

**The State of the PM₁₀ Monitoring
Network within NES Airsheds:
Benchmark Year - 2006**



**NIWA Client Report: CHC2006-146
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NIWA Project: PCAF051

The State of the PM₁₀ Monitoring Network within NES Airsheds: Benchmark Year - 2006

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Executive Summary

In September 2005 regional councils and unitary authorities identified forty-two areas where air quality is likely, or known, to exceed the Ambient Air Quality National Environmental Standards (NES). These areas are known as airsheds. In all but one of the forty-two airsheds particulate matter (PM₁₀) can be an issue at certain times of the year and concentrations have been shown, or are suspected, to be greater than 50 µgm⁻³ (24-hour average).

Monitoring PM₁₀ in accordance with the requirements of the NES necessitates equipment which is highly technical, expensive and that demands significant resources to commission and operate. The implementation of the NES has significantly increased the requirements of PM₁₀ monitoring in New Zealand, both in terms of spatial coverage of the network and for the quality of data collected.

This aims of this report are to:

- Present a benchmark review of the state of New Zealand's PM₁₀ monitoring network in 2006 – the first year after the implementation of the NES.
- Make recommendations on enhancing the PM₁₀ monitoring network
- Highlight knowledge gaps on monitoring PM₁₀ in New Zealand

In 2006, NES compliant PM₁₀ monitoring was being undertaken in 33 (80%) of the 42 airsheds in New Zealand, whereas 8 (20%) airsheds did not have NES compliant PM₁₀ monitoring or no monitoring at all.

Within the 33 airsheds which had NES compliant PM₁₀ monitoring, Beta Attenuation Monitors (BAM) were used in 20 (61%), Tapered Element Oscillating Microbalances (TEOM) in 6 (18%) and TEOM-FDMS in 7 (21%).

In October 2005, a national workshop was held in Christchurch to highlight and discuss the issues raised in “*Review and Gap Analysis of PM₁₀ Monitoring in New Zealand*” A workshop outcomes report was circulated to the workshop attendees for review/comment. This report integrates the outcomes of the “Gap Analysis” workshop to provide guidance on enhancing the PM₁₀ monitoring network and to briefly discuss knowledge gaps.

Ideally all airsheds would contain at least one NES compliant PM₁₀ monitoring site. A number of areas of the country do not have adequate monitoring information in order to achieve the requirements of the NES. Other areas could improve the information they collect. There is certainly potential to enhance New Zealand's PM₁₀ monitoring network. This report provides guidance to ensure that the monitoring

undertaken is representative and cost-effective, especially for smaller regions without large resources. A number of options to improve the network are considered. These options include:

- Installation of additional permanent NES compliant monitors
- “Screening” monitoring
- “Campaign” monitoring
- Developing and using “*proxy measurements*”
- Use of industry sourced air quality data
- Better Spatial resolution/representation of current sites

This report briefly highlights the knowledge gaps on monitoring PM₁₀ in New Zealand. The work currently undertaken by the air quality research team to address each specific gap is noted. The knowledge gaps discussed are:

- Better Spatial Resolution/Representation of PM₁₀ data within Airsheds
- Different Methods of Monitoring PM₁₀
- Particulate Matter Component Composition and Source Apportionment
- Monitoring Background and/or Natural Concentrations of PM₁₀
- PM_{2.5} in Urban Areas
- Measuring Particle Numbers (rather than Particle Mass)

The stakeholders who attended the “*Review and Gap Analysis of PM₁₀ Monitoring in New Zealand*” workshop, were asked to prioritise the importance of the issues covered at that workshop. The workshop attendees rated the importance of issues in order as:

1. Enhancing the monitoring network
2. Source apportionment
3. Comparing methods of monitoring PM₁₀
4. Background concentrations of PM₁₀
5. PM_{2.5}
6. Particle numbers

Workshop feedback suggests that, with the exception of particle numbers, all issues (1 to 5) were of significant interest and relevance to stakeholders.

1. Introduction

1.1 Background

In September 2005 regional councils and unitary authorities identified forty-two areas where air quality is likely, or known, to exceed the Ambient Air Quality National Environmental Standards (NES). These areas are known as airsheds.

In all but one of the forty-two airsheds particulate matter (PM₁₀) can be an issue at certain times of the year and concentrations have been shown, or are suspected, to be greater than 50 µgm⁻³ (24-hour average). The exception is the Marsden Point airshed, in Northland, which has been identified as an airshed where the sulphur dioxide standard can be exceeded.

Airsheds and their boundaries were drawn by councils using existing knowledge of air quality in the region, the location of significant sources and the effects of topography (hills and valleys) and climate on the dispersion of pollution. Maps which show the location and outlines of the airshed boundaries can be found at <http://www.mfe.govt.nz/laws/standards/airsheds/>. Detailed legal boundaries of the designated airsheds are held by Land Information New Zealand.

Regulation 15 of the NES requires the following

If it is likely that the ambient air quality standard for a contaminant will be breached within an airshed, the regional councils must –

a. monitor the airshed in relation to that contaminant; and

b. conduct the monitoring –

I. in that part of the airshed where –

A. there are one or more people; and

B. the standard is breached by the greatest margin or the standard is breached most frequently, which ever is the most likely; and

II. in accordance with the relevant method listed in schedule 2.

Schedule 2 of the NES provides the standards methods which must be used for ambient air quality monitoring. That schedule lists two options for monitoring PM₁₀:

Continuous high volume sampling in accordance with United States Code of Federal Regulations, Title 40 – Protection of Environment, Part 50, Appendix J, “Reference method for the determination of particulate matter as PM₁₀ in the atmosphere”

Continuous high volume sampling in accordance with AS3580.9.6 “ Methods of sampling and analysis of ambient air – Determination of suspended particulate matter PM₁₀ high volume sampler with size selective inlet – Gravimetric method.

The USEPA reference method incorporates a number of other equivalent methods, which include Beta Attenuation Monitors (BAM) and Tapered Element Oscillating Microbalances (TEOM)s.

Monitoring PM₁₀ in accordance with the requirements of the NES necessitates equipment which is highly technical, expensive and that demands significant resources to commission and operate. The implementation of the NES has significantly increased the requirements of PM₁₀ monitoring in New Zealand, both in terms of spatial coverage of the network and for the quality of data collected.

1.2 Aims and Objectives

Aims of this report are to:

- Present a benchmark review of the state of New Zealand’s PM₁₀ monitoring network in 2006 – the first year after the implementation of the NES.
- Make recommendations on enhancing the PM₁₀ monitoring network
- Highlight the major knowledge gaps on monitoring PM₁₀ in New Zealand

1.3 Structure of the Report

To achieve the aims of this report it is structured as follows:

- Section 2: Monitoring of PM₁₀ within NES Airsheds by Region.
- Section 3: Overview of the PM₁₀ Monitoring Network within the NES Airsheds

Sections 2 and 3 are based on information provided by regional councils to the Ministry of the Environment early in 2006. Care has been taken to ensure this

information is up-to-date and presented accurately. However, this section may well benefit from input and review by individual regional councils.

- Section 4 Recommendations for enhancing the PM₁₀ monitoring network
- Section 5: Knowledge Gaps on Monitoring PM₁₀ in New Zealand
- Section 6: Priority Needs for Enhancing PM₁₀ Monitoring in New Zealand

In October 2005 a national workshop was held in Christchurch to highlight and discuss the issues raised in the “Review and Gap Analysis of PM₁₀ Monitoring in New Zealand” report. Stakeholders, including Central and Regional Government, Industry, Scientists and Consultants were invited to attend. A total of 43 people attended the workshop. A workshop outcomes report was written to highlight the key points and the action points which arose out of discussions. This workshop outcomes report was circulated to the workshop attendees for review/comment. Detailed feedback was received from 15 of the 43 attendees. Sections 4, 5 and 6 of this report integrate the outcomes of the “Gap Analysis” workshop into context with the information presented in this report.

2. Monitoring of PM₁₀ within NES Airsheds by Region

2.1 Northland

Figure 2.1 shows the airsheds and particulate monitoring sites for the Northland Region. Table 2.1 lists the PM₁₀ monitoring equipment used within each airshed.

Figure 2.1 and Table 2.1 show that:

- 5 airsheds have been identified and gazetted for the Northland region;
- NES compliant monitoring is being undertaken in one PM₁₀ airshed (Whangarei) and in the SO₂ airshed (Marsden Point);
- Non-NES compliant PM₁₀ monitoring is being undertaken in one airshed (Kaitaia);
- There is no monitoring in two airsheds (Kerikeri and Dargaville).

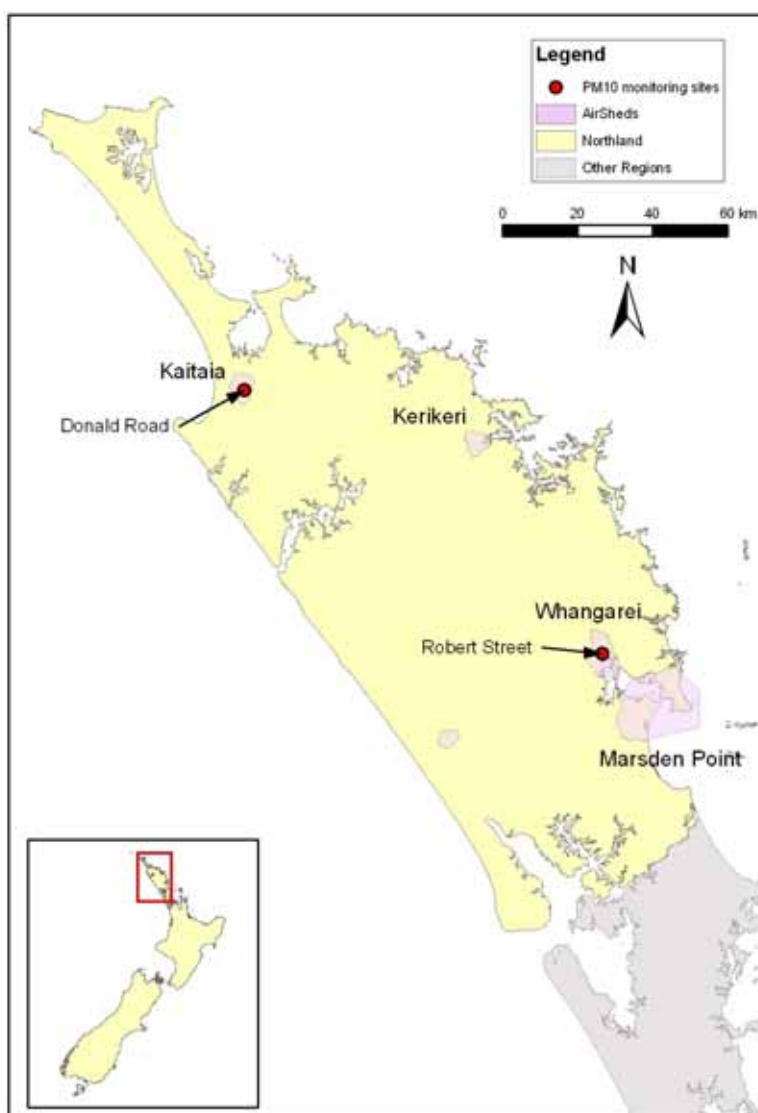


Figure 2.1: Northland Region’s NES airsheds and PM₁₀ monitoring sites - 2006

Table 2.1: Summary of Northland’s PM₁₀ Monitoring Network - 2006

Airshed	Site Name	PM ₁₀ Monitoring Equipment used
Kaitaia	Donald Road	Non-NES compliant method (Grimm)
Kerikeri	No Monitoring	No Monitoring
Whangarei	Robert Street Water Street	BAM HiVol
Marsden Point	Whangarei Heads School	SO ₂ only – API-M100
Dargaville	No Monitoring	No Monitoring

2.2 Auckland

Figure 2.2 shows the airsheds and particulate monitoring sites for the Auckland Region. The ARC gazetted just one airshed, but detail is provided on three smaller areas. Table 2.2 lists the PM₁₀ monitoring equipment used within each airshed.

