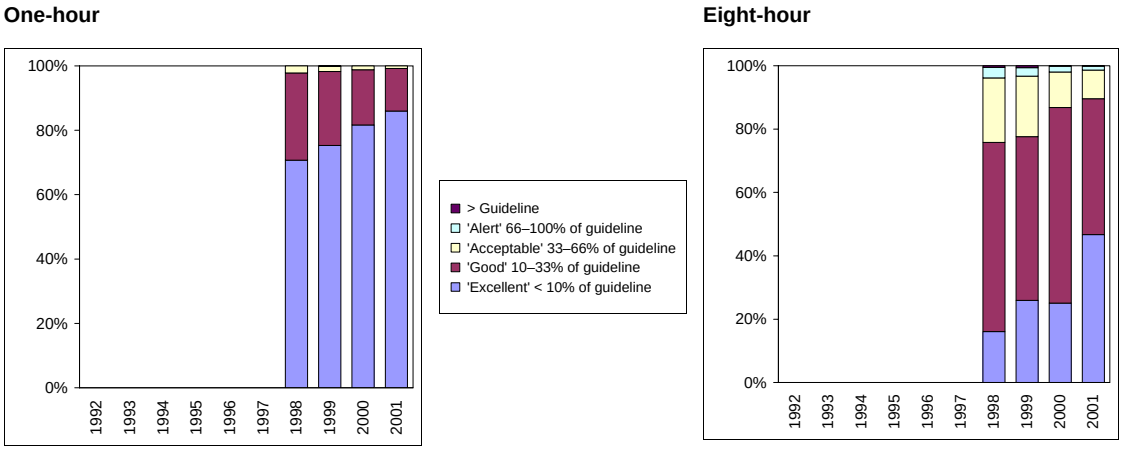


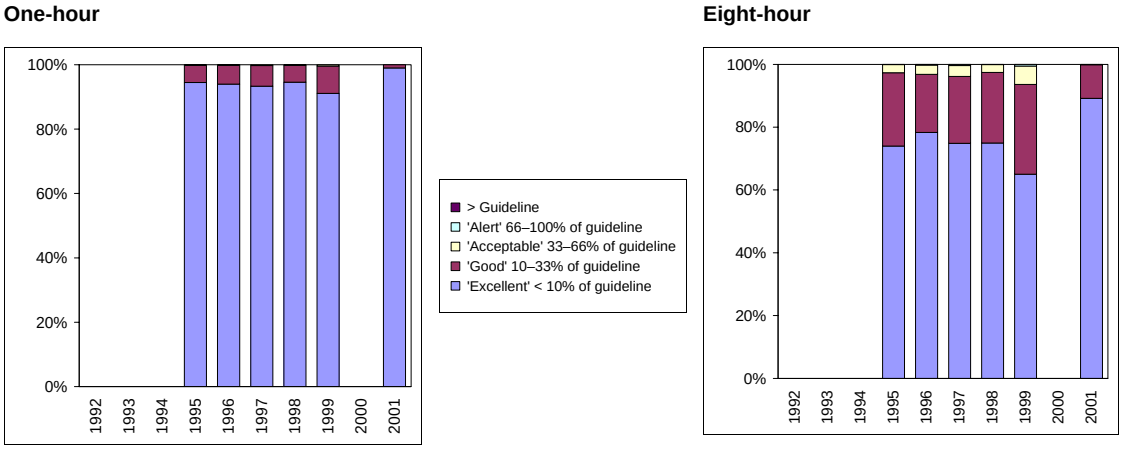
Figure 2.2: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories at Queen Street (carpark site), Auckland



2.1.2 Takapuna

Figure 2.3 shows data for CO concentrations measured at the Takapuna air quality monitoring site. The majority of the CO concentrations measured are less than 66% of both the one-hour and eight-hour guideline values. A small proportion of the eight-hour average concentrations (less than 1%) were in the 'alert' category for the years 1995 to 1999. No guideline value exceedences for CO have been measured at this site. The maximum one-hour and eight-hour average concentrations measured were 17 and 9 mgm^{-3} respectively.

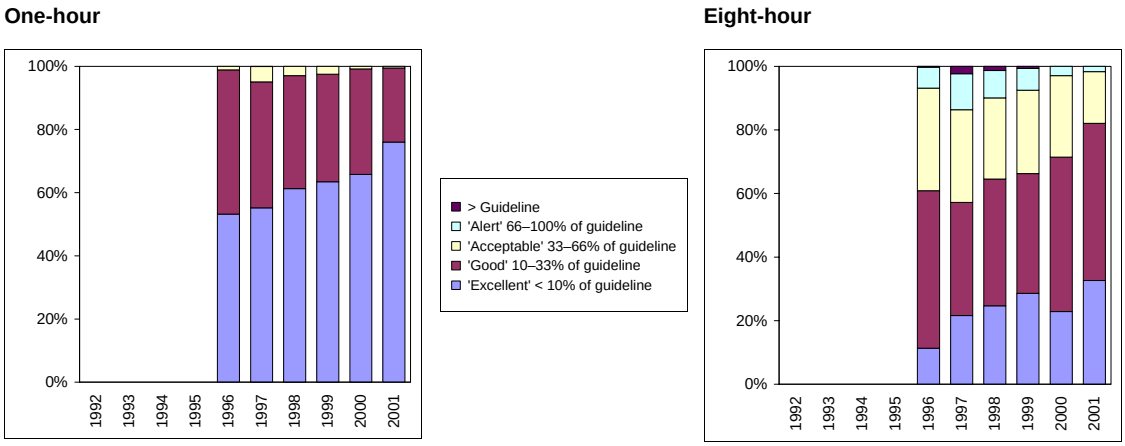
Figure 2.3: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories at Takapuna, Auckland



2.1.3 Khyber Pass

Concentrations of CO have been measured at the Khyber Pass Road site since October 1996. The eight-hour average concentrations have exceeded the guideline value most years during the months April to August inclusive. During 1996 to 1999, over 7% of the eight-hour average concentrations were within the 'alert' air quality category. The majority of the one-hour average concentrations measured at this site were in the 'excellent' or 'good' air quality categories (Figure 2.4). The maximum one-hour and eight-hour average concentrations from 1996 to 2001 were 22 and 14 mgm^{-3} respectively.

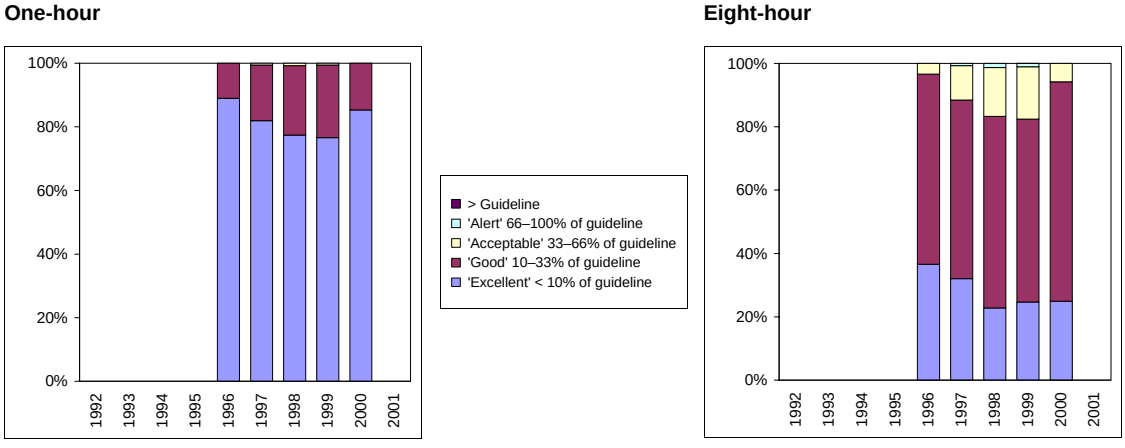
Figure 2.4: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories at Khyber Pass, Auckland



2.1.4 Hobson

Figure 2.5 shows concentrations of CO measured at the Hobson air quality monitoring site from 1995 to 2000. With the exception of one pollution episode during June 1999, CO concentrations have not exceeded the one-hour or eight-hour average guideline values. Over 80% of the measured concentrations are less than 33% of the guideline value. The maximum one-hour and eight-hour average CO concentrations measured at this site were 19 and 11 mgm^{-3} respectively.

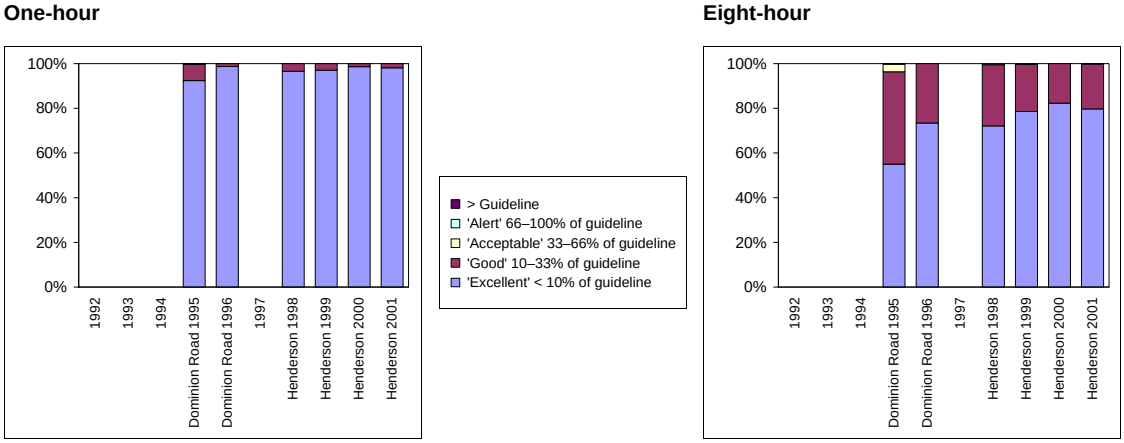
Figure 2.5: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories at Hobson, Auckland



2.1.5 Henderson and Dominion Road

Figure 2.6 shows the results of air quality monitoring for CO at the Dominion Road site during 1995 and 1996 and at the Henderson site from 1998 to 2001. At both sites, CO concentrations were generally within the 'excellent' or 'good' air quality categories with only a small percentage of measurements above 33% at Dominion Road during 1995. The eight-hour and one-hour average guideline values were both exceeded at Dominion Road during a pollution episode in July 1995. During this time, a maximum one-hour average concentration of 73 mgm^{-3} and eight-hour average concentration of 14 mgm^{-3} was recorded. The maximum one-hour and eight-hour average concentrations measured at Henderson were much lower at 20 and 5 mgm^{-3} respectively.

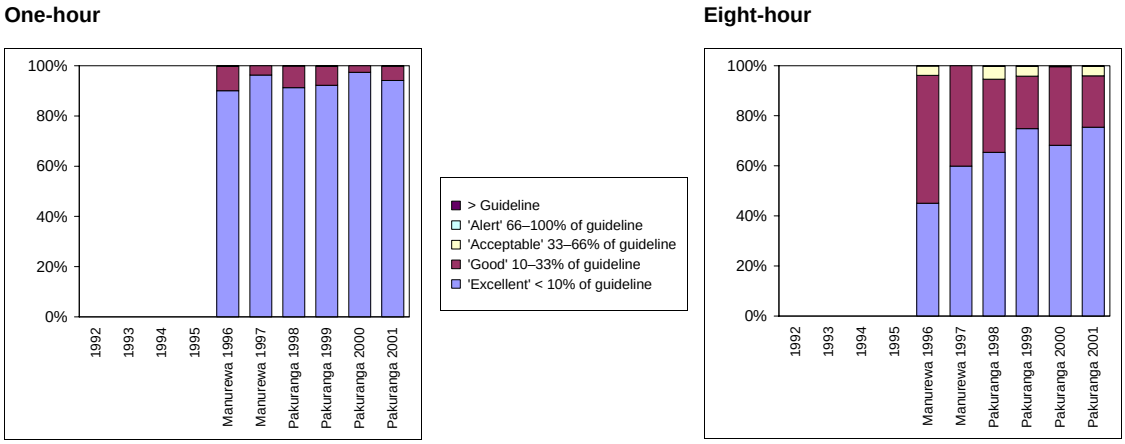
Figure 2.6: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories at Henderson and Dominion Road, Auckland



2.1.6 Manurewa and Pakuranga

Concentrations of CO were measured in Manurewa in 1996 and 1997 and in Pakuranga from 1999 to 2001. No guideline value exceedences were recorded in either location and the majority of the CO concentrations were in the 'excellent' or 'good' air quality categories (Figure 2.7). The maximum one-hour and eight-hour average concentrations in Manurewa were 14 and 8 mgm^{-3} and in Pakuranga, 13 and 9 mgm^{-3}.

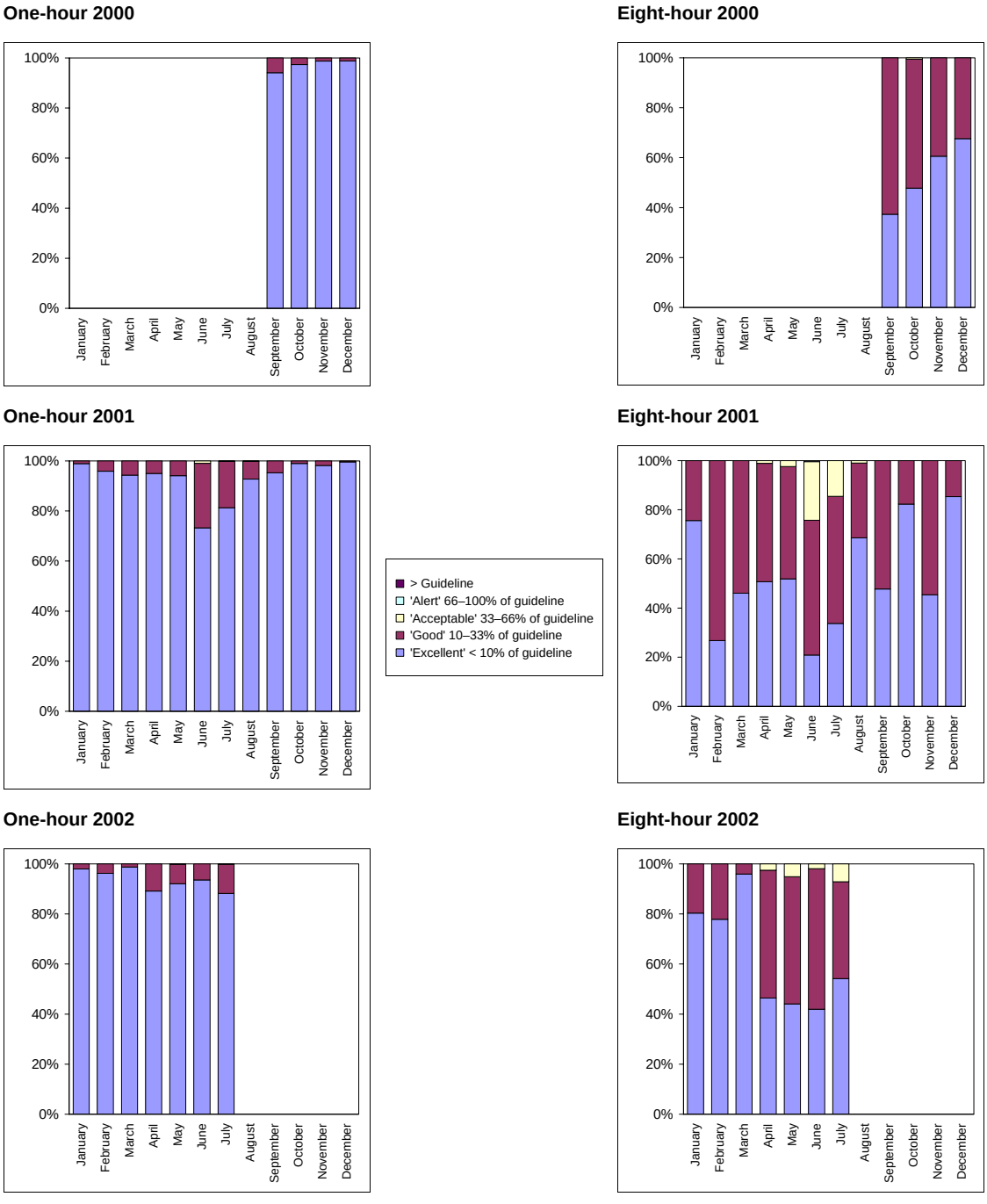
Figure 2.7: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories at Manurewa and Pakuranga, Auckland



2.1.7 Manukau

In addition to monitoring carried out by the Auckland Regional Council, the Manukau City Council has carried out some CO monitoring at a site in Otara. Figure 2.8 shows the majority of the CO concentrations measured at Manukau were in the 'excellent' or 'good' air quality categories.

Figure 2.8: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories at Manukau, Auckland



2.2 Wellington region

Concentrations of CO have been measured in a number of locations in the Wellington region. These include the Civic Centre from March to May 1998, Huia Pool from May 1998 to May 1999, Vivian Street from May to September 1998 and the San Marino apartments from January to September 2002. The summary data for CO monitoring is shown in Table 2.2.

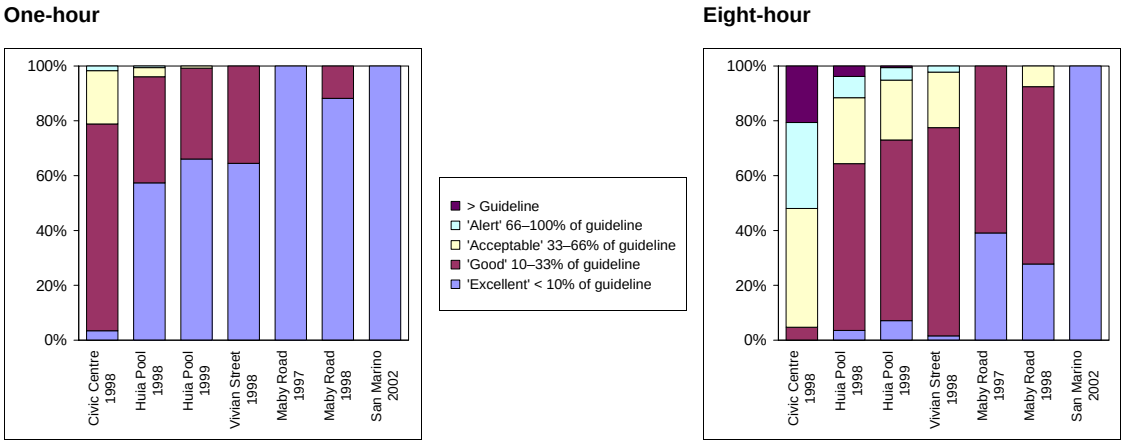
Figure 2.9 shows the percentage of measured one-hour and eight-hour average CO concentrations in each of the air quality categories where data was available for the sites in Wellington and Maby Road in Lower Hutt. It should be noted, however, that the data does not reflect a full calendar year of monitoring.

Table 2.2: Summary data for CO monitoring in Wellington

	Civic Centre 1998	Huia Pool 1998	Huia Pool 1999	Vivian Street 1998	Maby Road 1997	Maby Road 1998	San Marino 2002	Upper Hutt 2000	Upper Hutt 2001	Upper Hutt 2002
One-hour average CO concentrations										
% valid data	16%	59%	39%	62%	15%	9%	62%	42%	80%	2%
% data > 30 mgm^{-3}	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
99.9 %ile mgm^{-3}	26	25	12	9	3	7	1	2	2	0
Maximum mgm^{-3}	26	27	12	10	3	7	1	2	2	0
Eight-hour average CO concentrations										
% valid data	16%	59%	39%	62%	15%	9%	61%	40%	78%	2%
% data > 10 mgm^{-3}	21%	4%	1%	0%	0%	0%	0%	0%	0%	0%
Days > guideline	21	15	4							
99.9 %ile mgm^{-3}	25	25	11	9	3	6	1	2	2	0
Maximum mgm^{-3}	25	26	11	9	3	6	1	2	2	0

	Masterton 1999	Masterton 2000	Birch Lane 2001	Birch Lane 2002
% valid data	27%	23%	32%	30%
% data > 30 mgm^{-3}	0%	0%	0%	0%
99.9 %ile mgm^{-3}	2	1	2	1
Maximum mgm^{-3}	2	1	2	1
Eight-hour average CO concentrations				
% valid data	26%	22%	31%	30%
Hours > 10 mgm^{-3}	0%	0%	0%	0%
99.9 %ile mgm^{-3}	2	1	2	1
Maximum mgm^{-3}	2	1	2	1

Figure 2.9: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories in Wellington



Concentrations of CO that exceed the eight-hour average guideline value were measured at both the Civic Centre and Huia Pool air quality monitoring sites, with the majority of the CO concentrations at the former site greater than 66% of the guideline value. Figure 2.10 shows the percentage of measured eight-hour average CO concentrations within air quality categories for each month of monitoring. This shows seasonal variations in CO concentrations at the Huia Pool site, with guideline value exceedences occurring during the months of April to July only.

Figure 2.10: Percentage of measured eight-hour average CO concentrations within air quality categories at the Civic Centre, Wellington and Huia Pool

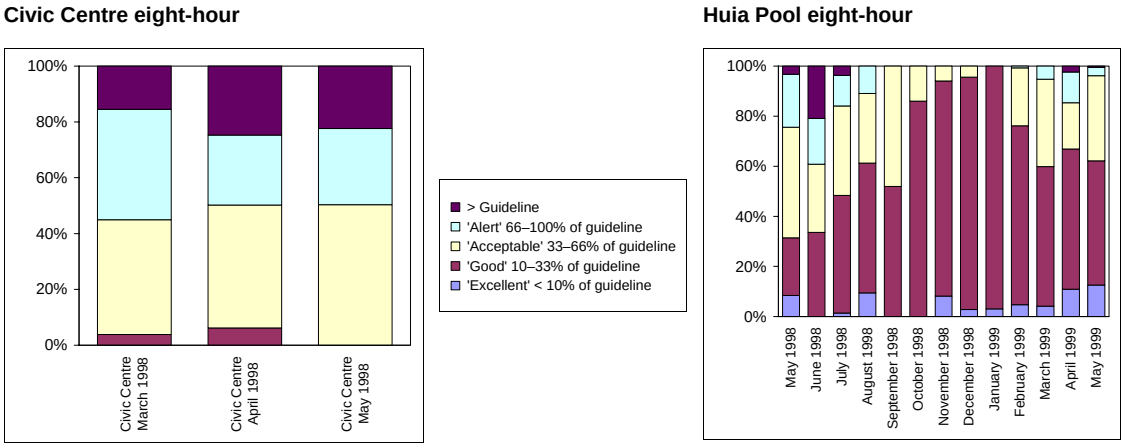
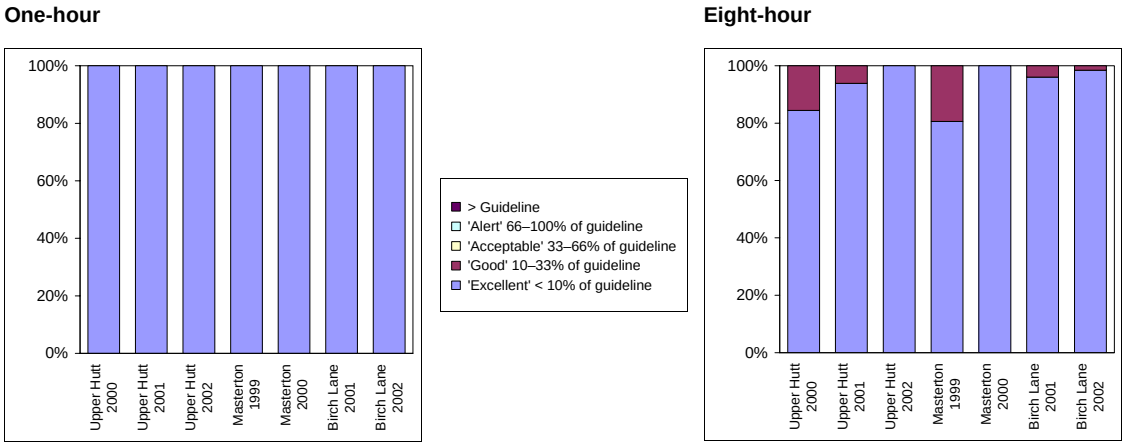


Figure 2.11 shows the concentrations of CO measured at other monitoring sites in the Wellington region within the air quality categories. These data indicate concentrations are typically within the 'excellent' or 'good' air quality categories, with no guideline value exceedences or values above 66% of the guideline value in these areas.

Figure 2.11: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories in Upper Hutt, Lower Hutt and Masterton



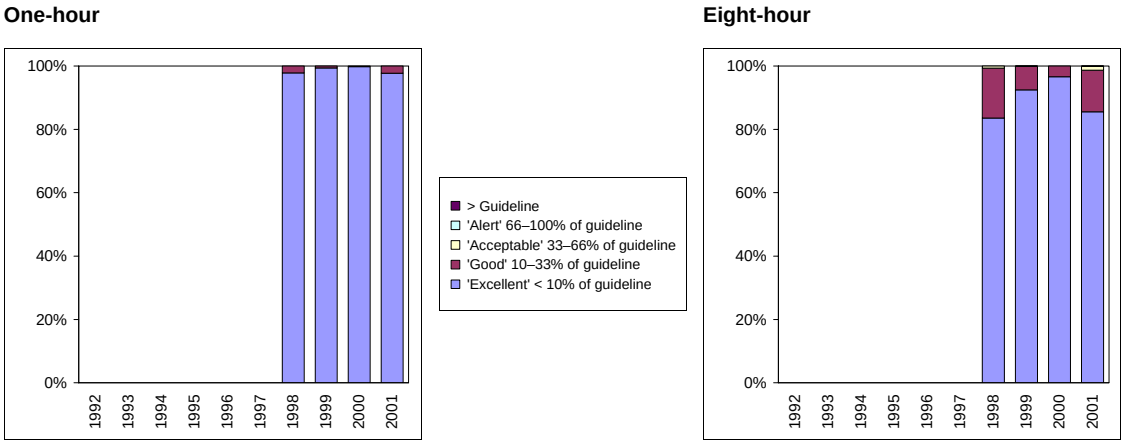
2.3 Hamilton

Air quality monitoring for CO has been carried out at a monitoring site in Peachgrove Road, Hamilton since November 1997. Summary data for CO monitoring at this site are shown in Table 2.3. Figure 2.12 shows the majority of the measured concentrations fall within the 'excellent' air quality category and that no concentrations that are greater than 66% of the guideline value have been recorded. The maximum one-hour and eight-hour average CO concentrations measured between 1998 and 2001 were 9 and 7 mgm^{-3} respectively.

