Inhalable particulate (PM10) Regional Monitoring Programme Report 2003

Technical Report 2003–99

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Taranaki Regional Council Private Bag 713 STRATFORD

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Executive summary

On 9 August 2002 the Taranaki Regional Council signed a memorandum of understanding with the Ministry for the Environment that set up a partnership for state of the environment monitoring. The memorandum included an air monitoring schedule that described a partnership to undertake monitoring of inhalable particulate. This work was subsequently undertaken over the winter of 2003 (June to November).

This report describes the monitoring programme implemented by the Council to assess the quality of the ambient air in New Plymouth during the period under review, and the results of that work. The work entailed the sampling of air on a continuous basis for 24 hours, every three days, and determination of the average concentration of PM10 in air sampled during that period.

The Council also undertook, as a further stage of investigation, analysis of 6 filters used during the monitoring, to confirm the likely origins of suspended particulate matter collected during each sampling period.

The monitoring showed that overall, 80% of samples fell into the Ministry's 'excellent' or 'good' categories, and all results met the 'acceptable' category. The highest result was $30.9 \ \mu gm^3$, and the mean of all results $12 \ \mu gm^3$. One cluster of results was potentially influenced by roading works when a nearby carpark was reconstructed. Removing these samples from consideration, the average PM10 concentration (24-hour average) measured in New Plymouth across all measurements was 10.7 $\ \mu gm^3$, or 20% of the Ministry's guideline, with a maximum result of 24.6 $\ \mu gm^3$ and a minimum of 0.6 $\ \mu gm^3$.

There was a strong influence from sea salt, with the mean PM10 level during on-shore winds 66% higher than the mean PM10 level during off-shore winds.

By comparison with other sites in New Zealand, the air in New Plymouth (taken as representative of the air across the ring plain of Taranaki) was shown to be 'excellent' to 'good' according to the categories used by the Ministry for the Environment. A review of monitoring around New Zealand undertaken by the Ministry has shown that the Ministry's PM10 guideline (twenty-four hour exposure) has been exceeded at 28 sites in various cities and towns.

By virtue of undertaking this work, the Council and Ministry have fulfilled their respective commitments as agreed in the 'Environmental Information Sharing Agreement' of 2002.

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1. Introduction

This report describes monitoring undertaken by the Taranaki Regional Council in partnership with the Ministry for the Environment during 2003. As agreed in the Air Schedule of the Environmental Information Sharing Agreement which was signed between the Ministry for the Environment and Taranaki Regional Council on August 9 2002, the Council undertook monitoring of the levels of suspended particulate within the size range of less than 10 micrometres effective diameter (PM10), in the air of New Plymouth between 6 May and 28 October 2003.

The costs of provision of the monitoring device, training for Council staff in its care, calibration and maintenance, and analysis, were met by the Ministry, while the Council provided staff resources to maintain the monitor and to analyse results. The Council has a separate weather monitoring station in New Plymouth, and data from that station has been incorporated into this report

1.1 Project background

1.1.1 Ambient air quality guideline for particles

The Ministry for the environment and the Ministry of Health have jointly released updated air quality guidelines for New Zealand ('Ambient Air Quality Guidelines', May 2002). The guidelines include a guideline for PM10, of 50 μ gm⁻³ (24-hour average) and 20 μ gm⁻³ (annual average). A separate good practice guide specifies the preferred methods of measurement and data management (MfE2000).

Particles can derive from many sources, including motor vehicles (particularly diesels), solid and oil-burning processes for industry and power generation, incineration and waste burning, photochemical processes, and natural sources such as pollen, abrasion, and sea spray.

PM10 particles are linked to adverse health effects that arise primarily from the ability of particles of this size to penetrate the defences of the human body and enter deep into the lungs. Health effects from inhaling PM10 include increased mortality and the aggravation of existing respiratory and cardiovascular conditions such as asthma and chronic pulmonary diseases.

1.1.2 Location

New Plymouth is a coastal city lying due north of Mt Taranaki (2815 m) and on the northern coastline of the Taranaki region. The region is on the west coast of the North Island of New Zealand (Figure 1). The topography of the region consists of a ring plain surrounding the conical mountain (a dormant volcano), with hill country running along the eastern side of the region, 20 kilometres from New Plymouth at its nearest point. The hill country is sparsely populated. New Plymouth, with a population of 44,000, is the region's only major city. The region has an area of 723,610 square kilometres and a population of 103,000 (2001 Census).



Figure 1 Taranaki region and landforms

By comparison with other regions, Taranaki has a relatively low population density, an exposed landscape, minimal vehicle congestion, and no significant industrial zones with air pollution problems. The predominant fuel is natural gas, used in petrochemical industries and for thermal electricity generation. Coal or heavy oil usage in the region is negligible. As a rural region there is some domestic use of fire wood.