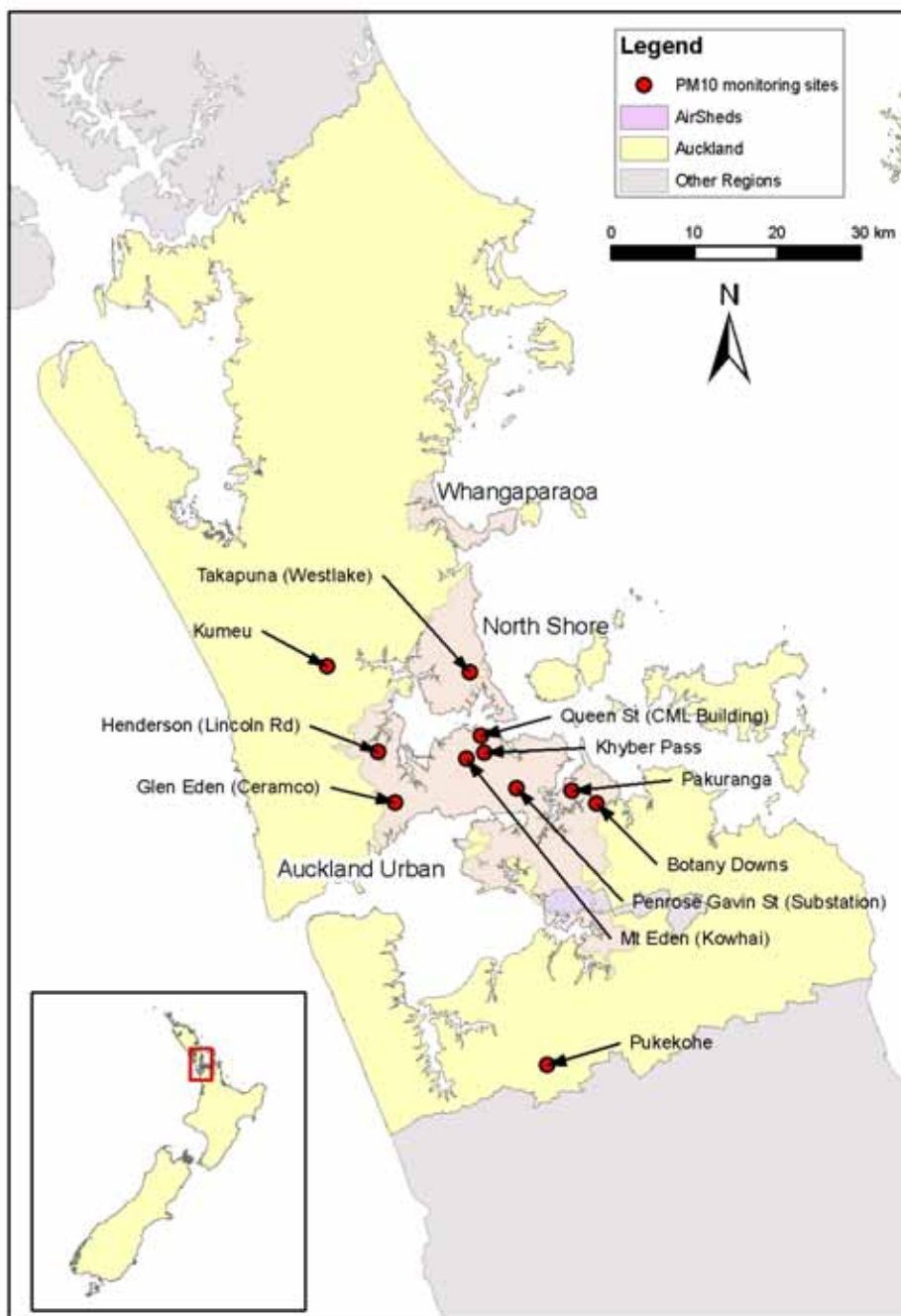


Figure 2.2: Auckland Region's NES airsheds and PM₁₀ monitoring sites -2006

Table 2.2: Summary of Auckland's PM₁₀ Monitoring Network - 2006

Airshed	Detailed Areas	Site Name	PM₁₀ Monitoring Equipment used		
Auckland	Whangaparaoa	No Monitoring	No Monitoring		
	North Shore	Takapuna (Westlake)		BAM and Partisol	
		Auckland Urban	Henderson (Lincoln Rd)		BAM and Partisol
			Glen Eden (Ceramco Park)		BAM
			Queen Street		Partisol
			Khyber Pass		BAM and Partisol
			Mount Eden (Kowhai School)		BAM and Partisol
			Penrose (Gavin Street)		BAM and HiVol
			Pakuranga		BAM
			Botany Downs		BAM
	Outside Airshed	Pukekohe		BAM	
		Kumeu		BAM	

Figure 2.2 and Table 2.2 show that:

- One airshed has been identified and gazetted for the Auckland region. This large airshed has been sub-divided into three smaller areas;
- NES compliant PM₁₀ monitoring is being undertaken at nine sites within the Auckland airshed. Eight of the nine monitoring sites are within the Auckland Urban area, the other site is in the North Shore. No PM₁₀ monitoring is being undertaken in Whangaparaoa;
- NES compliant PM₁₀ monitoring is also being undertaken at two sites outside the defined airshed.

2.3 Waikato

Figure 2.3 shows the airsheds and particulate monitoring sites for the Waikato Region. Table 2.3 lists the PM₁₀ monitoring equipment used within each airshed.

Figure 2.3 and Table 2.3 show that:

- 4 airsheds have been identified and gazetted for the Waikato region;
- NES compliant PM₁₀ monitoring is being undertaken in all four PM₁₀ airsheds.

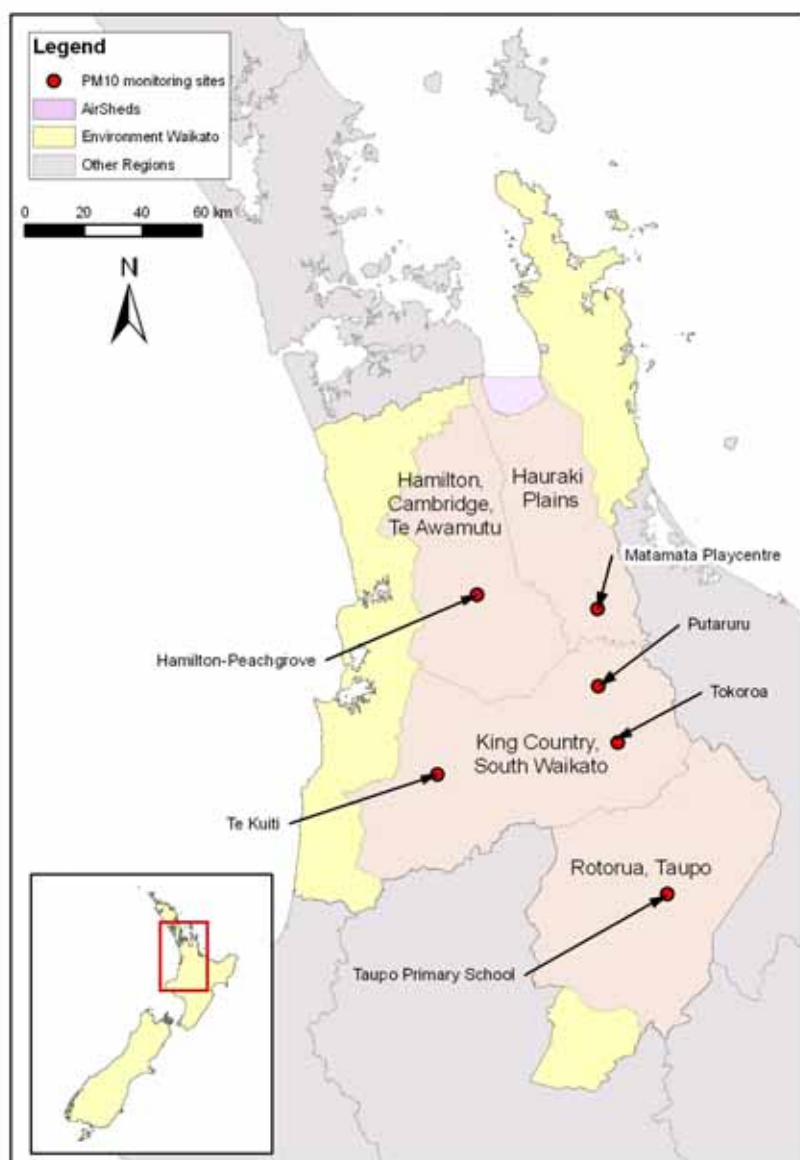


Figure 2.3: Waikato Region’s NES airsheds and PM₁₀ monitoring sites - 2006

Table 2.3: Summary of Waikato Region’s PM₁₀ Monitoring Network - 2006

Airshed	Site Name	PM ₁₀ Monitoring Equipment used
Hamilton Cambridge and Te Awamutu	Hamilton-Peachgrove	TEOM
Hauraki Plains	Matamata Playcentre	BAM
King Country	Te Kuiti Tokoroa Putaruru	BAM BAM BAM
Rotorua, Taupo	Taupo Primary School	BAM

2.4 Bay of Plenty

Figure 2.4 shows the airshed and particulate monitoring sites for the Bay of Plenty Region. Table 2.4 lists the PM₁₀ monitoring equipment used within that airshed.

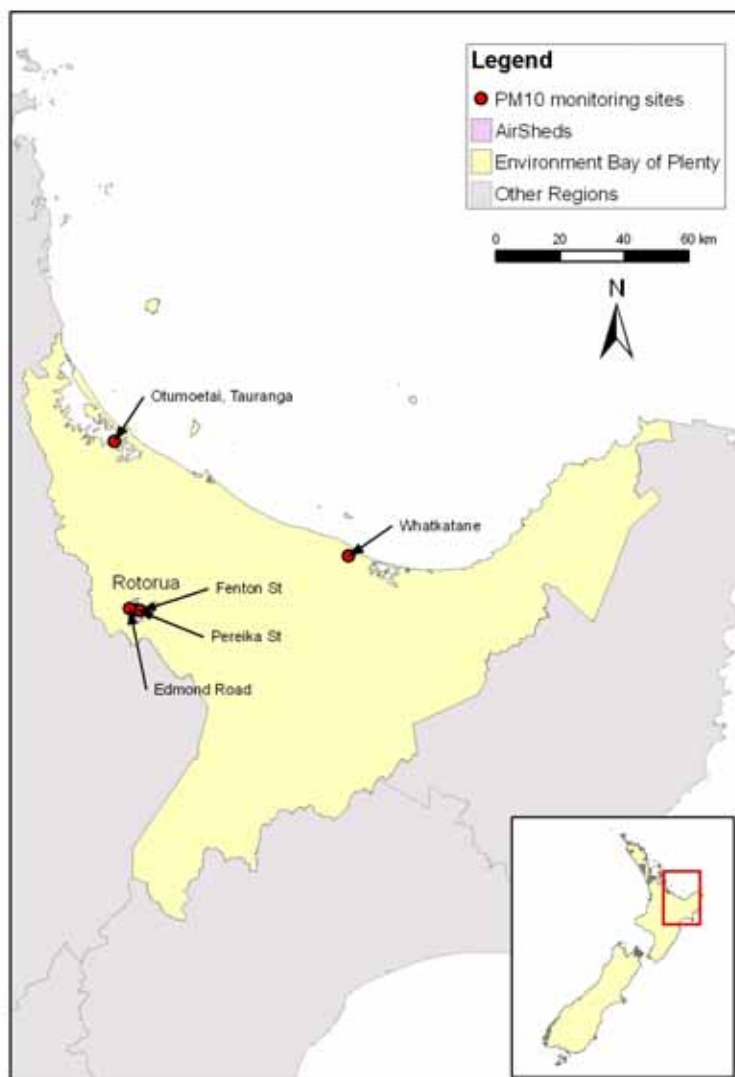


Figure 2.4: Bay of Plenty Region’s NES airsheds and PM₁₀ monitoring sites

Table 2.4: Summary of Bay of Plenty’s PM₁₀ Monitoring Network - 2006

Airshed	Site Name	PM ₁₀ Monitoring Equipment used
Rotorua	Pereika St Edmond Road Fenton Street	TEOM TEOM-FDMS TEOM
Outside Airsheds	Whakatane, King Street Tauranga, Otumoetai	TEOM-FDMS TEOM-FDMS

Figure 2.4 and Table 2.4 show that:

- One airshed has been identified and gazetted for the Bay of Plenty region;
- NES compliant PM₁₀ monitoring is being undertaken at three sites within the Rotorua PM₁₀ airshed;
- PM₁₀ is also being monitored at two other sites (Whakatane and Tauranga).