Table 2.3: Summary data for CO monitoring in Hamilton

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
One-hour average CO concentrations										
% valid data							85%	91%	99%	91%
Hours > 30 mgm^{-3}							0	0	0	0
99.9 %ile mgm^{-3}							7	4	4	8
Maximum mgm^{-3}							9	7	5	9
Eight-hour average CO concentrations										
% valid data							84%	91%	99%	91%
Hours > 10 mgm^{-3}							0	0	0	0
99.9 %ile mgm^{-3}							5	3	2	7
Maximum mgm^{-3}							5	4	3	7

Figure 2.12: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories in Hamilton



2.4 Northland region

Monitoring for CO was carried out in Whangarei between June and August 1994 and again during September and October 2000. The site was intended to measure peak CO concentrations at two sites, one residential and another site in the central city. The maximum one-hour average CO concentration measured during 1994 was 30.5 mg/m^3 and the maximum eight-hour average concentration was 15.5 mg/m^3. For the 2000 monitoring period, the maximum one-hour average CO concentration measured was 9.7 mgm^{-3} and the maximum eight-hour average concentration was 6.1 mgm^{-3}.

2.5 Hawkes Bay region

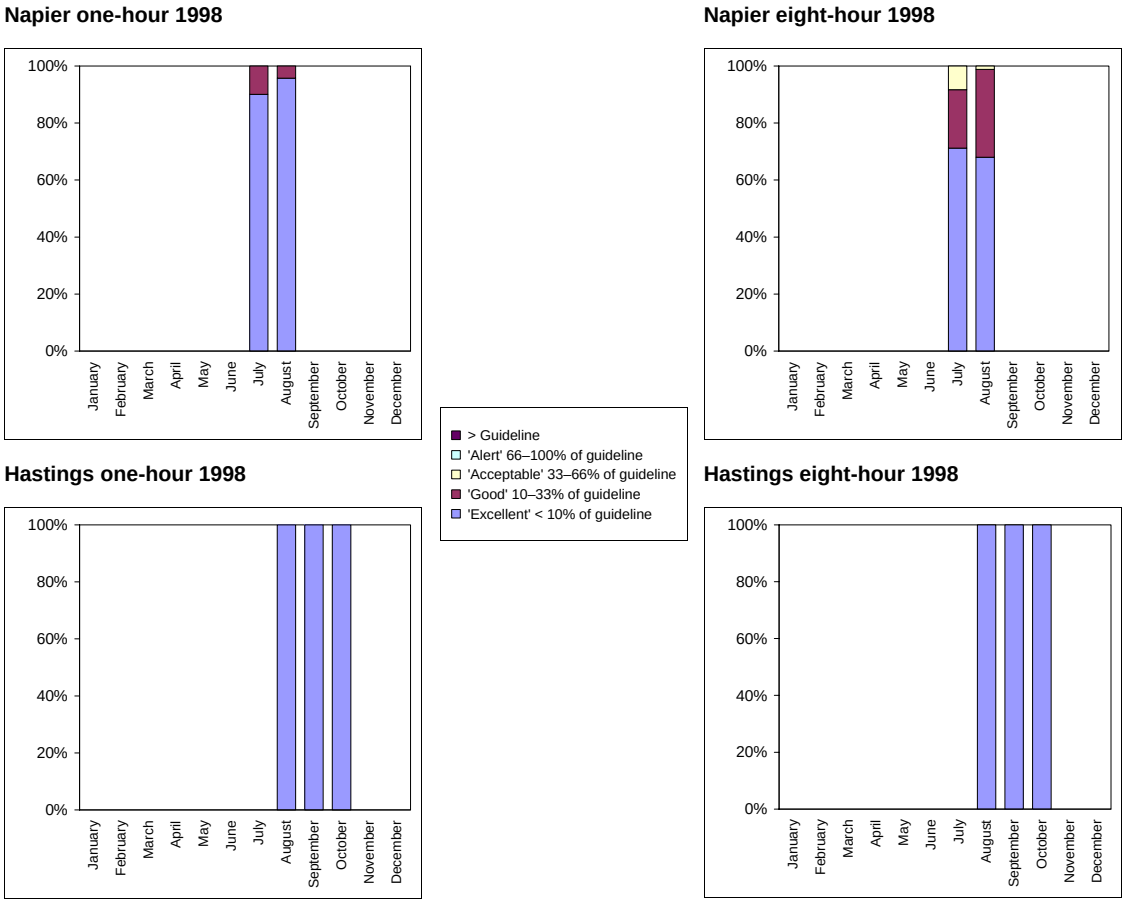
A small amount of monitoring for CO was carried out in Napier and Hastings during the winter and spring of 1998. Summary data for this monitoring is shown in Table 2.4. Figure 2.13 shows the percentage of measured concentrations that are within the air quality categories for each month of monitoring. In Hastings, all CO measured concentrations were less than 10% of the guideline value. Higher concentrations were measured in Napier, with around 8% of the eight-hour average concentrations during July in the 'acceptable' category. No guideline value exceedences were measured at either site.

Table 2.4: Summary data for CO monitoring in the Hawkes Bay region

One-hour average	Hastings 1998	Napier 1998
% valid data	18%	12%
Hours > 30 mgm^{-3}	0	0
99.9 %ile mgm^{-3}	3.7	9
Maximum mgm^{-3}	4.4	9

Eight-hour average	Hastings 1998	Napier 1998
% valid data	18%	11%
Hours > 10 mgm^{-3}	0	0
99.9 %ile mgm^{-3}	2.1	5.3
Maximum mgm^{-3}	2.2	5.4

Figure 2.13: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories in Napier and Hastings



2.6 Bay of Plenty region

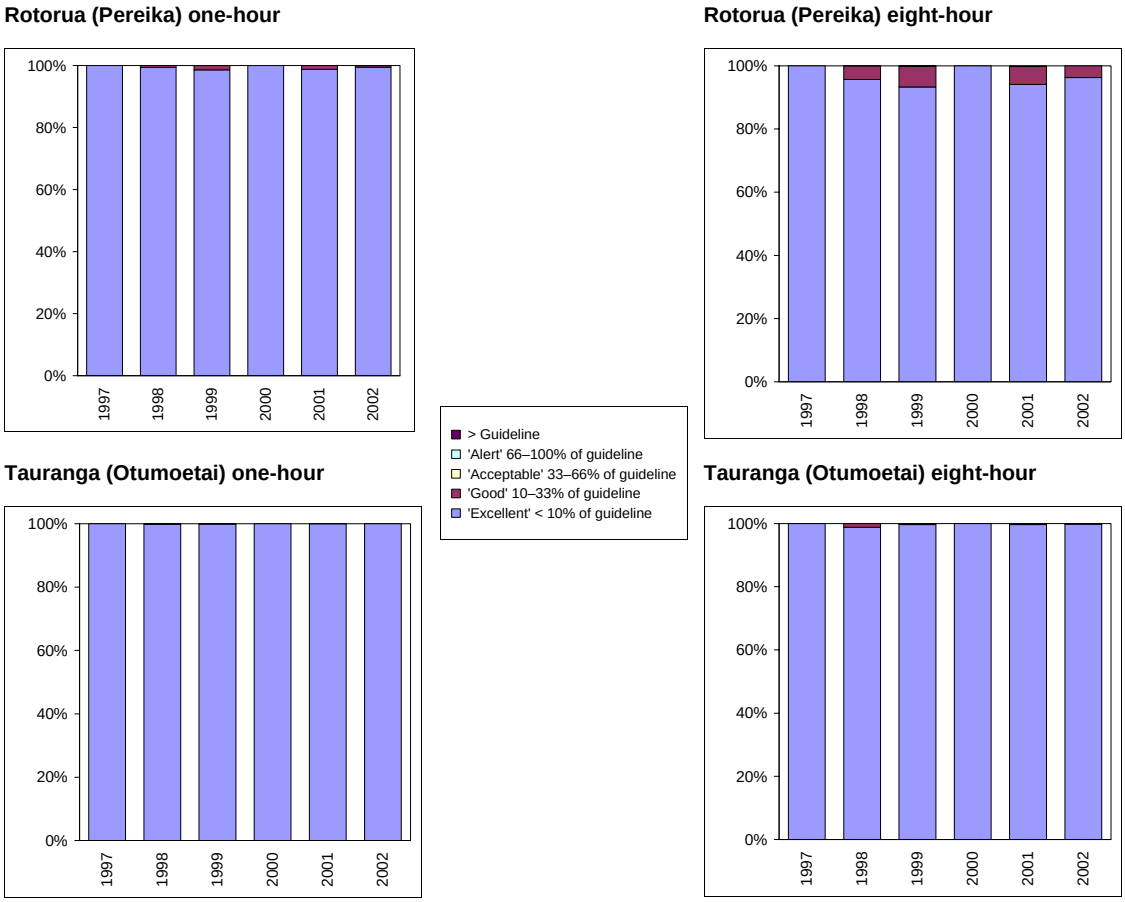
Monitoring of CO in the Bay of Plenty has been carried out in Rotorua and Tauranga. The summary statistics for this monitoring is shown in Table 2.5.

Figure 2.14 shows the percentage of measured concentrations within the air quality categories at the residential neighbourhood sites of Pereika Road in Rotorua and the Otumoetai Road in Tauranga. At both sites, CO concentrations are typically 'excellent' for both the one-hour and eight-hour average concentrations. Concentrations of CO have also been measured at an ambient air quality site in Opotiki during 2002. Figure 2.16 shows all concentrations measured at this site were 'excellent'.

Table 2.5: Summary data for CO monitoring in the Bay of Plenty

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
One-hour average CO concentrations Rotorua (Pereika)										
% valid data				98%		5%	89%	98%	18%	98%
Hours > 30 mgm^{-3}				0		0	0	0	0	0
99.9 %ile mgm^{-3}				3.9		0.3	4.1	4.7	0.3	4.7
Maximum mgm^{-3}				5.8		0.4	5.7	7.1	0.3	6.7
Eight-hour average CO concentrations Rotorua (Pereika)										
% valid data				100%		5%	91%	99%	18%	99%
Hours > 10 mgm^{-3}				0		0	0	0	0	0
99.9 %ile mgm^{-3}				2.5		0.2	2.8	3.4	0.1	3.6
Maximum mgm^{-3}				3.2		0.2	3.6	4.0	0.1	4.6
One-hour average CO concentrations Tauranga (Otumoetai)										
% valid data				97%		7%	67%	63%	18%	87%
Hours > 30 mgm^{-3}				0		0	0	0	0	0
99.9 %ile mgm^{-3}				2.2		0.6	2.9	2.7	0.8	2.7
Maximum mgm^{-3}				3		0.7	4	3.2	1	3
Eight-hour average CO concentrations Tauranga (Otumoetai)										
% valid data				98%		8%	69%	64%	18%	89%
Hours > 10 mgm^{-3}				0		0	0	0	0	0
99.9 %ile mgm^{-3}				1.1		0.2	1.6	1.3	0.3	1.3
Maximum mgm^{-3}				1.4		0.2	1.8	1.4	0.3	2.0
One-hour average CO concentrations Tauranga (Marsh)										
% valid data									77%	96%
Hours > 30 mgm^{-3}									0	0
99.9 %ile mgm^{-3}									5.9	4.9
Maximum mgm^{-3}									9.3	6.7
Eight-hour average CO concentrations Tauranga (Marsh)										
% valid data									80%	97%
Hours > 10 mgm^{-3}									0	0
99.9 %ile mgm^{-3}									4.4	3.6
Maximum mgm^{-3}									4.9	4.6
One-hour average CO concentrations Rotorua (Fenton) and Opotiki										
		Opotiki 2002				**1997**	**1998**	**1999**	**2000**	
% valid data		74%				5%	29%	58%	18%	
Hours > 30 mgm^{-3}		0				0	0	0	0	
99.9 %ile mgm^{-3}		2.1				0.3	5.8	5.5	4.1	
Maximum mgm^{-3}		3.6				0.4	6.4	8.3	6.2	
Eight-hour average CO concentrations Rotorua (Fenton) and Opotiki										
% valid data		77%				5%	30%	61%	18%	
Hours > 10 mgm^{-3}		0				0	0	0	0	
99.9 %ile mgm^{-3}		1.1				0.2	3.7	4.6	2.6	
Maximum mgm^{-3}		1.8				0.2	4.0	5.3	2.7	

Figure 2.14: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories in Rotorua and Tauranga



Concentrations of CO have also been measured at a traffic-peak monitoring site in both Rotorua and Tauranga. Figure 2.15 shows the percentage of CO concentrations within air quality categories measured at these sites by month. The majority of CO concentrations are 'excellent' or 'good', with a small proportion of the eight-hour average concentrations in the 'acceptable' category. No guideline value exceedences were recorded at either site.

Figure 2.15: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories in Rotorua and Tauranga traffic-peak sites

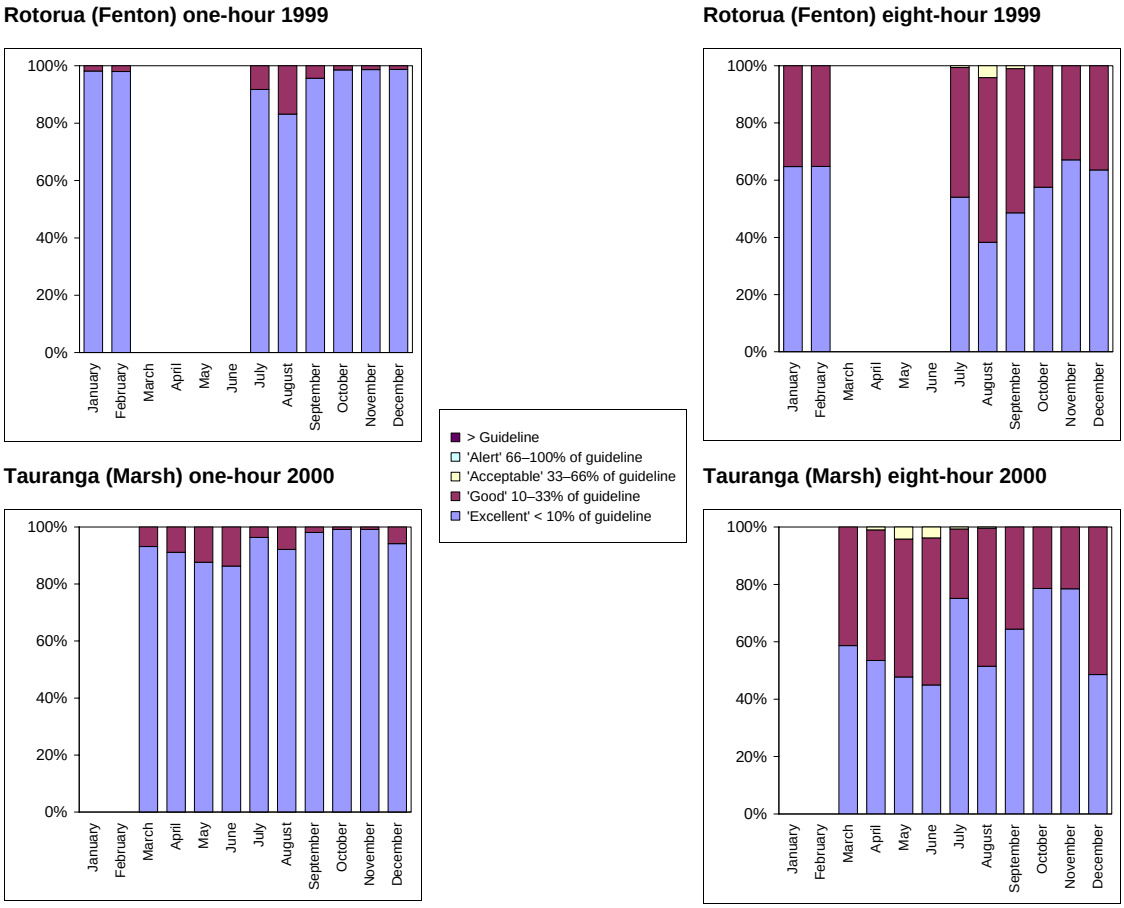
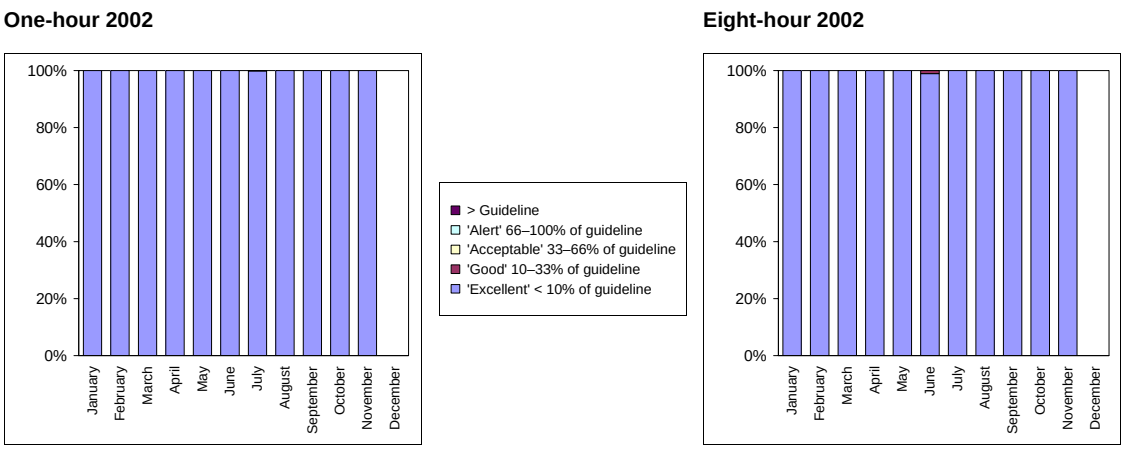


Figure 2.16: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories in Opotiki



2.7 Canterbury region

Air quality monitoring data for CO in the Canterbury region includes measurements for Christchurch from 1988, for Timaru from 1997 and shorter-term monitoring in the areas of Ashburton, Rangiora and Kaiapoi. With the exception of some peak traffic monitoring at selected sites within Christchurch, all CO monitoring sites within the region meet the residential-neighbourhood site classification. Summary data for CO monitoring for ambient air sites in the Canterbury region are shown in Table 2.6.

Table 2.6: Summary data for CO monitoring in the Canterbury region

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
One-hour average CO concentrations, St Albans, Christchurch (Packe Street)										
% valid data	81%	79%	92%	91%	99%	95%	99%	98%	96%	98%
Hours > 30 mgm^{-3}	3	5	7	0	0	0	0	0	0	0
Days > guideline	1	3	3	0	0	0	0	0	0	0
99.9 %ile mgm^{-3}	28	30	26	19	18	21	16	19	14	16
Maximum mgm^{-3}	34	38	41	25	27	27	20	25	20	20
Eight-hour average CO concentrations, St Albans, Christchurch (Packe Street)										
% valid data	80%	78%	92%	91%	98%	95%	99%	98%	96%	98%
Hours > 10 mgm^{-3}	141	103	51	43	30	97	25	67	17	39
Days > guideline	17	13	4	9	7	11	5	12	3	7
99.9 %ile mgm^{-3}	24	20	23	12	12	18	12	17	11	14
Maximum mgm^{-3}	29	22	28	14	20	20	13	21	16	16
One-hour average CO concentrations, St Albans, Christchurch (Coles Place)										
% valid data							41%	87%	100%	99%
Hours > 30 mgm^{-3}							0	0	0	0
99.9 %ile mgm^{-3}							18	16	12	13
Maximum mgm^{-3}							22	21	18	16
Eight-hour average CO concentrations, St Albans, Christchurch (Coles Place)										
% valid data							41%	87%	100%	99%
Hours > 10 mgm^{-3}							77	47	10	13
Days > guideline							9	9	3	3
99.9 %ile mgm^{-3}							13	14	10	10
Maximum mgm^{-3}							14	18	13	12
One-hour average CO concentrations, Beckenham, Christchurch										
% valid data				52%	100%	23%				
Hours > 30 mgm^{-3}				0	0	0				
99.9 %ile mgm^{-3}				10	10	2				
Maximum mgm^{-3}				13	15	4				
Eight-hour average CO concentrations, Beckenham, Christchurch										
% valid data				52%	100%	23%				
Hours > 10 mgm^{-3}				0	0	0				
99.9 %ile mgm^{-3}				8	8	1				
Maximum mgm^{-3}				8	9	1				

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
One-hour average CO concentrations, Hornby, Christchurch										
% valid data				53%	100%	99%	100%	97%	90%	26%
Hours > 30 mgm^{-3}				0	0	0	0	0	0	0
99.9 %ile mgm^{-3}				8	7	8	6	8	7	2
Maximum mgm^{-3}				9	29	12	12	11	9	3
Eight-hour average CO concentrations, Hornby, Christchurch										
% valid data				53%	100%	99%	100%	96%	90%	26%
Hours > 10 mgm^{-3}				0	5	0	0	0	0	0
Days > guideline				0	1	0	0	0	0	0
99.9 %ile mgm^{-3}				6	7	6	4	6	4	1
Maximum mgm^{-3}				7	12	7	5	7	5	1
One-hour average CO concentrations, Ashburton										
% valid data								86%	100%	24%
Hours > 10 mgm^{-3}								0	0	0
99.9 %ile mgm^{-3}								6	5	1
Maximum mgm^{-3}								10	9	1
Eight-hour average CO concentrations, Ashburton										
% valid data								85%	100%	24%
Hours > 10 mgm^{-3}								0	0	0
99.9 %ile mgm^{-3}								3	3	0
Maximum mgm^{-3}								4	4	0
One-hour average CO concentrations, Rangiora										
% valid data								84%	100%	18%
Hours > 30 mgm^{-3}								0	0	0
99.9 %ile mgm^{-3}								6	5	1
Maximum mgm^{-3}								9	9	1
Eight-hour average CO concentrations, Rangiora										
% valid data								84%	100%	18%
Hours > 10 mgm^{-3}								0	0	0
99.9 %ile mgm^{-3}								4	4	0
Maximum mgm^{-3}								4	5	0
One-hour average CO concentrations, Kaiapoi										
% valid data										78%
Hours > 30 mgm^{-3}										0
99.9 %ile mgm^{-3}										7
Maximum mgm^{-3}										9
Eight-hour average CO concentrations, Kaiapoi										
% valid data										78%
Hours > 10 mgm^{-3}										0
99.9 %ile mgm^{-3}										5
Maximum mgm^{-3}										6

2.7.1 Christchurch

Figure 2.17 shows the percentage of measured CO concentrations within air quality categories at the Packe Street and Coles Place monitoring sites in central Christchurch. Results indicate a large proportion of the data are within the 'excellent' or 'good' air quality categories. However, data also shows guideline value exceedences of both the one-hour and eight-hour average CO concentrations. While one-hour average guideline value exceedences are limited to during the years between 1992–1994, the eight-hour guideline value has been exceeded each year from 1988–2001 (Figure 2.18).