The retail and commercial part of New Plymouth lies towards the foreshore. The residential areas on the inland side of the city are located on rising ground. The building on the roof of which the sampler was located, the New Plymouth District Council offices, is a three-storey building. However, houses to the south are at similar or higher altitudes because of the rising land. Thus, the sampler was located in the path of air flows either about to impinge on or having already passed over the residential areas of the southern part of the city. Figures 2 and 3 show the location of the District Council building in relation to the residential areas to the south of the building. In Figure 3, the land rises beyond the left (southwards) of the photograph, so that residential properties in this direction are in fact higher than the roof of the Council building.

Figure 4 shows the orientation of the coastline in relation to wind directions. A 16point wind rose was used for analysis of results. Wind directions from west-southwest through west, north-west, north, and north-east were deemed to be on-shore winds, while wind directions from east-north-east through east, south-east, south, and south-west were deemed to be off-shore winds.

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Figure 2Location of PM10 sampler in New Plymouth



Figure 3Photograph of sampling location in relation to residential areas



Figure 4Coastal orientation of New Plymouth

1.1.3 Meteorology

Taranaki's climate is determined by its westerly position, its mid latitude location, and its topography. The region lies in the path of weather systems moving west over the Tasman Sea. The region is generally sunny and windy, with moderate temperatures and regular rainfall throughout the year. Westerly winds predominate in spring and summer, often bringing unsettled and showery weather. About 40% of New Plymouth's rain comes with winds from the north or north-east, usually falling as steady rain for several hours or longer. South easterlies tend to be dry. The annual rainfall for New Plymouth averages around 1500 mm. Rainfall across the region varies from around 1000 mm on the southern coast, to 2000 mm at the highest points of the ringplain around Stratford, and higher rainfall in the hill country and on Mt Taranaki.

Wind roses for the region are shown in Figure 5.



Figure 5 Wind roses for Taranaki

1.2 Monitoring programme

1.2.1 Introduction

Section 35 of the Resource Management Act sets out an obligation for the Taranaki Regional Council to gather information, monitor, and conduct research on 'the state of the whole or any part of the environment of its region....'

The Taranaki Regional Council may therefore make and record measurements of physical and chemical parameters, take samples for analysis, carry out surveys and inspections, conduct investigations, and seek information.

The purpose of the monitoring site was to provide information on the regional level of inhalable particulates to the Ministry for the Environment's environmental monitoring and reporting programme. The Council gained robust and defensible data to support and inform its air quality management policies and practices.

1.2.2 Monitoring equipment and techniques

PM10 was monitored on a one day in three basis using a HiVol sampler and 200 mm x 250 mm filters prepared and supplied by Watercare Services Ltd. Analytical techniques, preparation techniques and filters complied with the requirements of the recommended monitoring method US CFR 40, Part 50, Appendix J 'Reference Method for the Determination of Particulate Matter as PM₁₀ in the Atmosphere'.

Filters were collected by Council staff and forwarded to Watercare on a monthly basis. Results were returned to the Council generally within two weeks in hard copy and electronic form, and the Council forwarded results to the Ministry.



The instrument is shown in Figure 6 during calibration.

Figure 6 HiVol PM10 sampler

2. Results

2.1.1 Results of PM10 monitoring

A total of 58 filters were collected during the period. Sampling was disrupted for two scheduled sampling periods when very high winds disturbed the sampler, on 28 September 2003 and again on 31 October 2003. In addition, the samples collected on 16 September, 19 September, 25 September, 4 October, and 7 October 2003 were collected during a period of earthworks on the carpark and road immediately outside the Council building. Data has therefore been analysed both including and excluding these samples, as they may reflect abnormal ambient conditions due to unusually high dust sources in close proximity to the sampler, and do not reflect ambient conditions over the wider area.

A full set of results is set out in Table 8, in Appendix II.

A wind rose for the duration of sampling is presented in Appendix III, together with a graph of wind speed. It shows a strong domination of winds from the south-east and south, or almost directly off-shore, with 37% of all winds from these two directions. This frequency was almost exactly double the duration of winds from the north-west or north (almost directly on-shore), of 19%.12% of winds were from the west (slightly on-shore) and 13.5% of winds were from the south-west (slightly off-shore). Conditions were calm (less than 1 km hr⁻¹) for 3% of the total period. Wind speed varied from 0 to 47 km hr⁻¹, with an average wind speed of 10 km hr⁻¹. Wind directions are rarely stable for long periods in Taranaki. Wind directions for brief periods are shown in Appendix V. These show that it was rare for the wind direction to remain constant for more than 12 hours, and wind directions can often oscillate through 360° over a brief period.