2.5 Gisborne

Figure 2.5 shows that no NES air sheds have been defined or gazetted for the Gisborne Region and that there are two PM₁₀ monitoring sites.

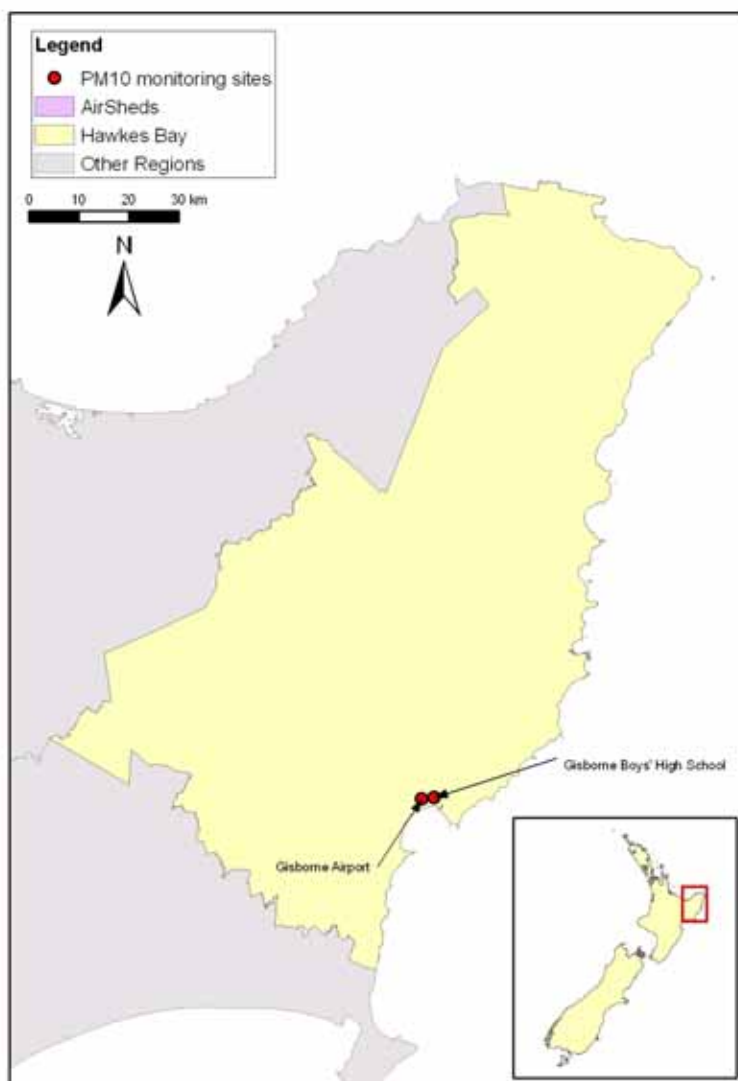


Figure 2.5: Gisborne Region’s NES airsheds and PM₁₀ monitoring sites -2006

2.6 Hawkes Bay

Figure 2.6 shows the airsheds and particulate monitoring sites for the Bay of Plenty Region. Table 2.6 lists the PM₁₀ monitoring equipment used within each airshed.

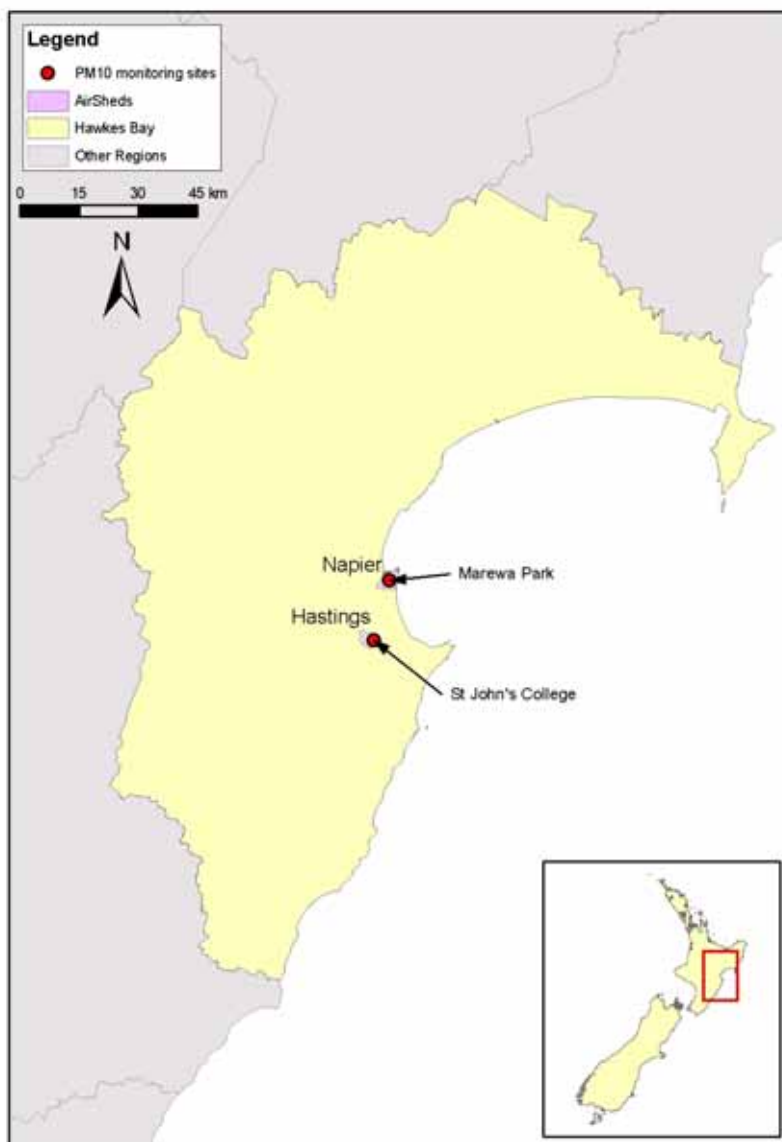


Figure 2.6: Hawkes Bay Region’s NES airsheds and PM₁₀ monitoring sites –2006

Table 2.6: Summary of Hawkes Bay PM₁₀ Monitoring Network - 2006

Airshed	Site Name	PM ₁₀ Monitoring Equipment used
Napier	Marewa Park	BAM
Hastings	St John's College	BAM

Figure 2.6 and Table 2.6 show that:

- Two airsheds have been identified and gazetted for the Hawkes Bay region;
- NES compliant PM₁₀ monitoring is being undertaken in both PM₁₀ airsheds.

2.7 Manawatu-Wanganui

Figure 2.7 shows the airsheds and particulate monitoring sites for the Manawatu-Wanganui Region. Table 2.7 lists the PM₁₀ monitoring equipment used within each airshed.

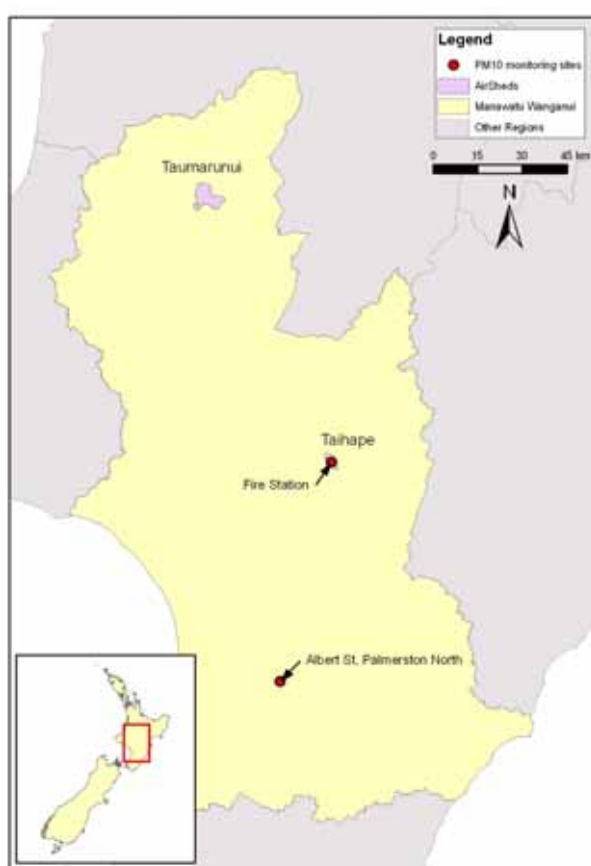


Figure 2.7: Manawatu-Wanganui Region’s NES airsheds and PM₁₀ monitoring sites - 2006

Table 2.7: Summary of Manawatu-Wanganui PM₁₀ Monitoring Network - 2006

Airshed	Site Name	PM ₁₀ Monitoring Equipment used
Taihape	Fire Station	BAM
Taumarunui	No Monitoring	No Monitoring
Outside Airsheds	Palmerston North, Mark Hokowhitu School, Albert Street	BAM

Figure 2.7 and Table 2.7 show that:

- Two airsheds have been identified and gazetted for the Manawatu-Wanganui region;
- NES compliant PM₁₀ monitoring is being undertaken in the Taihape airshed;
- No monitoring is being undertaken in the Taumaranui airshed;
- NES compliant PM₁₀ monitoring is also being undertaken at Palmerston North which is outside the defined airsheds.

2.8 Taranaki

Figure 2.8 shows that no NES airsheds have been defined or gazetted for the Taranaki Region.

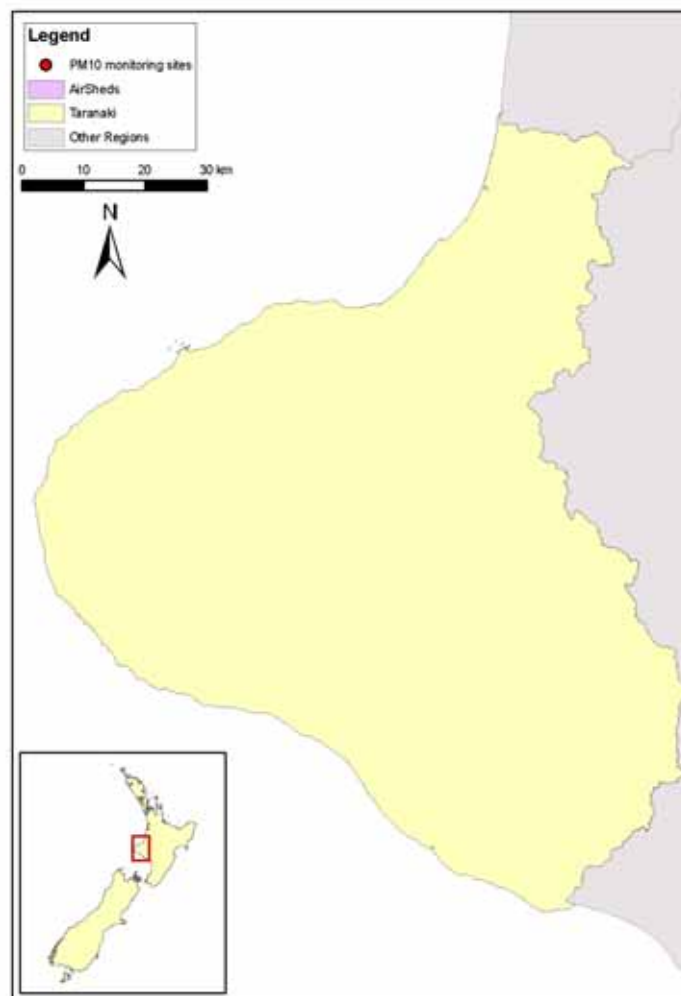


Figure 2.8: Taranaki Region's NES airsheds and PM₁₀ monitoring sites - 2006

2.9 Wellington

Figure 2.9 shows the airsheds and particulate monitoring sites for the Wellington Region. Table 2.9 lists the PM₁₀ monitoring equipment used within each airshed.