Figure 2.17: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories at Packe Street and Coles Place, Christchurch

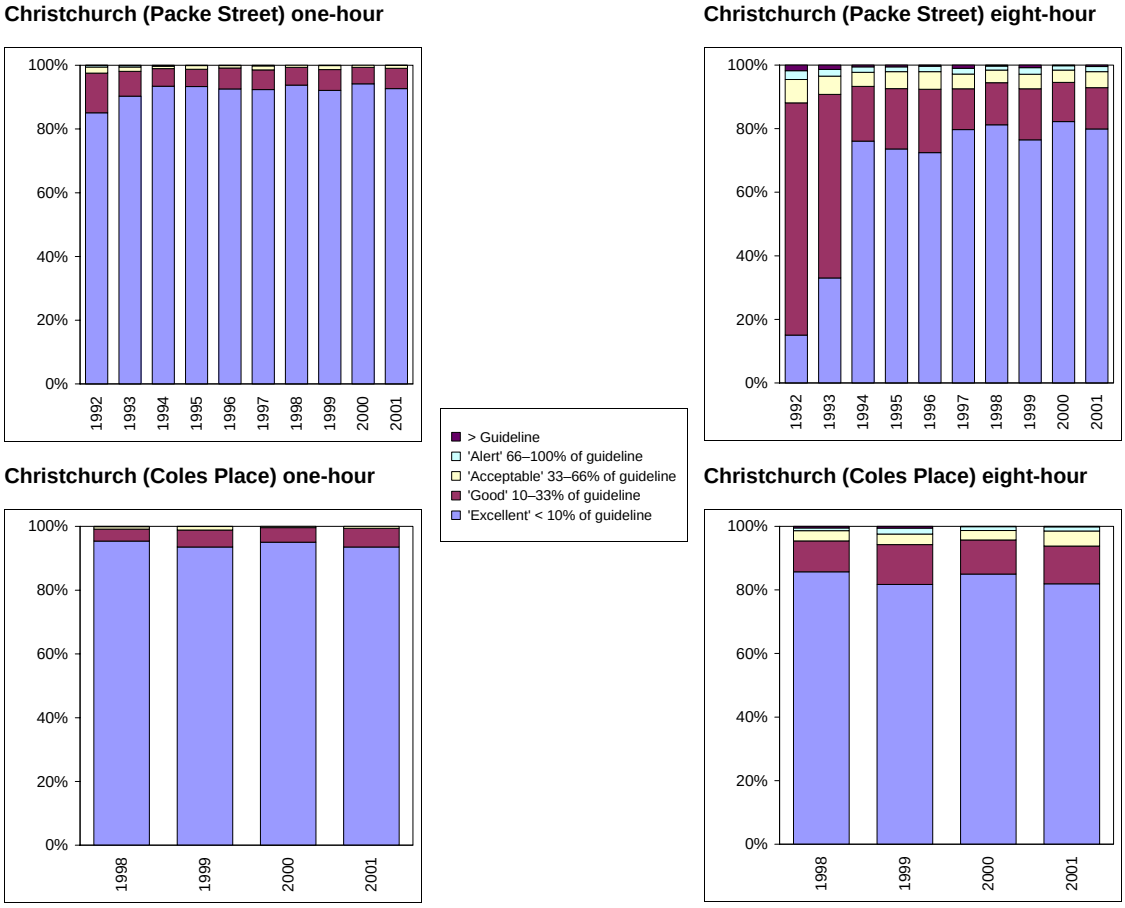
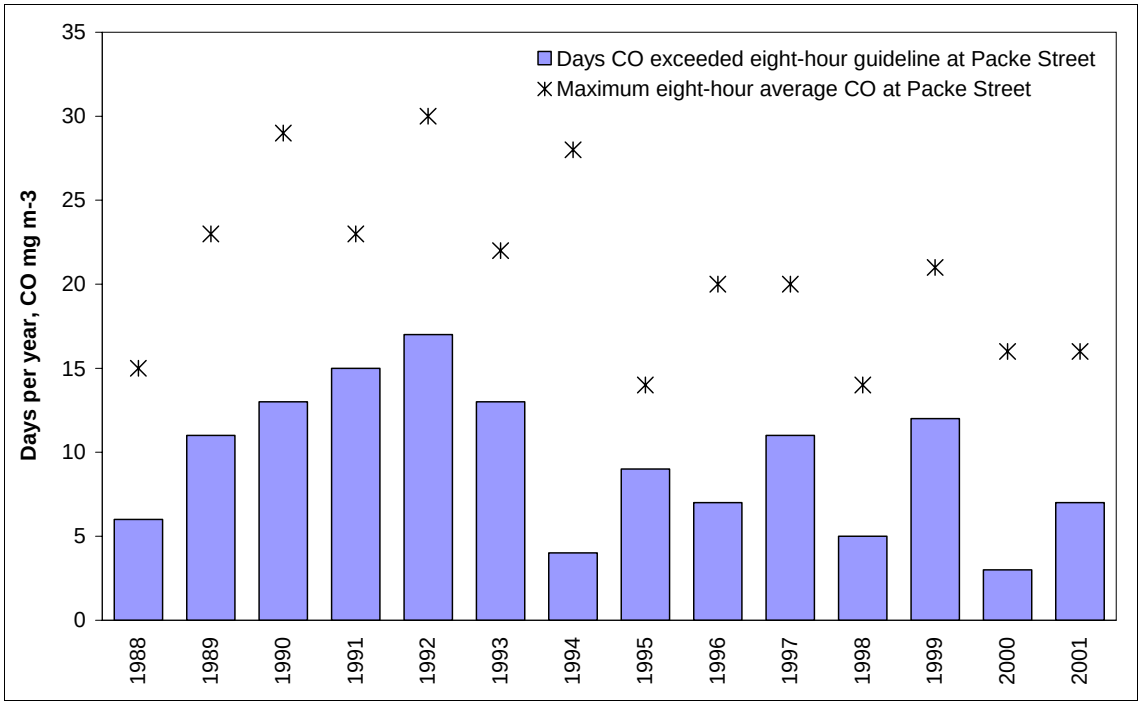
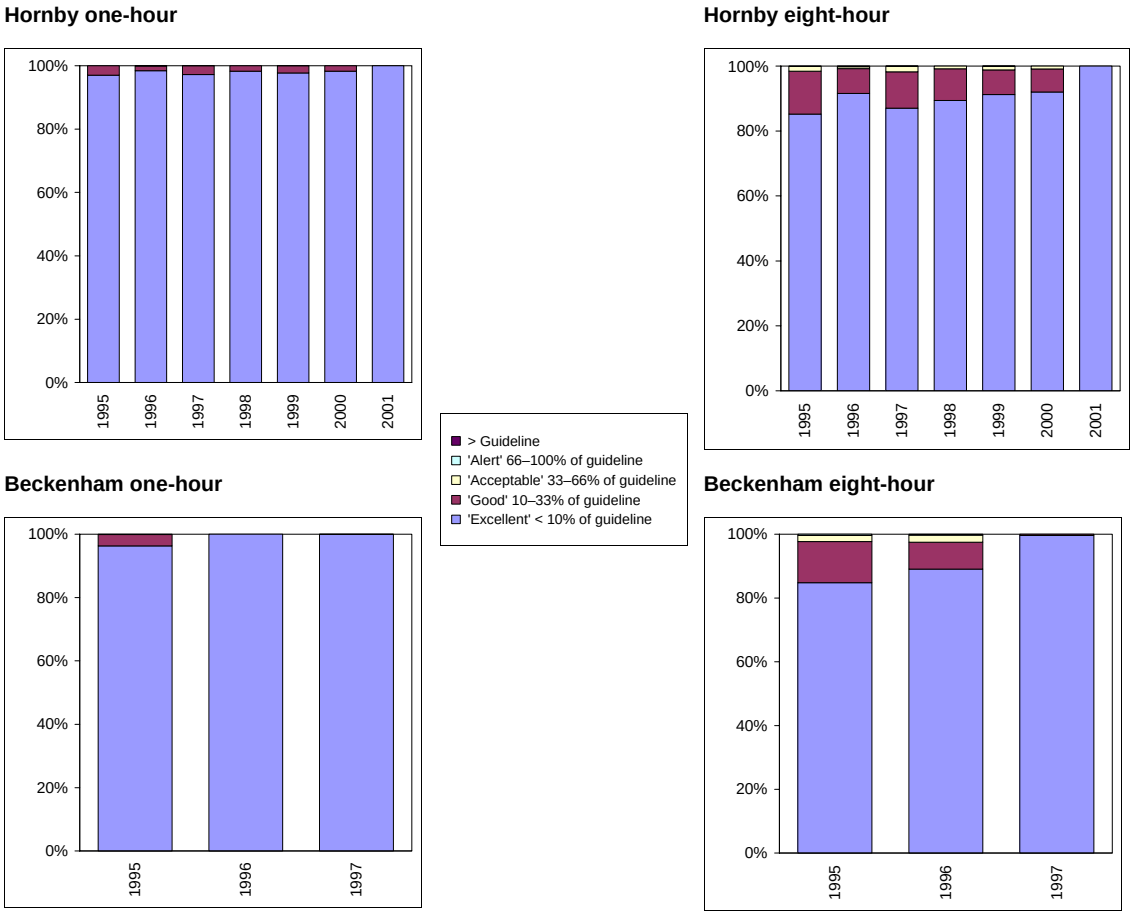


Figure 2.18: Maximum eight-hour average CO concentrations and number of days per year the guideline value was exceeded at Packe Street, Christchurch



Concentrations of CO have also been measured in other locations in Christchurch. Figure 2.19 shows the percentage of measured CO concentrations within air quality categories at Hornby and Beckenham. The majority of the CO concentrations measured at these sites were within the 'excellent' or 'good' air quality categories and no guideline value exceedences were recorded.

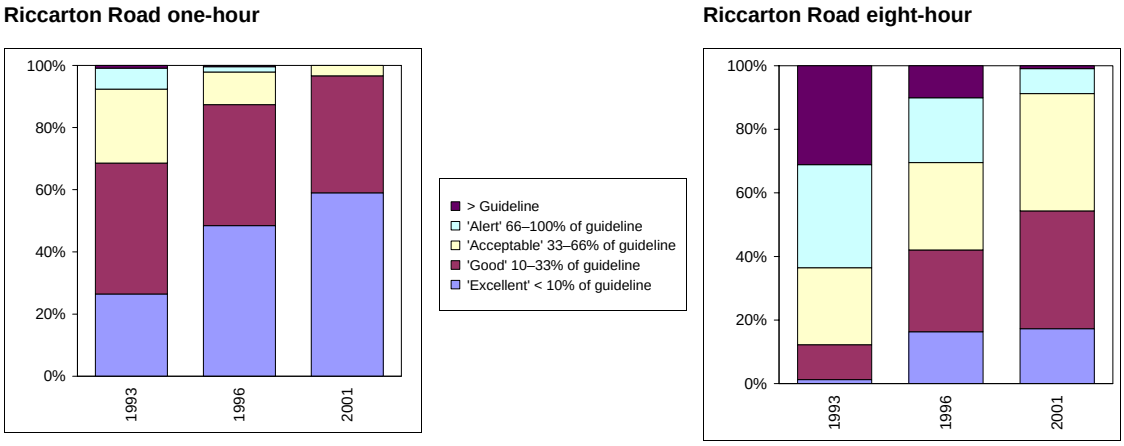
Figure 2.19: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories at Hornby and Beckenham, Christchurch



Concentrations of CO have also been measured in Christchurch at a peak traffic site in Riccarton Road in 1993, 1996 and 2001. The results of all three studies are detailed in the Environment Canterbury Report *Investigations of Street Level Monitoring of Carbon Monoxide in Christchurch* (Gunatilaka, 2002). The monitoring periods were June and July 1993, April to June 1996 and May to September 2001. Figure 2.20 shows the percentage of measured CO concentrations within air quality categories for these studies. Note that differences in the months sampled and in the placement of the sampler mean that the results are not directly comparable between years.

Although eight-hour average concentrations are worse relative to the air quality guideline value, exposure along Riccarton Road for this duration is less likely. The one-hour average guideline value was exceeded during both 1993 and 1996.

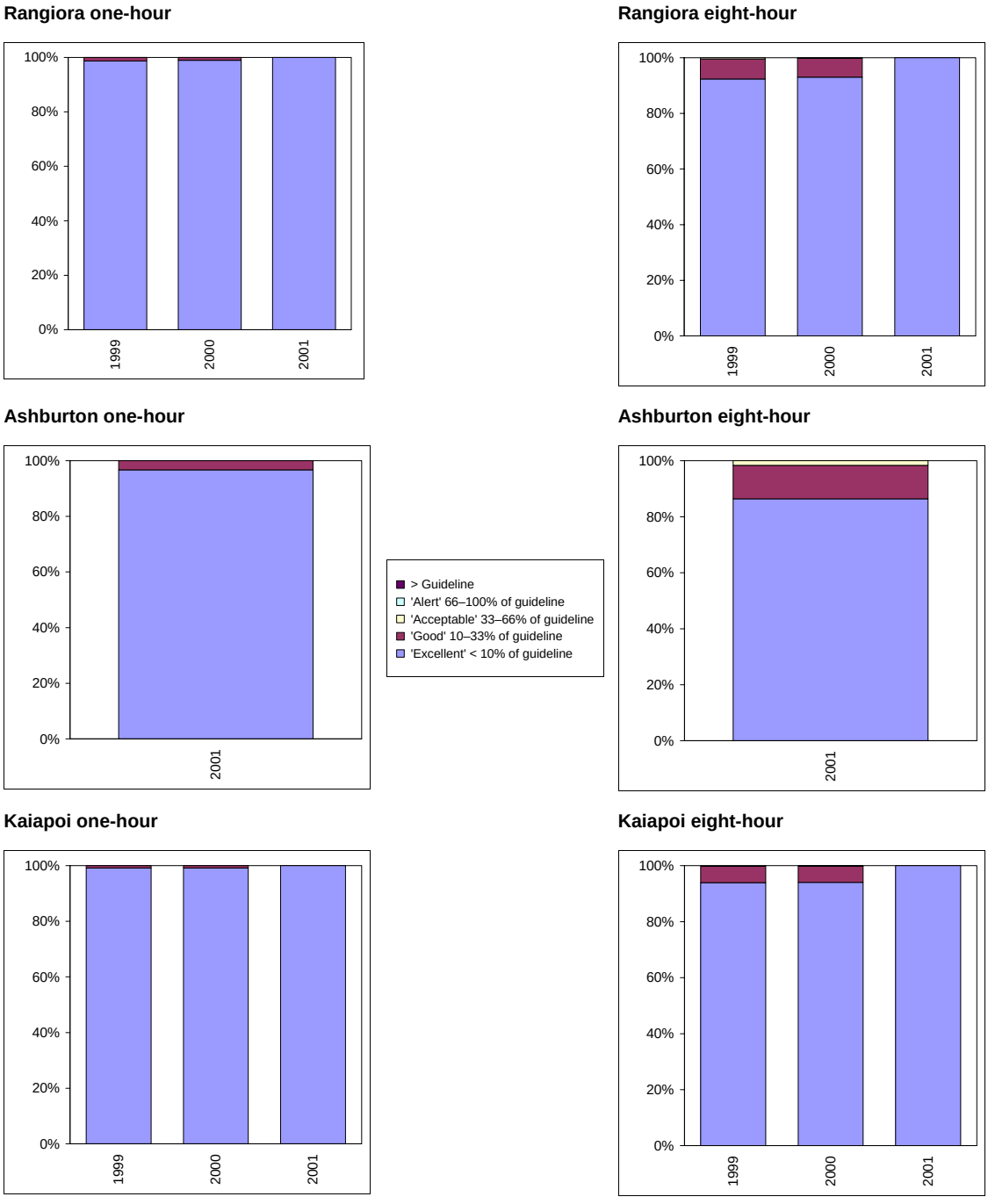
Figure 2.20: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories on Riccarton Road, Christchurch



2.7.2 Ashburton, Rangiora and Kaiapoi

Concentrations of CO measured in Ashburton (1999 to 2001), Rangiora (1999 to 2001), and Kaiapoi (2001) relative to air quality categories are shown in Figure 2.21. The majority of the CO concentrations were less than 33% of the guideline value, with less than 1% of the data being within the 'acceptable' air quality category.

Figure 2.21: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories in Rangiora, Ashburton and Kaiapoi



2.8 Otago region

Concentrations of CO have been measured in Mosgiel in 1999 and 2000 and in Dunedin in 2002. Figure 2.22 shows the percentage of the eight-hour average CO concentrations measured in both Dunedin and Mosgiel were greater than 33% of the air quality guideline value. Both the one-hour and eight-hour average guideline values were exceeded at the latter site, with maximum-measured concentrations of 36 and 11 mgm^{-3} respectively. Figure 2.23 shows the percentage of the monthly eight-hour average CO concentrations within the air quality categories for Dunedin. Some seasonal variations are apparent with higher CO concentrations measured during the winter months. During May and June 2002, about 3–4% of the CO concentrations were within the 'alert' category.

Figure 2.22: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories in Dunedin and Mosgiel

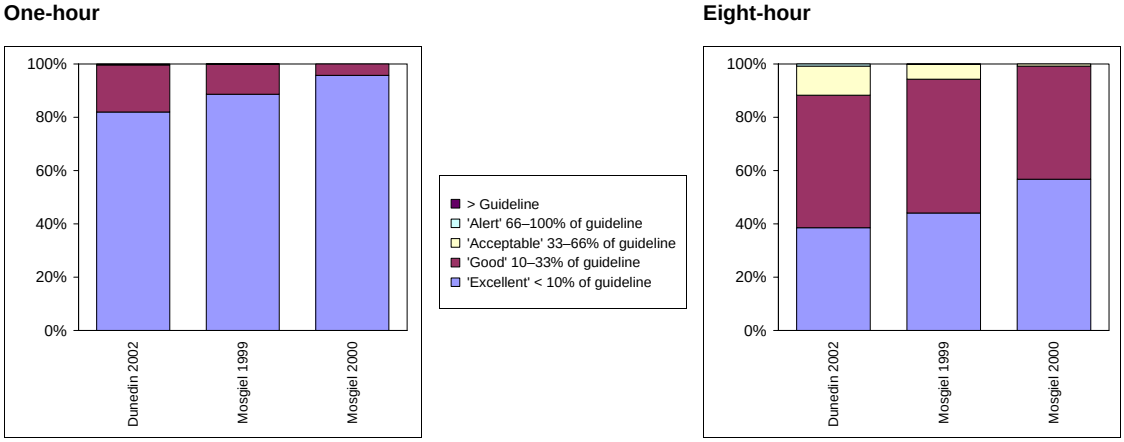
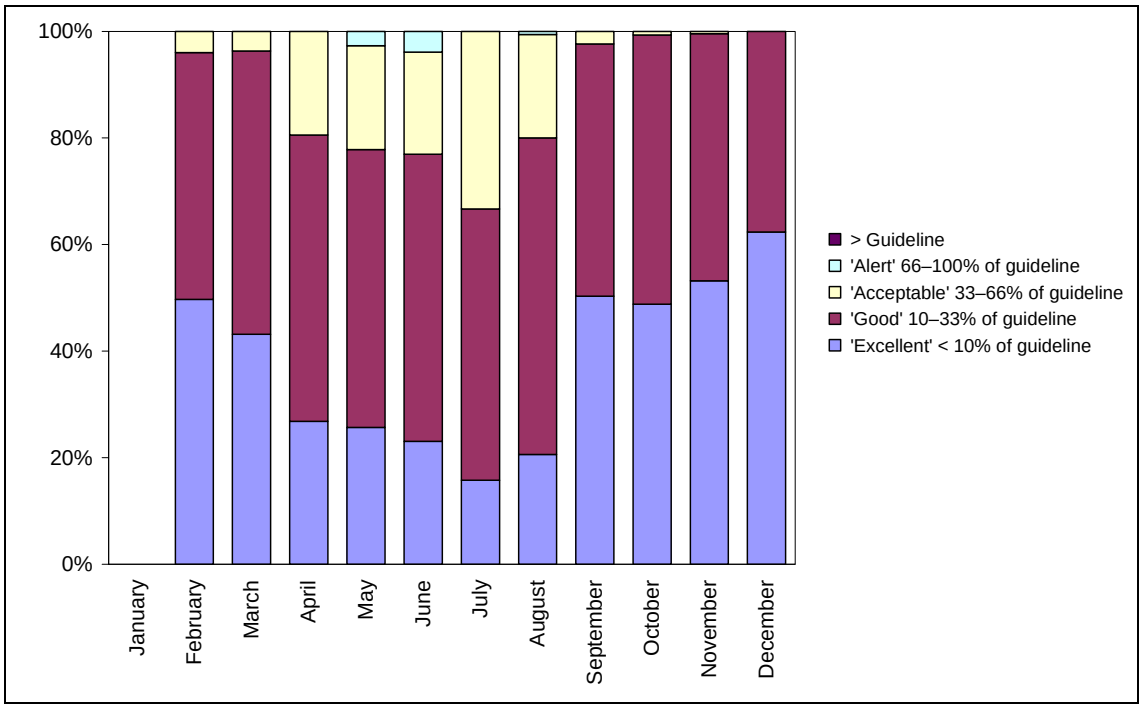


Figure 2.23: Percentage of measured eight-hour average CO concentrations within air quality categories in Dunedin, 2002



2.9 Nelson

Concentrations of CO have been measured in Nelson during both 2001 and 2002. In 2001, CO concentrations were measured at the Victory School monitoring site and at the Hospital monitoring site. Concentrations of CO at the Hospital site were 'excellent' with maximum concentrations of 9 and 5 μgm^{-3} for the one-hour and eight-hour averages respectively (Figure 2.24). Maximum CO concentrations measured at Victory School were within the 'acceptable' and 'good' air quality categories for the eight-hour and one-hour averages respectively for both 2001 and 2002 (Figure 2.25). Summary data for this monitoring is shown in Table 2.7.

Table 2.7: Summary data for CO monitoring in Nelson

One-hour average	Victory School 2001	Victory School 2002	Hospital 2001
% valid data	45%	27%	42%
Hours > 30 mgm^{-3}	0	0	0
99.9 %ile mgm^{-3}	7.8	7.6	7.4
Maximum mgm^{-3}	8.7	8.8	9

Eight-hour average	Victory School 2001	Victory School 2002	Hospital 2001
% valid data	45%	27%	41%
Hours > 10 mgm^{-3}	0	0	0
99.9 %ile mgm^{-3}	4.9	4.0	4.6
Maximum mgm^{-3}	5.0	4.2	5

Figure 2.24: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories in Nelson

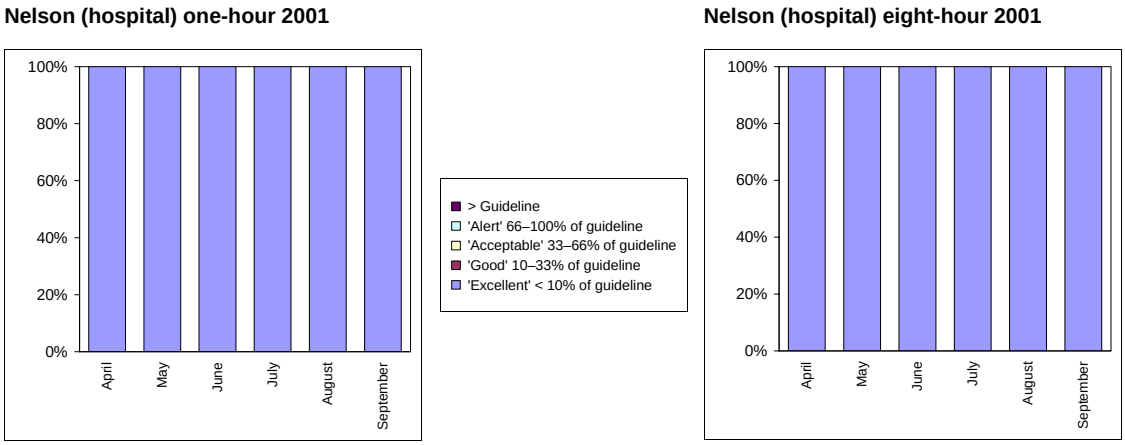
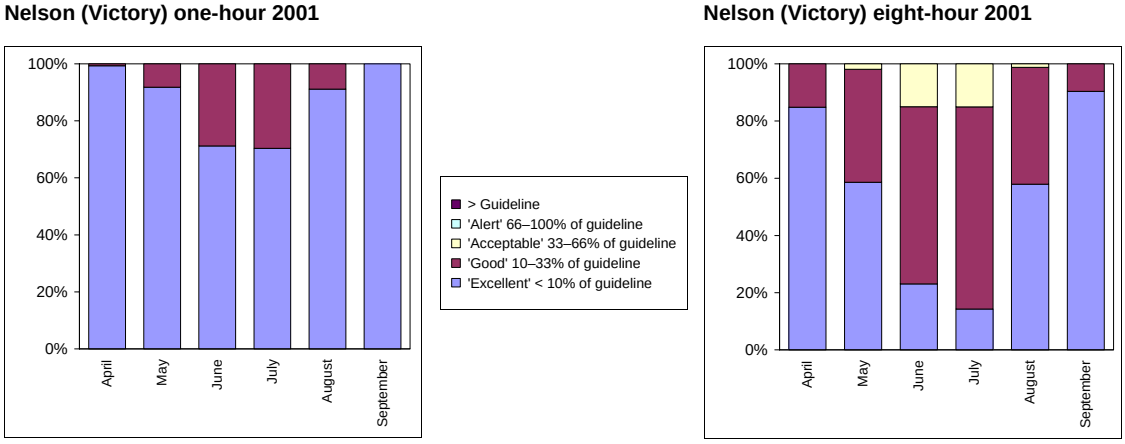
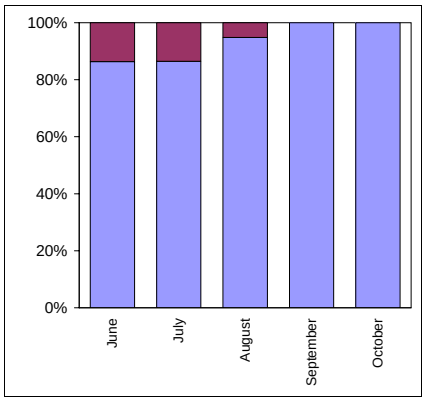


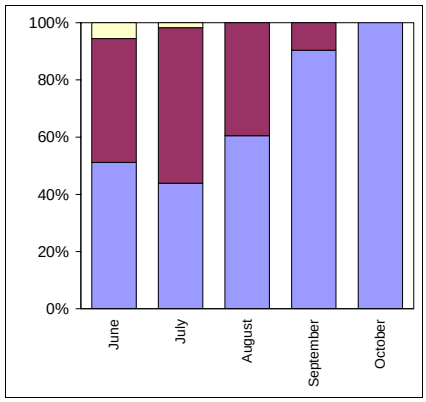
Figure 2.25: Percentage of measured one-hour and eight-hour average CO concentrations within air quality categories at the Victory site in Nelson



Nelson (Victory) one-hour 2002



Nelson (Victory) eight-hour 2002



2.10 Southland

The Ministry for the Environment undertook monitoring of CO in Invercargill and Gore for a period of one month in 1996. The maximum one-hour average CO concentrations in Invercargill and Gore were 15.0 mgm^{-3} and 2.1 mgm^{-3} respectively. These are both within the one-hour average guideline value of 30 μgm^{-3}. The maximum eight-hour average CO concentrations measured at the sites were 8.2 and 1.7 mgm^{-3} respectively.

2.11 Summary of CO concentrations

In most areas of New Zealand, concentrations of CO are within the 'good' or 'excellent' air quality categories for the majority of the time. The main exceptions are found in 'traffic peak' or 'traffic dense' sites such as Khyber Pass Road in Auckland and Riccarton Road in Christchurch. In addition, concentrations of CO in excess of the guideline values have been recorded at the 'residential neighbourhood' St Albans and Hornby monitoring sites in Christchurch and at the Big Fresh monitoring site in Dunedin. Carbon monoxide concentrations have also exceeded guideline values at "traffic" sites in Auckland at Khyber Pass, Queen Street and Dominion Road, in Wellington at the Civic Centre and in Christchurch at Riccarton Road.