Appendix IV contains all results in graphical form, collated against average daily wind speed and direction, and rainfall. A pictorial presentation of the colour of each filter is also given.

A summary of data is given in Table 1, below. The 'corrected' data set has had the samples collected during the period of earthworks removed from inclusion. A 95% ile value is included (i.e. the value below which 95% of the results lie). While it is common to calculate a 99% ile or 99.9% ile figure, this is not considered appropriate in this case given that only 58 samples were collected altogether.

All results in µgm ⁻³	Mean	Median	Minimum	Maximum	95%ile
Full set of results (58 samples)	12.0	12.4	0.6	30.9	24.6 (1)
'Corrected' set of results excluding possible roadworks interference (53 samples)	10.7	11.5	0.6	24.6	19 (2)
Full set of samples collected with on-shore wind* (16 samples)	15.8	16.1	7.1	30.9	25.9 ⁽³⁾
Full set of samples collected with off-shore wind* (42 samples)	9.0	10.4	0.6	23.7	21.1 ⁽⁴⁾

Table 1 Summary of PM10 results

*wind direction towards (1) 55th highest of 58 (2) 50th highest of 53 (3) 15th highest of 16 (4) 40th highest of 42

The values in Table 1 clearly show the increase in PM10 levels when the wind is blowing from the sea. All statistical parameters presented in the table increased under these circumstances. Also of note is that the 95thile value is generally about 80% of the maximum value, indicating that a few events have values significantly higher than the typical range.

2.1.2 Speciation and source identification analysis

The Council sought to have selected filters collected during the PM10 measurement work analysed to identify the types of particles collected on the filters to suggest possible sources.

This work was carried out using scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) by the Research centre for Surface and Materials Science at the University of Auckland. The full report is attached to this report as Appendix VII.

A summary of the results is presented in Table 2.

Date of collection	PM10 µgm⁻³	Wind direction*	Conditions	Particle composition and likely source
18 May	21.1	Stable, off-shore (SSE)	No rain. Dirty appearance	Pollen; traces of iron; sea salt.
30 May 18.2 Stable, off-shore (SW)		No rain. Dirty appearance	Carbon; sea salt.	
30 June	21.3	Stable, on-shore (N)	Dirty appearance	Carbon; sea salt.
4 Sept	16.2	Stable, on-shore (NW)	Dirty appearance	Carbon; sea salt.
25 Sept	30.9	Stable, on-shore (NW)	A few showers. Dirty appearance	Carbon; sea salt. (note: this sample was possibly affected by local road-works)
25 Oct	12.7	Stable, off-shore (SE)	No rain.	Pollen; particles of silicon, calcium, aluminium, iron, oxygen (soils, clays, rocks)

 Table 2
 Speciation and source identification of collected material

* wind direction towards

3. Discussion

3.1 Earlier PM10 monitoring work

The Taranaki Regional Council has previously undertaken or accessed the results of other monitoring at various locations around the region, including sites within New Plymouth. The sampling periods or protocols, or analytical methodologies, have not in every case been consistent with the methodology set out in the Ministry's ambient air quality guidelines. For these reasons, earlier results should not be compared directly with the work now being reported. However, the results are presented in Table 3 below for indicative purposes (TRC 2003).

Average Range Site identification and description µgm⁻³ µgm⁻³ New Plymouth (urban) 9.6 0.7-26.0 Stratford (rural town) 9.2 1.7-24.1 Oaonui (coastal) 7.2 1.0-16.5 Egmont National Park (pristine) 1.6 0.2-3.6

 Table 3
 Comparative results of other PM10 monitoring in the Taranaki region

The results for the earlier New Plymouth work indicated that levels of PM10 were elevated when the wind blew from the sea, implicating salt spray as a major source. A similar result occurred at Oaonui, on the west coast of the region, where sea breezes typically had three times the concentrations of fine particulate found in breezes blowing across land towards the monitor. Peak values at the Stratford site were characterised as very brief and comparatively very high, and were probably caused by wood fires near by. At New Plymouth, the higher concentrations persisted for longer (e.g. overnight), indicating natural prevailing sources linked with particular meteorological conditions.

The values in Table 3 are consistent with those reported in the present study.

3.2 Discussion of New Plymouth results

Atmospheric particulate matter can arise from a number of sources, both natural and from human activity eg, vegetation pollens, smoke and ash, sea spray, dust from soils and paved surfaces, and manufacturing processes. While extremely fine particles may remain floating in the atmosphere for weeks or months, coarser dusts may settle out within timeframes ranging from a few seconds to minutes.

MfE 2002 proposes that regional air quality can be categorised based on a comparison with the ambient guidelines. These categories are set out in Table 4.

