Ambient Air Quality in Otago

Particulate Matter

1997 - 2004

AIR

Otago Regional Council

Ambient Air Quality in Otago 1997-2004

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Chairman's foreword

If you were asked to grade the quality of the air in Otago, most people would put it in the first class category. In fact it is true that Otago air quality is usually very good, however there are times especially during the winter when many urban areas, can suffer from high levels of pollution. This is because in addition to industrial discharges, we tend to use a lot of solid fuel such as coal and wood to heat our houses, which creates high levels of smoke in the air. To make matters worse, calm and cold winter nights can create a smoke trapping inversion layer, making some areas particularly prone to high levels of pollution.

The effect of this air pollution is not just a local amenity problem but can cause significant health problems as well. The health effects are particularly noticeable within the elderly and other vulnerable groups such as those suffering from respiratory problems.

The Otago Regional Council is committed to help make the air of Otago clean and create a healthier environment. The Regional Policy Statement provides for the sustainable management of the air resource and the Regional Plan: Air sets out objectives, policies and rules that the Council use for maintaining or enhancing the quality of the air. Industrial emissions are controlled through resource consents.

National environmental standards (NES) for ambient air quality in New Zealand were introduced by the Ministry for the Environment (MfE) in September 2005. One of the main contaminants that can exceed these standards is small suspended particles (PM_{10}) found in smoke. The NES sets the maximum allowable level of PM_{10} at 50 micrograms per cubic meter of air and the Otago Regional Council has monitoring equipment in several locations across the region to see whether this level is exceeded. To help reduce the level of emissions from solid fuel burning there is also a NES for wood burners.

This report provides a summary of the Otago Regional Council air quality monitoring programme for particulate matter, which has been in operation since 1997. It clearly identifies those towns where air pollution is a problem and where the maximum allowable PM_{10} level has been breached. This monitoring programme is providing essential information to help the Council understand the extent of the problem and how to introduce the most practicable management methods to achieve clean healthy air.

Stephen Cairns
Chairperson

Executive Summary

Otago air quality is generally very good. However, in localised areas, air pollution from human activity including domestic, industrial, commercial and transport sources can result in concentrations of pollutants that exceed the national ambient air quality standard. The Otago Regional Council began an air quality monitoring programme in 1997, which has focused on measuring suspended particulate (particles in the air less than 10 microns in diameter and referred to as PM_{10}), carbon monoxide (CO), nitrogen dioxide (NO_2), and sulphur dioxide (SO_2). This report presents the results of PM_{10} monitoring throughout the Otago region. Annual summary reports of PM_{10} levels have been produced since 1998, but these have generally been restricted to summarising a single year of data. The purpose of this report is to examine trends at the long–term sites, as well as to analyse data from short term monitoring sites.

The Otago Regional Council's air quality monitoring network consists of 4 permanent recording sites at North East Valley and Albany Street in Dunedin, Mosgiel, and Alexandra. Data have been collected from 14 other temporary sites Otago.

The guideline value for PM_{10} levels in Otago is a 24 hour average of 50 micrograms per cubic metre of air ($\mu g/m^3$) as set down in the Regional Plan: Air (ORC 2003). This guideline was designed to protect the ambient air quality in Otago. National Environmental Standard (NES) legislation passed in 2004 also sets the maximum 24 hour average PM_{10} level at 50 $\mu g/m^3$.

The results of the Otago Regional Council monitoring program show that there are several locations within Otago where PM_{10} levels exceed the standard. Most of these breaches occur during the winter months (June, July and August). In Alexandra, the NES limit is exceeded 57% of the time during winter (52 days), while in Mosgiel the number of winter exceedances is approximately 18% (17 days). In Dunedin, the number of winter exceedances is approximately 6% (6 days) at both Albany Street and North East Valley.

Winter average PM_{10} levels at permanent monitoring sites range from 60 $\mu g/m^3$ at Alexandra, to 35 $\mu g/m^3$ at Mosgiel, 24 $\mu g/m^3$ at North East Valley, and 18 $\mu g/m^3$ at Albany Street.

There are still insufficient data to show any significant long-term trends in annual average PM_{10} levels. The four permanent sites have shown the following short-term trends however:

- Alexandra annual average PM_{10} has fluctuated between 22 and 37$\mu g/m^3$ since 1999.
- In Mosgiel, the annual average level has increased from 17 $\mu g/m^3$ in 2001 to 27$\mu g/m^3$ in 2004.
- North East Valley annual averages have declined gradually from 19 $\mu g/m^3$ in 1997 to 13 $\mu g/m^3$ in 2004.
- Albany Street annual average has been reasonably steady at approximately 23 $\mu g/m^3$.

Continuous monitoring of PM_{10} levels in Alexandra in 2002 revealed that the one day in six Hi-Vol sampling often misses the minimum and maximum values, especially during the winter period. Datasets derived from one-in-six sampling are only an approximation to the actual particulate levels at a site.

Data collected from temporary recorder sites in smaller towns show that Arrowtown, Cromwell, Green Island, Palmerston, and South Dunedin all experience peaks in PM_{10} that are well above the Standard value.

The PM_{10} monitoring program will be expanded during 2005 to include continuous hourly average data from Alexandra and Mosgiel. New sites, as well as existing sampling locations will continue to be monitored around Otago to enable better definition of PM_{10} levels in the region.

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1. Introduction

Otago air quality is generally very good. However air pollution from human activity including domestic, industrial, commercial and transport sources can result in concentrations of pollutants that exceed the national air quality standard. The Otago Regional Council began an air quality monitoring programme in 1997, which has focused on measuring suspended particulate (particles in the air less than 10 microns in diameter and referred to as PM_{10}), carbon monoxide (CO), nitrogen dioxide (NO_2), and sulphur dioxide (SO_2). This report presents the results of PM_{10} monitoring throughout the Otago region. Results from all permanent and temporary suspended particulate monitoring sites are presented.

A National Environmental Standard (NES) for Air Quality was passed into legislation under the Resource Management Act in 2004. This Standard sets a maximum allowable concentration for sub-10 micron particulate matter (PM_{10}) at 50 micrograms per cubic metre of air, with one exceedance per year. The standard comes into force on 1 September 2005 and needs to be attained by 2013. If the standard is not met by 2013, councils will be unable to issue any new resource consents for PM_{10} discharges to air. Regional Authorities such at the Otago Regional Council will be required to continuously monitor PM_{10} on a daily basis to ensure these standards are met.

The Air Quality NES was introduced to improve human health. The main health effects of high levels of PM_{10} range from minor effects, such as nose and throat irritation, to more serious effects such as aggravation of existing respiratory and cardiovascular disease, increased hospital admissions and school absences, and premature death. Particle pollution in New Zealand is estimated to cause around 970 premature deaths each year (Ministry for the Environment, 2005). In other words, as a consequence of inhaling PM_{10} pollution, people with existing respiratory or heart disease may die earlier than they would have. Children, adults with obstructive lung disease, asthmatics, and the elderly are most sensitive to particle pollution.

This report identifies locations within Otago where air quality does not meet the NES. Estimates of the likely number of days where particulate levels will exceed the NES are also calculated for Alexandra and Mosgiel, using PM_{10} records and climate data. Eight years of PM_{10} data from permanent Dunedin and Alexandra monitoring sites (4 years for Mosgiel) are analysed for trends and the probability of exceedance of standard values.

The Otago Regional Council is currently installing continuous PM_{10} monitors in Alexandra, Mosgiel and North Dunedin as well as a mobile unit to be used at other locations with high PM_{10} levels. These units will help to define the air quality of Otago, providing better information on timing of excessive PM_{10} episodes with real-time data available to Council and the public via internet and media.

2. Monitoring Sites

The majority of air quality monitoring undertaken by the Otago Regional Council has been 24 hour average PM_{10} data. Dunedin and other smaller towns around Otago have been the primary target of PM_{10} monitoring, and the Otago Regional Council now has data from 18 sites around the region (Figure 2.2). Table 2.1 summarises the years of data on record, and the type of instrument used to measure PM_{10}. The current recommended method for monitoring particulate matter (AS/NZS 3580.9.9:2003) is one that draws a large volume of air across a pre-weighted filter for 24 hours (Ministry for Environment, 2004). The filter is weighed again after sampling, to determine the mass difference and hence a concentration. These monitors are commonly called High Volume samplers (Hi-Vol), and the Otago Regional Council uses Hi-Vols at North East Valley, Albany Street, Mosgiel and Alexandra.

In the winter of 2002, the Otago Regional Council contracted the National Institute of Water and Atmospheric Research (NIWA) to collect detailed PM_{10} data in Alexandra. NIWA used a Tapered Element Oscillating Microbalance (TEOM) monitor to collect hourly PM_{10} averages. A comparison of the TEOM data with Hi-Vol data collected by the Otago Regional Council over the same period is presented.

The Otago Regional Council also investigated PM_{10} levels at smaller towns and suburbs within Otago, and Airmetrics Mini-Vol Portable Air Samplers are used for this purpose. These instruments draw a smaller volume of air through a filter, and therefore results are only useful as a general indicator of PM_{10} levels.