3 Nitrogen Oxide (NOx) Emissions

Concentrations of nitrogen dioxide have been measured within a number of urban centres in New Zealand. Results of this monitoring are compared to the following ambient air quality guideline values for New Zealand:

- 200 mgm^{-3} (one-hour average)
- 100 mgm^{-3} (24-hour average).

The recommended monitoring method for nitrogen dioxide in New Zealand is AS3580.5.1 – 1993. This method specifies ozone chemiluminescence. Unless stated otherwise, all data presented in this section are based on monitoring methods that comply with AS3580.5.1 – 1993, which is the recommended method in the *Good Practice Guide for Air Quality Monitoring and Data Management* (MfE, 2000) and is the required method in the *Ambient Air Quality Guidelines* (MfE and MoH, 2002). The former publication also indicates that some measurements of NO_2 in New Zealand are made using passive sampling. Wet chemical methods have also been used in some locations.

3.1 Auckland region

Concentrations of NO_2 have been measured at seven sites in Auckland. These sites and their respective site classifications are:

- Penrose (Gavin Street) Industrial dense
- Mt Eden Residential neighbourhood
- Musick Point Special (remote) regional
- Dominion Road Traffic peak
- Khyber Pass Road Traffic peak
- Penrose (ACI) Industrial dense.

Summary data for each site is shown in Table 3.1.

Table 3.1: Summary data for NO_2 monitoring in Auckland

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
One-hour average NO_2 concentrations, Penrose (ACI) and One Tree Hill (1996)										
% valid data					21%				11%	84%
Hours >200 μgm^{-3}					0				0	0
99.9 %ile mgm^{-3}					53				67	109
Maximum mgm^{-3}					56				68	148
24-hour average NO_2 concentrations, Penrose (ACI) and One Tree Hill (1996)										
% valid data					21%				11%	88%
Days >100 μgm^{-3}					0				0	0
99.9 %ile μgm^{-3}					24				33	59
Maximum μgm^{-3}					25				33	65

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
One-hour average NO_2 concentrations, Dominion Road (1994 and 1995) and Khyber Pass Road										
% valid data			44%	80%			72%	95%	92%	98%
Hours >200 μgm^{-3}			13	0			20	24	20	54
Days exceeded			5	0			14	20	14	28
99.9 %ile mgm^{-3}			204	127			212	212	220	234
Maximum mgm^{-3}			363	162			418	246	434	277
24-hour average NO_2 concentrations, Dominion Road (1994 and 1995) and Khyber Pass Road										
% valid data			43%	76%			71%	93%	90%	95%
Days >100 μgm^{-3}			0	0			29	16	23	19
99.9 %ile μgm^{-3}			80	75			112	114	118	121
Maximum μgm^{-3}			80	76			117	119	122	135
One-hour average NO_2 concentrations, Penrose										
% valid data	92%	99%	77%	90%	89%	97%	99%	91%	89%	87%
Hours >200 μgm^{-3}	0	0	0	0	0	0	0	0	0	7.5
Days exceeded	0	0	0	0	0	0	0	0	0	5
99.9 %ile mgm^{-3}	89	104	59	70	87	78	76	79	86	189
Maximum mgm^{-3}	148	128	67	83	114	97	155	117	170	311
24-hour average NO_2 concentrations, Penrose										
% valid data	92%	98%	74%	89%	87%	97%	99%	90%	88%	86%
Days >100 μgm^{-3}	0	0	0	0	0	0	0	0	0	0
99.9 %ile μgm^{-3}	51	44	41	49	56	46	47	53	54	73
Maximum μgm^{-3}	53	49	44	51	67	68	51	58	57	93
One-hour average NO_2 concentrations, Mt Eden										
% valid data	69%	44%	77%	99%	92%	95%	96%	99%	97%	95%
Hours >200 μgm^{-3}	0	0	0	0	0	0	0	0	0	0
99.9 %ile mgm^{-3}	88	47	110	66	75	65	59	62	60	67
Maximum mgm^{-3}	198	52	144	71	89	85	87	71	77	74
24-hour average NO_2 concentrations, Mt Eden										
% valid data	67%	41%	76%	98%	92%	93%	96%	98%	97%	95%
Days >100 μgm^{-3}	0	0	0	0	0	0	0	0	0	0
99.9 %ile μgm^{-3}	33	31	61	41	45	42	34	40	39	43
Maximum μgm^{-3}	34	31	74	45	48	45	39	45	42	44
One-hour average NO_2 concentrations, Musick Point										
% valid data					32%	79%	59%	72%	71%	95%
Hours >200 μgm^{-3}					0	0	0	0	0	0
99.9 %ile mgm^{-3}					55	70	71	67	64	68
Maximum mgm^{-3}					58	74	137	89	67	76
24-hour average NO_2 concentrations, Musick Point										
% valid data					33%	79%	59%	72%	70%	94%
Days >100 μgm^{-3}					0	0	0	0	0	0
99.9 %ile μgm^{-3}					27	41	39	40	29	42
Maximum μgm^{-3}					29	42	41	45	30	46

Figure 3.1 and Figure 3.2 show the percentage of measured concentrations of NO_2 within air quality categories at these sites. Of all the sites, the highest concentrations were recorded at Khyber Pass Road where a large proportion of the data were within the 'alert' category for 24-our average concentrations. Guideline value exceedences occurred frequently for both the 24-our average and one-hour averaging periods at this site. The one-hour average guideline value has also been exceeded at Dominion Road in 1994 and at the Penrose monitoring site in 2001.

Figure 3.1: Percentage of measured one-hour and 24-hour average NO_2 concentrations within air quality categories at Dominion Road, Khyber Pass Road, One Tree Hill and Penrose (ACI site) in Auckland

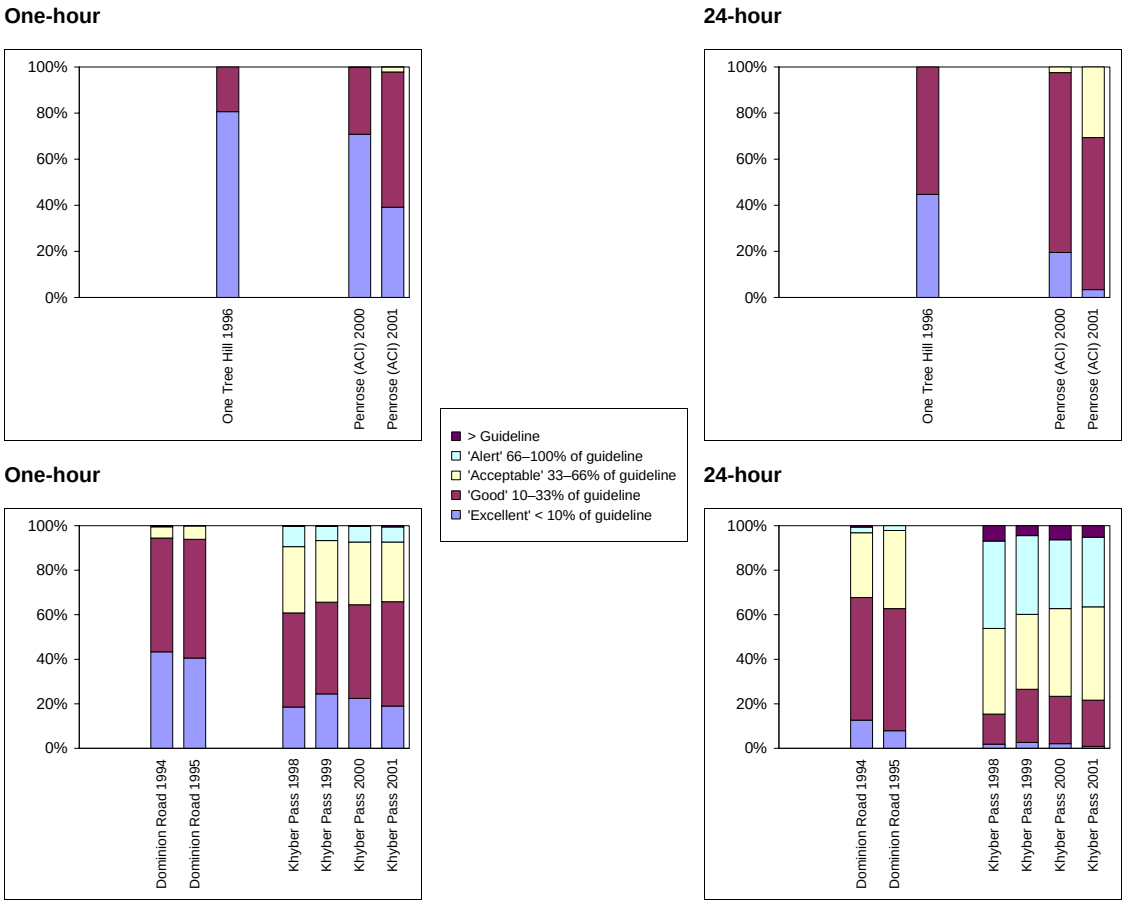
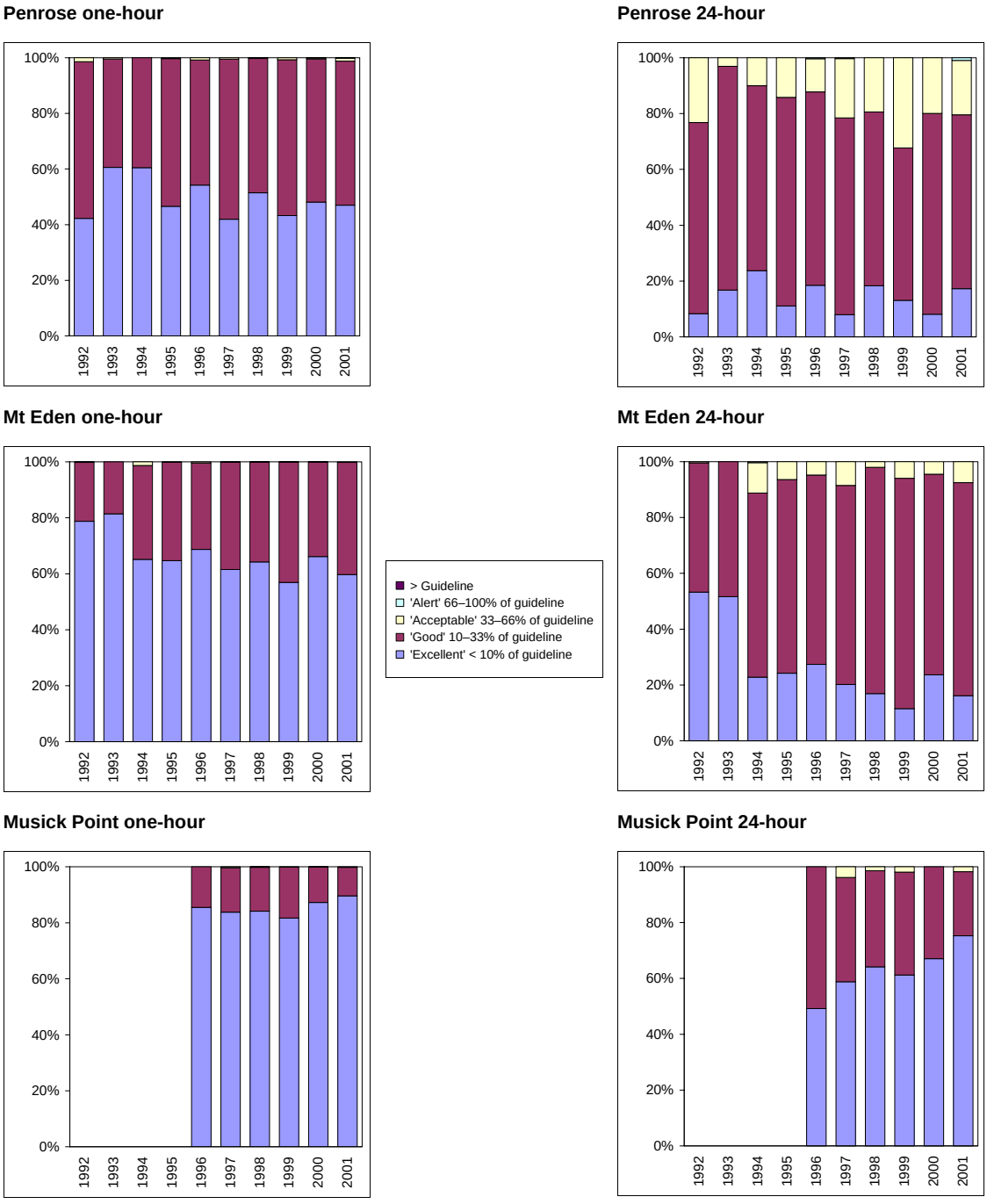


Figure 3.2: Percentage of measured one-hour and 24-hour average NO_2 concentrations within air quality categories at Penrose, Mt Eden and Musick Point in Auckland



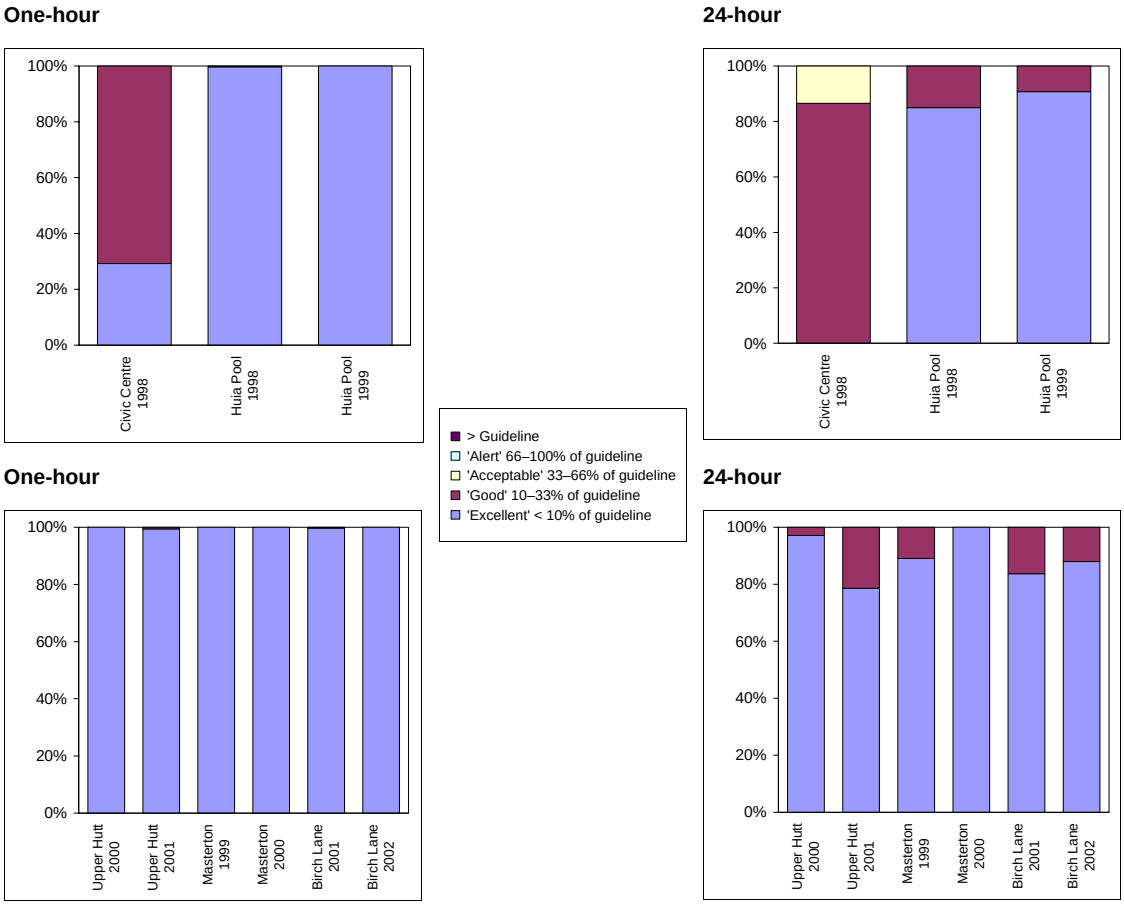
3.2 Wellington region

Concentrations of NO_2 have been measured in the Wellington region since 1998. Initially, monitoring was carried out at the Civic Centre and Huia Pool monitoring sites. Data from these sites indicates NO_2 concentrations are well within the guideline values, with 24-hour average concentrations at the Civic Centre typically being between 10 and 33% of the guideline value (Figure 3.3). Monitoring for NO_2 in Upper Hutt, Lower Hutt and Masterton indicates concentrations are typically within the 'excellent' or 'good' air quality categories. No guideline value exceedences for NO_2 have been measured in the Wellington region.

Table 3.2: Summary data for NO_2 monitoring in the Wellington region

	Civic Centre 1998	Huia Pool 1998	Huia Pool 1999	Upper Hutt 2000	Upper Hutt 2001	Masterton 1999	Masterton 2000	Birch Lane 2001	Birch Lane 2002
One-hour average NO_2 concentrations									
% valid data	16%	54%	39%	57%	68%	43%	34%	38%	57%
% data > 200 μgm^{-3}	0%	0%	0%	0%	0%	0%	0%	0%	0%
99.9 %ile μgm^{-3}	53	22	15	13	21	17	10	21	16
Maximum μgm^{-3}	53	23	15	13	22	17	10	21	17
24-hour average NO_2 concentrations									
% valid data	16%	53%	38%	53%	62%	39%	30%	28%	50%
%data > 100 μgm^{-3}	0%	0%	0%	0%	0%	0%	0%	0%	0%
99.9 %ile μgm^{-3}	50	19	14	11	20	16	10	19	16
Maximum μgm^{-3}	50	19	14	11	20	17	10	20	16

Figure 3.3: Percentage of measured one-hour and 24-hour average NO_2 concentrations within air quality categories in the Wellington region



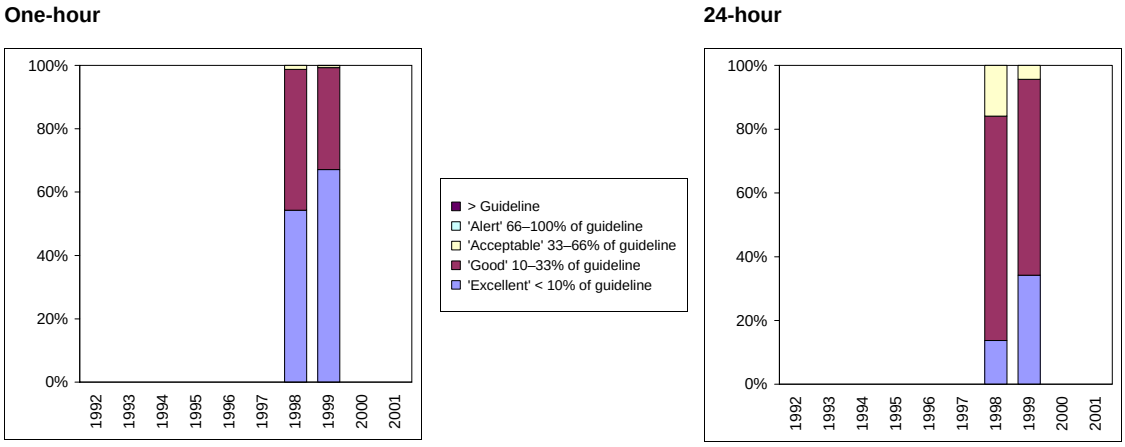
3.3 Hamilton

Air quality monitoring for NO_2 was carried out in Hamilton during 1998 and 1999. Summary data form this site is shown in Table 3.3. Results indicate that while one-hour average concentrations are within the 'excellent' or 'good' air quality categories, a large proportion of the 24-hour average concentrations is greater than 33% of the guideline value (Figure 3.4).

Table 3.3: Summary data for NO_2 monitoring in Hamilton

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
One-hour average NO_2 concentrations										
% valid data							77%	83%		
Hours >200 µgm^{-3}							0	0		
99.9 %ile µgm^{-3}							84	97		
Maximum µgm^{-3}							96	170		
24-hour average NO_2 concentrations										
% valid data							76%	82%		
Days >100 µgm^{-3}							0	0		
99.9 %ile µgm^{-3}							45	37		
Maximum µgm^{-3}							49	61		

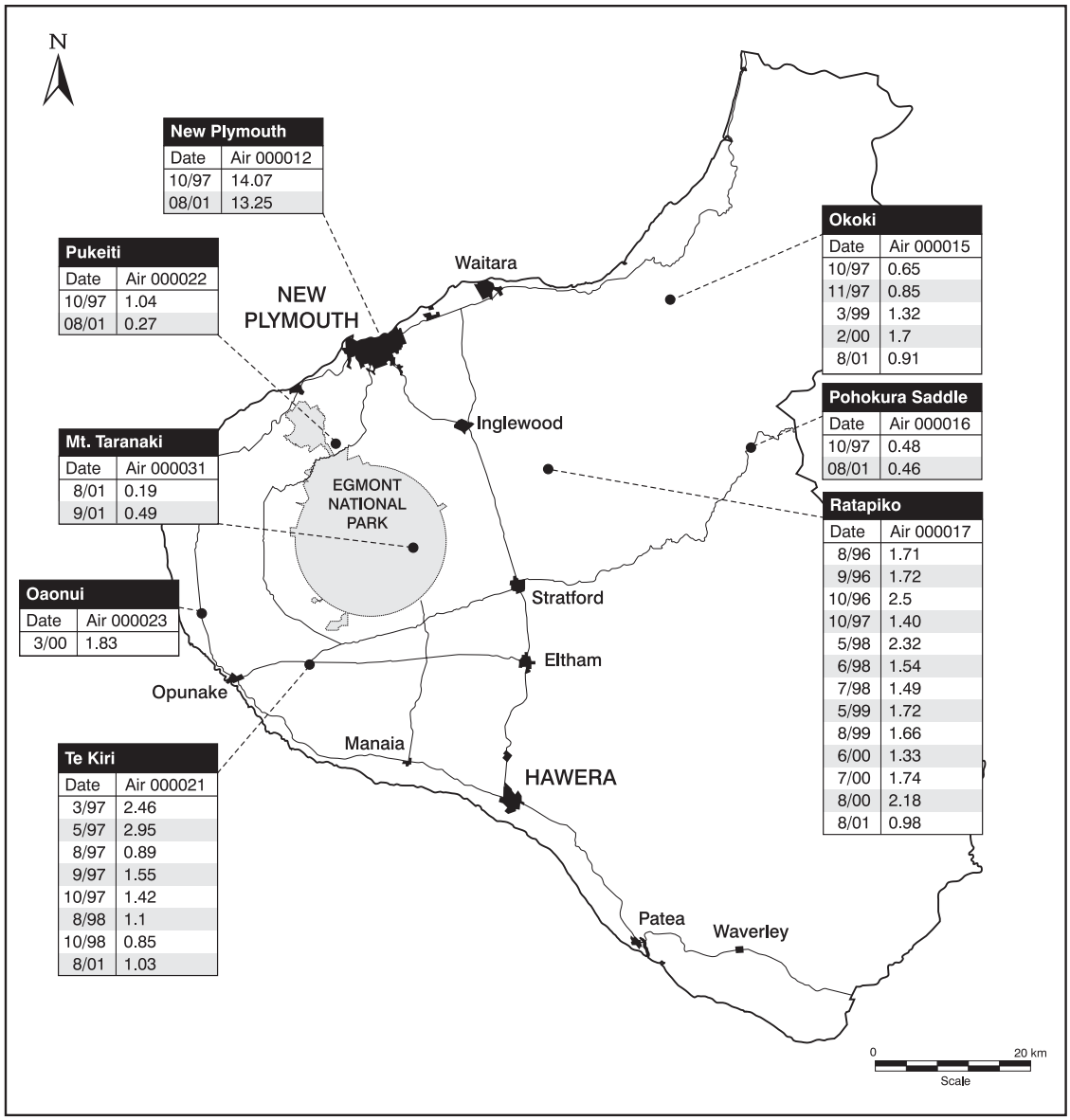
Figure 3.4: Percentage of measured one-hour and 24-hour average NO_2 concentrations within air quality categories in Hamilton



3.4 Taranaki region

Monitoring for NO_2 in Taranaki includes source monitoring of concentrations downwind of major industry from 1996–1998 as well as ambient air quality monitoring during 1997–1998. Additional ambient air quality monitoring for NO_2 was carried out during August 2001. All monitoring was carried out using passive samplers. Results are shown in Figure 3.5. It was not possible to graph the percentage of the measured concentrations within the air quality categories because of the limited number of samples. However, with the exception of the New Plymouth data, which were in the 'good' category, concentrations of NO_2 were within the 'excellent' category (less than 10% of the guideline value).