 Table 4
 Environmental Performance Indicator air quality categories

Measured	Less than 10% of guideline	10-33% of	33-66% of	66-100% of	More than 100%
value		guideline	guideline	guideline	of guideline
Category	excellent	good	acceptable	alert	action

The results obtained in the current work (corrected dataset) had an average of 11 μ gm³, 95% of results were below 22 μ gm³, and the peak value was 24.6 μ gm³. Given these results, the air in New Plymouth can be considered as 'excellent' or 'good' more than 80% of the time, and 'acceptable' at all times. When the wind direction is across land towards New Plymouth, then air quality falls into the 'excellent' or 'good' categories almost all the time.

Further details are set out in Tables 5-7. They again show that there are significant variations in air quality in the region, depending on whether the wind is from or towards the sea. For off-shore winds, levels of PM10 fell within the 'excellent' or 'good' categories more than 90% of the time. When the wind was on-shore, this proportion fell to 56% of the time, with 44% of all results falling into the 'acceptable' category- four times the frequency encountered when the wind was off-shore.

Table 5 Categorisa	Table 5 Categorisation of results - entire dataset					
Ministry for the Environment air quality guideline for PM10 = $50 \ \mu \text{gm}^{-3}$ - 24 hour average.						
Category	Measured values					
Excellent	$<10\%$ of the guideline, $(0-5\mu g/m^3)$	13 (22%)				
Good	10-33% of the guideline, $(5-17\mu g/m^3)$	34 (59 %)				
Acceptable	33-66% of the guideline, $(17-33 \mu g/m^3)$	11 (19%)				
Total number of samples		58 (100%)				

Table 5 Categorisation of results - entire dataset

Table 6 Categorisation of results - prevailing on-shore wind

Ministry for the Environment air quality guideline for PM10 = $50 \ \mu \text{gm}^{-3}$ - 24 hour average.					
Category	Measured values				
Excellent	<10% of the guideline, (0-5µg/m ³)	00 (00%)			
Good	10-33% of the guideline, $(5-17\mu g/m^3)$	09 (56 %)			
Acceptable	33-66% of the guideline, (17-33 μ g/m ³)	07 (44%)			
Total number of samples		16 (100%)			

Table 7	Categorisation of	of results -	prevailing	off-shore	wind
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Ministry for the Environment air quality guideline for PM10 = $50 \ \mu \text{gm}^{-3}$ - 24 hour average.					
Category	Measured values				
Excellent	<10% of the guideline, (0-5µg/m ³)	13 (31%)			
Good	10-33% of the guideline, $(5-17\mu g/m^3)$	25 (60 %)			
Acceptable	33-66% of the guideline, (17-33 μ g/m ³)	04 (09%)			
Total number of samples		42 (100%)			

While no annual average for PM10 can be calculated from these results (insufficient data), there is no reason to consider that the Taranaki region would show an exceedance of the guideline value.

Monitoring of PM10 around New Zealand has shown that exceedances of the 24-hour standard have been determined in 28 cities, while exceedances of the annual guideline

have been determined in 6 of 15 locations. Exceedances typically occur where there is a high level of use of solid fuels for home heating, and/or high traffic volumes and densities.

3.3 Correlation of results with meteorological conditions

From the correlation analysis attached in Appendix VI, any association between PM10 and rainfall was almost non-existent. This appears a little surprising, as the normal assumption would be that drier periods increase dust burdens in the atmosphere. It suggests that the amount of sea spray in the atmosphere is largely independent of rainfall- or rather, that the amount of sea spray being carried onto land is unchanged whether it is raining (depositing sea spray) or not (wind carrying sea spray). Lending weight to this interpretation is that there was a strong correlation between PM10 and wind speed when the wind was on-shore- that is, stronger winds carried more sea salt onto the shore. There was also a strong correlation between rainfall and filter colour under on-shore conditions, suggesting that both wind and rain carry sea spray. For off-shore winds, wind speed was less of a factor, suggesting that the suspension or resuspension of surface dust is not a major contributing source for PM10 in Taranaki.

As to be expected, the colour of the filter papers correlated strongly with the amount of PM10 collected on them.

There was a strong correlation between wind direction and PM10, particularly for the on-shore wind directions.

3.4 Future monitoring requirements for PM10

In designing and implementing the state of the environment monitoring programmes for air in the region, the Taranaki Regional Council has taken into account the extent of information generated by other authorities, its relevance under the Resource Management Act, the obligations of the Act in terms of monitoring the state of the region's environment, and subsequently reporting to the regional community, the scope of assessments required at the time of renewal of permits, and the need to maintain a sound understanding of the environment within Taranaki.