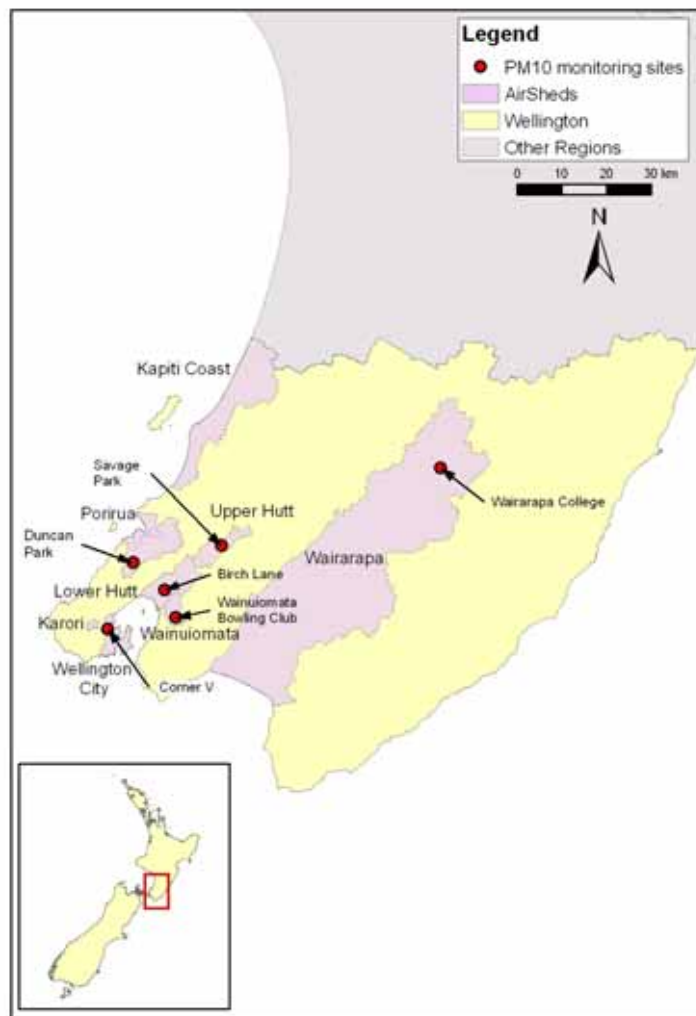


Figure 2.9: Wellington Region’s NES airsheds and monitoring PM₁₀ sites - 2006

Table 2.9: Summary of Wellington’s PM₁₀ Monitoring Network - 20006

Airshed	Site Name	PM ₁₀ Monitoring Equipment used
Wairarapa	Wairarapa College AQ	TEOM
Wainuiomata	Wainuiomata Bowling Club AQ	BAM
Upper Hutt	Savage Park AQ	BAM
Lower Hutt	Birch Lane AQ	TEOM
Wellington	Corner V AQ	BAM
Karori	No Monitoring	No Monitoring
Porirua	Duncan Park AQ	TEOM
Kapiti Coast	No Monitoring	No Monitoring

Figure 2.9 and Table 2.9 show that:

- Eight airsheds have been identified and gazetted for the Wellington region;
- NES compliant PM₁₀ monitoring is being undertaken in six of the eight airsheds;
- No monitoring is being undertaken in the Karori or Kapiti Coast airsheds.

2.10 Marlborough

Figure 2.10 shows the airshed and particulate monitoring site for the Marlborough Region. Table 2.10 lists the PM₁₀ monitoring equipment used within that airshed.

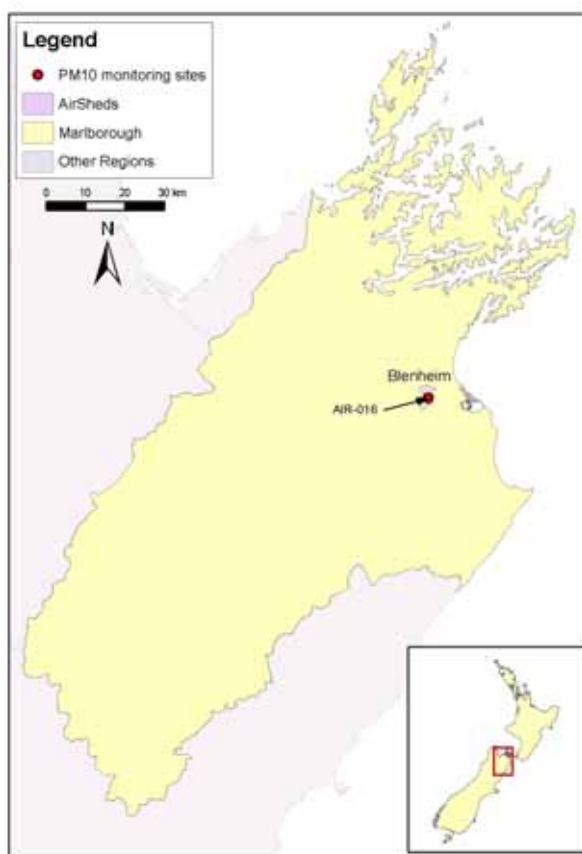


Figure 2.10: Marlborough Region’s NES airshed and PM₁₀ monitoring site - 2006

Table 2.10: Summary of Marlborough’s PM₁₀ Monitoring Network - 2006

Airshed	Site Name	PM ₁₀ Monitoring Equipment used
Blenheim	AIR-016	BAM

Figure 2.10 and Table 2.10 show that:

- One airshed has been identified and gazetted for the Marlborough region;
- NES compliant PM₁₀ monitoring is being undertaken at one site with the Marlborough PM₁₀ airshed.

2.11 Nelson

Figure 2.11 shows the airsheds and particulate monitoring sites for the Nelson Region. Table 2.11 lists the PM₁₀ monitoring equipment used within each airshed.

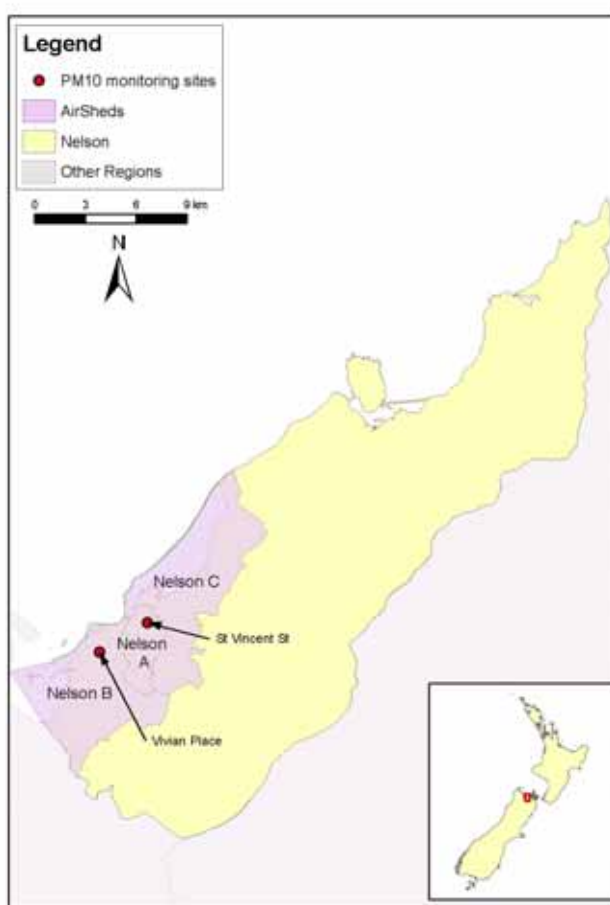


Figure 2.11: Nelson Region’s NES airsheds and PM₁₀ monitoring sites - 2006

Table 2.11: Summary of Nelson’s PM₁₀ Monitoring Network - 2006

Airshed	Site Name	PM ₁₀ Monitoring Equipment used
Nelson South	St Vincent Street	BAM
Tahunanui-Stoke	Vivian Place	BAM
Nelson City	No monitoring	No monitoring

Figure 2.11 and Table 2.11 show that:

- Three airsheds have been identified and gazetted for the Nelson region;
- NES compliant PM₁₀ monitoring is being undertaken in two of the three airsheds;
- No monitoring is being undertaken in the Nelson City airshed.

2.12 Tasman

Figure 2.12 shows the airshed and particulate monitoring site for the Tasman Region. Table 2.12 lists the PM₁₀ monitoring equipment used within that airshed.

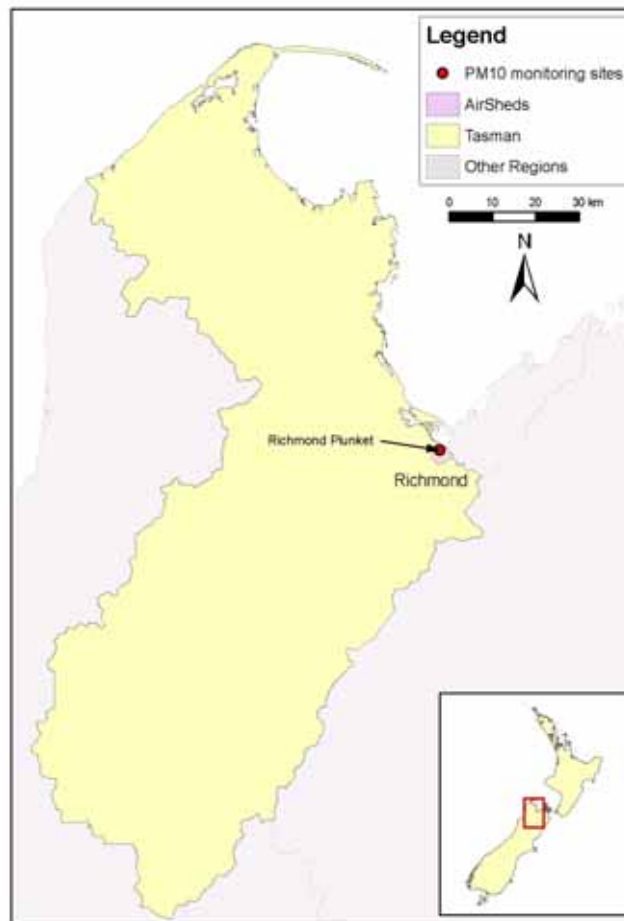


Figure 2.12: Tasman Region’s NES airsheds and PM₁₀ monitoring site - 2006

Table 2.12: Summary of Tasman’s PM₁₀ Monitoring Network - 2006

Airshed	Site Name	PM ₁₀ Monitoring Equipment used
Richmond	Richmond Plunket	BAM

Figure 2.12 and Table 2.12 show that:

- One airshed has been identified and gazetted for the Tasman region;
- NES compliant PM₁₀ monitoring is being undertaken at one site with the Richmond PM₁₀ airshed.

2.13 Canterbury

Figures 2.13a and 2.13b show the airsheds and particulate monitoring sites for the Canterbury Region. Table 2.13 lists the PM₁₀ monitoring equipment used within each airshed.