Figure 3.5: Concentrations of NO_2 measured in Taranaki



Source: TRC, 2002

3.5 Hawkes Bay region

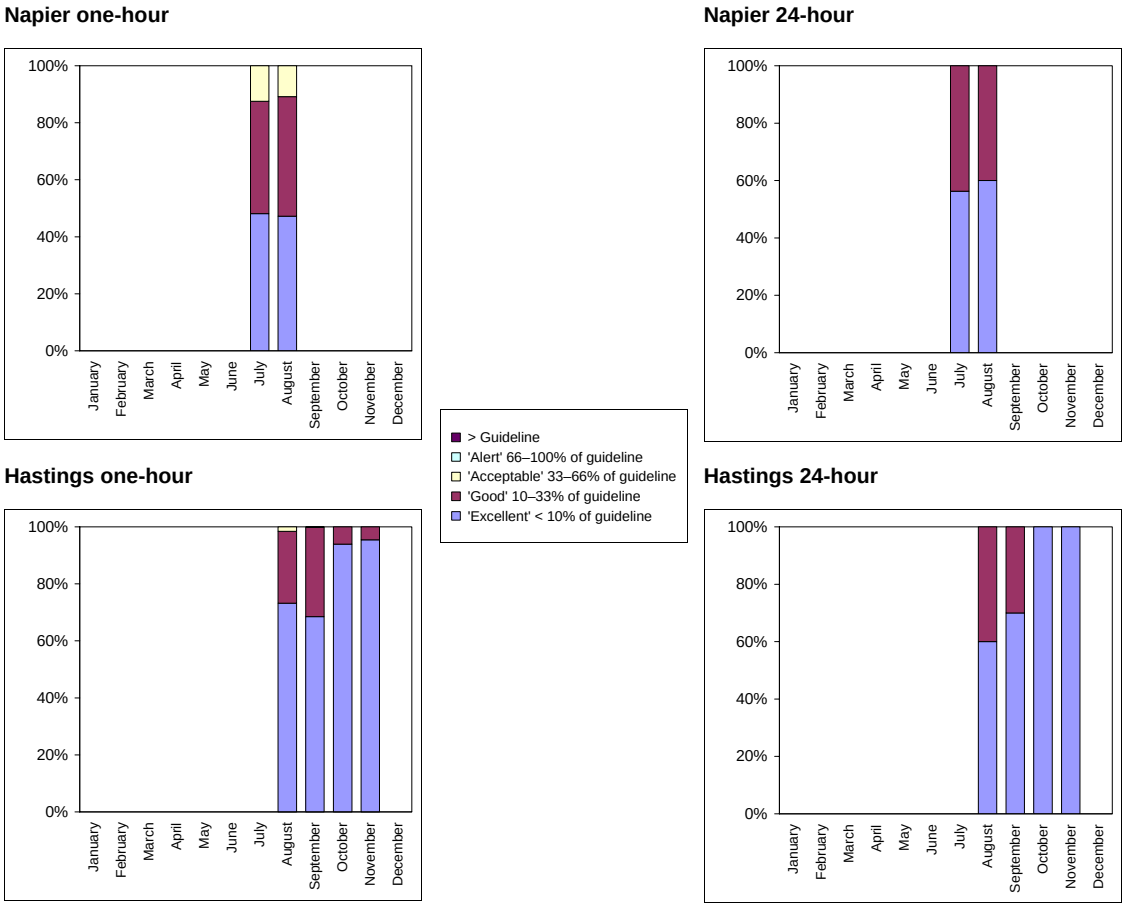
Some monitoring of NO_2 concentrations was carried out in Napier and Hastings during 1998 (Table 3.4). Figure 3.6 shows concentrations of NO_2 in these areas are generally 'excellent' or 'good', although the one-hour average NO_2 concentrations in Napier show some slightly elevated levels with about 12% of the data between 33% and 66% of the guideline value.

Table 3.4: Summary data for NO_2 monitoring in Hawkes Bay

One-hour average	Hastings 1998	Napier 1998
% valid data	18%	12%
Hours>200 µgm^{-3}	0	0
99.9 %ile µgm^{-3}	34	63
Maximum µgm^{-3}	36	66

24-hour average	Hastings 1998	Napier 1998
% valid data	18%	11%
Days>100 µgm^{-3}	0	0
99.9 %ile µgm^{-3}	13	28
Maximum µgm^{-3}	13	28

Figure 3.6: Percentage of measured one-hour and 24-hour average NO_2 concentrations within air quality categories in Napier and Hastings, 1998



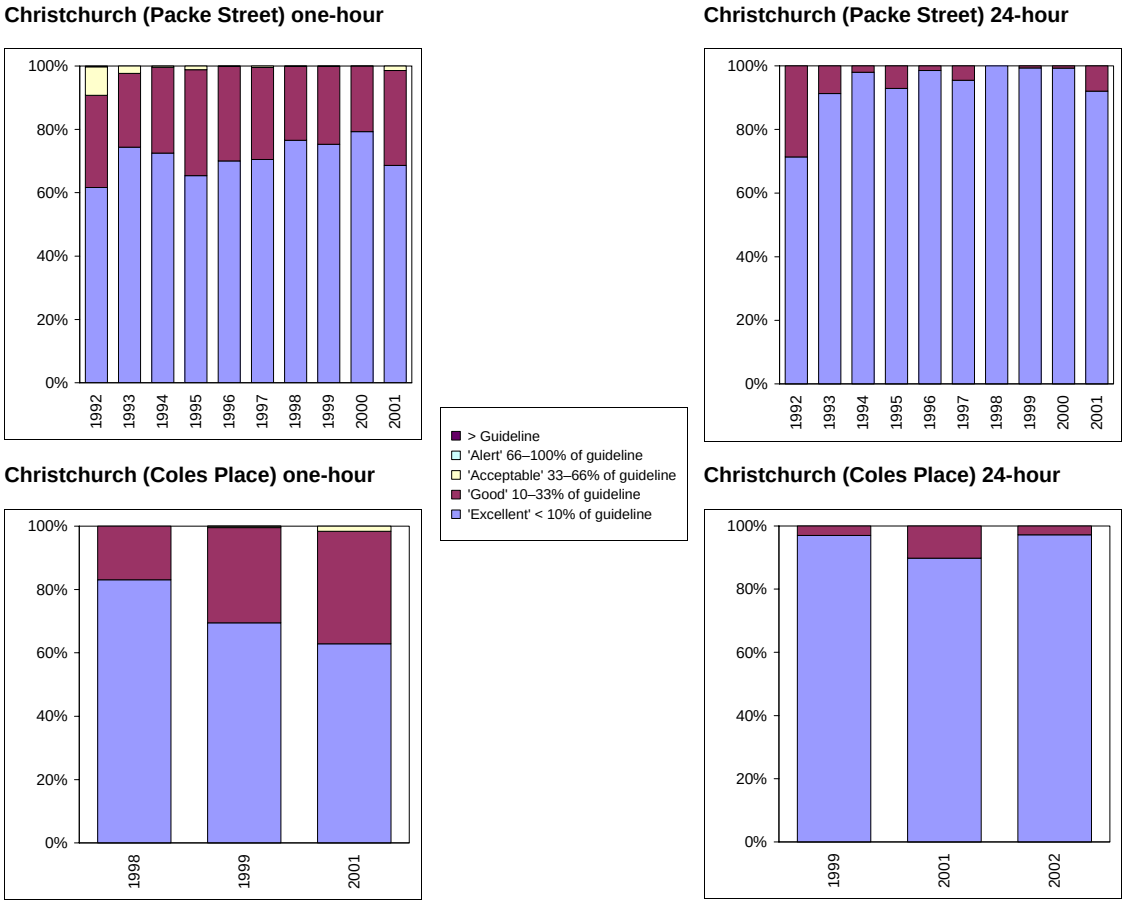
3.6 Canterbury region

Concentrations of NO_2 in Canterbury are limited to measurements in central Christchurch at the Packe Street and Coles Place monitoring sites (Table 3.5). Concentrations of NO_2 at these sites are generally within the 'excellent' or 'good' air quality categories, although some one-hour average concentrations during 1992 and 1993 were within the 'acceptable' category (Figure 3.7).

Table 3.5: Summary data for NO_2 monitoring in Christchurch

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
One-hour average NO_2 concentrations (Packe Street)										
% valid data	68%	65%	57%	84%	98%	98%	94%	92%	82%	97%
Hours >200 μgm^{-3}	0	0	0	0	0	0	0	0	0	0
99.9 %ile μgm^{-3}	149	113	77	88	67	91	65	66	62	92
Maximum μgm^{-3}	162	124	85	132	200	119	93	112	108	106
24-hour average NO_2 concentrations, St Albans (Packe Street)										
% valid data	64%	63%	55%	77%	94%	97%	93%	90%	80%	96%
Days >100 μgm^{-3}	0	0	0	0	0	0	0	0	0	0
99.5 %ile μgm^{-3}	75	50	39	46	40	45	33	35	34	48
Maximum μgm^{-3}	89	54	43	51	41	50	34	37	37	52
One-hour average NO_2 concentrations, St Albans (Coles Place)										
% valid data							42%	92%	6%	55%
Hours >200 μgm^{-3}							0	0		0
99.9 %ile μgm^{-3}							49	97		93
Maximum μgm^{-3}							61	161		110
24-hour average NO_2 concentrations, St Albans (Coles Place)										
% valid data							42%	91%	6%	54%
Days > 100 μgm^{-3}							0	0	0	0
99.5 %ile μgm^{-3}							26	44		46
Maximum μgm^{-3}							30	54		46

Figure 3.7: Percentage of measured one-hour and 24-hour average NO_2 concentrations within air quality categories at Packe Street and Coles Place, Christchurch



3.7 Otago region

Air quality monitoring of NO_2 concentrations in the Otago region are limited to a small number of 24-hour samples measured using wet chemical methods. Table 3.6 shows the results of this monitoring, which was carried out from 1997 to 1999. No graphical analysis was applied to the data owing to the limited number of samples. Results suggest that on the days monitored, NO_2 concentrations were much less than the 24-hour average NO_2 guideline value. Note, however, that the measurement method used does not comply with existing recommended monitoring methods and is likely to be indicative only.

Table 3.6: Concentrations of NO_2 measured in Otago (wet chemical)

Albany Street Dunedin 24-hour NO_2					
1997	**µgm^{-3}**	**1998**	**µgm^{-3}**	**1999**	**µgm^{-3}**
05 June 1997	11	12 June 1998	30	01 June 1999	17
11 June 1997	2	18 June 1998	23	07 June 1999	21
17 June 1997	6	24 June 1998	20	19 June 1999	25
11 July 1997	11	30 June 1998	30	25 June 1999	20
17 July 1997	20	06 July 1998	18	01 July 1999	25
23 July 1997	11	18 July 1998	15	07 July 1999	25
29 July 1997	3	24 July 1998	18	13 July 1999	20
04 August 1997	8	30 July 1998	24	19 July 1999	23
10 August 1997	5	05 August 1998	27	25 July 1999	20
22 August 1997	1	11 August 1998	25	31 July 1999	12
		17 August 1998	12	06 August 1999	21
		23 August 1998	14	12 August 1999	29
				18 August 1999	23
				24 August 1999	10
				30 August 1999	24

3.8 Nelson

Air quality monitoring for NO_2 in Nelson was carried out at the hospital and fire station air quality monitoring sites during 2001 and at the Victory School site during 2002. Summary data from this monitoring is shown in Table 3.7. Figure 3.8 shows the results of monitoring at the hospital and fire station air quality monitoring sites. Although no guideline value exceedences were measured, a small proportion of both the one-hour and 24-hour average NO_2 concentrations were within the 'alert' air quality category at the fire station site. In 2002, the NO_2 monitoring carried out at the Victory School site showed concentrations were generally within the 'excellent' or 'good' air quality categories (Figure 3.9).

Table 3.7: Summary data for NO_2 monitoring in Nelson

	Hospital	**Fire station**	**Victory School**
One-hour average	2001	2001	2002
% valid data	40%	32%	26%
Hours > 200 µgm^{-3}	0	0	0
99.9 %ile µgm^{-3}	53	127	37
Maximum µgm^{-3}	63	148	41

	Hospital	**Fire station**	**Victory School**
24-hour average	2001	2001	2002
% valid data	40%	42%	27%
No. > 100 µgm^{-3}	0	0	0
99.9 %ile µgm^{-3}	29	87	15
Maximum µgm^{-3}	31	117	15

Figure 3.8: Percentage of measured one-hour and 24-hour average NO_2 concentrations within air quality categories at the hospital and fire station sites in Nelson, 2001

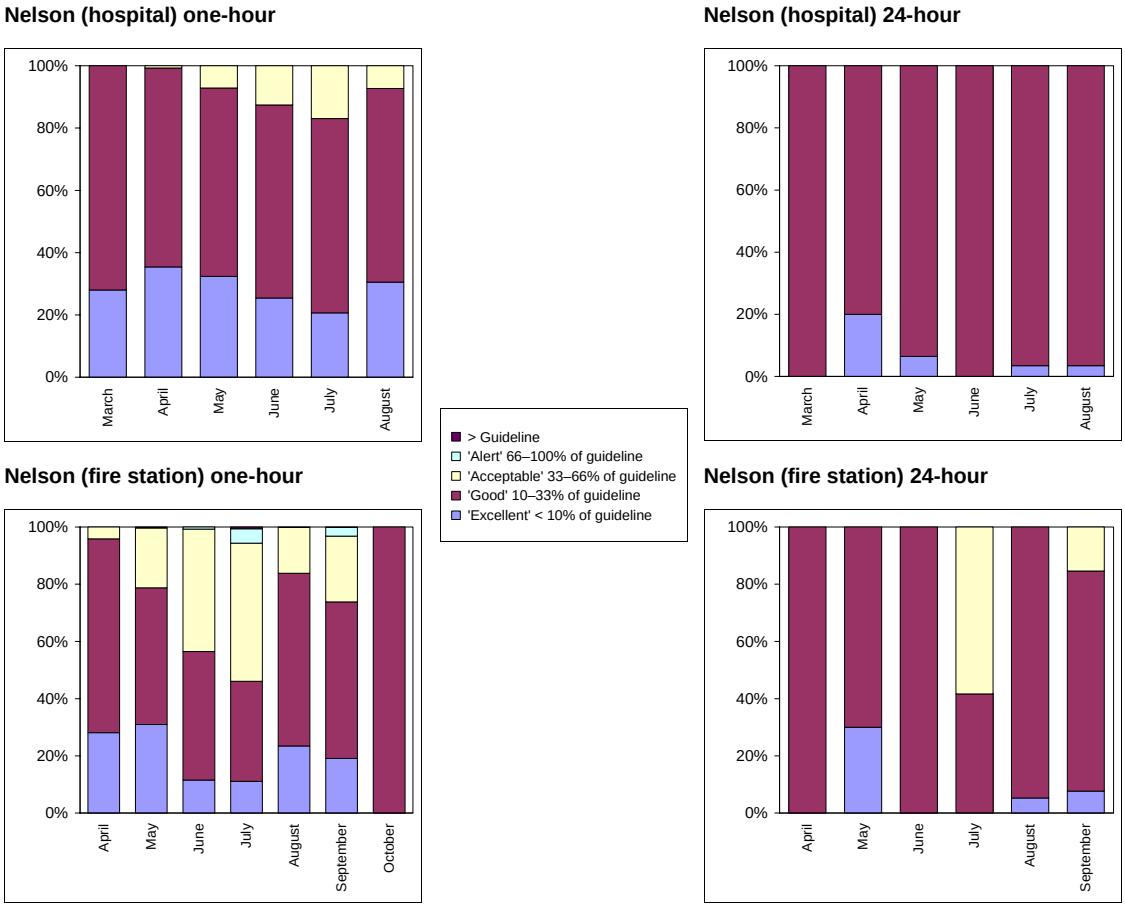
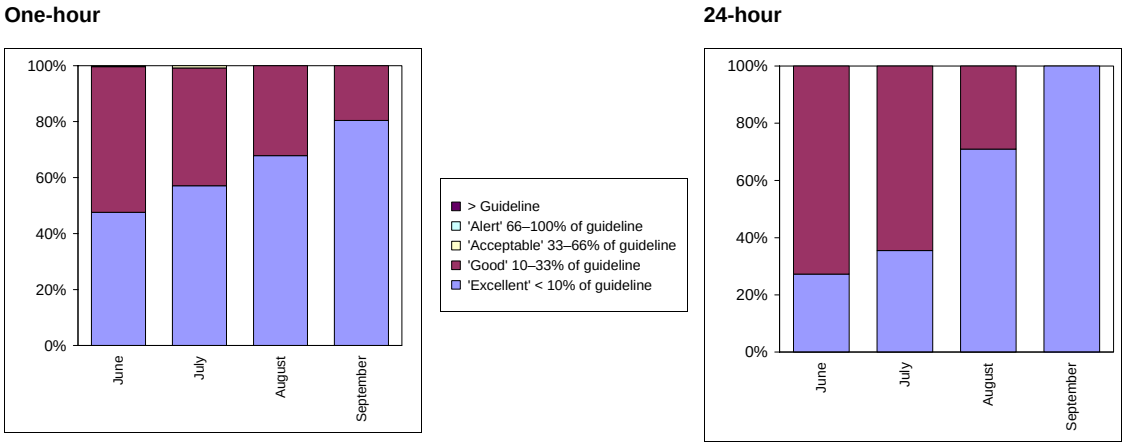


Figure 3.9: The percentage of measured one-hour and 24-hour average NO_2 concentrations within air quality categories at the Victory School site in Nelson, 2002



3.9 Summary of NO_2 concentrations

Concentrations of NO_2 are typically 'excellent' or 'good' the majority of the time at most air quality monitoring sites in New Zealand. Several guideline value exceedences of the one-hour and 24-hour guideline values have occurred each year at the Khyber Pass Road site. This site is classified as 'traffic peak'.

4 Sulphur Dioxide (SO_2)

Concentrations of sulphur dioxide have been measured within a number of urban centres in New Zealand. Results of this monitoring are compared to the following ambient air quality guideline values for New Zealand:

- 350 mgm^{-3} (one-hour average)
- 120 mgm^{-3} (24-hour average).

The recommended monitoring method for sulphur dioxide in New Zealand is AS3580.4.1 – 1990. This method specifies fluorescence. Unless stated otherwise, all data presented in this section are based on monitoring methods that comply with AS3580.4.1 – 1990, which is the recommended method in the *Good Practice Guide for Air Quality Monitoring and Data Management* (MfE, 2000) and is the required method in the *Ambient Air Quality Guidelines* (MfE and MoH, 2002). The former report also indicates that some measurements of SO_2 in New Zealand have been made using passive sampling and wet chemical techniques. The latter are a measure of total acidity and are not an accurate method for assessing SO_2 concentrations.

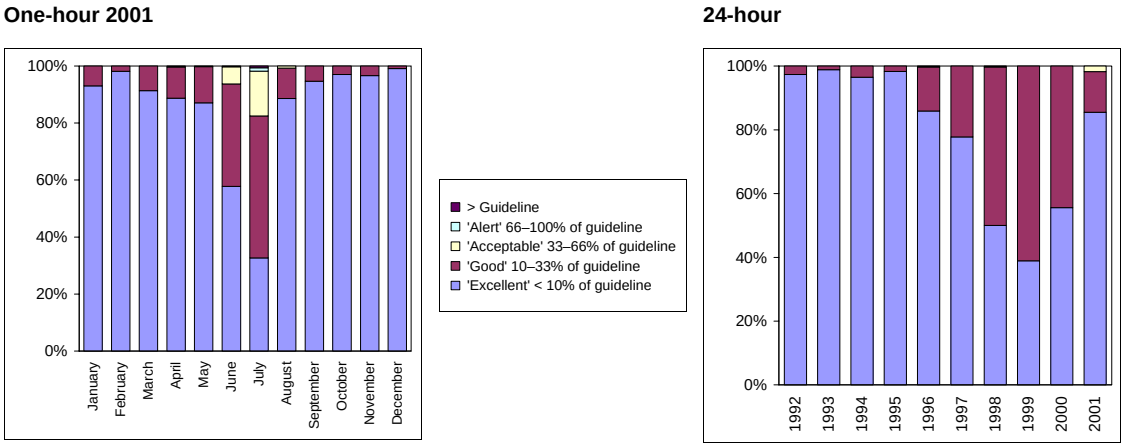
4.1 Auckland region

Concentrations of SO_2 have been measured in Auckland at the Penrose (ACI) monitoring site since 1990. Summary results of monitoring from 1992 to 2001 are shown in Table 4.1. Figure 4.1 shows the percentage of 24-hour average SO_2 concentrations from 1992 to 2001 and one-hour average concentrations for 2001, by month, within the air quality categories. The monthly data suggests some seasonal variations with slightly higher SO_2 concentrations during the winter months. However, most 24-hour and one-hour average SO_2 concentrations are within the 'excellent' and 'good' categories.

Table 4.1: Summary data for SO_2 monitoring in Auckland

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
One-hour average SO_2 concentrations, Penrose (ACI)										
% valid data										80%
Hours > 350 μgm^{-3}										0
99.9 %ile μgm^{-3}										94
Maximum μgm^{-3}										165
24-hour average SO_2 concentrations, Penrose (ACI)										
% valid data	94%	96%	94%	96%	97%	96%	100%	99%	95%	79%
Days > 120 μgm^{-3}	0	0	0	0	0	0	0	0	0	0
99.9 %ile μgm^{-3}	16	12	25	15	30	23	39	30	28	62
Maximum μgm^{-3}	17	21	31	17	43	24	48	32	30	69

Figure 4.1: Percentage of measured one-hour and 24-hour average SO_2 concentrations within air quality categories at Penrose, Auckland



4.2 Taranaki region

Air quality monitoring for SO_2 in Taranaki includes passive sampling carried out by NIWA around the time of the Mt Ruapehu eruptions during 1997 and 1998, some state of the environment monitoring and some site specific monitoring to assess the impact of a local fertiliser plant. Results of air quality monitoring are detailed in a Taranaki Regional Council Report (2002). This indicates that the ambient air concentrations of SO_2 that have been measured in Taranaki are 'excellent'. The site specific monitoring around the Ravensdown site (Table 4.2) shows elevated concentrations during the 1996 and 1997 period. However, concentrations measured during 1997–98 after the shutdown of the sulphuric acid plant, the superphosphate manufacturing plant and the chrome sulphate plant were considerably lower.

Table 4.2: Ambient SO_2 monitoring results from around the Ravensdown site for 1996–97 and 1997–98 monitoring periods

Monitoring period	Site	SO_2 µgm^{-3} one-hour average	SO_2 µgm^{-3} 24-hour average
1996–97	AIR006209	37	20
	AIR006210	114	66
	AIR006211	348	208
	AIR006214	108	66
	AIR006215	66	37
	AIR006219	265	154
	AIR006202	145	86
1997–98	AIR006221	8	4
	AIR006214	11	6
	AIR006215	8	4

Source: Adapted from TRC, 2002

4.3 Hawkes Bay region

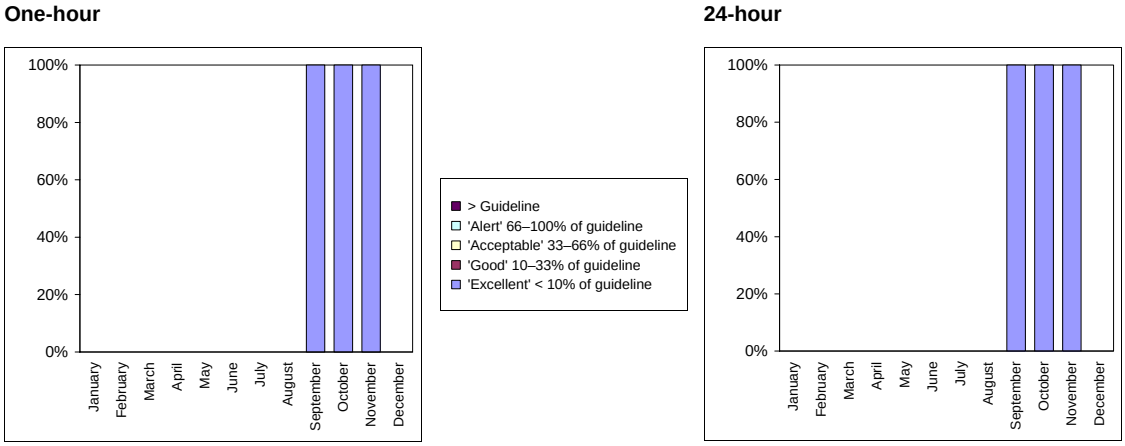
In the Hawkes Bay area, monitoring of SO_2 was carried out in Hastings in 1994 and 1998. Figure 4.2 shows the percentage of SO_2 concentrations within the air quality categories for the months September to November 1998. The maximum one-hour and 24-hour average concentrations measured were 9 μgm^{-3} and 5 μgm^{-3} respectively (Table 4.3).

Table 4.3: Summary data for SO_2 monitoring in Hawkes Bay

One-hour average	Hastings 1998
% valid data	12%
Hours > 350 μgm^{-3}	0
99.9 %ile μgm^{-3}	9
Maximum μgm^{-3}	12

24-hour average	Hastings 1998
% valid data	12%
Days > 120 μgm^{-3}	0
99.9 %ile μgm^{-3}	5
Maximum μgm^{-3}	5

Figure 4.2: Percentage of measured one-hour and 24-hour average SO_2 concentrations within air quality categories in Hastings, 1998



4.4 Canterbury region

Concentrations of SO_2 are measured at most monitoring sites within the Environment Canterbury air quality monitoring network. Measurements in Christchurch date back to 1988 and continuous SO_2 monitoring have also been carried out in Timaru since 1997. Summary data for SO_2 monitoring sites in the Canterbury region are shown in Table 4.4.