Figure 2.1 Hi Vol Air Quality Monitoring Site at Albany Street

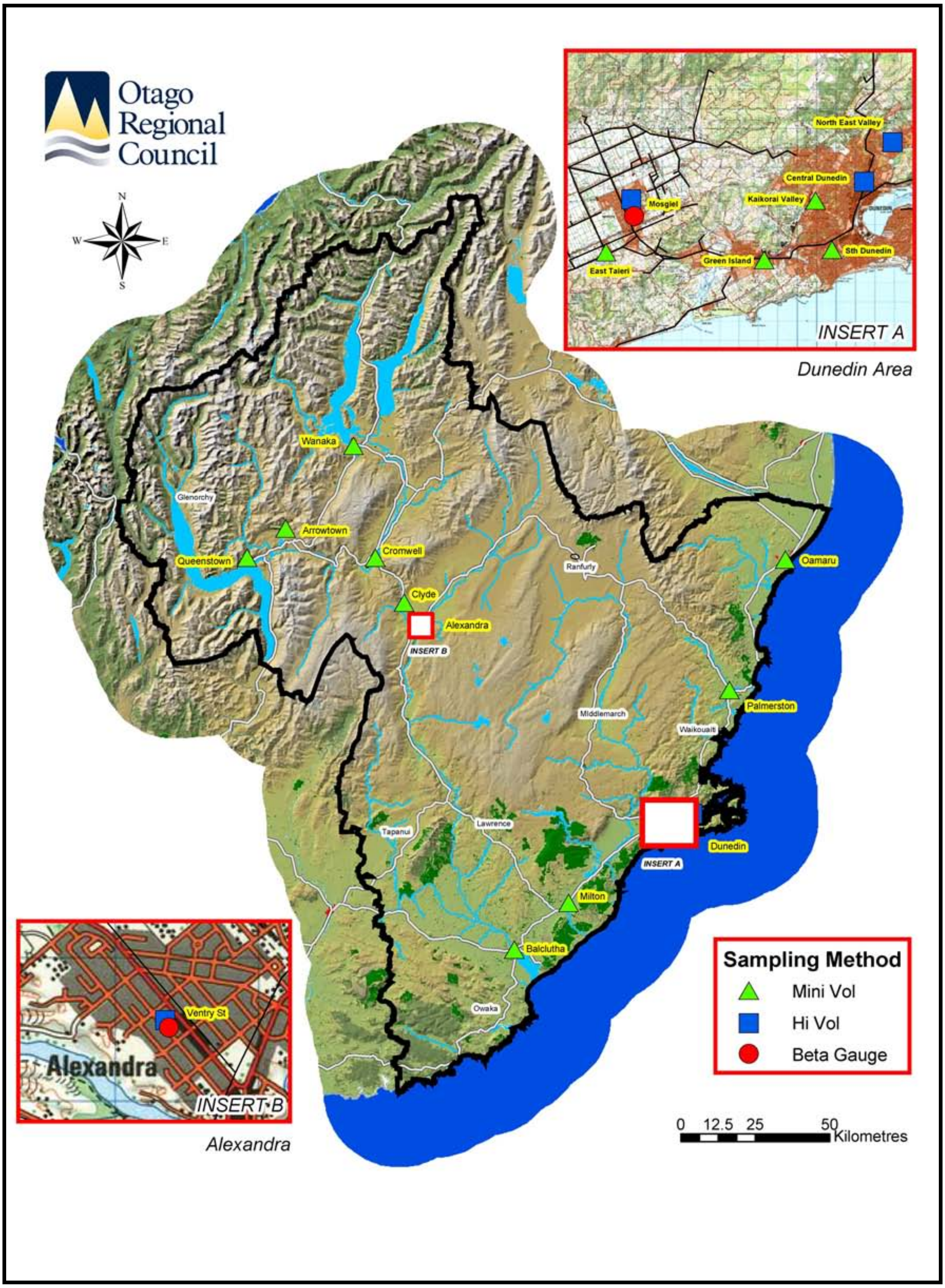

Figure 2.2 Location of Air Quality Monitoring sites in Otago

Table 2.1 Summary of Otago Regional Council Particulate Monitoring sites, 1997-2004

PM_{10} Instrument Type	Station Name	Location	Years of Record
Hi-Vol	Dunedin	North Road, North East Valley	1997-
Hi-Vol	Dunedin	Albany Street	1997-
Hi-Vol	Mosgiel	Mosgiel Industrial Estate	2001-
Hi-Vol TEOM	Alexandra	Ventry Street	1997- 2002
Mini-Vol	Mosgiel	Church Street	1997-2002
Mini-Vol	Green Island	Irmo Street	1997, 2000-2002
Mini-Vol	South Dunedin	Bayview Road	1998,2001-2002
Mini-Vol	Clyde	Cnr Halloway & Naylor St	2002
Mini-Vol	East Taieri		1997
Mini-Vol	Balclutha	Cnr Lanark & Paisley Streets	1997,2000
Mini-Vol	Oamaru	Harlich Street	1998
Mini-Vol	Milton	Union Street SH1	1997-2000
Mini-Vol	Queenstown	Brisbane Street	1999
Mini-Vol	Arrowtown	Criterion Street	1999,2003-2004
Mini-Vol	Cromwell	Ray Street	1999, 2004
Mini-Vol	Wanaka	Cnr Connor & Stone Streets	2003
Mini-Vol	Palmerston	Start Street	2003
Mini-Vol	Dunedin	School Street, Kaikorai Valley	2004

3. Ambient Air Quality Targets

The ambient air quality standards that apply in Otago are summarised in Table 3.1. The Otago guideline values are sourced from the Regional Plan: Air (ORC 2003), and the corresponding indicator level used in Otago Regional Council reports is also shown. The 50 $\mu g/m^3$ target matches the level set down by the Ministry for the Environment in the NES legislation (MfE 2004), and Table 3.2 shows national ambient air quality categories, and the associated Ministry for the Environment recommended action.

Table 3.1 Regional PM_{10} air quality guidelines

Averaging Period	Otago Guideline Levels (ORC 2003)	66% of Guideline	33% of Guideline	Recommended technique of measurement
	HIGH	**MEDIUM**	**LOW**	
24 hours	50 $\mu g/m^3$	33 $\mu g/m^3$	17 $\mu g/m^3$	AS 3580.9.6 -2003 AS 3580.9.7 -1990

Table 3.2 National ambient air quality categories used for indicators (MfE, 2002)

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

4. Quality Assurance

All monitoring sites have been operated by the Otago Regional Council since 1997, with the exception of the TEOM monitoring in Alexandra in 2002, which was operated by NIWA. The Otago Regional Council is responsible for site maintenance, calibration of equipment, and providing quality assured data. Procedures for the management of particulate monitoring sites are outlined in the Air Quality Manual (Otago Regional Council, 2003). Additional procedures are outlined in The Air Pollution Measurement Manual (CASANZ, 2000). Two Council staff attended Ambient Air Quality Monitoring courses run by the Ministry for the Environment and CASANZ (Clean Air Society Australia and New Zealand) in 2004. Policies and quality management procedures of the Otago Regional Council Resource Science Section are outlined in the Quality Manual (ORC, 2005).

Checks of PM_{10} instruments include calibration by external contractors, as well as regular inspections by Council staff. The Hi-Vol sampler is the standard method for measuring particulate matter in many parts of the world, and meets the relevant Australian Standard (AS2724.3). The TEOM is classified as an equivalent method for PM_{10} monitoring in accordance with the United States Environmental Protection Agency standard method. The Mini-Vol samplers do not meet relevant standards, but are useful for short term indicative survey work.

5. PM10 Results

This section summarises data collected from permanent sites in Mosgiel, Alexandra, North Dunedin and North East Valley, as well as data from 13 other temporary sites around Otago.

5.1 Permanent PM_{10} Sites

Four permanent PM_{10} monitoring sites around Otago provide year-round particulate data for Alexandra, Mosgiel, North East Valley and Albany Street (North Dunedin). Samples taken from these sites are 24-hour averages, and are taken every 6th day throughout the year. During the winters of 2003 and 2004 at Alexandra, and winter 2004 at Mosgiel, sampling was increased to every 3rd day. Winter is defined as the period 1st June to 31st August for the purpose of this report.

5.1.1 Alexandra

Table 5.1 summarises PM_{10} results from Alexandra. Annual average figures are not available for 1997 and 1998 as the monitor was not running for the entire year. Table 5.1 shows that average PM_{10} levels during the winter months have exceeded the NES value of 50 µg/m^3 every year since 1997. The percentage of winter sample days when PM_{10} exceeds the NES varies from 50% to 70%.

Increasing the number of samples from one day in six to one day in three during winter 2003 and 2004 did not provide statistics significantly different from other years.

Table 5.1 Summary of PM_{10} from Alexandra sampling site

Year	Number of days sampled - Annual	Annual Average PM_{10} (µg/m^3)	Number of days sampled - Winter	Winter Average PM_{10} (µg/m^3)	Percentage of winter sample days > 50µg/m^3	Max recorded PM_{10} (µg/m^3)
1997	26	*	14	59	57	178
1998	35	*	15	60	53	134
1999	61	22	16	51	50	87
2000	52	26	14	55	57	108
2001	51	30	13	77	69	193
2002	58	24	12	52	50	110
2003	79	37	30	64	50	162
2004	75	34	30	63	70	101
Average		**29**		**60**	**57%**	

5.1.2 Mosgiel

PM_{10} data from the permanent Mosgiel monitoring site began in June 2001. Previous sampling from a smaller instrument occurred in the winter of 1998, and from June 2000 until August 2001. The annual average PM_{10} value for 2001 was calculated by combining these two datasets. Sampling on every third day occurred in winter 2004, doubling the number of samples taken in previous winters.

Table 5.2 shows that the percentage of winter sample days where PM_{10} exceeds the 50 µg/m^3 NES increased to 37% in 2004. The average winter PM_{10} increased significantly in 2003 to 44 µg/m^3, with the 2004 value steady at the same level. The annual average level has tended to increase since regular monitoring began in 2001.

Table 5.2 Summary of PM_{10} from Mosgiel sampling sites

Year	Number of days sampled - Annual	Annual Average PM_{10} (µg/m^3)	Number of days sampled – Winter	Winter Average PM_{10} (µg/m^3)	Percentage of winter sample days > 50µg/m^3	Max recorded PM_{10} (µg/m^3)
1998			13	40	31	95
1999						
2000			14	28	7	70
2001	33	17*	13	24	0	43
2002	60	19	15	31	7	59
2003	61	22	15	44	27	100
2004	80	27	30	43	37	92
Average		**21**		**35**	**18%**	

*Value derived from two datasets

5.1.3 North East Valley (Dunedin)

Eight years of record are now available for the North East Valley site (Table 5.3). After some initial high PM_{10} readings in 1997 and 1998, peak levels have decreased, and there have been no measured exceedances of the 50 µg/m^3 limit since 2001 at this site. The winter average PM_{10} level has been reasonably steady at between 20 – 30 µg/m^3 over the length of record. The annual average PM_{10} level has gradually declined from 19µg/m^3 in 1997, to 13µg/m^3 in 2004.