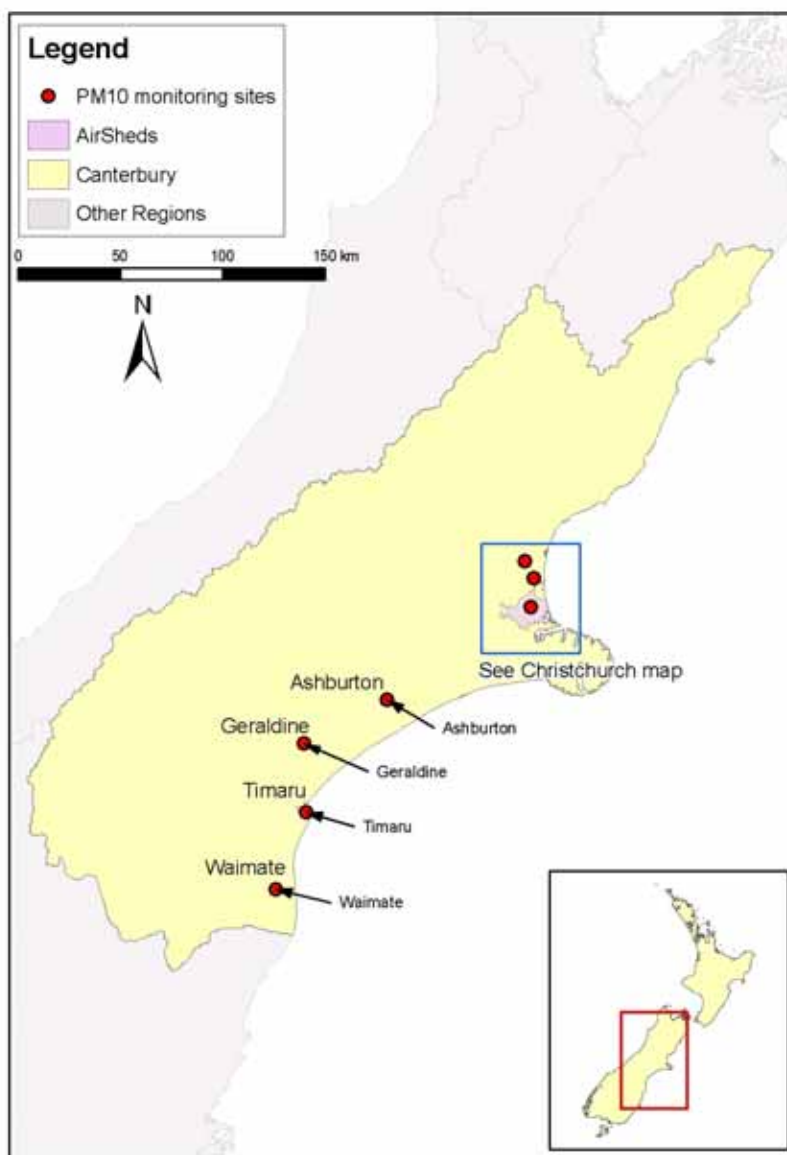


Figure 2.13a: Canterbury Region’s NES airsheds and PM₁₀ monitoring sites - 2006

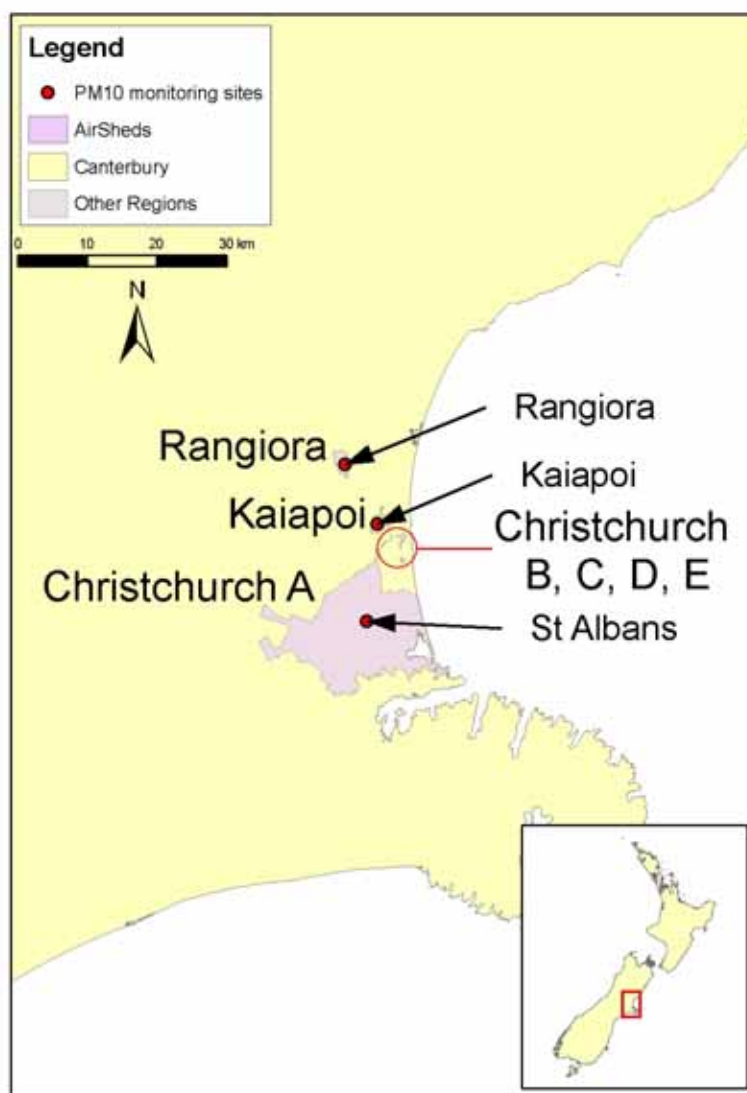


Figure 2.13b: Christchurch and Environs - NES airsheds and PM₁₀ monitoring sites - 2006

Table 2.13: Summary of Canterbury's PM₁₀ Monitoring Network - 2006

Airshed	Site Name	PM ₁₀ Monitoring Equipment used
Ashburton	Ashburton	TEOM
Christchurch A	St Albans	TEOM-FDMS
Geraldine	Geraldine	TEOM-FDMS
Kaiapoi	Kaiapoi	TEOM-FDMS
Rangiora	Rangiora	TEOM
Timaru	Timaru	TEOM-FDMS
Waimate	Waimate	TEOM-FDMS

Figures 2.13a, 2.13b and Table 2.13 show that:

- Seven airsheds have been identified and gazetted for the Canterbury region;
- NES compliant PM₁₀ monitoring is being undertaken in all of the seven airsheds.

2.14 West Coast

Figure 2.14 shows the airshed and particulate monitoring site for the West Coast Region. Table 2.14 lists the PM₁₀ monitoring equipment used within that airshed.

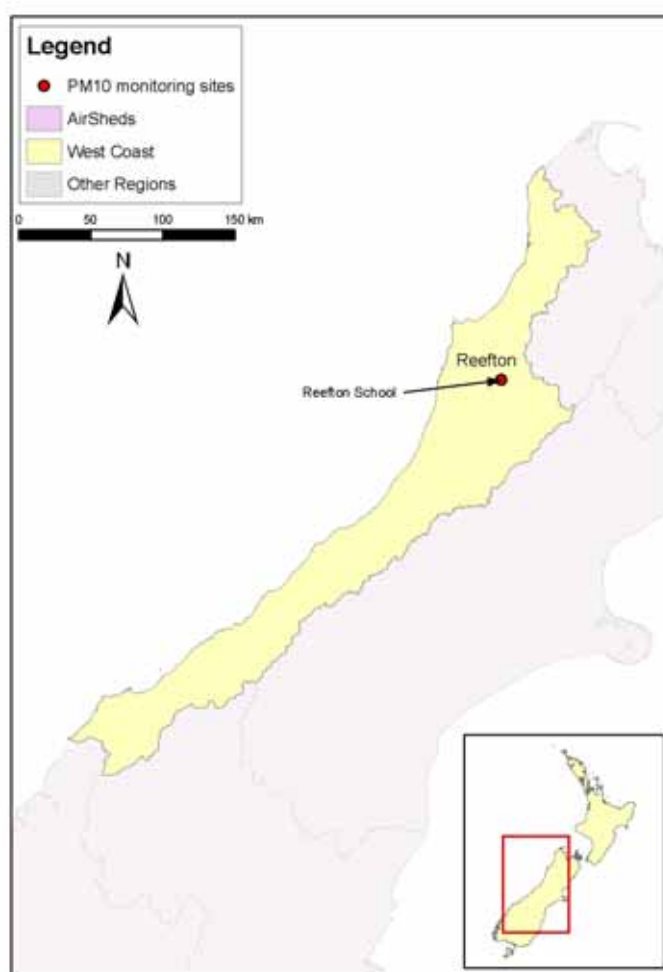


Figure 2.14: West Coast Region’s NES airsheds and PM₁₀ monitoring sites - 2006

Table 2.14: Summary of West Coast’s PM₁₀ Monitoring Network - 2006

Airshed	Site Name	PM ₁₀ Monitoring Equipment used
Reefton	Reefton School	BAM

Figure 2.14 and Table 2.14 show that:

- One airshed has been identified and gazetted for the West Coast region;
- NES compliant PM₁₀ monitoring is being undertaken at one site with the Reefton PM₁₀ airshed.

2.15 Otago

Figures 2.15a and 2.15b show the airsheds and particulate monitoring sites for the Otago Region. Table 2.15 lists the PM₁₀ monitoring equipment used within each airshed.