Table 4.4: Summary data for SO_2 monitoring in Canterbury

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
One-hour average SO_2 concentrations, Christchurch (Packe Street)										
% valid data	78%	64%	77%	55%	90%	99%	97%	97%	94%	93%
Hours > 350 µgm^{-3}	0	0	0	0	0	0	0	0	0	0
99.9 %ile µgm^{-3}	88	35	84	66	83	89	25	64	41	40
Maximum µgm^{-3}	95	80	120	85	124	106	34	90	56	64
24-hour average SO_2 concentrations, Christchurch (Packe Street)										
% valid data	72%	61%	76%	49%	87%	98%	96%	95%	93%	92%
Days > 120 µgm^{-3}	0	0	0	0	0	0	0	0	0	0
99.9 %ile µgm^{-3}	41	18	33	32	35	37	9	28	20	19
Maximum µgm^{-3}	43	18	39	34	40	48	10	31	32	20
One-hour average SO_2 concentrations, Christchurch (Coles Place)										
% valid data							42%	86%	100%	96%
Hours > 350 µgm^{-3}							0	0	0	0
99.9 %ile µgm^{-3}							43	42	43	47
Maximum µgm^{-3}							61	67	82	65
24-hour average SO_2 concentrations, Christchurch (Coles Place)										
% valid data							42%	85%	100%	94%
Days > 120 µgm^{-3}							0	0	0	0
99.5 %ile µgm^{-3}							13	17	18	20
Maximum µgm^{-3}							15	23	19	20
One-hour average SO_2 concentrations, Christchurch (Opawa)										
% valid data				52%	27%	96%	98%	48%		
Hours > 350 µgm^{-3}				0	0	0	0	0		
99.9 %ile µgm^{-3}				145	45	98	110	140		
Maximum µgm^{-3}				234	46	149	147	221		
24-hour average SO_2 concentrations, Christchurch (Opawa)										
% valid data				52%	27%	94%	98%	49%		
Days > 120 µgm^{-3}				0	0	0	0	0		
99.5 %ile µgm^{-3}				57	19	39	42	41		
Maximum µgm^{-3}				63	19	43	47	47		
One-hour average SO_2 concentrations, Christchurch (Hornby)										
% valid data				41%	95%	94%	98%	100%	76%	100%
Hours > 350 µgm^{-3}				0	0	0	0	0	0	0
99.9 %ile µgm^{-3}				183	114	204	145	228	225	234
Maximum µgm^{-3}				235	162	252	195	298	294	334
24-hour average SO_2 concentrations, Christchurch (Hornby)										
% valid data				41%	94%	93%	97%	99%	76%	100%
Days > 120 µgm^{-3}				0	0	0	0	0	0	0
99.5 %ile µgm^{-3}				53	39	75	52	69	79	87
Maximum µgm^{-3}				56	42	100	59	87	90	104

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
One-hour average SO_2 concentrations, Timaru										
% valid data						58%	100%	100%	92%	93%
Hours > 350 µgm^{-3}						0	0	0	0	0
99.9 %ile µgm^{-3}						74	55	72	45	47
Maximum µgm^{-3}						92	111	165	123	72
24-hour average SO_2 concentrations, Timaru										
% valid data						57%	100%	100%	92%	93%
Days > 120 µgm^{-3}						0	0	0	0	0
99.5 %ile µgm^{-3}						26	24	28	19	17
Maximum µgm^{-3}						27	36	31	21	18
One-hour average SO_2 concentrations, Ashburton										
% valid data								75%	99%	22%
Hours > 350 µgm^{-3}								0	0	0
99.9 %ile µgm^{-3}								26	25	13
Maximum µgm^{-3}								42	37	27
24-hour average SO_2 concentrations, Ashburton										
% valid data								74%	99%	21%
Days > 120 µgm^{-3}								0	0	0
99.5 %ile µgm^{-3}								8	9	3
Maximum µgm^{-3}								9	12	3
One-hour average SO_2 concentrations, Rangiora										
% valid data								94%	82%	14%
Hours > 350 µgm^{-3}								0	0	0
99.9 %ile µgm^{-3}								22	18	10
Maximum µgm^{-3}								63	28	11
24-hour average SO_2 concentrations, Rangiora										
% valid data								93%	81%	13%
Days > 120 µgm^{-3}								0	0	0
99.5 %ile µgm^{-3}								8	10	7
Maximum µgm^{-3}								11	10	7
One-hour average SO_2 concentrations, Kaiapoi										
% valid data										70%
Hours > 350 µgm^{-3}										0
99.9 %ile µgm^{-3}										17
Maximum µgm^{-3}										55
24-hour average SO_2 concentrations, Kaiapoi										
% valid data										69%
Days > 120 µgm^{-3}										0
99.5 %ile µgm^{-3}										7
Maximum µgm^{-3}										8

4.4.1 Christchurch

Concentrations of SO_2 have been measured in central Christchurch since 1988. Figure 4.3 shows that in central Christchurch concentrations of SO_2 are typically 'excellent' or 'good'. Higher concentrations have been measured in other more industrial areas of the city (Figure 4.4). The maximum one-hour and 24-hour average concentrations recorded in Hornby are 334 and 104 μgm^{-3} respectively. In Opawa maximum concentrations for the same averaging periods were 298 and 63 μgm^{-3}.

Figure 4.3: Percentage of measured one-hour and 24-hour average SO_2 concentrations within air quality categories at Packe Street and Coles Place in central Christchurch

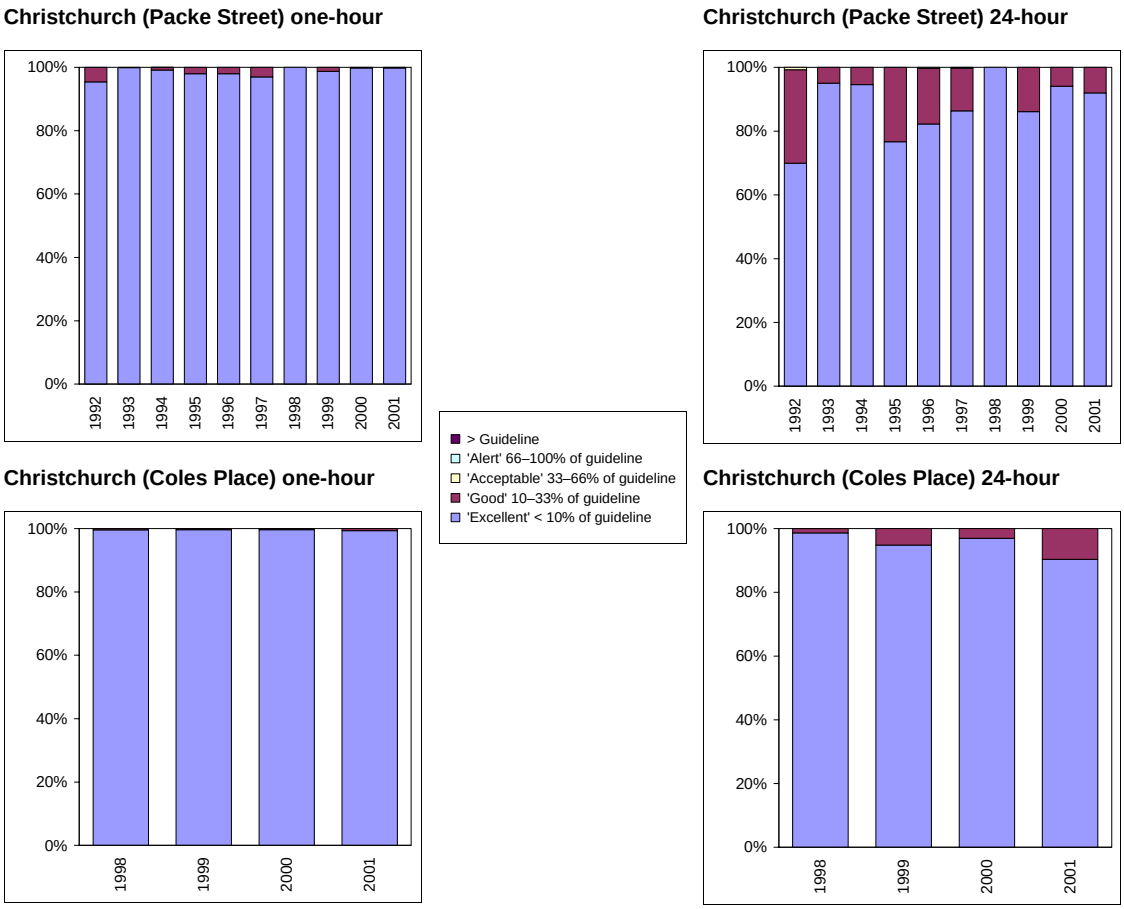
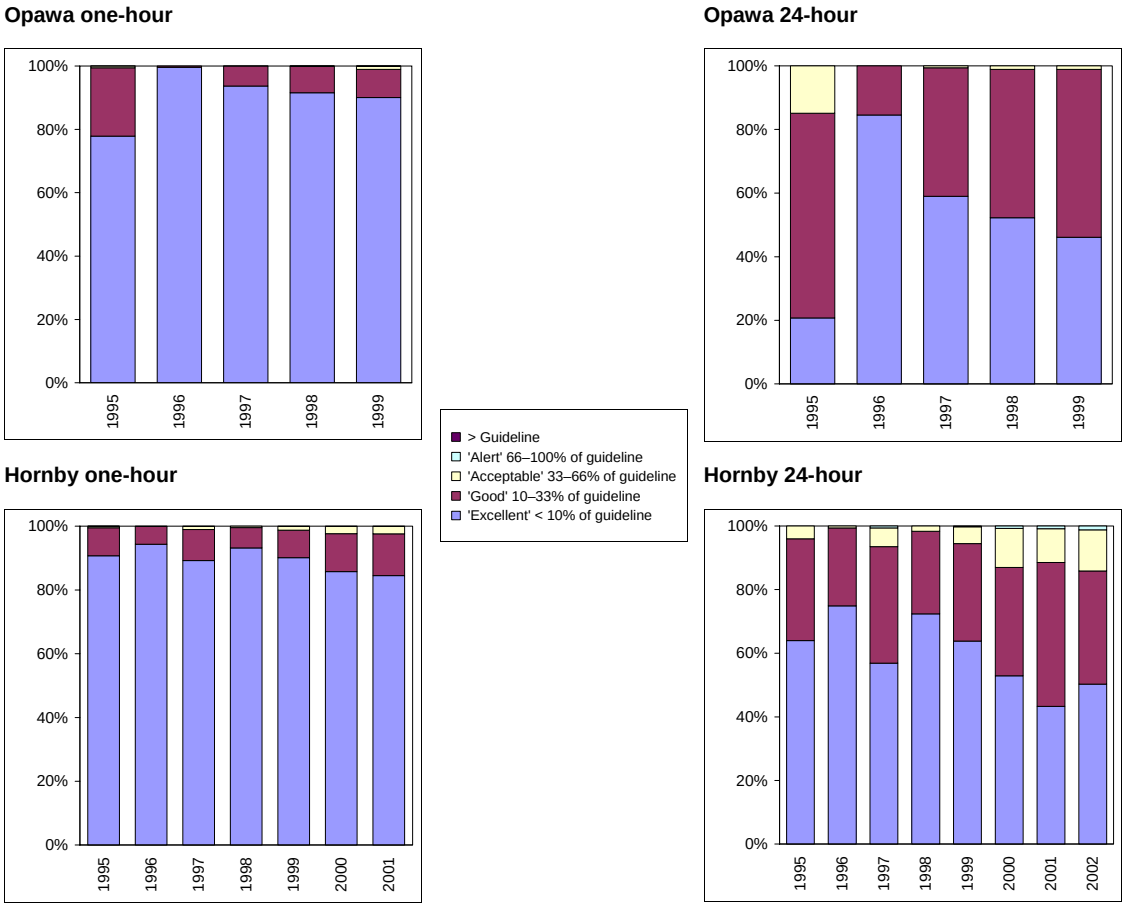


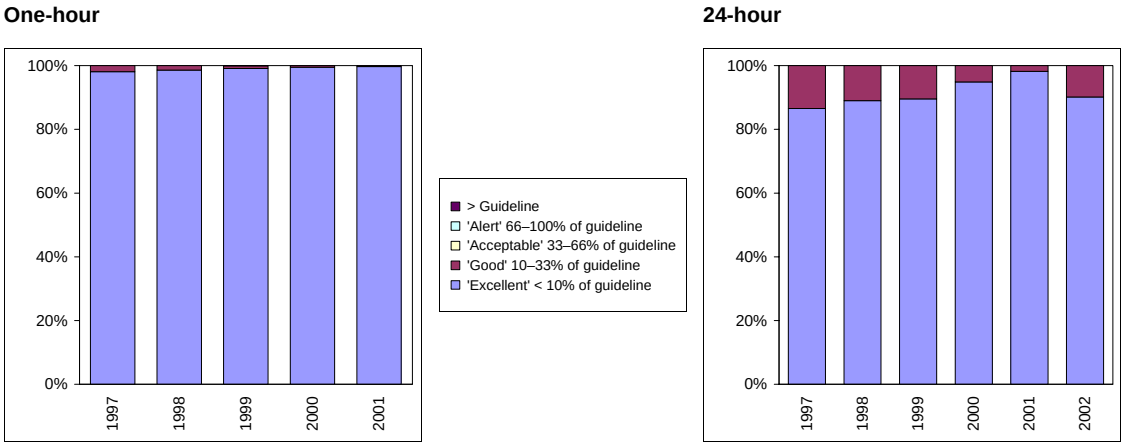
Figure 4.4: Percentage of measured one-hour and 24-hour average SO_2 concentrations within air quality categories in Hornby and Opawa, Christchurch



4.4.2 Timaru

Concentrations of SO_2 have been monitored at the Timaru monitoring site since 1997. Figure 4.5 shows concentrations are well within the guideline values, with the majority of measurements falling within the 'excellent' air quality category.

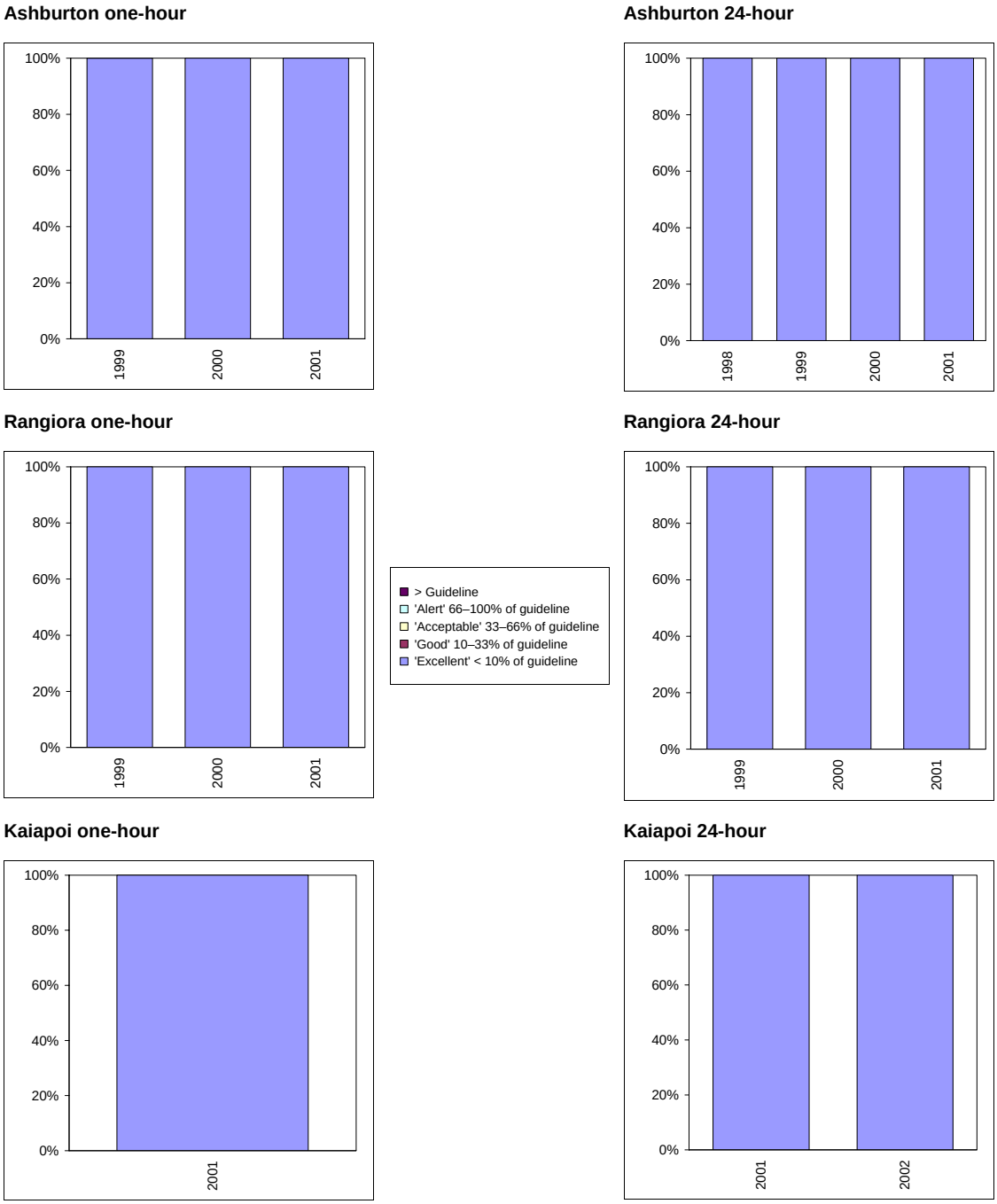
Figure 4.5: Percentage of measured one-hour and 24-hour average SO_2 concentrations within air quality categories in Timaru



4.4.3 Ashburton, Rangiora and Kaiapoi

Concentrations of SO_2 that were measured in Ashburton, Rangiora and Kaiapoi from 1999 to 2001 were all within the 'excellent' air quality category (Figure 4.6).

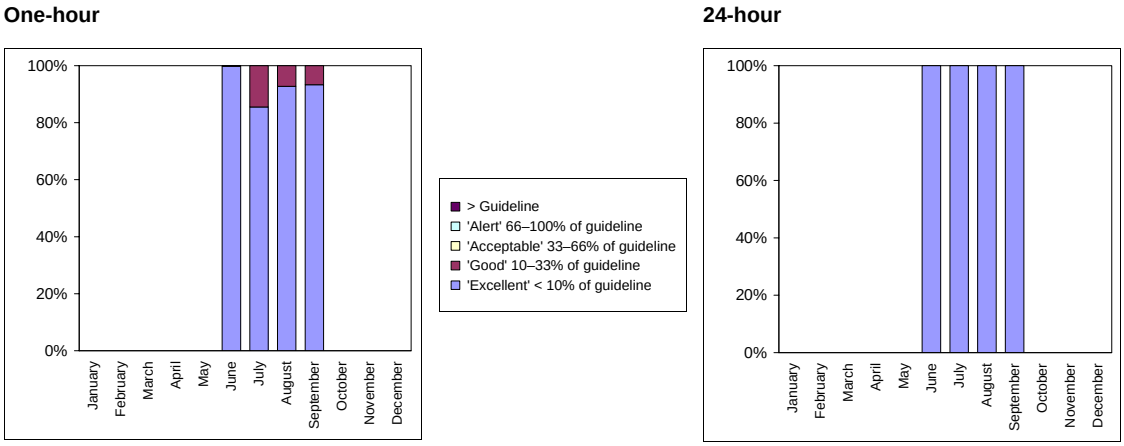
Figure 4.6: Percentage of measured one-hour and 24-hour average SO_2 concentrations within air quality categories in Ashburton, Rangiora and Kaiapoi



4.5 West Coast

Continuous monitoring for SO_2 was carried out on the West Coast during 2001 at Greymouth. Figure 4.7 shows concentrations were within the 'excellent' or 'good' air quality categories for the duration of the monitoring period.

Figure 4.7: Percentage of measured one-hour and 24-hour average SO_2 concentrations within air quality categories in Greymouth, 2001



4.6 Otago region

Measurements of SO_2 concentrations in Dunedin are limited to a small number of 24-hour samples measured using wet chemical methods. Table 4.5 shows the results of this monitoring, which was carried out from 1997 to 2000. No graphical analysis was applied to the data owing to the limited number of samples. Results suggest that on the days monitored, SO_2 concentrations were much less than the 24-hour average SO_2 guideline value. Note, however, that the measurement method used does not comply with existing recommended monitoring methods and is likely to be indicative only.

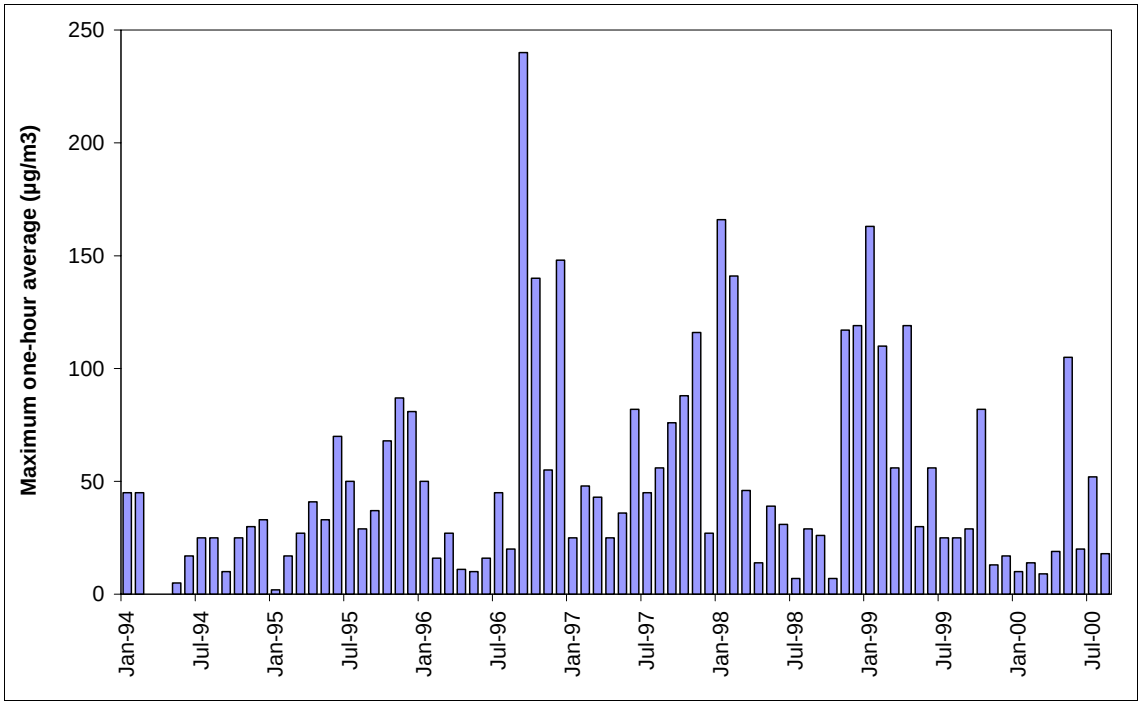
Table 4.5: Concentrations of SO_2 measured in Dunedin (wet chemical)

Albany Street Dunedin 24-hour SO_2					
1997/98	**μgm^{-3}**	**1999**	**μgm^{-3}**	**2000**	**μgm^{-3}**
29 July 1997	17	07 July 1999	7	01 June 2000	11
04 August 1997	80	13 July 1999	9	07 June 2000	12
10 August 1997	8	19 July 1999	15	13 June 2000	12
16 August 1997	41	31 July 1999	22	19 June 2000	15
22 August 1997	19	06 August 1999	20	25 June 2000	20
28 August 1997	9	12 August 1999	20	07 July 2000	25
08 September 1997	9	18 August 1999	30	13 July 2000	18
12 June 1998	11	24 August 1999	26	19 July 2000	11
18 June 1998	14	30 August 1999	35	25 July 2000	15
24 June 1998	20	05 September 1999	20	31 July 2000	10
		07 September 1999	26	06 August 2000	6
		23 September 1999	29	12 August 2000	9
		29 September 1999	25	18 August 2000	11
				24 August 2000	9
				30 August 2000	8

4.7 Northland region

In the Northland region, monitoring of SO_2 has been carried out at Takahiwai between January 1994 and July 2000. The Takahiwai site is generally representative of rural conditions, however a petroleum refinery – a significant source of sulphur dioxide – is situated approximately 4 km due east of the analyser. Most elevated results at this site occur during easterly winds when emissions from the refinery impact upon the analyser.

Figure 4.8: Maximum monthly one-hour average SO_2 (µg/m^3) concentrations recorded at the Takahiwai monitoring site



Air quality in this area can be described as 'good' or 'excellent', however, there are occasions when SO_2 concentrations have reached the 'alert' category, for example a short period in September 1996. Other peak measurements recorded 1996, 1997, and 1998 (ranging between 130–150 µg/m^3) have put the air quality in the 'acceptable' category.

4.8 Summary of SO_2 concentrations

Air quality monitoring for SO_2 in New Zealand is largely limited to monitoring carried out in Canterbury, the long-term monitoring site in Penrose (ACI), Auckland and around some industrial sources. Data for Christchurch shows some areas of the city where SO_2 concentrations have reached the 'acceptable' or 'alert' categories. However, there have been no guideline value exceedences for the one-hour average or 24-hour average from 1992–2001. In other areas of Canterbury, concentrations are typically 'excellent'. In Auckland (Penrose) and around some industrial sites, one-hour average SO_2 concentrations reached the 'alert' category. The limited amount of SO_2 monitoring that has been carried out in other parts of New Zealand does not indicate concentrations of concern.

5 Ozone

Concentrations of ozone in New Zealand have been measured in Auckland and on the outskirts of Christchurch. Results of this monitoring are compared to the following ambient air quality guideline values for New Zealand:

- 150 mgm^{-3} (one-hour average)
- 100 mgm^{-3} (eight-hour average).

The recommended monitoring method for ozone in New Zealand is AS3580.6.1 – 1990. This method specifies UV absorption. All data presented in this section are based on monitoring methods that comply with AS3580.6.1 – 1990, which is the recommended method in the *Good Practice Guide for Air Quality Monitoring and Data Management* (MfE, 2000) and is the required method in the *Ambient Air Quality Guidelines* (MfE and MoH, 2002).

5.1 Auckland

Concentrations of ozone have been measured in a number of locations in Auckland. Figure 5.1 shows the percentage of O_3 concentrations measured in Pukekohe and Musick Point from 1997 to 2001. Results are within the air quality categories, however, more recent monitoring at Musick Point in 2002 (not shown on the graph) has recorded 2 exceedences of the eight-hour guideline value. The majority of the measured concentrations in these locations are between 10% and 66% of the guideline values, with less than 20% of the data within the 'alert' category. At Pukekohe the maximum eight-hour average concentration was 96 μgm^{-3}.