In the case of PM10 monitoring, the Council has now undertaken ambient monitoring in four surveys, and has accessed date generated by consent holders or applicants at various sites over several periods. The data has consistently shown that the air of the region is of good quality in respect of PM10. While it may be appropriate in due course to repeat a survey to confirm the on-going state of the region's air, regular monitoring of PM10 has been shown to not be a priority requiring the allocation of the Council's resources for regional monitoring. A recommendation to this effect is attached to this report.

4. Recommendations

- 1. THAT it be noted that the Taranaki Regional Council and the Ministry of the Environment have respectively met their obligations and commitments to monitor the state of the ambient air in Taranaki, as set out in the Air Schedule of the Environmental Information Sharing Agreement entered into by the two parties;
- 2. THAT it be noted that PM10 monitoring of ambient air in New Plymouth has shown no exceedances of the 2002 ambient air quality guidelines, and that air falls into the Ministry's Environmental Performance Indicator categories of 'acceptable' to 'excellent' at all times;
- 3. THAT it be noted that sea spray is a major contributor to PM10 in the Taranaki region.

Bibliography and references

- MfE2000: 'Good practice guide for Ambient Air Quality Monitoring and Data Management', Ministry for the Environment, 2000
- MfE 2002: 'Ambient Air Quality Guidelines', Ministry for the Environment and Ministry of Health, May 2002
- TRC 2003: 'Taranaki- our place, our future', report on the state of the environment of the Taranaki region, Taranaki Regional Council 2003

Appendix I Monitoring contract

Standard Long-Form Contract

MINISTER FOR THE ENVIRONMENT

INDEPENDENT CONTRACTOR/CONSULTANCY AGREEMENT

Administered for the Minister by



CONTRACT NUMBER	02/03-0306-L				
CONTRACTOR'S NAME	Taranaki	Regional Council			
SERVICE TO BE PROVIDED	Installation and maintenance of PM10 monitoring equipment in New Plymouth				
DURATION	Start date	e: April 22 2003 Completion	date: May 2	3 2003	
CONTRACTOR'S DETAILS	Full legal name: Taranaki Regional Council				
	Trading name : n/a (if different)				
	Full address: 47 Cloten Road, Private Bag 713, Stratford				
	MAIN C	CONTACT PERSON	BACKUP CONTACT PERSON		
	Name:	Gary Bedford	Name:	James Kitto	
	Title : Quality	Director – Environmental	Title:		
	Phone:	06 765 7127	Phone:	06 765 7127	
	Mobile:		Mobile:		
	Fax:	06 765 5097	Fax:	06 765 5097	
	Email:	gary.Bedford@trc.govt.nz	Email:	james.kitto@trc.govt.nz	

	MAIN CONTACT PERSON	BACKUP CONTACT PERSON	
	Name: Gillian Marks	Name: Caroline Austwick	
	Title: Policy Adviser	Title: Senior Policy Adviser	
MINISTER	Phone : 04 917 7432	Phone : 04 917 7475	
FOR THE	Mobile : n/a	Mobile : n/a	
ENVIRONMENT	Fax: 04 917 7523	Fax : 04 917 7523	
DETAILS	Email : gillian.marks@mfe.govt.nz	Email:caroline.austwick@mfe.govt.nz	
	Main address for written/general correspondence to the Minister	Location : Ministry for the Environment Grand Annex Building 84 Boulcott St Wellington	
		PO Box: PO Box 10362 City/Town: Wellington	

CONTRACT START DATE	April 22 2003
CONTRACT COMPLETION DATE	May 23 2003

	MINISTER'S OBJECTIVES/REQUIREMENTS
TYPE AND SCOPE OF	Give a concise description of the outputs/outcome required
SERVICE TO BE PROVIDED TO MINISTER BY CONTRACTOR	The contractor will establish a PM10 monitoring site in New Plymouth for a 6 month period between May and October 2003 as agreed to in the Air Schedule of the Environmental Information Sharing Agreement which was signed between the Ministry for the Environment and Taranaki Regional Council on August 9 2002.
	The Air Schedule states that:
	'The Ministry will pay the cost of hiring an appropriate PM10 monitor or will provide an appropriate monitor for the Council to use. The Ministry will also cover the initial cost of setting up the equipment and teaching staff how to use it. Taranaki Regional Council will cover the cost of running, calibrating and maintaining the equipment and also data management and analysis'.
	The purpose of this monitoring site is to provide PM10 monitoring information to the Ministry for the Environment's environmental monitoring and reporting programme.
	Output One: The contractor will hire an appropriate PM10 HiVol monitor and filters for the 6 month period of monitoring.
	Output Two: The contractor will install the monitoring equipment. This will