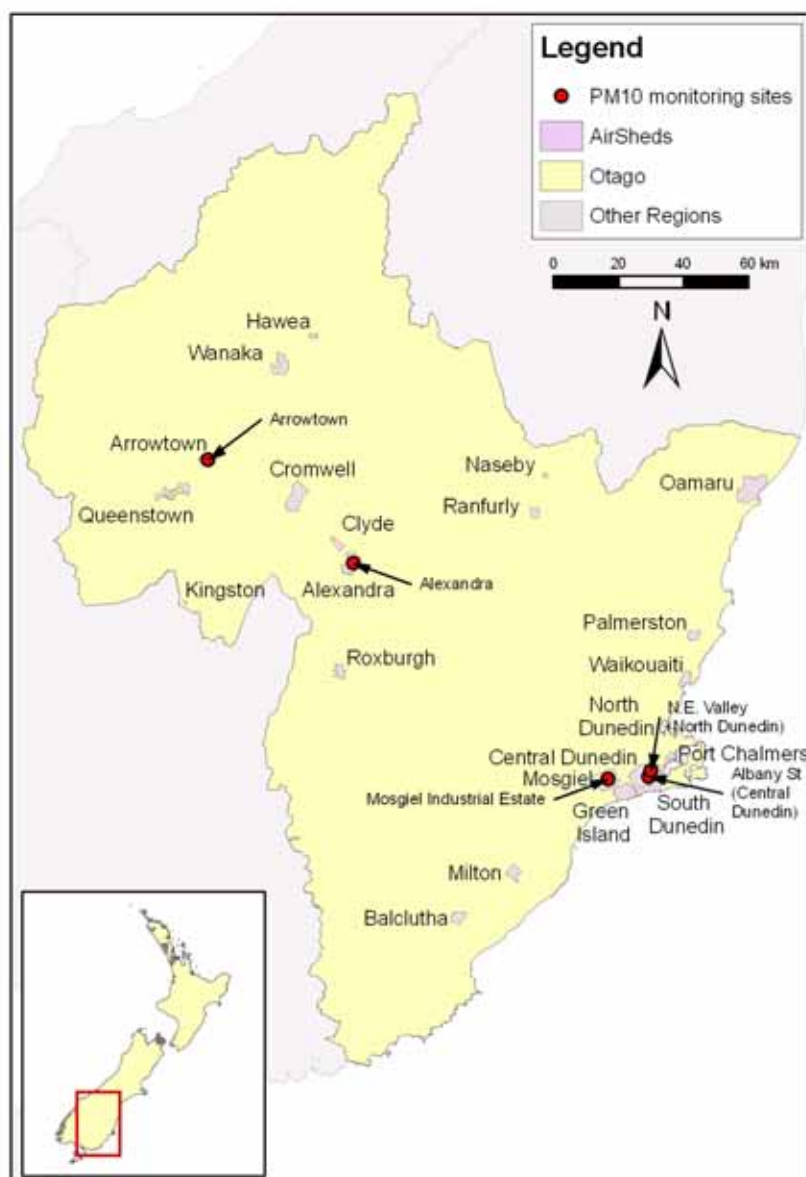


Figure 2.15a: Otago Region’s NES airsheds and PM₁₀ monitoring sites - 2006

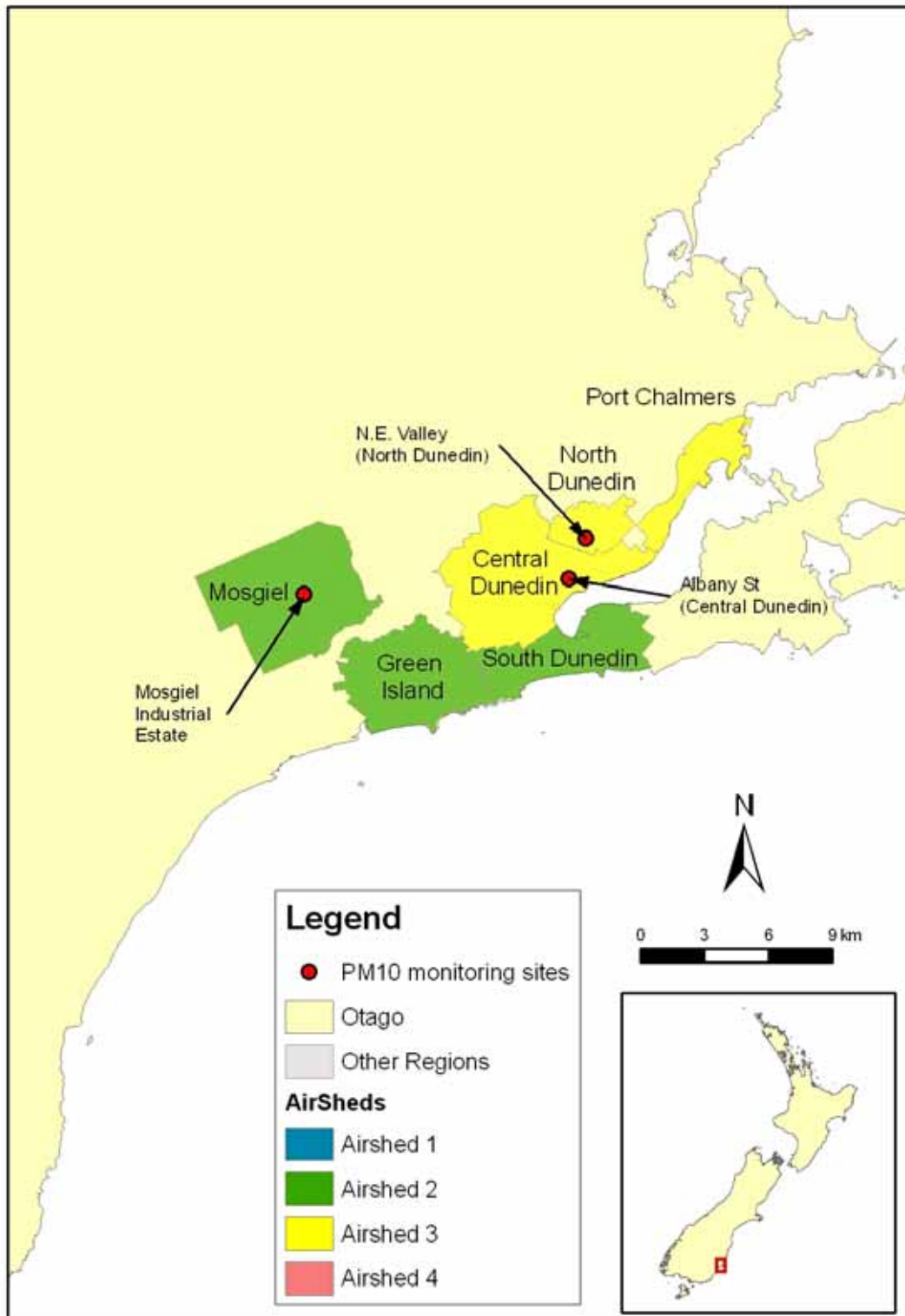


Figure 2.15b: Dunedin and Environs - NES airsheds and PM₁₀ monitoring sites - 2006

Table 2.15: Summary of Otago's PM₁₀ Monitoring Network - 2006

Airshed	Site Name	PM₁₀ Monitoring Equipment used
Airshed 1	Arrowtown	BAM
	Alexandra	BAM
	Roxburgh	No Monitoring
	Ranfurly	No Monitoring
	Clyde	No Monitoring
	Cromwell	No Monitoring
	Naseby	No Monitoring
Airshed 2	Mosgiel	BAM
	South Dunedin	No Monitoring
	Green Island	No Monitoring
	Palmerston	No Monitoring
	Milton	No Monitoring
Airshed 3	Central Dunedin	BAM
	North Dunedin	HiVol
	Port Chalmers	No Monitoring in 2006
	Waikouaiti	No Monitoring in 2006
	Oamaru	No Monitoring in 2006
Airshed 4	Kingston	No Monitoring in 2006
	Queenstown	No Monitoring in 2006
	Wanaka	No Monitoring in 2006
	Hawea	No Monitoring in 2006

Figures 2.15a, 2.15b and Table 2.15 show that:

- Four airsheds have been identified and gazetted for the Otago region;
- NES compliant PM₁₀ monitoring is being undertaken at sites within in three of the four airsheds;
- No monitoring is being undertaken in airshed 4.

2.16 Southland

Figure 2.16 shows the airsheds and particulate monitoring sites for the Southland Region. Table 2.16 lists the PM₁₀ monitoring equipment used within that airshed.

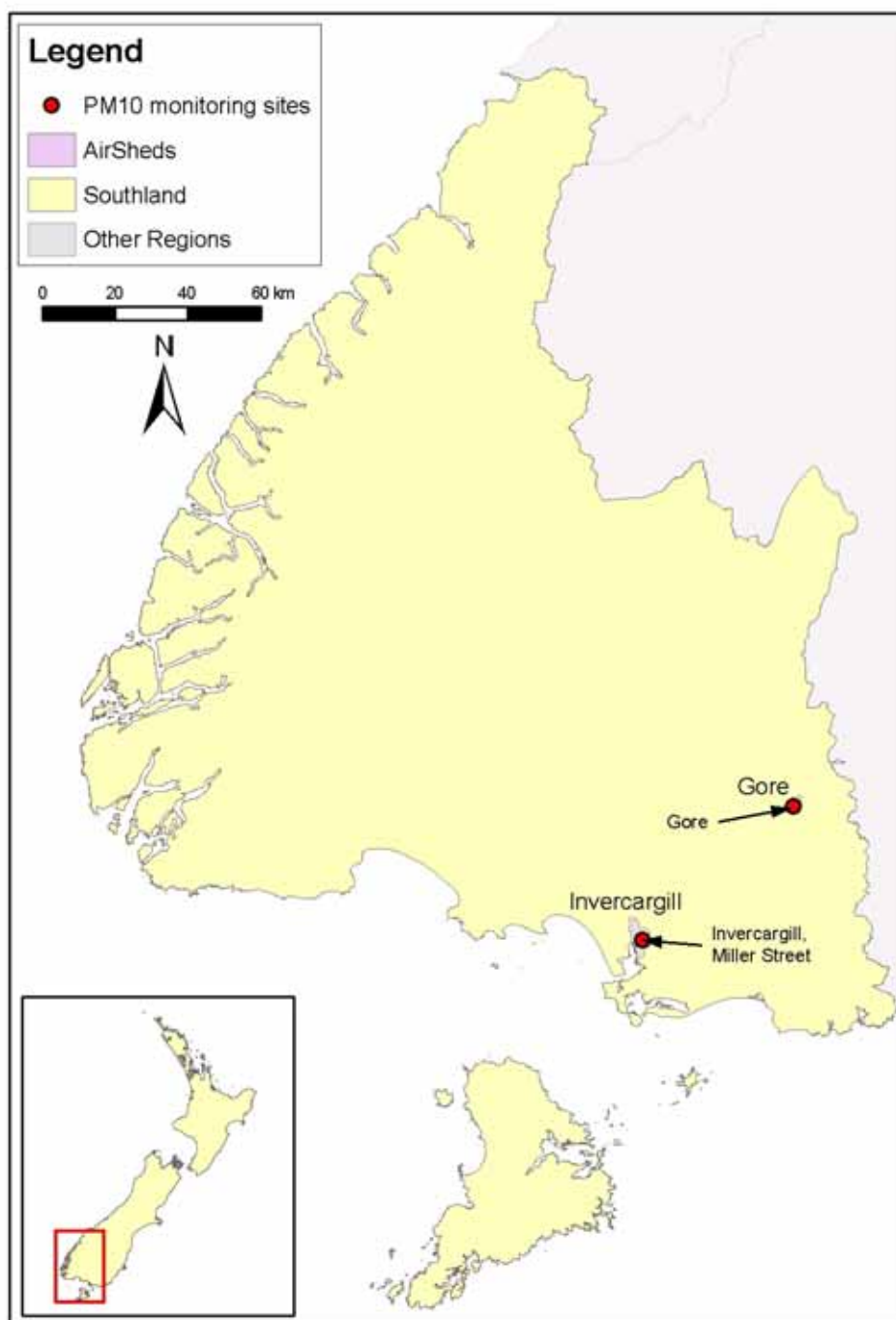


Figure 2.16: Southland Region’s NES airsheds and PM₁₀ monitoring sites

Table 2.16: Summary of Southland’s PM₁₀ Monitoring Network

Airshed	Site Name	PM ₁₀ Monitoring Equipment used
Invercargill	Miller Street	BAM
Gore	Main Street	BAM

Figure 2.16 and Table 2.16 show that:

- Two airsheds have been identified and gazetted for the Southland region;
- NES compliant PM₁₀ monitoring is being undertaken in both airsheds.

3. Overview of the PM₁₀ Monitoring Network within the NES Airsheds

3.1 Airsheds Monitored for PM₁₀ in 2006

Forty-two Airsheds have been defined under the NES in New Zealand, of those, 41 airsheds are for PM₁₀ and 1 airshed is for SO₂ (Marsden Point airshed, Northland). In 2006 33 airsheds were being monitored for PM₁₀ with NES compliant methods and 8 were either not being monitored or being monitored with non-NES compliant methods (Kaitaia airshed, Northland). Figures 3.1 and 3.2 illustrate the numbers and relative proportion of monitored and un-monitored (or monitored using non-NES complaint methods) NES airsheds in 2006. Note that some airsheds may have more than one monitoring site within them and these have been highlighted in Section 2, however, for the purposes of this report these additional monitoring sites have not been included in the following analyses.

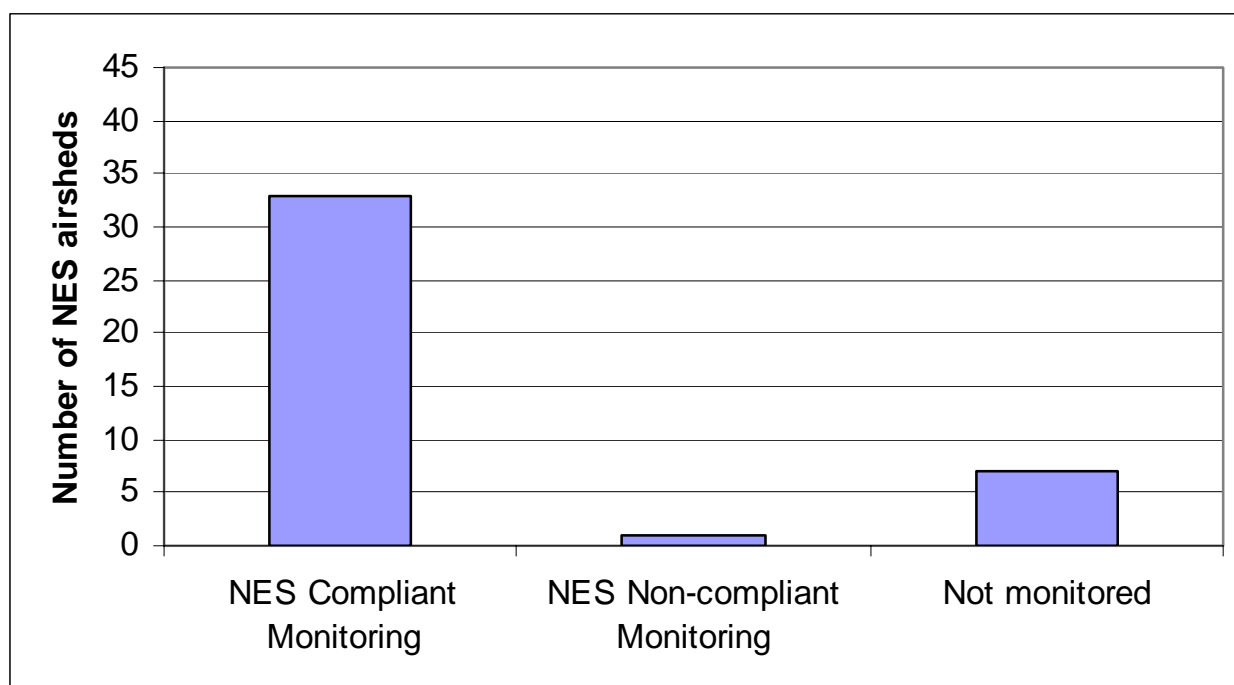


Figure 3.1: Number of NES airsheds monitored for PM₁₀ monitoring in 2006

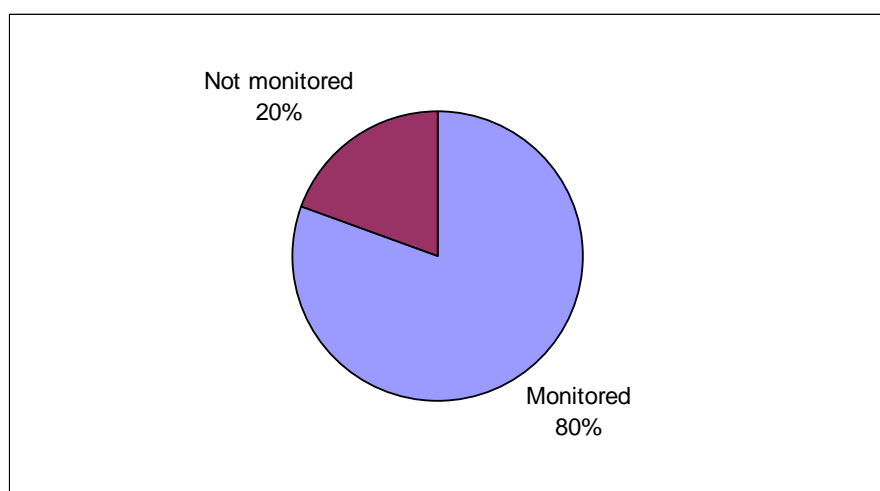


Figure 3.2: Proportion of NES airsheds with PM₁₀ monitoring in 2006

Figures 3.1 (and 3.2) shows that in 2006, NES compliant PM₁₀ monitoring was being undertaken in 33 (80%) of the 42 airsheds in New Zealand. Eight (20%) of airsheds either had no monitoring or did not have NES compliant PM₁₀ monitoring.