Table 5.3 Summary of PM_{10} from North East Valley sampling site

Year	Number of days sampled – Annual	Annual Average PM_{10} (µg/m^3)	Number of days sampled – Winter	Winter Average PM_{10} (µg/m^3)	Percentage of winter sample days > 50µg/m^3	Max recorded PM_{10} (µg/m^3)
1997	55	19	15	24	13	72
1998	60	18	14	35	29	88
1999	58	18	14	25	7	51
2000	58	14	16	18	6	57
2001	59	14	16	21	0	41
2002	60	14	16	19	0	35
2003	60	16	14	27	0	50
2004	61	13	15	20	0	37

5.1.4 Albany Street (North Dunedin)

Results from the Albany Street monitoring station show there are few sampling days that exceed the 50 µg/m^3 NES for PM_{10} (Table 5.4). The average winter PM_{10} level has generally remained steady at 20 – 30 µg/m^3 since records began, with the exception of 1998, when the maximum recorded reading to date of 71 µg/m^3 helped push the winter average to 38 µg/m^3. Annual average PM_{10} has also remained steady at 20 – 27 µg/m^3. The number of winter exceedances of the NES has ranged from 0 to 6% since the Castle

Street power station was upgraded to reduce emissions in 2002, compared with a range of 0 to 15% prior to the upgrade.

Table 5.4 Summary of PM_{10} from Albany Street sampling site

Year	Number of days sampled - Annual	Annual Average PM_{10} ($\mu g/m^3$)	Number of days sampled – Winter	Winter Average PM_{10} ($\mu g/m^3$)	Percentage of winter sample days > $50 \mu g/m^3$	Max recorded PM_{10} ($\mu g/m^3$)
1997	54	24	15	26	7	65
1998	60	23	15	38	7	71
1999	59	27	14	24	14	59
2000	58	21	13	21	0	48
2001	53	24	13	31	15	60
2002	56	21	12	21	0	48
2003	60	22	14	28	0	48
2004	62	20	16	22	6	57
Average		**23**		**26**	**6%**	

5.2 Alexandra TEOM Data

Daily average PM_{10} data for Alexandra between 14 June and 30 September 2002 are shown in Figure 6.1. These data were collected from a TEOM (tapered element oscillating microbalance) monitor and the corrected data are compared with PM_{10} results from the regular Hi-Vol monitoring. The TEOM machine was useful as it gave close to real time reporting, and allows the better understanding of the effect of factors such as wind changes and solid fuel burning on pollution concentrations. However, the disadvantage in using this device is that a certain amount of particulate collected by the machine is vaporised during the process, giving results somewhat lower than those of the Hi-Vol. A correction was applied to the TEOM data by applying regression analysis against Hi-Vol results taken on the same sample days. Although not ideal, this correction provides for the best possible use of these data.

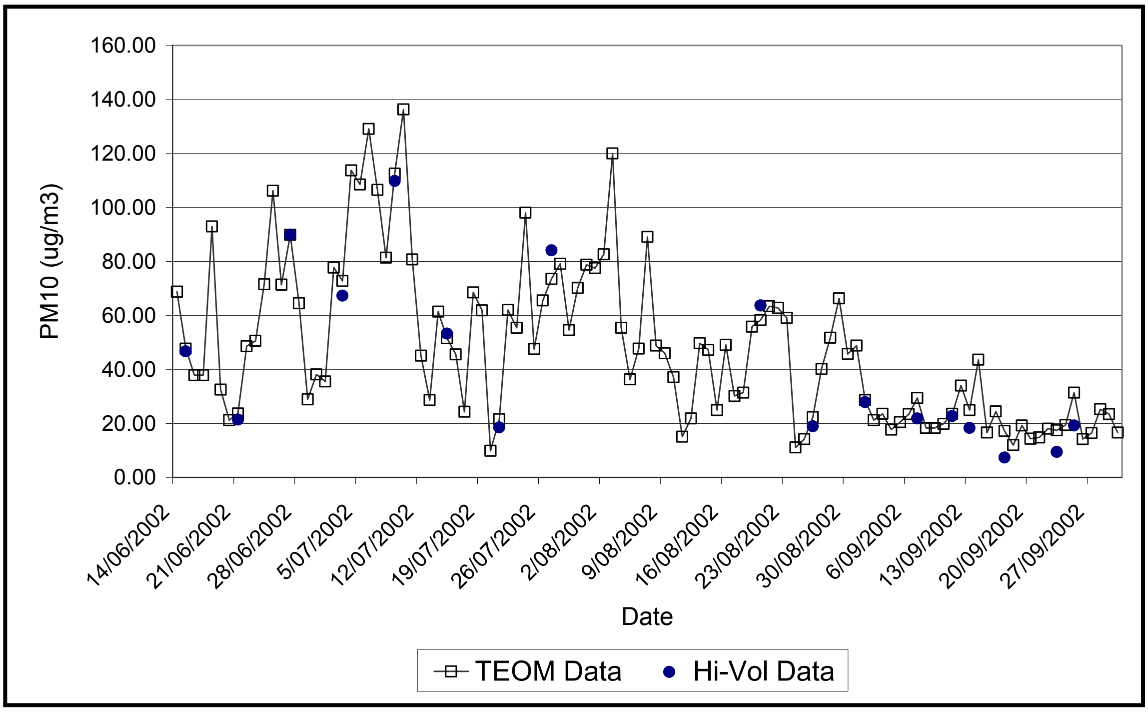

Figure 5.1 Daily average PM_{10} data from TEOM* and Hi-Vol monitors

***TEOM data has been corrected using Regression Analysis**

The temporal variation of PM_{10} levels was considered by averaging values for each hour of the day over the 109 days of TEOM record (Figure 5.2). Average hourly windspeed is also presented in Figure 5.2, and some distinct trends are shown. PM_{10} levels peak in the evening between 6pm and midnight, with a smaller peak in the morning between 8am and 11am. Average daily windspeed increases from 11am through until the early evening, coinciding with a drop in PM_{10} levels.

The patterns shown in Figure 5.2 are likely caused by a number of factors. Increasing windspeed in the afternoon will help to disperse PM_{10}, while colder temperatures and inversion layers are more likely in the evening; the same time as people return from work and are lighting their fires, increasing PM_{10} output. The mid-morning peak in PM_{10} is also likely to be caused by increased PM_{10} output from fires.

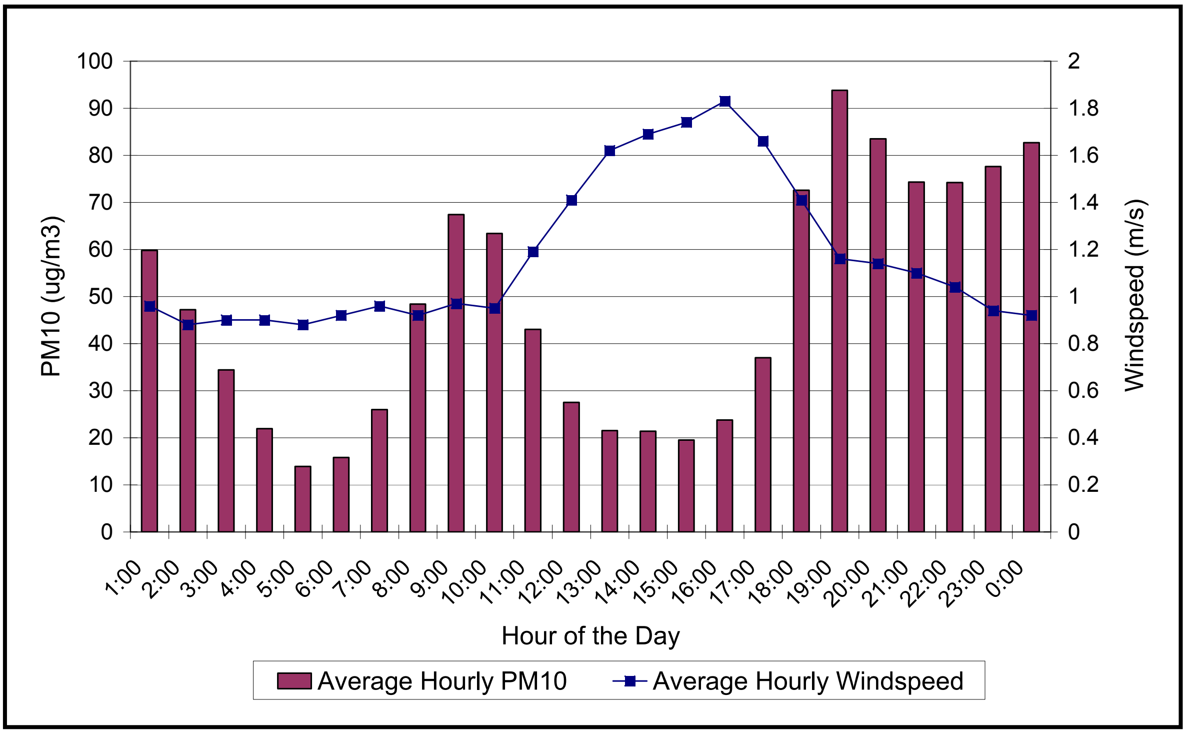

Figure 5.2 Average hourly PM_{10} and average hourly windspeed from Alexandra, 14 June to 30 September 2002

Figure 6.1 shows that several peaks in daily average PM_{10} were not recorded by the one day in six sampling of the Hi-Vol. Table 5.5 shows that average daily PM_{10} calculated from the corrected TEOM data are 48 µg/m^3, while the Hi-Vol data gives an average daily PM_{10} level of 41 µg/m^3. The percentage of winter sample days that exceed 50 µg/m^3 as calculated from the daily TEOM data are 64% for 2002, slightly higher than the level estimated from the irregular Hi-Vol sampling (60%). The 10, 20, 80 and 90 percentile values all show lower PM_{10} levels for 1 day in 6 monitoring.

In summary, the data collected in 2002 suggests that the one day in six Hi-Vol sampling gives a lower average PM_{10} level, higher standard deviation, lower maximum level, and less 50 µg/m^3 exceedances compared to the continuous data collected from the TEOM. Further continuous monitoring from Alexandra and other sites is required to confirm this relationship.

Table 5.5 Statistical Parameters for PM_{10} data collected continuously from Alexandra TEOM, and 1 day in 6 Hi-Vol sampling.