Figure 5.1: Percentage of measured one-hour and eight-hour average O_3 concentrations within air quality categories in Pukekohe and Musick Point, Auckland

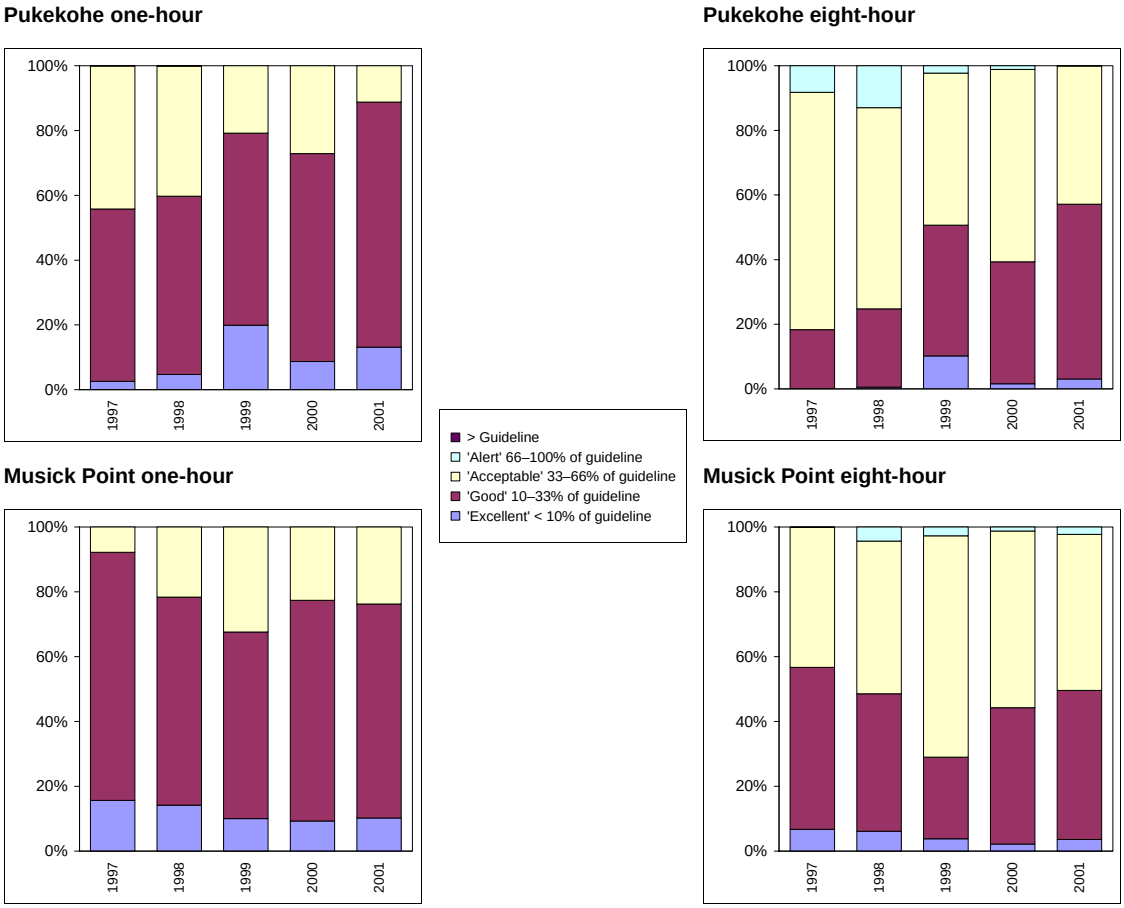
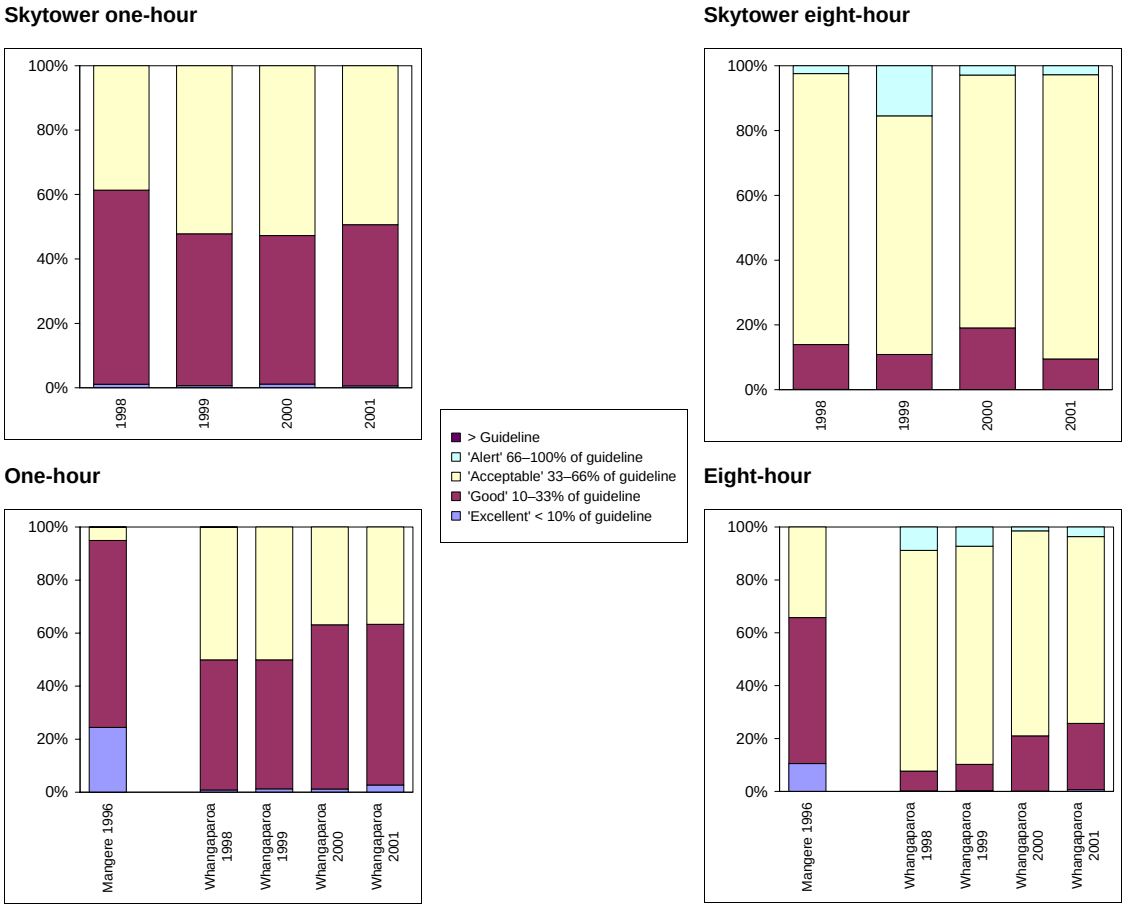


Figure 5.2 shows concentrations of O_3 measured at the Skytower, Mangere and Whangaparoa within each air quality category. At the Skytower and Whangaparoa sites, the majority of the eight-hour average measurements are within the 'acceptable' category with up to 15% of the data in the 'alert' category.

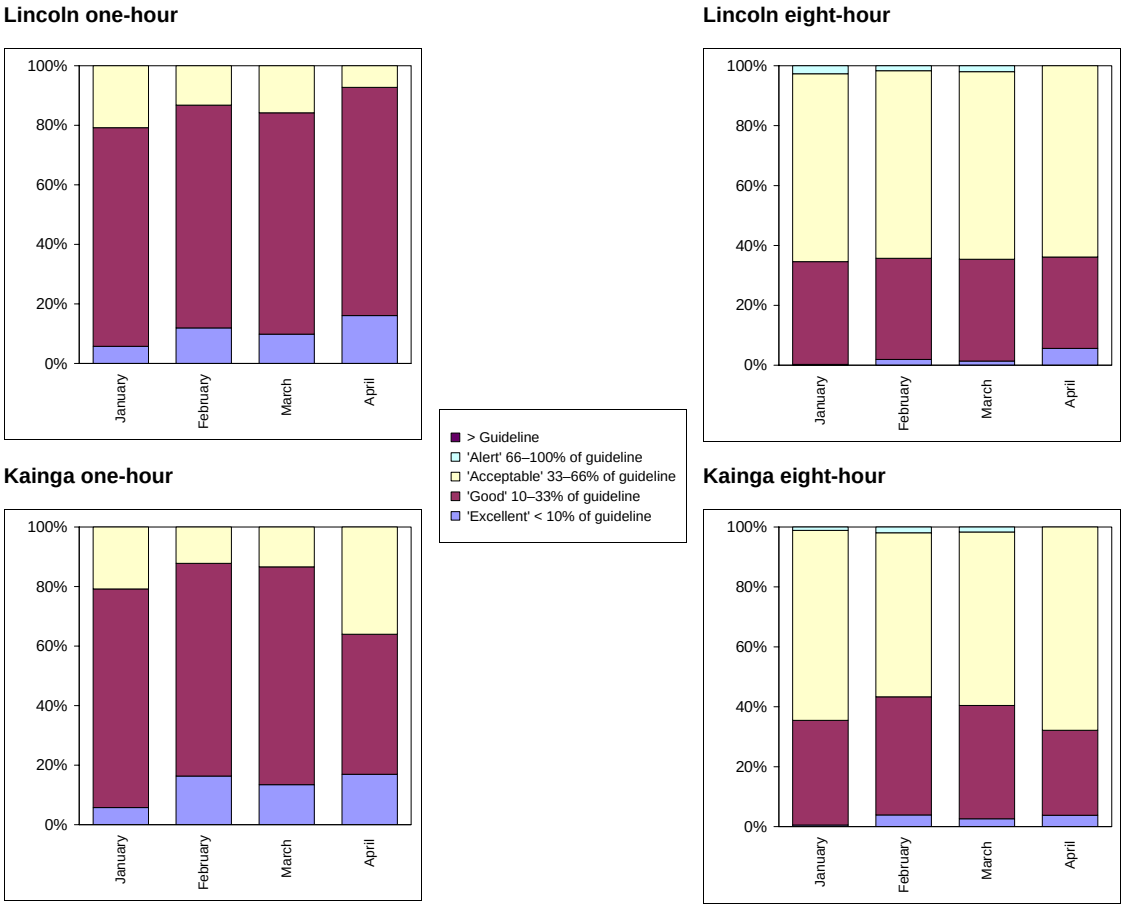
Figure 5.2: Percentage of measured one-hour and eight-hour average O_3 concentrations within air quality categories at the Skytower, Mangere and Whangaparoa, Auckland



5.2 Christchurch

Concentrations of ozone were measured on the outskirts of Christchurch during the months January to April 1998. Sites downwind of the city were chosen to allow time, after the release of precursor emissions, for the formation of ozone to occur. The sites were at Lincoln, 20 km to the south west of the city centre, and Kainga, 13 km to the north of Christchurch. Figure 5.3 shows the percentage of O_3 concentrations measured during 1998 within each air quality category. A large proportion of the eight-hour average concentrations were within the 'acceptable' category, while the one-hour average concentrations were mostly 'good' or 'excellent'. The maximum one-hour and eight-hour average concentrations at Lincoln were 97 μgm^{-3} and 76 μgm^{-3}, and at Kainga, 93 μgm^{-3} and 75 μgm^{-3} respectively.

Figure 5.3: Percentage of measured one-hour and eight-hour average O_3 concentrations within air quality categories at Lincoln and Kainga in Canterbury



6 Benzene

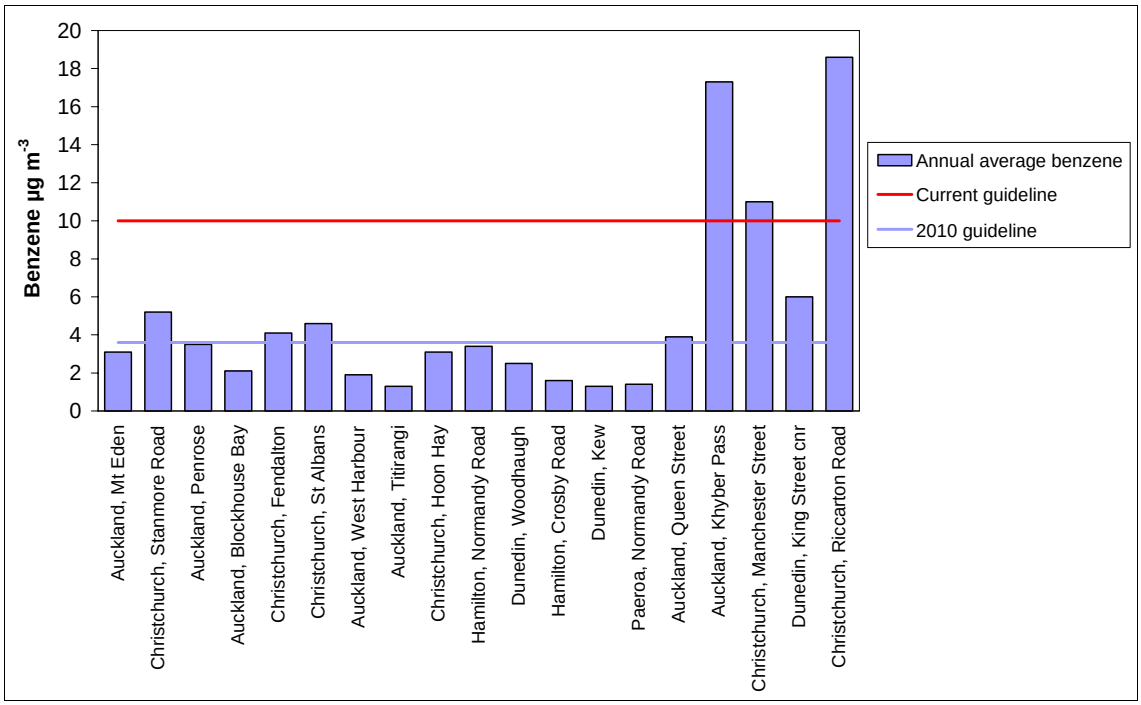
Concentrations of benzene in New Zealand have been measured in Auckland, Christchurch, Hamilton and Dunedin as part of a Ministry of Health study. In addition, separate studies of benzene concentrations have been carried out in Auckland, Christchurch and Nelson. Results of this monitoring are presented relative to the current annual average guideline value for New Zealand of 10 μgm^{-3} and the 2010 annual average guideline value of 3.6 μgm^{-3}.

The required monitoring method for benzene in New Zealand is the USEPA method TO1. Most benzene monitoring in New Zealand, however, has been carried out using passive sampling methods that do not comply with this technique.

6.1 Auckland, Hamilton, Christchurch and Dunedin – the MoH study

The Ministry of Health measured concentrations of benzene at different types of monitoring sites within the main urban centres of New Zealand from 1996 to 1999. Results of the study are documented in *Benzene and Other Toxic Organics* (Stevenson, 1999). Figure 6.1 shows that the current guideline value for benzene was exceeded only at sites located in central Auckland or Christchurch, near to major roads. The 2010 guideline value was also exceeded in Christchurch at a number of residential sites such as St Albans and Fendalton.

Figure 6.1: Benzene concentrations measured in Auckland, Christchurch, Dunedin and Hamilton from 1996 to 1999

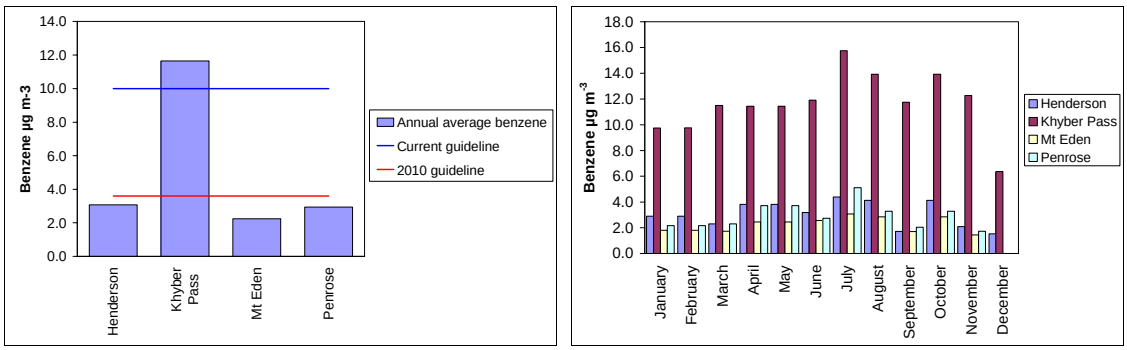


Source: From data presented in *Benzene and Other Toxic Organics* (Stevenson, 1999).

6.2 Auckland

Concentrations of benzene have been measured at a number of sites in Auckland since June 2000. Figure 6.2 compares annual average benzene concentrations to the current and 2010 guideline values and shows seasonal variations in benzene concentrations at the different monitoring sites. Annual average concentrations measured during 2002 are within both guideline values at the Henderson, Mt Eden and Penrose sites. The annual average concentration of 11.7 μgm^{-3} at Khyber Pass Road exceeds both guideline values.

Figure 6.2: Concentrations of benzene measured in Auckland during 2002



6.3 Christchurch

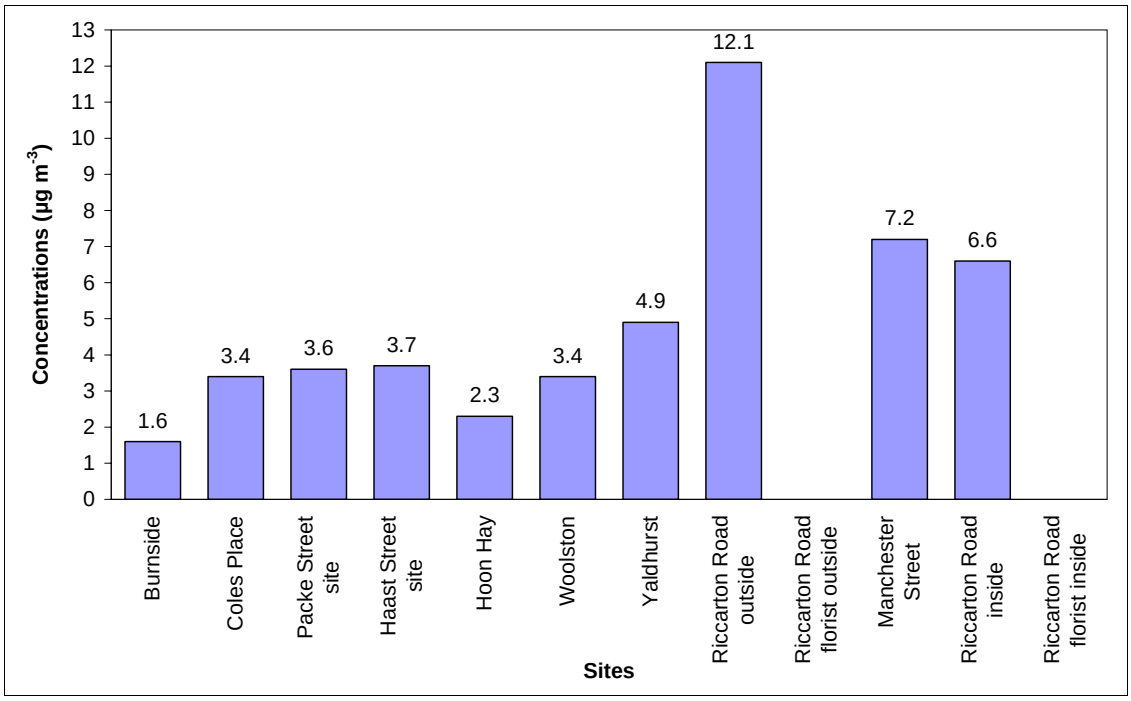
In addition to the monitoring carried out by the Ministry of Health in 1997 and 1998, Environment Canterbury conducted benzene monitoring at a number of sites in Christchurch during 2001. The monitoring programme sampled benzene, toluene, ethylbenzene and xylene at a range of ambient (residential neighbourhood), street level (traffic peak) and indoor sites (Gunatilaka, 2003). The sites used in the study and their classifications were:

- Burnside — outer suburb – reserve – ambient
- Coles Place — inner city suburb – ambient
- Haast Street — inner city suburb – ambient
- Hoon Hay — outer suburb – ambient
- Manchester Street — inner city – roadside
- Packe Street — inner city suburb – ambient
- Riccarton Road florist – inside — major arterial road – indoor
- Riccarton Road florist – outside — major arterial road – roadside
- Riccarton Road – inside — major arterial road – indoor
- Riccarton Road – outside — major arterial road – roadside
- Woolston — outer suburb – ambient
- Yaldhurst — outer suburb – ambient.

Figure 6.3 shows the annual average benzene concentrations measured at each of the monitoring sites. This indicates that the current guideline value for benzene is exceeded at one traffic site on Riccarton Road, which may not be representative of a person's typical annual exposure. The 2010 guideline value is currently exceeded at a number of traffic and residential sites. No annual averages were derived for the Riccarton Road florist indoor or outdoor sites because of incomplete sampling.

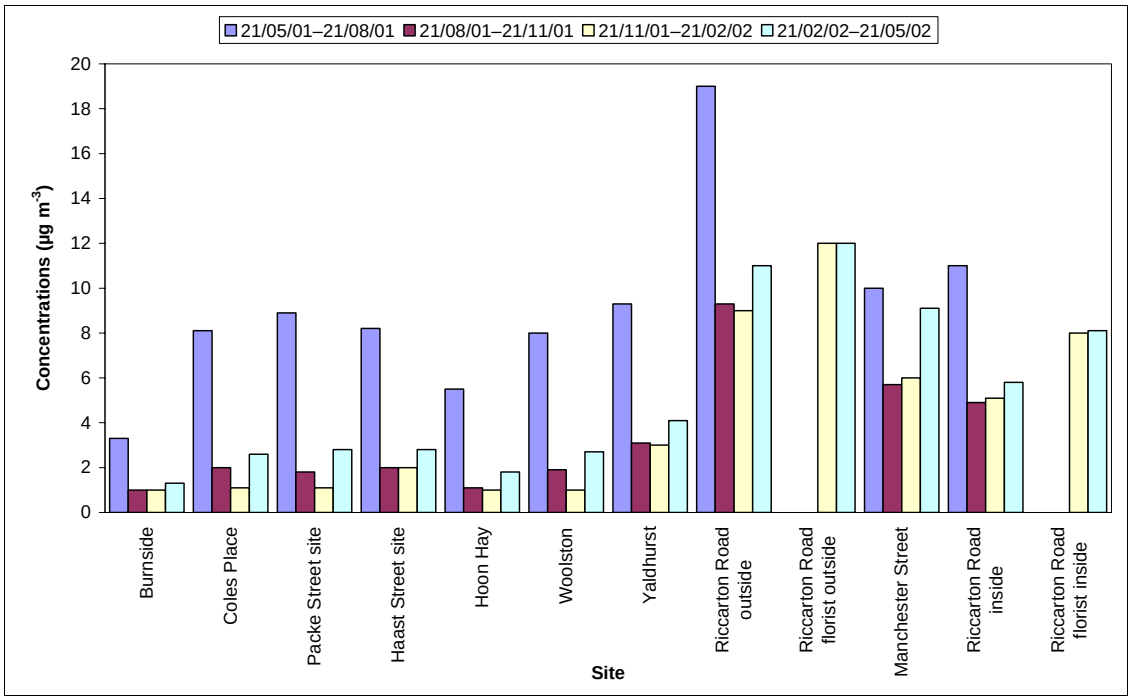
Based on a comparison of the 2001 results to the 1996–99 Ministry of Health data, Gunatilaka (2003) suggests that concentrations of benzene in Christchurch are decreasing, with roadside sites showing a 32% reduction, and ambient sites being around 13–15% of the 1998/1999 concentrations.

Figure 6.3: Annual average concentrations of benzene in Christchurch



Source: Gunatilaka, 2003

Figure 6.4: Three-month average benzene concentrations measured in Christchurch



Source: Gunatilaka, 2003

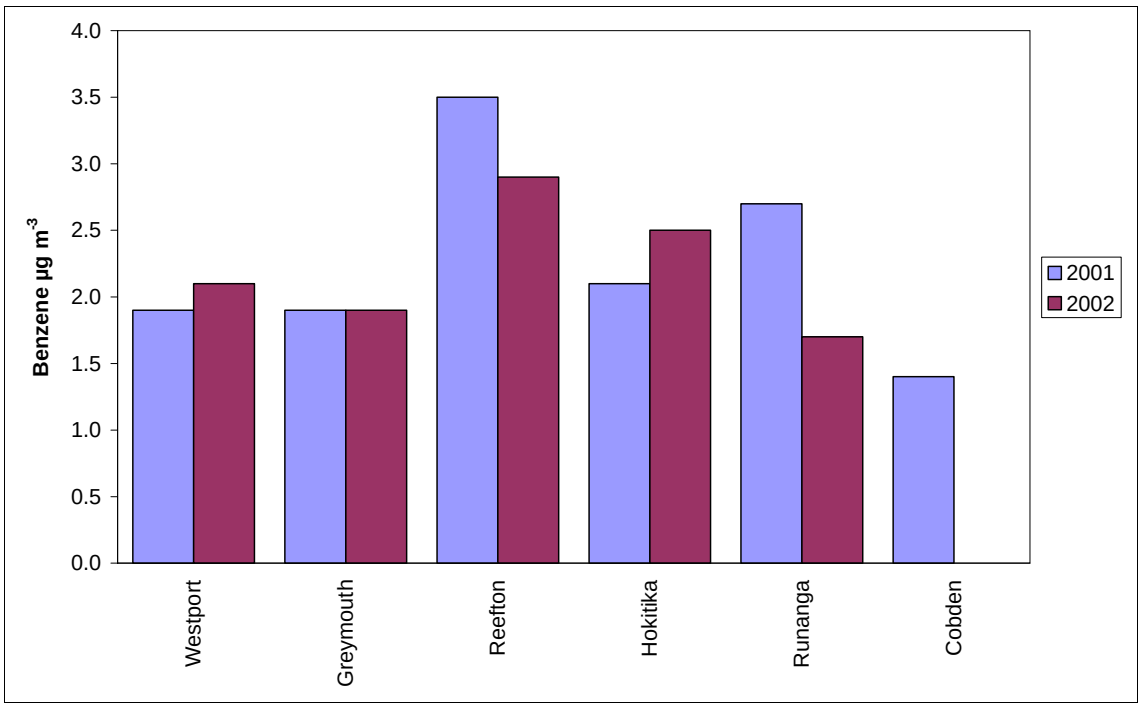
6.4 Nelson

Concentrations of benzene have been measured in Nelson using both passive sampling and a DOAS continuous sampler. Results of the monitoring are detailed in Bluett and Peterson (2001). Sampling using the DOAS monitor was carried out for the period May to August, although data were missing for significant periods during this time. Based on the data available, an average benzene concentration for the sampling period of 6.8 μgm^{-3} was estimated. Passive sampling data indicated similar results, although some problems occurred with the sampling during June and July. As sampling was limited to winter months, extrapolation to an annual average was not possible.