include travel to and from the monitoring site.		
Output Three: The contractor will gain appropriate staff training from the equipment supplier on how to operate and maintain the PM10 monitor (including how to undertake calibrations and quality assurance).		
The data and any associated reports (including site information and summary meteorological statistics) will be provided to the Minister upon completion of the monitoring. In addition to the above outputs, the contractor will cover and fund the cost of running, calibrating and maintaining the equipment as well as data management and analysis. In consideration for this work, the Minister will provide the contractor with a non-exclusive licence to use the data and any associated reports for any purpose, in consultation with the Minister.		
CONTRACTOR SERVICE DELIVERABLES		
Deliverable	Delivery date	
Output 1	May 16 2003	
Output 2	May 16 2003	
Output 3	May 23 2003	
 NOTES: Attach, where appropriate, a Contractor I relevant documents (if appropriate). Variations are to be recorded by using a completed and attached to this document 	Delivery Plan and copies of other "Variation Form" which should be t.	

	FIXED PRICES			
-	Deliverable	P	Price	
TYPE AND SCOPE OF SERVICE TO BE PROVIDED	Output 1	\$7,050.00	\$7,050.00	
	Output 2	\$4,610.00		
CONTRACTOR	Output 3	\$360.00		
	HOURLY RATES			
	Personnel Type	R	ate	
DISBURSEMENTS	ltem	Cost		
	N/A			
TOTAL FIXED CHARGE/PRICE FOR THIS CONTRACT	\$ 12,020 (plus GST)			
 (a) Hourly rates and fixed charges/prices include an allowance for the use of any equipment/property not supplied by the Minister, and the Contractor's use of a reasonable amount of materials and consumables. (b) Overtime hourly rates are the same as standard rates. (c) Amounts are in NZ\$ and exclude GST (if any). All other taxes and duties are included. (d) Any disbursements not included in this contract must be agreed to by the Minister in advance of being incurred. 2. If only hourly rates are used: (a) Hourly rates are to be charged pro rata per part hour. (b) Invoices must detail by personnel type the time expended and the charging rates used. (c) The Minister will only pay for a reasonable number of hours. 3. If the fixed total charge/price may be exceeded, the Contractor is to promptly advise the Minister. 4. If a fixed charge/price is stated, it prevails over hourly rates unless the hourly rates price is lower. 5. If work content changes by more than 5% due to variation by the Minister, then fixed charges/prices may be adjusted by agreement between the Minister and the Contractor. 6. Hourly rates and fixed charges/prices may be reviewed by the Minister every 12 months for inflation adjustment. 				
WHEN PAYMENTS ARE TO BE MADE BY MINISTER TO CONTRACTOR				
	If not specified, payment is not due has been provided to the Minister	e until the relevant servi s satisfaction.	ce deliverable	
	Name	Role	Estimated dedicated hours	
CONTRACTOR'S KEY PERSONNEL WHO WILL PERFORM THE SERVICE	Gary Bedford	Principal	20	

		Subcontractor's name and contact details	Activities to be performed by subcontractor	Contract value	
st	NOMINATED JBCONTRACTORS OF CONTRACTOR	WaterCare Laboratory Services	Outputs 1-3	\$12,020	
GENE	RAL CONTRACTUAL PRO	OVISIONS			
These p Ministe apply o	provisions apply between HER M er for the Environment ("Minister or prevail it must be agreed to in v	IAJESTY THE QUEEN in ri r", "Ministry" or "Crown") a writing by the Minister and	ght of New Zealand, acting nd the Contractor. If any c be attached to this docum	g by and through the other provision is to ent.	
CONT	RACTOR'S OBLIGATION	S/RIGHTS			
The Co	ntractor:				
1. Po M	erform services/price: must perfo finister's objectives/requirements	orm the service by when, wh to the Minister's satisfaction	ere and for the price specifi ;	ed to achieve the	
2. A tin M go	Access: may access the relevant pro- mes to perform this contract subje finistry must be minimised and ar ood by the Contractor;	operty of the Ministry and ir ct to the Ministry's security a ny damage or problem to the	formation for reasonable p and operational requirement extent caused by the Contr	urposes at reasonable nts. Disruption to the ractor promptly made	
3. C M st	Care of property: must keep secure finister's property or information top using and return the Minister's	e, take good care of and not a while within the Contractor' s property and information a	allow any unauthorised acc s possession or control. Th is and when requested by t	ess to or use of the e Contractor must he Minister;	
 4. Operational requirements: will: (a) comply with the Ministry's reasonable security, operational and documentation requirements (particularly in relation to access to and use of property and information, hazardous substances, health and safety, environmental protection and appearance and conduct of personnel and property); (b) have and comply with the Contractor's own appropriate health and safety plan, and promptly notify the Minister: (i) if any hazard exists at relevant properties due to the Contractor; and (ii) of any accident or serious harm that occurs to, or is caused by, the Contractor at relevant properties; (c) ensure that every necessary resource consent and other authorisation for the Contractor to establish, use and maintain facilities and equipment used by the Contractor at relevant properties are obtained and maintained; (d) not allow any unauthorised discharge of any contaminant, or making of excessive noise, by the Contractor at relevant properties; (e) not supply any ozone depleting substance without having the necessary exemption in each case; and 					
5. K	5. Keep the Minister informed : must keep the Minister informed about progress, including about delays or problems as these may in turn cause problems for the Minister;				
6. S e	6. Sourcing : is responsible for efficiently and economically sourcing and providing everything the Contractor needs to perform the service at the Contractor's risk and cost;				
7. Si cc th re tc ac re	7. Standards/quality assurance : will perform the service with due skill, care and diligence and will have and comply with appropriate standards and quality assurance systems. If a standard is not specified, then it will be the best standard in the applicable profession or industry. The Minister's representatives may observe and review anything being done by the Contractor or any subcontractor in relation to this contract and have access to relevant property at all reasonable times for this purpose. The Contractor will assist the Minister with acceptance tests (where requested), and will promptly carry out, at the Contractor's cost, any service required to remedy any defect;				
8. Po (a (b) (c	ersonnel: will: a) perform this contract using only b) end the involvement with this c requested by the Minister (eg o c) ensure that the specified key per	appropriately trained, qual ontract of any of the Contrac due to security or misconduc rsonnel perform the service;	ified, experienced and supe tor's personnel to the exten ct reasons); and	ervised personnel; t reasonably	