Parameter	Continuous Monitoring	1 day in 6 Monitoring
Average	48.1	41.2
Standard Deviation	29.5	31.4
Maximum	136.3	109.8
Minimum	9.85	7.4
Exceedances of 50 $\mu g/m^3$ limit	64%	60%
10 percentile	17.1	14.7
20 percentile	21.2	18.6
80 percentile	71.5	66.6
90 percentile	89.3	86.4

5.3 Temporary PM_{10} Sites

5.3.1 Arrowtown

Particulate levels at the Arrowtown sampling site are often well above the national standard for air quality, and the results from winter 2003 and 2004 are significantly higher than those collected in 1999 (Figure 5.3). The winter average increased from 28 $\mu g/m^3$ in 1999 to approximately 50 $\mu g/m^3$ during the last two years. The winter maximum also increased from 55 $\mu g/m^3$ in 1999 to over 100 $\mu g/m^3$, during 2003 and 2004. Only 9 days were sampled in 1999, with many high pollution days possibly being missed. The number of sample days was 14 and 15 in 2003 and 2004 respectively. The percentage of sample days where the NES was exceeded was 11% in 1999, 29% in 2003, and 27% in 2004. It is possible that 1999 was a warmer winter than 2003 and 2004 in Arrowtown, with less particulate matter from household fires. However a review of winter temperatures from Queenstown Airport (the nearest climatological site) showed no significant difference between 1999 and 2003 – 2004.

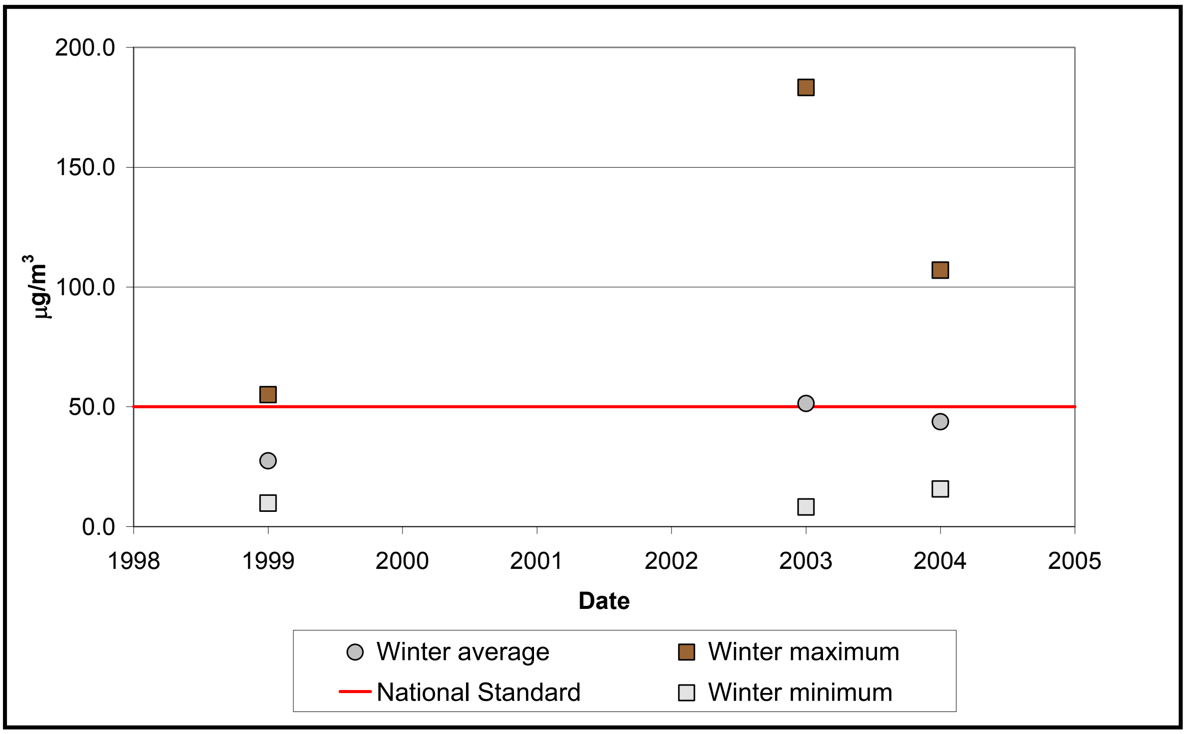

Figure 5.3 Winter maximum, average and minimum 24-hour PM_{10} concentrations in Arrowtown

5.3.2 Balclutha

PM_{10} monitoring was undertaken in Balclutha in 1997 and 2000 (Figure 5.4). Only one of the 32 samples taken over these two years exceeded the 50 µg/m^3 national standard. There are insufficient data to comment on any likely trends.

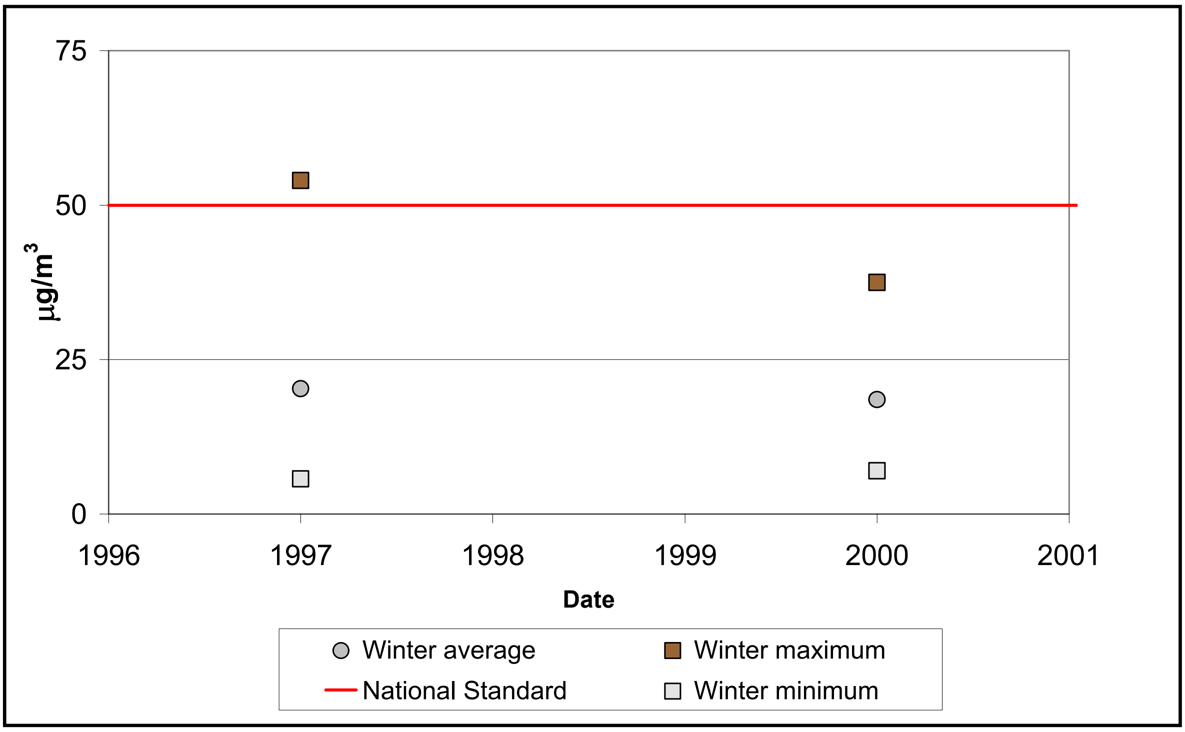

Figure 5.4 Winter maximum, average and minimum 24-hour PM_{10} concentrations in Balclutha

5.3.3 Clyde

Particulate matter has only been sampled at Clyde over the winter of 2002 (Figure 5.5). The maximum reading from the 16 samples taken over this period was 49 µg/m^3, with an average of 22 µg/m^3 for the winter period. The 2002 winter average in nearby Alexandra was 52 µg/m^3, with the greatest reading being 110 µg/m^3. These results suggest that PM_{10} levels in Clyde may be approximately half those recorded in Alexandra. There are only 12 simultaneous data points between these two towns, and further monitoring in Clyde is required to confirm this relationship.

The 2002 results from Alexandra gave the second lowest winter average since records began in 1997, suggesting that this was a reasonably moderate pollution year. In addition, only one day in six was sampled, meaning other high pollution days may have been missed. The results from Clyde may therefore not be representative of the long-term situation.

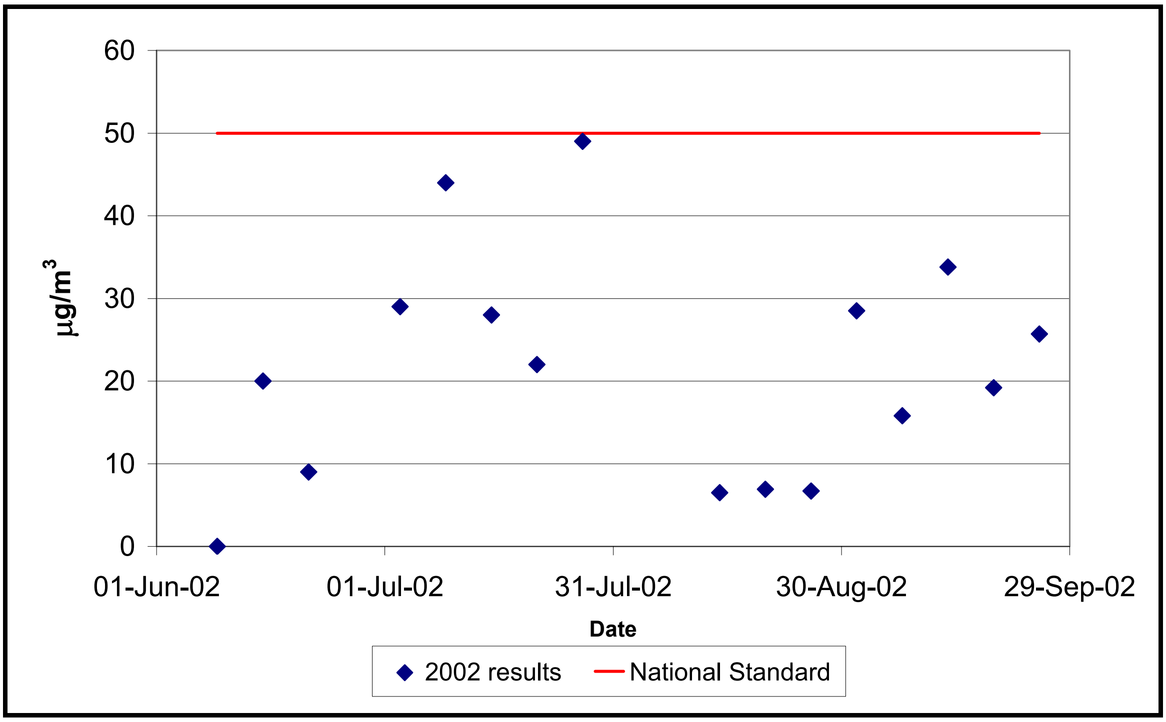

Figure 5.5 Average 24-hour PM_{10} concentrations for winter 2002 in Clyde

5.3.4 Cromwell

Winter sampling has shown that particulate levels in Cromwell are often well above the NES. Sampling has been undertaken in 1999 and 2004, and Figure 5.6 shows that winter daily average PM_{10} levels was 34 µg/m^3 in 1999 and 37 µg/m^3 in 2004. The maximum recorded levels were 73µg/m^3 in 1999 and 97 µg/m^3 in 2004. Approximately one third of all particulate samples at Cromwell are above the national standard of 50 µg/m^3, although only one day in six monitoring means that many high pollution days may not have been sampled.