6.5 West Coast

Passive sampling for benzene was carried out on the West Coast of the South Island during June, July and August of 2001 and 2002. All winter averages were within both the current and 2010 guideline values for benzene. The highest winter average concentration of 3.5 μgm^{-3} was measured in Reefton during 2001 (Figure 6.5).

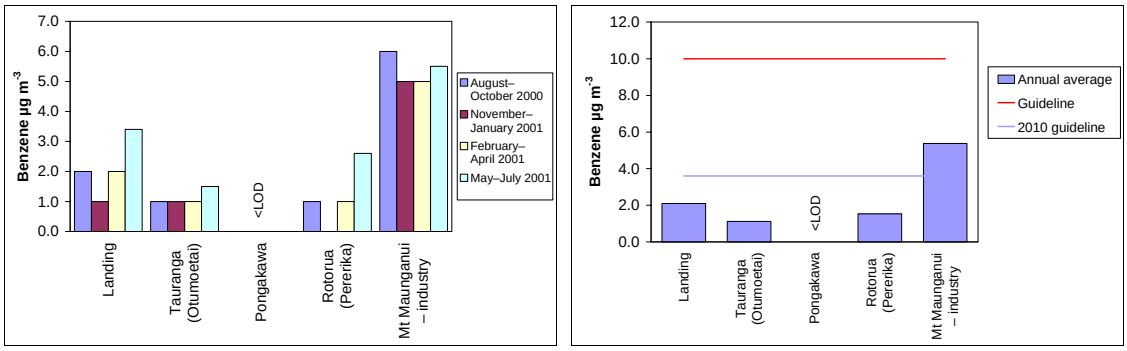
Figure 6.5: Concentrations of benzene measured on the West Coast in 2001 and 2002



6.6 Bay of Plenty

Concentrations of benzene have also been measured at a number of sites in the Bay of Plenty. Figure 6.6 shows the three-month and annual average benzene concentrations measured from August 2000 to July 2001. In most areas, the highest benzene concentrations were measured during the period May to July 2001. Annual average concentrations were within the guideline values, although the Mount Maunganui industry site concentrations were above the 2010 guideline values. Concentrations at the background site in Pongakawa were below the level of detection.

Figure 6.6: Concentrations of benzene measured in Bay of Plenty in 2000 and 2001



7 Benzo(a)pyrene (BaP)

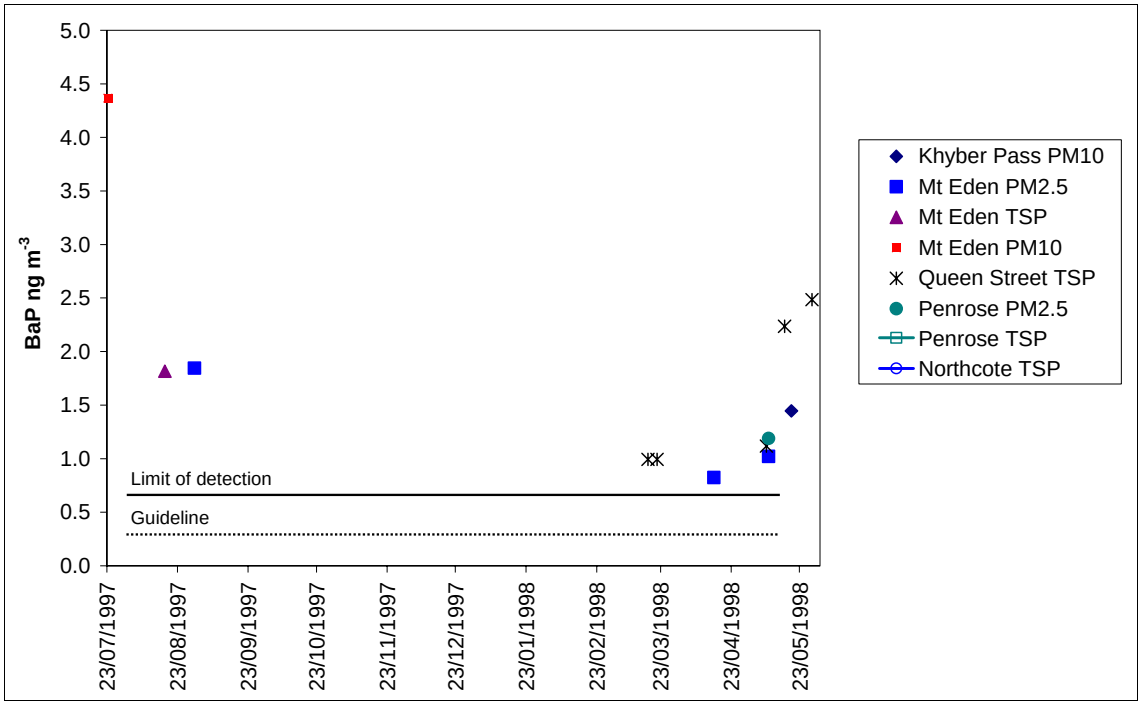
Monitoring of ambient air concentrations of BaP in New Zealand is limited to a small amount of sampling carried out in Auckland during 1997–1998 and Christchurch in 1999. Results of these sampling programmes are compared to the annual average ambient air quality guideline value of 0.0003 µgm^{-3} (MfE and MoH, 2002).

7.1 Auckland

Air quality monitoring for benzo(a)pyrene was carried in Auckland during 1997 and 1998. Other contaminants monitoring included: naphthalene, acenaphthylene, acenaphthene, fluorine, phenanthrene, anthracene, fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, indeno[1,2,3-cd]pyrene, dibenz[a,h]anthracene and benzo[ghi]perylene.

The analysis was carried out on the particulate phase only and included samples from the $PM_{2.5}$, PM_{10} and TSP size fractions. A total of 148 particulate filters were analysed. However, only 12 samples (8%) recorded BaP concentrations above the detection limit of around 0.8 ngm^{-3}. The maximum BaP concentration measured was 4.4 nanograms per cubic metre (ngm^{-3}) at the Mt Eden site (PM_{10} size fraction). An annual average estimate of BaP concentrations was unable to be derived from the study because the detection limit for the method used (around 0.8 ngm^{-3}) was higher than the guideline value (0.3 ngm^{-3}).

Figure 7.1: Concentrations of BaP measured in Auckland in 1997 and 1998

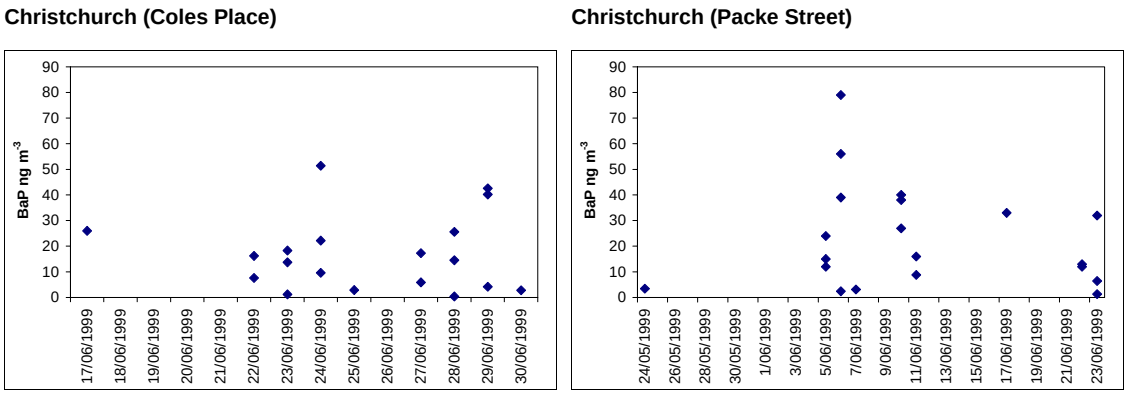


7.2 Christchurch

Concentrations of BaP were measured in Christchurch during the winter of 1999 at two sites in central Christchurch. Samples were collected over four different monitoring periods: 24-hour averages collected from 4 pm to 4 pm, evening peak monitoring from 4 pm to 8 pm, night time monitoring from 8 pm to 6 am and daytime sampling from 6 am to 4 pm. Results from all four monitoring periods are shown in Figure 7.2. This shows a maximum peak concentration of 79 ngm^{-3}. The 24-hour average concentrations range from around 3 ngm^{-3} to 39 ngm^{-3}.

Environment Canterbury has made an estimate of the annual average BaP concentration for central Christchurch based on the results of the monitoring and strong associations between the BaP concentrations and concentrations of PM_{10} (Gunatilaka, 2001). This indicates an annual average concentration for BaP of at least 4 ngm^{-3}. This is over 10 times the guideline value of 0.3 ngm^{-3} (0.0003 μgm^{-3}).

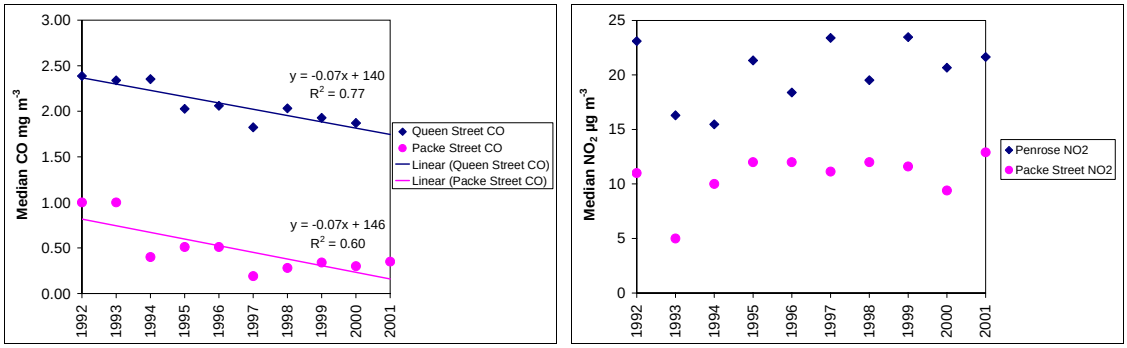
Figure 7.2: Concentrations of BaP measured in 1999 at Coles Place and Packe Street, Christchurch



8 Trends in Contaminant Concentrations in New Zealand

Figure 8.1 shows the median CO and NO_2 concentrations measured at long-term air quality monitoring sites in Auckland and Christchurch. While no trends in NO_2 concentrations are evident at either site, median CO concentrations at Queen Street, Auckland and Packe Street, Christchurch suggest a decrease in CO concentrations over the period 1992 to 2001. This decrease in CO concentrations is likely to represent reductions in motor vehicle CO emissions as well as possible improvements in emissions from domestic home heating in Christchurch.

Figure 8.1: Median CO and NO_2 concentrations measured in Auckland and Christchurch from 1992 to 2001



A long-term record of one-hour average SO_2 concentrations is also available for the St Albans monitoring site in Christchurch. No significant changes in the median SO_2 concentration are evident in the St Albans SO_2 data from 1992 to 2001. In Auckland, median SO_2 concentrations are variable with higher values recorded during 1997–2000. Changes in ambient air concentrations of SO_2 in most areas will depend on variations in industrial sources of SO_2 or in the use of coal for domestic home heating. The latter could change with significant variations in coal type (e.g. changes in the sulphur content) or the extent of coal use.

Because only a limited amount of air quality monitoring has been carried out in New Zealand for O_3, BaP and benzene it is not possible to determine trends in concentrations of these contaminants.

9 Summary

Air quality monitoring of CO, NO_2 and SO_2 has been carried out in a number of urban centres within New Zealand. For the majority of the time, concentrations of these contaminants are 'excellent' or 'good' in most locations. Of these contaminants, the main concerns arise from CO and NO_2 concentrations at sites located to major roadways such as Khyber Pass Road and in areas such as Christchurch, where elevated concentrations at 'residential' sites can occur.

Air quality monitoring for O_3 has been carried out at a number of locations within Auckland and at two sites on the outskirts of Christchurch. Although guidelines have not been exceeded at these sites, a large proportion of the data were within the 'acceptable' category and in Auckland up to 15% of the data were in the 'alert' air quality category.

Concentrations of benzene have been monitored in Auckland, Christchurch, Hamilton, Dunedin, Nelson, in the Bay of Plenty and on the West Coast. Annual average concentrations have been within the current guideline of 10 μgm^{-3} (annual average) and 2010 guideline (3.6 μgm^{-3}) at most 'residential' sites. Guideline exceedences have been recorded at Khyber Pass Road in Auckland and at Riccarton Road in Christchurch.

Measurements of BaP were carried out in Christchurch during 1999. Data show strong correlations with PM_{10} concentrations and indicate that the annual average BaP concentrations are at least 4 ngm^{-3}, more than 10 times the guideline concentration. Based on these results, it is likely that BaP concentrations also exceed ambient air quality guidelines in areas where elevated PM_{10} concentrations occur as a result of solid fuel burning for domestic home heating. Concentrations of PM_{10} in New Zealand, documented in the MfE report *Monitoring of PM_{10} in New Zealand* (MfE, 2003) show PM_{10} concentrations of concern in many locations where solid fuel burning is a major contributor. Consequently, it is likely that concentrations of BaP are of concern in many urban areas of New Zealand.

Table 9.1: Areas where CO, NO_2, SO_2 and O_3 have exceeded guideline values between 1992 and 2002

CO	NO_2	SO_2	O_3	Benzene	BaP
• Auckland – 'traffic' sites • Christchurch 'traffic' and 'residential' sites • Wellington 'traffic' sites • Dunedin 'residential' sites	• Auckland 'traffic' sites	None	None	• Auckland 'traffic' sites • Christchurch 'traffic' sites	• Christchurch 'residential' sites • Also likely in other urban areas of New Zealand

References

Bluett J, Peterson J. 2001. *Ambient Air Monitoring, Nelson City, Autumn–Winter 2001*. NIWA report AK01182.

Gunatilaka M. 2002. *Hazardous Air Pollutant Monitoring in Christchurch*. Environment Canterbury Report No. R01/31.

Gunatilaka M. 2002. *Investigations of Street Level Monitoring of Carbon Monoxide in Christchurch*. Environment Canterbury Report No. U02/66.

Gunatilaka M. 2003. *Hazardous Air Pollutants Concentrations of BTEX (Benzene, Toluene, Ethylbenzene and Xylene) in Christchurch (2001/2002).* Environment Canterbury Report No. R03/9.

Ministry for the Environment (MfE) and Ministry of Health (MoH). 2002. *Ambient Air Quality Guidelines*. Ministry for the Environment, Wellington.

Ministry for the Environment (MfE). 1994. *Ambient Air Quality Guidelines*. Ministry for the Environment, Wellington.

Ministry for the Environment (MfE). 1999. *Good Practice Guideline for Air Quality Monitoring and Data Management*. Ministry for the Environment, Wellington.

Ministry for the Environment (MfE). 2000. *Proposals for Revised and New Ambient Air Quality Guidelines – Discussion document*. Ministry for the Environment, Wellington.

Stevenson C. 1999. *Benzene and Other Toxic Organics*. Report prepared for the Ministry of Health.

Taranaki Regional Council. 2002. *Monitoring of Nitrogen Oxides, Sulphur Oxide and Ammonia Levels in Taranaki, 1993–2002*. Internal report. Taranaki Regional Council, Stratford.

Appendix One

This appendix comprises a comprehensive summary of all air quality monitoring sites in New Zealand at the time of publication of this report.

Region	Location	Site established	Site classification	Contaminants
Auckland	Queen Street	From December 1998	Traffic peak	PM_{10}, $PM_{2.5}$, CO
	Queen Street	1990–98	Traffic peak	PM_{10}, CO
	Khyber Pass	From March 1998	Traffic peak	PM_{10}, CO, NO_x
	Takapuna	From November 1996 to April 2002	Residential peak	PM_{10}, CO, NO_2
	Takapuna	May 1995 to March 1996, October 1996 to August 1999	Residential peak	PM_{10}, CO, NO_2
	Henderson	From July 1998	Residential peak	PM_{10}, CO
	Glen Eden	From September 2000	Residential neighbourhood	PM_{10}
	Manukau – East Tamaki Road	From July 1998	Residential neighbourhood	PM_{10}, CO
	Penrose (ACI) – 766 Great South Road	From April 1994	Industrial dense	PM_{10}, $PM_{2.5}$, lead, SO_x
	Penrose – Gavin Street	From April 1994	Industrial dense	NO_2
	South Manurewa	From August 2001	Residential neighbourhood	PM_{10}
	West Manurewa	From August 2001	Residential neighbourhood	PM_{10}
	Hobson Street	1996–2001	Traffic peak	CO
	Mt Eden – 17 Kelly Street	From February 1997 to April 2002	Residential neighbourhood	PM_{10}, $PM_{2.5}$, lead, NOx
	Pakuranga	From June 1998	Residential peak	CO
	Musick Point	From October 2001	Special (remote) regional	NOx, O_3, NMHC
	Skytower	From April 1998	Special (special)	O_3
	Dominion Road	April 1994–June 2002	Traffic peak	CO, NOx
	Whangaparoa	From April 1998	Special (remote) regional	O_3
	Pukekohe	From October 1996	Special (remote) regional	O_3
Waikato	Peachgrove Road, Hamilton	From June 1998	Residential peak	PM_{10}, CO, NOx
	South Waikato District Council, Tokoroa (a)	1999	Residential neighbourhood	PM_{10}
	Billah Street Reservoir, Tokoroa (b)	From January 2001	Residential neighbourhood	PM_{10}
	Te Kuiti City Council Offices, Te Kuiti	April–November 1998	Residential neighbourhood	PM_{10}
	Gillies Street Reserve, Taupo	2001 and 2002	Residential neighbourhood	PM_{10}

Region	Location	Site established	Site classification	Contaminants
Bay of Plenty	Pererika Street, Rotorua	From December 1997	Residential neighbourhood	PM_{10}, CO
	Fenton Street, Rotorua	December 1998–February 1999	Traffic peak	CO
	Otumoetai Road, Tauranga	From December 1997	Residential neighbourhood	PM_{10}, CO
	Marsh Street, Tauranga	March 2000–February 2001	Traffic peak	CO
	Quay Street, Whakatane	From December 1997	Residential neighbourhood	PM_{10}
	Pongakawa Bush Road, Paengaroa	From December 1997	Background – special (rural)	PM_{10}
Taranaki	New Plymouth Central	May 2000	Residential neighbourhood	PM_{10}
	New Plymouth Central	20 February 2000–20 March 2000	Residential neighbourhood	PM_{10}
	New Plymouth Central	13 November 2000–30 December 2000	Residential neighbourhood	PM_{10}
Northland	Robert St Boat Garage, Whangarei	October 2000–August 2001	Residential neighbourhood	PM_{10}
	State Highway One, Kaitaia	November–December 2001 – three samples only	Traffic peak	PM_{10}
Gisborne	Oates Road, Gisborne	From April 1993 to December 2000	Residential neighbourhood	PM_{10}
	McDonalds Road, Gisborne	From November 1993	Background – special (rural)	PM_{10}
Hawkes Bay	Nelson Park, Napier	From July 2001	Residential neighbourhood	PM_{10}
	Guppy Road, Napier	February 1996 to June 1999	Residential regional	PM_{10}
	Vigor Brown Street, Napier	1994, 1998	Residential neighbourhood	CO, NOx
	York Street, Hastings	1994, 1998	Residential neighbourhood	NOx, SOx, CO

Region	Location	Site established	Site classification	Contaminants
Wellington	Civic Square, Wellington	1998		PM_{10}, CO, NOx
	Government House, Wellington	1998		PM_{10}
	Queens Wharf, Wellington	1998		CO
	Vivian Street, Wellington	1998		CO
	Basin Reserve, Wellington	1998–1999		CO
	WRC Otaki Depot, Rural Otaki	October 1998 to February 2000	Background rural	PM_{10}
	Birch Lane, Lower Hutt	From April to June 2001	Residential neighbourhood	PM_{10}, NOx, CO
	Huia Street, Lower Hutt	May 1998–June 1999	Residential neighbourhood	PM_{10}, NOx, CO
	Maby Road, Lower Hutt	1997–1998		PM_{10}, NOx, CO
	Oak Park Avenue, Te Aro	From 2002		CO
	Hutt Park Road, Lower Hutt	From 2002		PM_{10}, $PM_{2.5}$, VOC
	Trentham Fire Station, Upper Hutt	From May 2000	Residential neighbourhood	PM_{10}, NOx, CO
	Moohan Street, Wainuiomata	From September 2000	Residential neighbourhood	PM_{10}
	Memorial Park, Masterton	1999	Residential neighbourhood	PM_{10}, NOx, CO
	Wairarapa College, Masterton	From 2002	Residential neighbourhood	PM_{10}, NOx, CO
Nelson	Fire Station	May–September 2000	Residential neighbourhood	PM_{10}, NOx
	St Vincent Street	From March 2001	Residential neighbourhood	PM_{10}
	Victory School	From 2001	Residential neighbourhood	PM_{10}, NOx, CO
	Waimea Road	March to December 2001	Residential peak	PM_{10}, NOx, CO
Tasman	Richmond	May–September 2000	Residential neighbourhood	PM_{10}
Marlborough	106 Middle Renwick Road, Blenheim	From February 2000	Residential neighbourhood	PM_{10}
	High Street Fire Station, Picton	March to September 2000	Residential neighbourhood	PM_{10}

Region	Location	Site established	Site classification	Contaminants
Canterbury	St Albans – Coles Place, Christchurch	From 1998	Residential neighbourhood	PM_{10}, SO_2, CO, NOx
	St Albans – Packe Street, Christchurch	From 1989 to 2001	Residential neighbourhood	PM_{10}, SO_2, CO, NOx
	Opawa – Mary McLean Place, Christchurch	From July 1996 to June 1999	Industrial neighbourhood	PM_{10}, SO_2
	Hornby – South Hornby School, Christchurch	From June 1995 to December 1998	Residential neighbourhood	PM_{10}, SO_2, CO
	Beckenham – 66 Colombo Street, Christchurch	From June 1995 to March 1997	Residential neighbourhood	PM_{10}, CO
	41A Peraki Street, Kaiapoi	From April 2001	Residential neighbourhood	PM_{10}, SO_2, CO
	Timaru Main School, Timaru	From January 1997	Residential neighbourhood	PM_{10}, SO_2, CO
	Ashburton Domain, Ashburton	December 1997–December 1998	Residential neighbourhood	PM_{10}, SO_2, CO
	14 Cambridge Street, Ashburton	March 1999–December 2000	Residential neighbourhood	PM_{10}, SO_2, CO
	St Joseph's School, Rangiora	January 1999–December 2000	Residential neighbourhood	PM_{10}, SO_2, CO
West Coast	49 Palmerston Street, Greymouth	May–August 2001	Residential neighbourhood	PM_{10}, SO_2
Otago	Harlich, Oamaru	June–August 1998	Residential neighbourhood	PM_{10}
	Ventry Street, Alexandra	From April 1997–September 1998	Residential neighbourhood	PM_{10}
	Ventry Street, Alexandra	From April 1998 onwards	Residential neighbourhood	PM_{10}
	30 Ray Street, Cromwell	June–August 1999, June–August 2001	Residential neighbourhood	PM_{10}
	Albany Street, Dunedin	From January 1997	Residential neighbourhood	PM_{10}
	North Road North East Valley, Dunedin	From January 1997	Residential neighbourhood	PM_{10}
	Cumberland Street, Dunedin	2002		CO
	Church Street, Mosgiel	June–August 1998 and June 2000–September 2001	Residential neighbourhood	PM_{10}
	Factory Road, Mosgiel	From June 2000	Residential neighbourhood	PM_{10}
	BNZ Bank, Mosgiel	From 1999		CO
	Union SH1, Milton	June–September 1999	Residential neighbourhood	PM_{10}
	Cnr Lanark and Paisley, Balclutha	June–September 1997, June–September 2000	Residential neighbourhood	PM_{10}
	Bush Creek Road, Arrowtown	July–September 1999	Residential neighbourhood	PM_{10}
	Camp and Shotover, Queenstown	June–August 1999	Commercial/ residential	PM_{10}
	Irmo, Dunedin Green Island	June–September 1997, June–August 2000, July–August 2001	Residential neighbourhood	PM_{10}

About the Ministry for the Environment

The Ministry for the Environment works with others to identify New Zealand's environmental problems and get action on solutions. Our focus is on the effects people's everyday activities have on the environment, so our work programmes cover both the natural world and the places where people live and work.

We advise the Government on New Zealand's environmental laws, policies, standards and guidelines, monitor how they are working in practice, and take any action needed to improve them. Through reporting on the state of our environment, we help raise community awareness and provide the information needed by decision makers. We also play our part in international action on global environmental issues.

On behalf of the Minister for the Environment, who has duties under various laws, we report on local government performance on environmental matters and on the work of the Environmental Risk Management Authority and the Energy Efficiency and Conservation Authority.

Besides the Environment Act 1986 under which it was set up, the Ministry is responsible for administering the Soil Conservation and Rivers Control Act 1941, the Resource Management Act 1991, the Ozone Layer Protection Act 1996, and the Hazardous Substances and New Organisms Act 1996.

Head Office
Grand Annexe Building
84 Boulcott Street
PO Box 10-362
Wellington, New Zealand
Phone (04) 917 7400, fax (04) 917 7523
Internet www.mfe.govt.nz

Northern Regions Office
8–10 Whitaker Place
PO Box 8270
Auckland
Phone (09) 913 1640, fax (09) 913 1649

South Island Office
Level 4
Price Waterhouse Centre
119 Armagh Street
PO Box 1345
Christchurch
Phone (03) 963 0940, fax (03) 963 2050