9. Subcontractors: will:

- (a) not subcontract in relation to this contract without the Minister's prior approval where the value of the subcontract exceeds \$1,000 or any special skill or process is involved;
- (b) keep the Minister informed about the involvement of subcontractors with the intention that the Minister has full transparency of relevant subcontracts;
- (c) ensure that the Minister's representatives have access to subcontractors' properties at reasonable times to observe and review anything being done in relation to this contract;
- (d) end the involvement with this contract of any subcontractor or any of their personnel to the extent reasonably requested by the Minister; and
- (e) ensure each relevant subcontract contains provisions allowing the Minister to directly benefit from and enforce the subcontract;
- 10. **Prices/invoices**: will promptly provide the Minister with correct tax invoices for the service delivered, priced in accordance with this contract;
- 11. **Insurance**: must, at the Contractor's cost, have and maintain appropriate insurance cover (including public liability and professional indemnity cover each of at least \$500,000 for each event) during, and for a period of 12 months following the completion of, this contract;
- 12. General assurances: assures the Minister that:
 - (a) every good the Contractor provides will be new and unused on delivery, and if a shelf life or calendar life (by time, not utilisation) or a utilisation life is applicable, at least 95% of each of those lives will remain on delivery;
 - (b) goods and services will only be provided or used when necessary or as authorised by the Minister;
 - (c) ownership, possession, use or resale by the Minister of each good and the result of the service provided by the Contractor will not infringe any proprietary or other intellectual property right or interest of any person;
 (d) clear title to anything supplied will pass to the Minister when title passes;
 - (d) clear title to anything supplied will pass to the Minister when title passes;
 - (e) all information provided, or to be provided, to the Minister by the Contractor is accurate, complete and true;
 - (f) all information and documentation provided to the Minister which is intended to be published must be in a form and to a standard which is suitable for publication;
- 13. **Compliance with laws/authorisations**: will ensure each good and service the Contractor provides complies with all New Zealand, and each relevant jurisdiction's, laws, codes and standards and is responsible for ensuring that every necessary and prudent authorisation is obtained to ensure that the Contractor can perform this contract and the Minister can own (where intended), possess, use free of charge and resell unrestricted, each good and the result of each service provided;
- 14. **Confidentiality**: must keep confidential and secure any information of the Minister which would reasonably be expected to be commercially sensitive or confidential. No disclosures or use of that information by the Contractor is allowed without the Minister's prior written consent. The Contractor will not advertise that it supplies goods or services to the Minister without the Minister's consent;
- 15. **Maintain records**: will produce and maintain records to the extent and in a form which enables prompt and accurate verification of a matter in relation to this contract;
- 16. No assignment: must not assign any benefit or burden of this contract;
- 17. **Official information requests**: will immediately transfer to the Minister any request received by it for information under the Official Information Act 1982 in relation to this contract and advise the person requesting the information of such transfer;
- 18. **Intellectual property**: will, on the Minister's request and free of charge, transfer to the Crown every proprietary right to any intellectual property developed pursuant to this contract and to every output of the service. Intellectual property held by the Contractor prior to the commencement of this contract and intellectual property discovered by the Contractor through its activities in a similar research area on behalf of other clients is specifically excluded from this contract;
- 19. **Protect Minister**: will promptly make good, and protect the Minister and the Minister's representatives from, any damage, loss or cost, and any claim or proceedings, to the extent caused or contributed to by the Contractor in relation to this contract **to a maximum of \$36,000 for each and every event**;
- 20. **Minister not liable**: accepts that the Minister will not be liable (in contract or tort, including negligence) to the Contractor for any indirect damage, loss or cost in relation to this contract; and
- 21. **Relationship/authority limited**: accepts that this is a contract for services and the Contractor is only an independent contractor (not an employee) and does not have the Minister's authority to say or do anything on the Minister's behalf except to the extent authorised in writing by the Minister in each case.