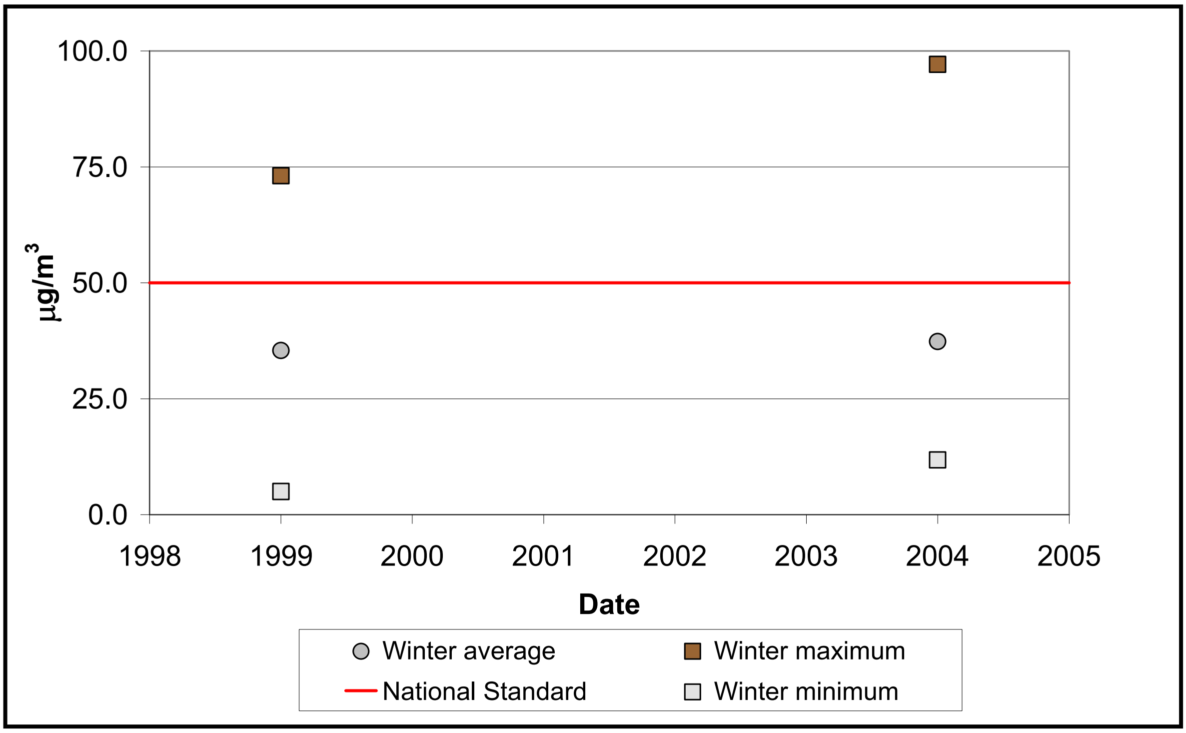

Figure 5.6 Winter maximum, average and minimum 24-hour PM_{10} concentrations in Cromwell

5.3.5 East Taieri

Eleven 24 hour samples were taken at East Taieri during the summer and early autumn of 1997 (February to April). Figure 5.7 shows that none of these samples approached the national standard of 50 µg/m^3. The East Taieri data are useful as they give an idea of ambient particulate levels away from main centres in the Otago region. The average PM_{10} level at East Taieri over this period was 6.6 µg/m^3, with a maximum recorded value of 22 µg/m^3. Particulate levels at East Taieri may be higher over the winter months,

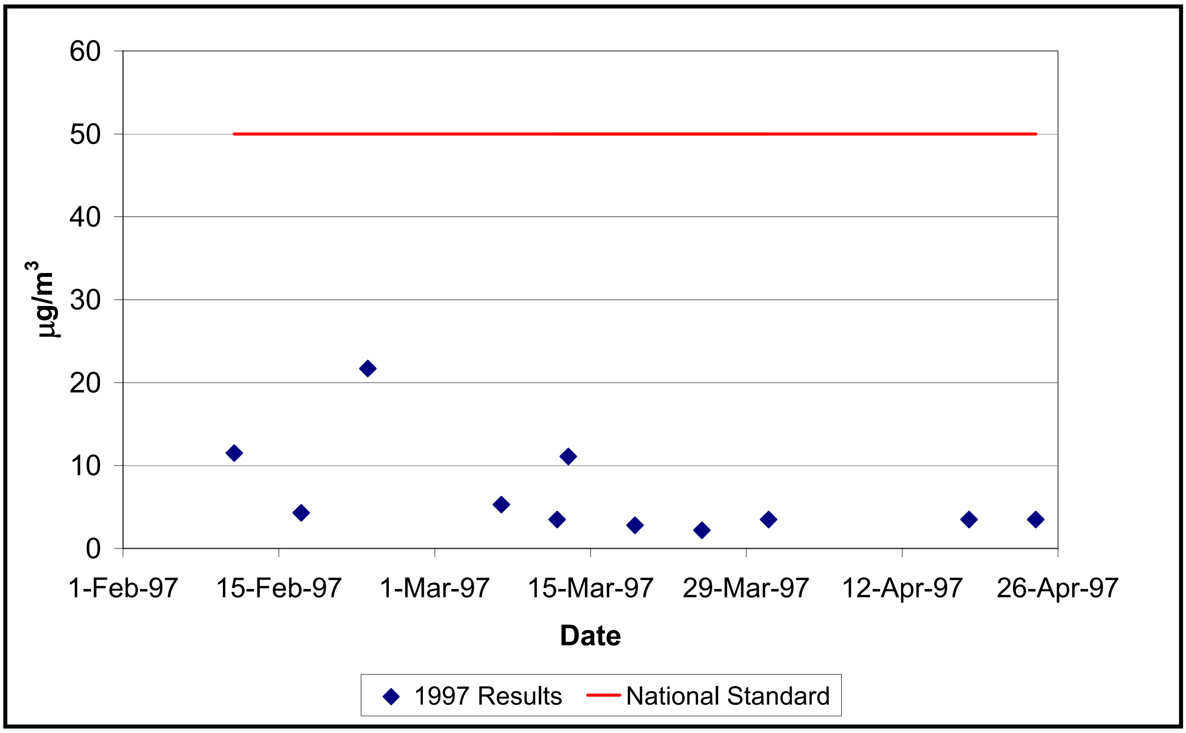

Figure 5.7 Average 24-hour PM_{10} concentrations for Feb – April 1997 in East Taieri

5.3.6 Green Island

Figure 5.8 shows winter average particulate levels in Green Island Dunedin to be between 29 and 35 µg/m^3. The winter maximum for each year ranges from 58 to 107 µg/m^3, and was always above the national standard. The number of exceedances of the 50 µg/m^3 national standard is between 1 and 2 per year (6 in total over 4 years of record). The results indicate that under certain conditions this location is at risk for particulate levels to be well above the NES.

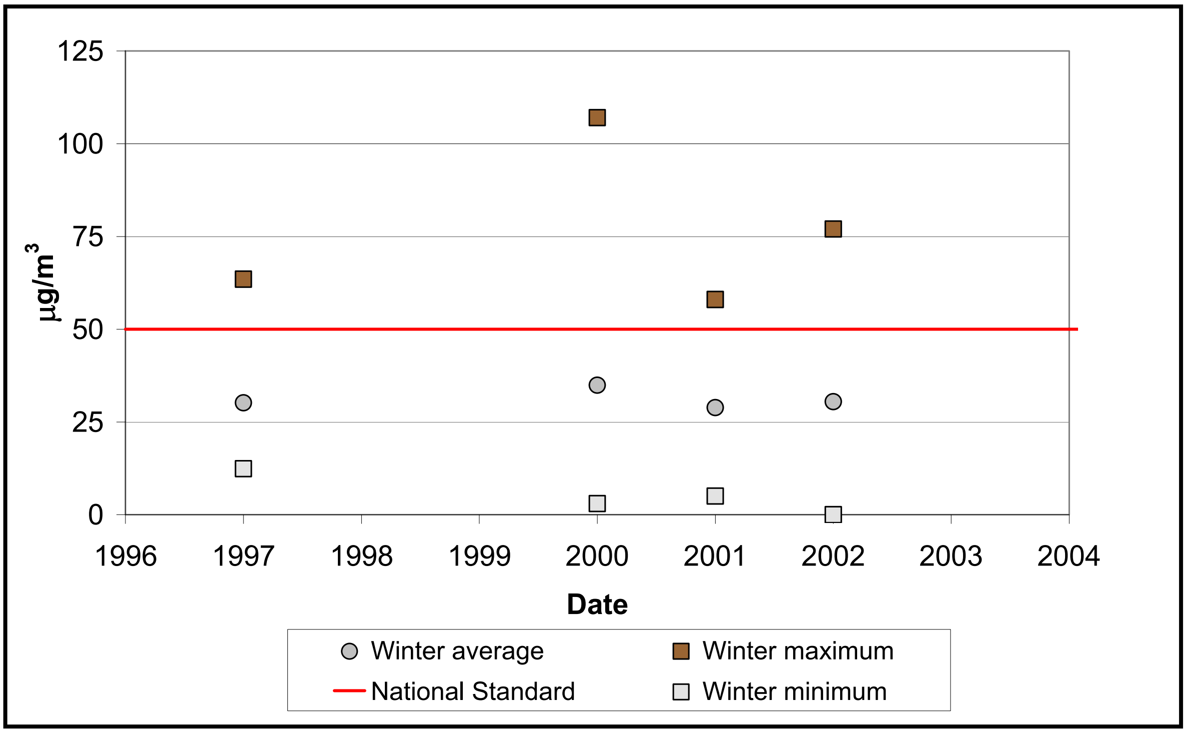

Figure 5.8 Winter minimum, average and maximum 24-hour PM_{10} concentrations at Green Island

5.3.7 Kaikorai Valley

Fifteen samples were taken in Kaikorai Valley over the winter months of 2004 (Figure 5.9). There were no exceedances of the NES, although one third of the results were between 33-50 µg/m^3. The maximum reading was 47 µg/m^3, and the winter average was 24 µg/m^3. These results suggest that Kaikorai Valley does not have a serious problem with particulate levels, although exceedances of the national standard could occur under cold and calm conditions.