3.2 Equipment used for Monitoring PM₁₀

The NES compliant monitoring equipment employed within the airsheds to monitor PM₁₀ in 2006 included BAM, TEOM, and TEOM-FDMS. Figures 3.3 and 3.4 illustrate the numbers and relative proportion of the different types of equipment used to monitor PM₁₀.

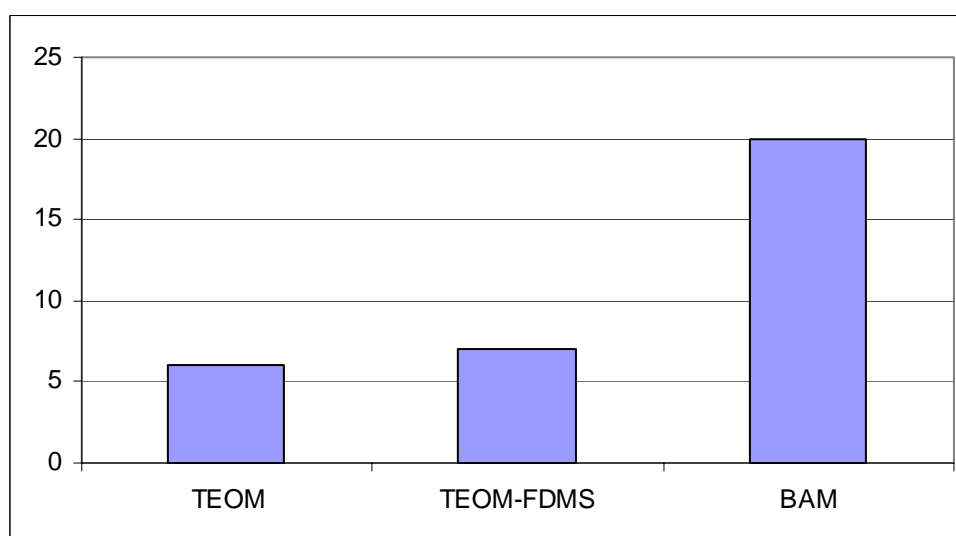


Figure 3.3: Different types of PM₁₀ equipment used in the 33 monitored NES airsheds in 2006

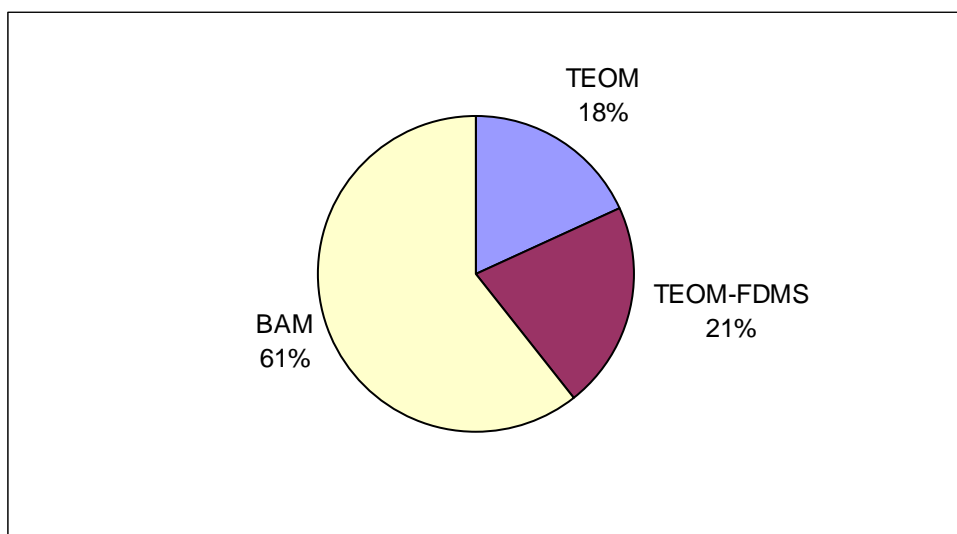


Figure 3.4: Relative deployment of different types of PM₁₀ equipment used in the 33 monitored NES airsheds in 2006

Figures 3.3 (and 3.4) shows that within the 33 airsheds with NES compliant PM₁₀ monitoring, BAMs were used in 20 (61%), TEOMs in 6 (18%) and TEOM-FDMS in 7 (21%).

4. Gaps within and Enhancement of the PM₁₀ monitoring network

The national and regional air quality monitoring networks provide the fundamental data on air quality upon which compliance with the NES is assessed. An effective and efficient PM₁₀ monitoring network will ensure that adequate information is available on

- the air quality in regions that might be affected by exceedences, and on
- progress of implementation and mitigation strategies towards achieving better air quality.

The Monitoring and Network Design Objective aims to develop tools and provide information that will facilitate the design of the PM₁₀ monitoring network to meet the requirements of the National Environmental Standards (NES) as effectively as possible.

In October 2005, a national workshop was held in Christchurch to highlight and discuss the issues raised in “*Review and Gap Analysis of PM₁₀ Monitoring in New Zealand*” (Bluett, Wilton, Fisher and Gimson, 2005). Stakeholders, including Central

and Regional Government, Industry, Scientists and Consultants were invited to attend. A total of 43 people attended the workshop. The material presented at that workshop and the outcomes of the workshop are available at http://www.niwascience.co.nz/ncces/air_quality/.

A workshop outcomes report was written to highlight the key issues and the action points which arose out of discussions. This workshop outcomes report was circulated to the workshop attendees for review/comment. Detailed feedback was received from 15 of the 43 attendees.

One of the major aims of this report is to provide guidance which will assist in enhancing New Zealand's PM₁₀ monitoring network. This section of the report integrates the outcomes of the "Gap Analysis" workshop with the information presented in this report to:

- Identify the gaps in the PM₁₀ monitoring network (Section 4.1);
- Provide guidance which will help enhance New Zealand's PM₁₀ monitoring network in a cost effective manner (Section 4.2).

4.1 Identifying the Network Gaps

A number of areas of the country do not have adequate monitoring information in order to achieve the requirements of the Standards. Other areas could improve the information they collect. Two types of network gaps have been identified:

- The eight airsheds currently without any PM₁₀ monitoring
- detailed in section 4.2
- Hot spots- within larger air sheds
- detailed in section 5.1

4.2 Enhancing the Monitoring Network

There is certainly potential to enhance New Zealand's PM₁₀ monitoring network and there are a number of options that can be considered. Ideally all airsheds would contain at least one NES compliant PM₁₀ monitoring site. However, the cost to set up an NES compliant PM₁₀ monitoring site is significant and the resources available to fund the sites limited. Therefore, in reality it is unlikely all airsheds will be

monitored. The focus of this report's recommendations is on ensuring that any additional monitoring undertaken is representative and cost-effective, especially for smaller regions with insufficient resources. A number of options which can be used to enhance the monitoring network are discussed below.

4.2.1 Installation of Additional Permanent NES Compliant Monitors

The installation of additional permanent NES compliant monitors is the most obvious and direct way to enhance the PM₁₀ monitoring network. However plugging all eight gaps that exist in the current network will require significant resources in terms of capital expenditure, person time and expertise. At least in the short term, it is unlikely that sufficient resources will be available to complete the network. It is therefore recommended that the focus for investment in the network should be on making the most effective use of the available resources and the first step is to prioritise monitoring of airsheds which have little or no PM₁₀ data. Airsheds where exceedences have been recorded in the past should be the first to be considered for permanent monitoring sites. Other locations will need to be prioritised by the use of one or more of the tools outlined in the following sections.

The Weighted Risk-Element Decision Matrix (WRE-DM) (Bluett, Wilton, Fisher and Gimson, 2005) has been designed with the aim of providing Regional Councils with a semi-quantitative process to facilitate the prioritisation of airsheds that are currently not monitored. WRE-DM can be used as a concept and/or framework upon which Councils can develop and improve to meet their individual needs and available data.

A more quantitative approach to prioritising network gaps is to undertake an air pollution exposure assessment of the people living with in each airshed. The Air Quality research programme is contracted to deliver "*A workshop and follow-up report providing guidance to councils on how to assess population exposure to air pollution and to identify where screening and standard method air quality monitoring needs to be undertaken to comply with standards.*" The workshop is scheduled to be delivered in November 2006. The follow up report should be available in December 2006.

Once the available resources for permanent monitoring sites are exhausted, or if there are insufficient funds in the first place then undertaking one or more of the following actions may prove helpful.

4.2.2 “Screening” Monitoring

Screening monitoring uses relatively cheap and easy to set up sampling methodologies, e.g. Mini-vol samplers. The data collected during a screening monitoring programme will not meet the requirements of the NES, but can provide indicative and very useful information. It may be useful to run screening monitoring programmes for preliminary investigations into airsheds which are not monitored. These methods/instruments can be used to assess and/or confirm the monitoring priority of airsheds within a Region. Screening monitoring could also be used to choose the most useful permanent or campaign site/s within a particular airshed.

4.2.3 “Campaign” Monitoring

Campaign monitoring involves using standard monitoring methods for defined periods of time usually during the months of the year when the highest pollution levels are expected. Mobile air quality monitoring laboratories can be very useful for campaign monitoring. The advantage of campaign over screening monitoring is the superior data quality produced by the standard methods of monitoring which can be set up in air quality monitoring trailers/caravans. One mobile air quality monitoring laboratory could be rotated over a number of airsheds or sites within an airshed during one winter. A particular campaign monitoring programme can be repeated at a later point in time in an attempt to track changes in air quality. The frequency at which the campaign is repeated needs careful consideration. It is worth noting that the most useful data to assess long-term changes in air quality is obtained from permanent sites with long-term data records.

4.2.4 Developing and Using “Proxy Measurements”

There is no real substitute for good quality - long record monitoring data. But in locations where PM monitoring is not practical and/or economic there may be some value gained by using campaign monitoring data and developing a semi-quantitative and robust proxy measurement methodology, e.g. use of PM₁₀ measurements from close by or from a “similar source/town”. There are a number of criteria that would need to be met before this method would be suitable. In particular a good correlation between datasets would be required.

Nelson City Council (NCC) have used this approach. NCC found a relationship (with an r-squared value of about 0.9) between the data collected at their long-term monitoring site (Nelson City Valley) with a campaign monitoring site in Tahuanui (3-4 km away but in a separate airshed). This allowed NCC to hindcast the number of exceedences experienced in Tahuanui based on the monitoring data collected at the

permanent site in Nelson city. Following and as a result of the proxy measurement work, NCC have set up a permanent monitoring site in Tahunui.