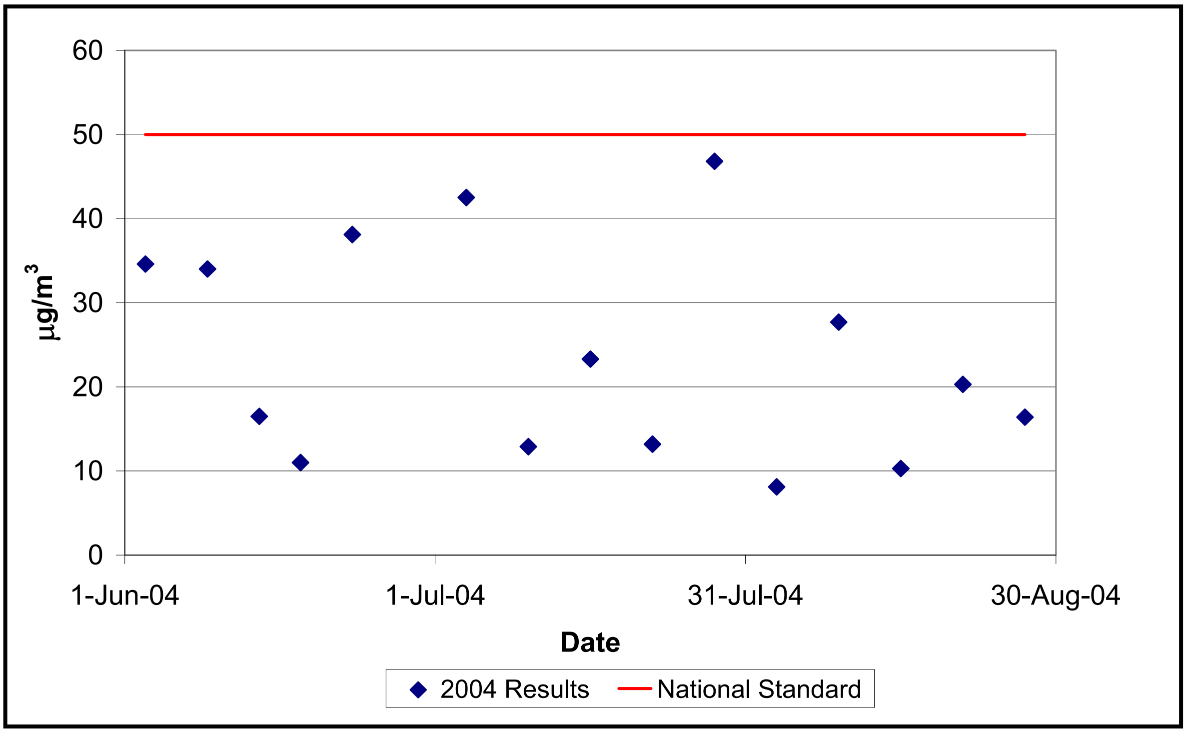

Figure 5.9 Average 24-hour PM_{10} concentrations for winter 2004 in Kaikorai Valley

5.3.8 Milton

Sixteen samples were taken in Milton during the winter months of 1999 (Figure 5.10). There were two exceedances of the 50 µg/m^3 NES, and one third of the results were over 33 µg/m^3 (Medium – High level). The maximum reading was 57 µg/m^3, and the winter average was 27 µg/m^3.

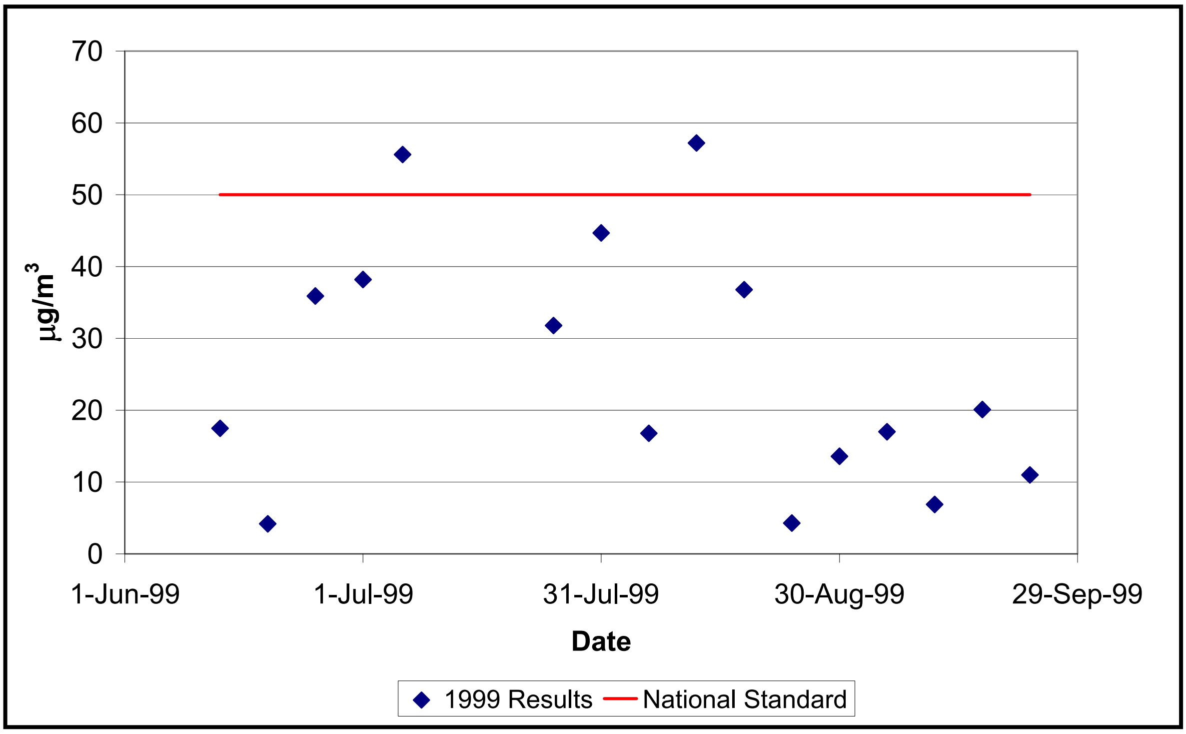

Figure 5.10 Average 24-hour PM_{10} concentrations for winter 1999 in Milton

5.3.9 Oamaru

Of the 15 samples taken at Oamaru during winter 1998, one was above the NES of 50 µg/m^3 (Figure 5.11). The average PM_{10} level was 23 µg/m^3, and one fifth of the readings were in the Medium – High range.

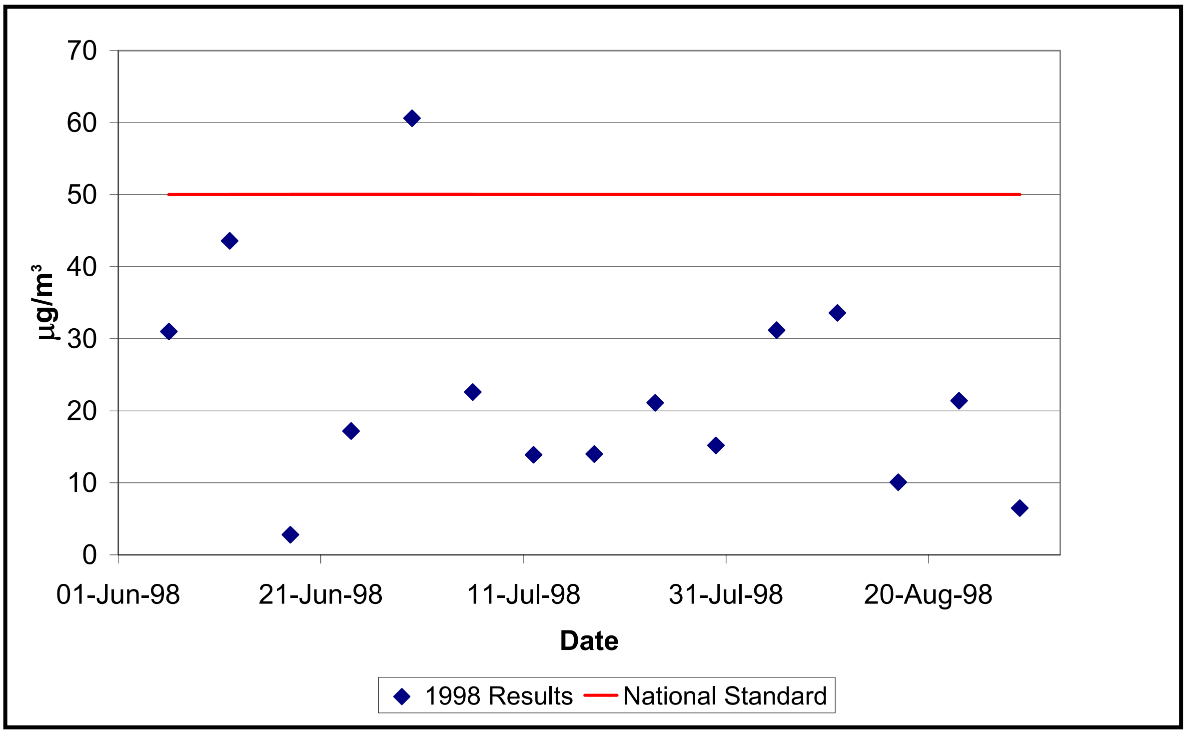

Figure 5.11 Average 24-hour PM_{10} concentrations for winter 1998 in Oamaru

5.3.10 Palmerston

Of the 14 samples taken in Palmerston during winter 2003, 30% were above the NES of 50 μg/m^3 while 65% were in the low range (below 33 μg/m^3). Average PM_{10} level for the winter months in 2003 was 33 μg/m^3. The highest reading of 86 μg/m^3 indicates that Palmerston can experience high PM_{10} levels on occasion.

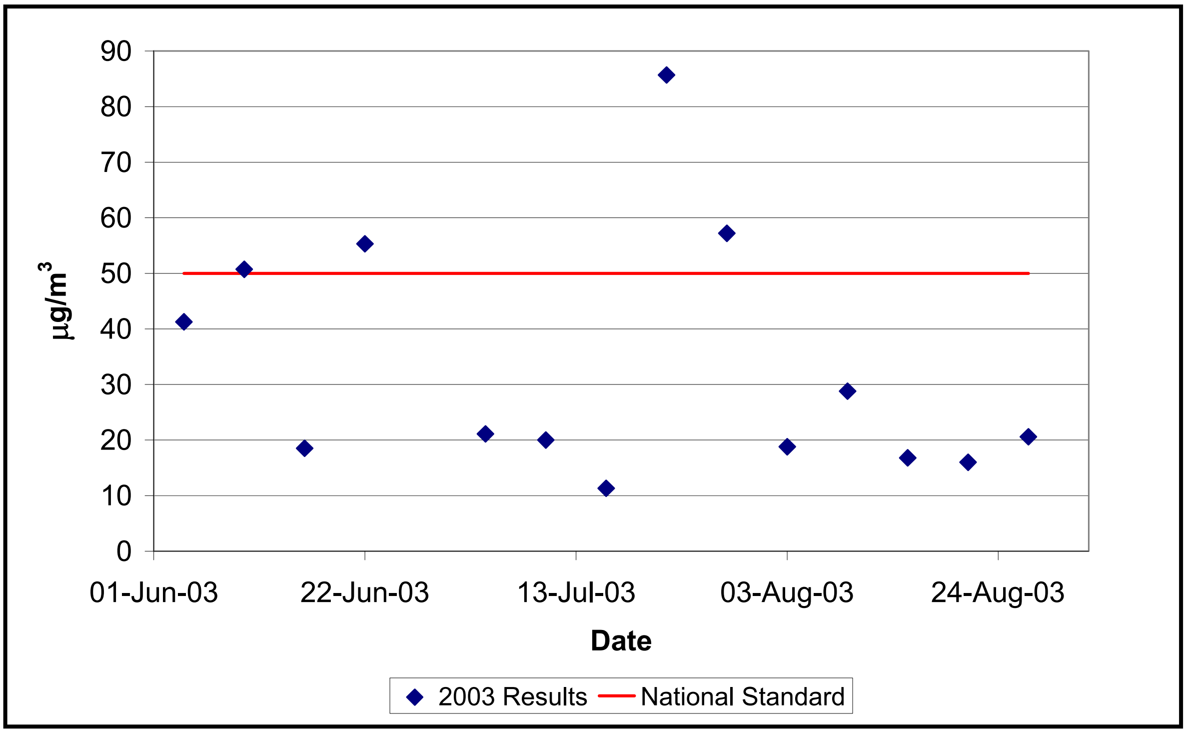

Figure 5.12 Average 24-hour PM_{10} concentrations for winter 2003 in Palmerston

5.3.11 Queenstown

Thirteen daily PM_{10} readings were taken during winter 1999 (Figure 5.13). The maximum recorded reading was 36µg/m^3, and the average value was 18µg/m^3. These results indicate that in 1999, Queenstown did not have high particulate levels.

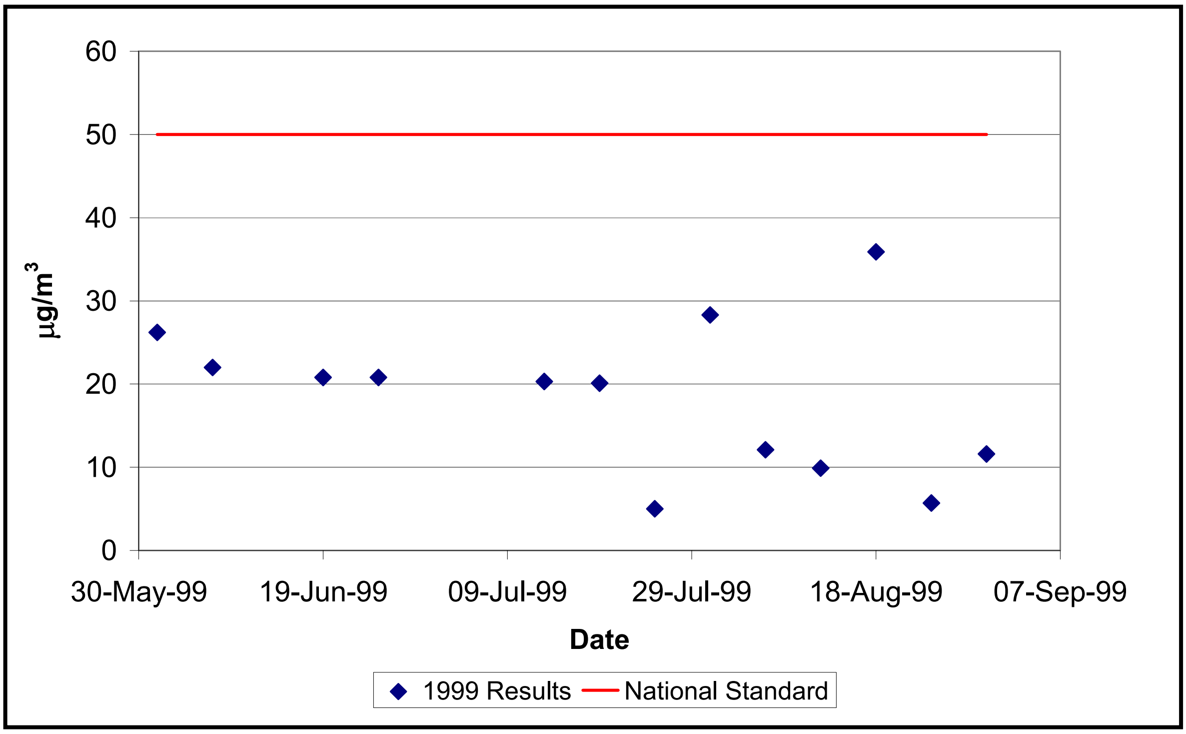

Figure 5.13 Average 24-hour PM_{10} concentrations for winter 1999 in Queenstown

5.3.12 South Dunedin

One day in six sampling at South Dunedin over three winters (1998, 2001, 2002) shows maximum PM_{10} levels of up to 85 µg/m^3, and average PM_{10} of approximately 30 µg/m^3 (Figure 5.14). The NES of 50 µg/m^3 was breached on seven occasions over the three years of sampling, indicating that South Dunedin can experience high PM_{10} levels over winter.

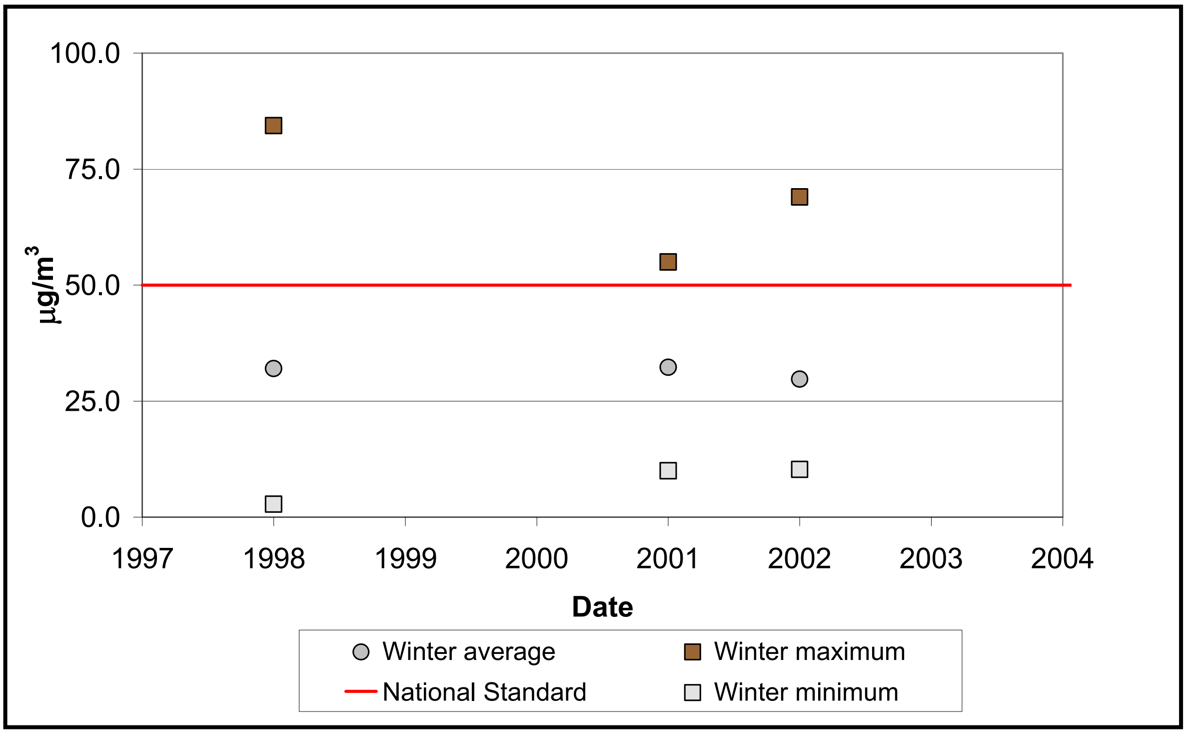

Figure 5.14 Winter minimum, average and maximum 24-hour PM_{10} concentrations in South Dunedin

5.3.13 Wanaka

PM_{10} samples were taken at Wanaka during winter 2003, and there were no breaches of the 50 µg/m^3 NES.