4.2.5 Use of Industry Sourced Air Quality Data

Quite a number of industrial sites around New Zealand are required to monitor PM₁₀ in the areas that surround their plants. For some airsheds it may be possible to supplement PM₁₀ monitoring gaps with industrial data. This issue was raised and discussed in detail at the “Gap Analysis” workshop with the following outcomes:

- Develop protocols for the nationally consistent use of industrial data which would allow control of variables such as: background concentrations, influence of point sources of pollution and sampling methods;
- Protocols should where possible be referenced to MfE endorsed Guidance and/or Standard Methods (where applicable);
- Note the importance of meta-data is when analysing industrial data. It can allow the isolation of the effects of point sources;
- Industrial data is used in New South Wales to augment environmental monitoring. These sites are tagged industrial rather than NEPM in the meta-data;
- Both Regional Councils and industry may benefit from enhanced relationships;
- Regional Councils should be encouraged to collect, integrate into an electronic data base and make available, details on industrial emission sources in their areas;
- Where appropriate, RC’s should require industry to supply ambient air quality data – (preferably continuous) as part of consent conditions. ARC and NRC can advise on this;
- Considered approaching industry and requesting access to any AQ data they may have. Industry will often provide data, if they know what it will be used for and they can see the benefit in supplying the data – often this is a communication issue;

- Any data supplied by industry would need to be assessed with respect to location and the relationship to the airshed of interest.

5. Knowledge Gaps on Monitoring PM₁₀ in New Zealand

The last major aim of this report is to highlight the knowledge gaps on monitoring PM₁₀ in New Zealand. This section integrates the outcomes of the “Gap Analysis” workshop with the information presented in this report to briefly describe the major knowledge gaps and to note what work is being undertaken to address each gap.

5.1 Better Spatial Resolution/Representation of PM₁₀ Data within Airsheds

The NES requires that monitoring “*be conducted in that part of the airshed where the monitoring the standard is breached by the greatest margin or the standard is breached most frequently, which ever is the most likely*”. This requirement poses a number of questions for regional councils collecting PM₁₀ data. These questions include: “*Is the data we collect representative of other parts of the airshed? Are we monitoring in the worst place within the airshed? How many monitors do we need?*”

This issue is acknowledged as important by New Zealand’s Air Quality Research Programme and is included specifically within a number of milestones and the following outputs:

- Make recommendations on to how collect representative data by determining the optimal number and siting of PM monitors within an airshed;
- Development of low cost indicator and survey methods of monitoring, using model output to assist in specifying representative sites and survey durations, and implementation of these methods to identify and assess pollution hot-spots.

Within the Research Programme work on this issue is ongoing, and will intensify if a revised set of outputs for 2006-2008 are accepted by the Foundation. The proposed revision to the programme outputs is a report that details the spatial variation of PM₁₀ concentrations across urban areas in New Zealand. The report will:

- Utilise monitoring and/or dispersion modelling data;
- Employ GIS mapping to maximise the usefulness and impact of the study outputs;

- Assess the representativeness of data recorded at fixed site PM₁₀ monitors in 2 major urban areas in NZ;
- Provide an empirical model and/or alternative methods which will enhance Urban Air Pollution Exposure Assessments in New Zealand;
- Provide a tool by which Regional Councils can review their air quality monitoring networks in terms of meeting the requirements of the NES.

The scheduled delivery date for the proposed report is June 2008.

5.2 Different Methods of Monitoring PM₁₀

The NES regulations define which PM₁₀ monitoring methods are to be used to determine compliance with the PM₁₀ Standard. Schedule 2 of the regulation provides for two methods for monitoring fine particulate – both of them gravimetric. However included in these gravimetric methods are “equivalent” methods which use alternative technology to determine PM₁₀ concentrations in ambient air. In this context ‘equivalency’ is a formalised criterion that implies some defined approval from a suitable regulating organisation such as the Ministry for the Environment, Standards NZ/Australia, or US EPA. TEOM, TEOM-FDMS and BAM instruments are equivalent methods commonly used to measure PM₁₀ in New Zealand.

Because “equivalent methods” employ differing technologies to measure PM₁₀ a common question is “*How to the results of equivalent methods compare with gravimetric results?*” There is a large body of literature on this topic, however, there are only a few studies that have addressed this question in the New Zealand context. A comprehensive comparison between gravimetric and equivalent methods has just been undertaken as part of New Zealand’s Air Quality Research Programme. The report entitled “*PM₁₀ in New Zealand’s Urban Air: A Comparison of Monitoring Methods*” is currently in draft format and is due to be finalised and published in November 2006.

5.3 Particulate Matter Component Composition and Source Apportionment

Particulate matter component composition and source apportionment were addressed at the “Gap Analysis” workshop and the following recommendations for action were made:

- The Foundation programme invest time and/or resources into a nationwide study that:

- Identifies contributions of natural sources and road dust in urban areas
- Further develops source profiles for New Zealand, in particular differences between different types of combustion processes
- Examines relationships between external variables that may allow for some proxy indications of sources
- Further investigation of secondary particulate, its formation and interaction with marine and anthropogenic sources. This would require measurement and also some particle size information. These are also important constituents and our understanding of the chemistry and interactions with the NZ environment is not very strong.
- Review the Australian Department of Environment and Heritage's study on the determination of road dust and wind blown dust

The issue of particulate matter component composition and source is still live for the Air Quality Research Team. Currently the team is collaborating in two field programmes. The first sampling site is located in Hastings and is a collaboration with Hawkes Bay Regional Council and the Institute of Geological and Nuclear Science (GNS). The second field programme is a collaboration with Auckland Regional Council, collecting samples at two sites in Auckland.

Both source apportionment sampling programmes run from March 2006 to March 2007. The analysis and reporting are scheduled to be completed by June 2007.

5.4 Monitoring Background and/or Natural Concentrations of PM₁₀

Background and/or natural concentrations of PM₁₀ in New Zealand are an issue of interest because the NES does not make a distinction between pollutant sources, only the total PM₁₀ loading is reported. However, from the perspective of an authority charged with the responsibility managing air quality, it is important to understand the proportion of the total PM₁₀ loading that is from natural sources (which cannot be mitigated) and that from anthropogenic sources (which can be controlled).

Background and natural concentrations of PM₁₀ were addressed at the "Gap Analysis" workshop and the following recommendations for action made:

- The Foundation programme invest time and/or resources into a nationwide study that:
 - Evaluates the contribution of natural sources to PM₁₀ concentrations in likely hotspots to provide an indication of likely worst-case contributions;
 - Considers the difference between oceanic and continental sourced natural PM;
 - Provides options for the inclusion of background sources in areas where site-specific source apportionment has not been carried out and air quality management is required;
 - Addresses the health effects of natural sources of PM – Toxicological study which considers the importance of chemistry and physiological interactions within the human body;
 - Assesses the potential use of non-urban ambient air quality monitoring and source apportionment studies to evaluate the contribution of background sources to PM₁₀ concentrations in urban air.

The issue of Background and natural concentrations of PM₁₀ is still live for the Air Quality Research Team and the action point recommendations will be woven into the work stream as appropriate and where possible over the next two years.

5.5 PM_{2.5} in Urban Areas

In New Zealand, the National Environmental Standard for particulate matter has been set on PM₁₀ at the value of 50 µgm⁻³ (24-hour average). No standard has been set for PM_{2.5}. However in any areas that experience frequent exceedences of the standard the predominant source of particulate matter tends to be emissions from solid-fuel home heaters. Given the combustive source of this particulate matter, it is likely that a relatively large proportion of the PM falls within the fine fraction (PM_{2.5}). Therefore PM_{2.5} is an issue worthy of further investigation in New Zealand.

PM_{2.5} was addressed at the “Gap Analysis” workshop and the following recommendations for action made:

- The Foundation programme invest time and/or resources into a nationwide study that:
 - Quantifies the relationship between PM_{10} and $PM_{2.5}$ in urban New Zealand;
 - Explores and explains any regional and seasonal differences in the ratio of PM_{10} and $PM_{2.5}$;
 - Reviews the methods used to monitor $PM_{2.5}$ in New Zealand and compares these with the methods attached to the overseas $PM_{2.5}$ standards;
 - Reviews the $PM_{2.5}$ monitoring network in New Zealand in terms of the numbers of monitors and their siting.
- Regional Councils be encouraged to continue to monitor $PM_{2.5}$. However it is acknowledged that the NES monitoring requirements make PM_{10} the priority pollutant. Any $PM_{2.5}$ monitoring undertaken is at the “expense” of a more complete PM_{10} programme

The issue of $PM_{2.5}$ is still live for the Air Quality Research team and the action point recommendations will be woven into the work stream as appropriate and where possible over the next two years.

5.6 Measuring Particle Numbers (rather than Particle Mass)

All of New Zealand’s long-term PM_{10} monitoring programmes are designed around collecting data on mass concentrations. However, interest in the collection of particulate data in terms of particle numbers has increased over the last five years as health researchers have investigated biological mechanisms responsible for adverse health impacts associated with concentrations of particles in the air.

Measuring particle numbers (rather than particle mass) was addressed at the “Gap Analysis” workshop and the following recommendations for action made:

- FRST research team to revisit the TSI particle number data collected as part of the CAPS-2000 monitoring programme;
- Air quality researchers carrying out monitoring in New Zealand consider the inclusion of a particle numbers in their sampling programme;

- This may only be possible via a collaborative effort with organisations that have particle counting equipment;
- NIWA’s Ocean–Atmosphere Interactions Research Team be scoped out as a potential collaborator and/or source of equipment;
- Queensland University of Technology may also be a potential collaborator – there are other international research programmes that may also be keen to participate in, and benefit from, sampling in New Zealand.

Currently particle numbers is much more a science research issue than a concern for air quality managers. The Foundation Research Programme will keep a “*watching brief*” on international developments on particle numbers, but currently the issue is of low priority.

6. Priority Needs for Enhancing PM₁₀ Monitoring in New Zealand

The stakeholders who attended the Christchurch workshop on the “*Review and Gap Analysis of PM₁₀ Monitoring in New Zealand*” report were asked to prioritise the importance of the issues covered at that workshop. Figure 6.1 shows the priority ranking and relative importance of the 6 issues as determined by the stakeholders who attended the workshop.

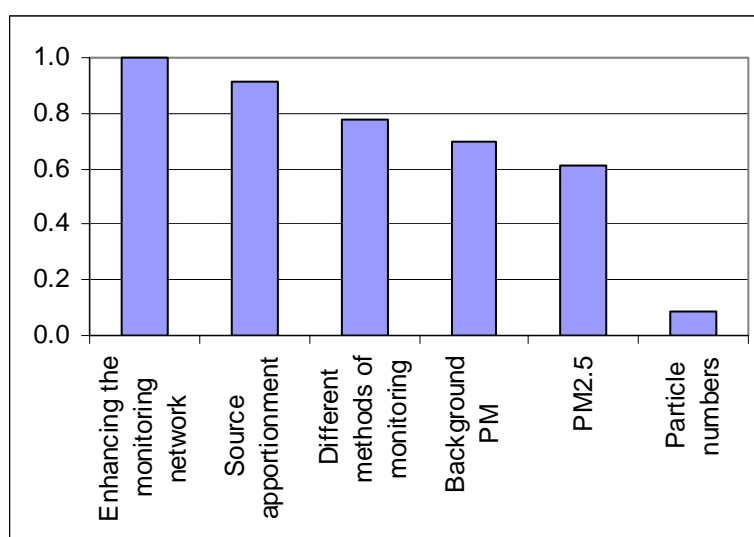


Figure 6.1: Priority ranking and relative importance of 6 issues as determined by stakeholders

Figure 6.1 shows that the workshop attendees rated the importance of issues in order as:

- 1) Enhancing the monitoring network
- 2) Source apportionment
- 3) Comparing methods of monitoring PM₁₀
- 4) Background concentrations of PM₁₀
- 5) PM_{2.5}
- 6) Particle numbers

Figure 6.1 suggests that with the exception of particle numbers, all issues were of significant interest and relevance to the stakeholders.

7. Acknowledgements

This report could not have been written without the information supplied by, and support of, the Ministry for the Environment.

To those Stakeholders, including Central and Regional Government, Industry, Scientists and Consultants, who attended the workshop on the “*Review and Gap Analysis of PM₁₀ Monitoring in New Zealand*” report. An additional acknowledgement is owed to those stakeholders who provided feedback on the workshop outcomes report.

Cover photograph: Greater Wellington Regional Council

Maps of Airsheds and Monitoring Sites: Helen Hurren and Jochen Bind, NIWA.

8. Reference

Bluett, J., Wilton, E., Fisher, G. and Gimson, N, 2005. Review and Gap Analysis of PM₁₀ Monitoring in New Zealand. *from* www.niwa.co.nz/ncces/