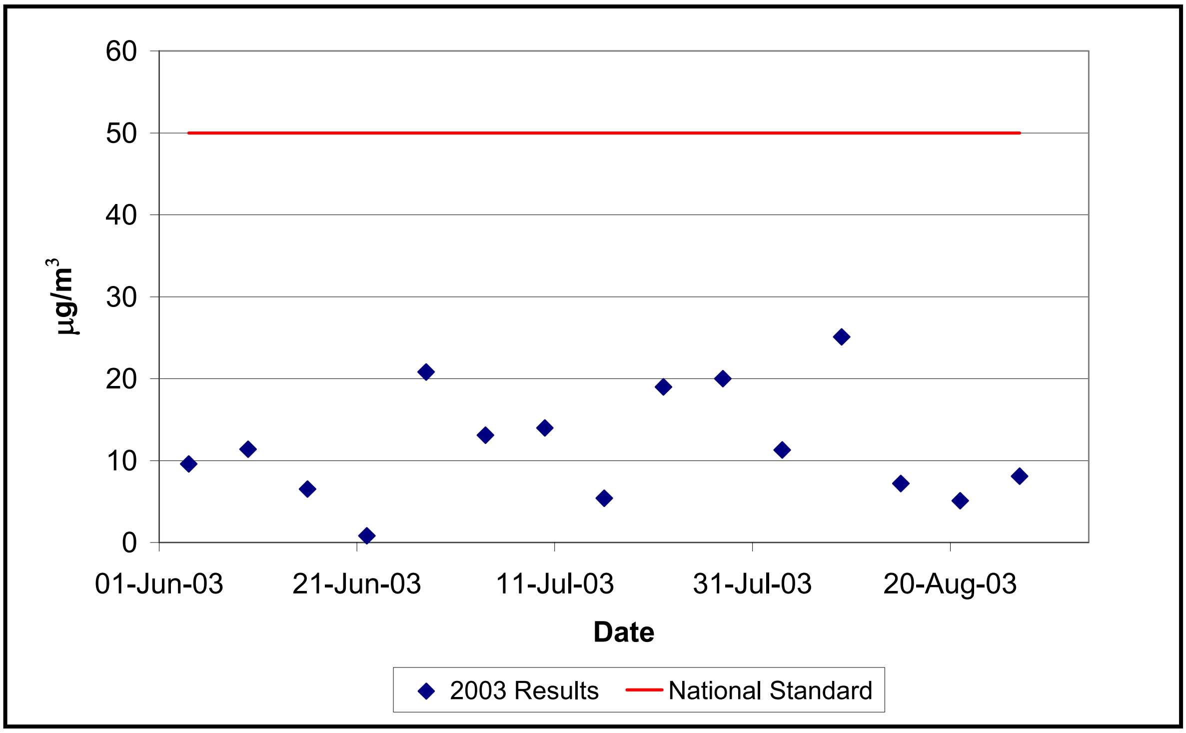

Figure 5.15 Average 24-hour PM_{10} concentrations for winter 2003 in Wanaka

Otago Regional Council

5.4 Correlation between sites

The NES for Air Quality (Ministry for Environment, 2004) stipulates monitoring requirements for Regional Councils. Several towns or locations may be included in one airshed, with monitoring undertaken in the town that is most likely to exceed the standard by the greatest margin, or where it is exceeded most frequently. For regulatory purposes, monitoring data from this town can be assumed to be representative of the air quality in other towns within the same air quality management area.

Data from several monitoring sites were compared with nearby sites, or sites with similar physical and climatic characteristics to determine if the above method is useful. The results of linear regression analysis between a number of particulate monitoring sites shows there is very little correlation between any sites in Otago. The multiple regression correlation coefficient, (R^2), is a measure of the proportion of variability explained by, or due to the regression (linear relationship) in a sample of paired data, it is a number between zero and one and a value close to one suggests a good correlation. A negative value indicates an inverse relationship between the variables. R^2 values for Dunedin and Central Otago sites are shown in Table 5.6.

Table 5.6 R^2 Values for Regression Analysis between paired PM_{10} monitoring sites

Source Site	Secondary Site	R^2 Value	Comment
Alexandra	Cromwell	0.23	
Cromwell	Arrowtown	0.09	
Alexandra	Clyde	0.15	
Alexandra	Arrowtown	-0.11	
South Dunedin	Albany Street (North Dunedin)	-0.68	
Green Island	Mosgiel	0.26	
Green Island	Albany Street (North Dunedin)	-0.04	
Green Island	South Dunedin	-0.38	
North East Valley	Albany Street (North Dunedin	0.24	431 paired values

5.4.1 Central Otago

The highest R^2 value for comparisons between Central Otago monitoring sites is between Alexandra and Cromwell. There is a general trend of increasing PM_{10} at Cromwell, as Alexandra levels increase (Figure 5.16). There is considerable scatter between these two sites however, and it would be unwise to predict Cromwell PM_{10} levels based solely on the Alexandra readings.

Figure 5.17 shows a similar trend for Clyde, as PM_{10} levels often increase as Alexandra levels rise, with Clyde levels being approximately half those at Alexandra.

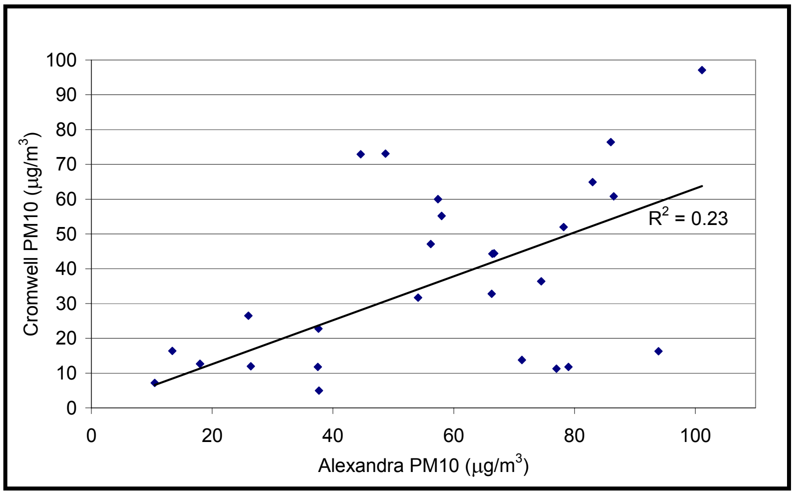

Figure 5.16 Scatter-plot of Alexandra and Cromwell daily PM_{10} values

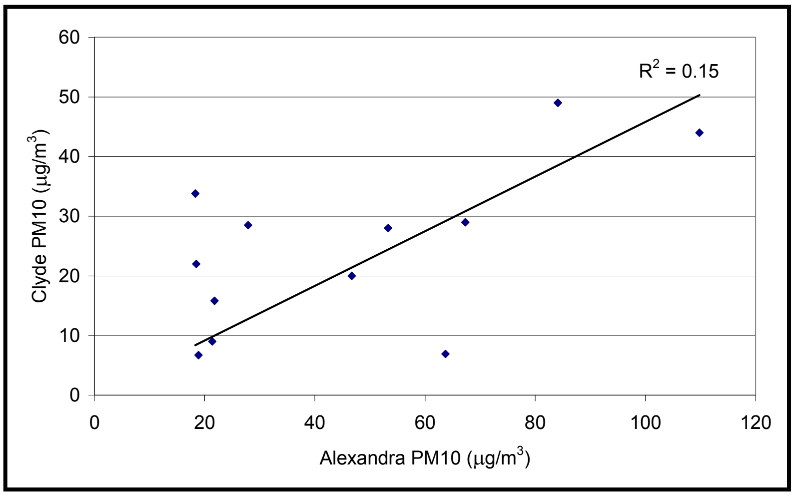

Figure 5.17 Scatter-plot of Alexandra and Clyde daily PM_{10} values

5.4.2 Dunedin

The South Dunedin airshed seems to respond differently to North Dunedin. Simultaneous data values collected from within these two areas show there is a moderately strong negative correlation (R^2 of -0.68) between the two datasets (Table 5.6).

An attempt was made to determine whether Green Island is in the same airshed as other Dunedin sites. Samples from Green Island were compared with those taken on the same day at Mosgiel, Albany Street and South Dunedin. The only positive correlation was found between Green Island and Mosgiel, (Figure 5.18) although the r^2 value of 0.26 between these two sites is poor. The scatter-plot shown in Figure 5.18 does suggest a general trend of increasing PM_{10} levels at Green Island as Mosgiel levels rise. However, the lack of a strong relationship implies that the meteorology and topography of Green

Island creates a distinct airshed, and that PM_{10} readings from other Dunedin sites cannot be used to infer readings at Green Island.

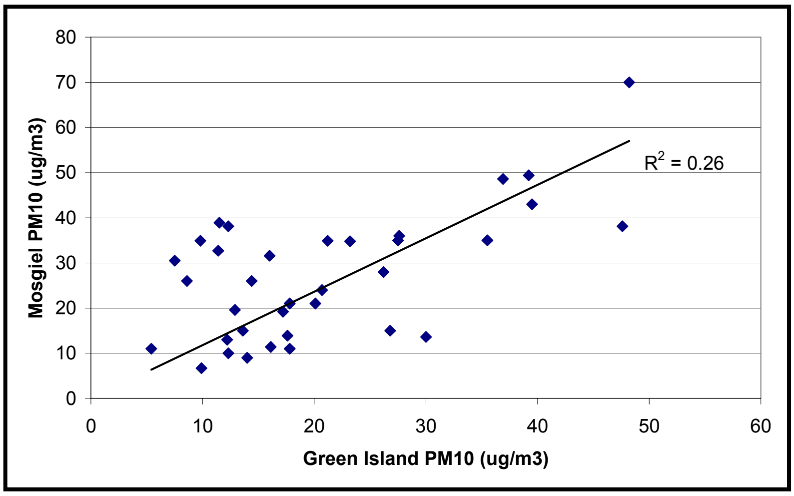

Figure 5.18 Scatter-plot of Green Island and Mosgiel daily PM_{10} values

5.5 Summary of PM_{10} Exceedances

Table 5.7 gives the estimated number of days during winter (June til August) PM_{10} is likely to exceed the NES of 50 μg/m^3, based on information collected to date. Most sites only take measurements on every sixth day, so the figures in Table 5.7 are only approximate. The accuracy of these assessments is likely to be higher at sites with longer records however.

Table 5.7 An Estimate of the number of breaches of PM_{10} NES in Otago towns

Location	Number of winter days average daily PM_{10} is likely to exceed the standard value	Number of years record
Alexandra	52	8
Palmerston	24	1
Cromwell	30	2
Arrowtown	18	3
Mosgiel	17	6
South Dunedin	14	3
Green Island	9	4
North East Valley	6	8
Albany Street	6	8

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