MINISTER'S OBLIGATIONS/RIGHTS

The Minister:

- 1. **Engagement**: engages the Contractor to provide the service;
- 2. Acceptance: may at any time perform any reasonable acceptance test or review/audit of the service or the results/outcomes;
- 3. **Payment**: will, if acceptance by the Minister of the relevant service deliverable(s) has been completed, pay the Contractor by the 20th day of the month following the month in which the Minister receives a correct tax invoice for the relevant service delivered;
- 4. **Intellectual property**: will own any intellectual property developed pursuant to this contract and will own every output of the service;
- 5. **Termination by notice**: may terminate this contract at any time by giving the Contractor at least one month's written notice;

6. Non-compliance remedies: may:

- (a) withhold any payment otherwise due to the Contractor until the matter is resolved to the Minister's satisfaction;
- (b) suspend or cancel (in whole or in part) this contract by written notice to the Contractor; and/or
- (c) have the requirement performed by the Minister's representatives or anyone else at the Contractor's cost;
- if:
- (d) the Contractor breaches, or fails to properly or promptly perform, any of the Contractor's obligations and fails to remedy the situation to the Minister's satisfaction within 5 working days after notice from the Minister of the breach or failure;
- (e) the Contractor has a conflict of interest with the Minister's interests which the Minister considers sufficiently inappropriate;
- (f) any direct or indirect change of ownership or control of the Contractor occurs which, in the reasonable opinion of the Minister, reduces the Contractor's ability to perform its obligations under this contract; or
- (g) the Contractor is or becomes insolvent or bankrupt, is in or goes into receivership or liquidation; or
- (h) the Minister believes that the Contractor is generally in financial difficulty which, in the reasonable opinion of the Minister, reduces the Contractor's ability to perform its obligations under this contract;
- 7. **Observe and review**: may observe and review any aspect of the performance of the service during this contract; and
- 8. **Property removal**: may relocate, store or dispose of, at the Contractor's risk and cost, any of the Contractor's property not removed from the Minister's property by when reasonably required by the Minister.

GENERAL

- 1. **Force Majeure**: Neither party will be liable to the other for any failure or delay in performance of this contract due to any circumstance reasonably beyond the control of the affected party.
- 2. **Disputes**: If a party believes that there is a dispute concerning this contract, that party will promptly notify the other parties giving details of the dispute. If it is not resolved within 5 working days by the contract authorities of the parties for this contract, it will be immediately referred to senior representatives of the parties. If they do not resolve it within 10 working days, it will be submitted to arbitration. The arbitration will be take place in Wellington if requested by the Minister.

- 3. Interpretation: Unless specifically otherwise stated:
 - (a) "Minister" includes the Ministry for the Environment;
 - (b) no executive or prerogative power or right, or any immunity, of the Crown is affected by this contract;
 - (c) "including" and similar words do not imply any limitation;
 - (d) headings are to be ignored;
 - (e) "Variation Form" means a document recording a variation to this contract which must be signed by both the Minister and the Contractor and which should be attached to this document;
 - (f) amounts are in NZ\$ and exclude GST (if any);
 - (g) if the Contractor comprises more than one person, each of those person's liability to the Minister is joint and several;
 - (h) references to a party or a person includes any form of entity and their respective successors, assigns and representatives; and
 - (i) time is of the essence.

SPECIAL CONTRACTUAL PROVISIONS

The Minister grants to the contractor a non-exclusive licence to use the data and associated reports generated from this agreement for any purpose, in consultation with the Minister.

	For the Contractor	For the Minister
SIGNATURES OF CONTRACT AUTHORITIES	(Signature)	(Signature)
	Name: Position: Date:	Name: Position: Date:

Appendix II

Sample results

Date	May	Date	June	Date	July
		02.06.2003	12.8	03.07.2003	13.9
06.05.2003	9.1	06.06.2003	19.0	06.07.2003	10.9
09.05.2003	5.0	09.06.2003	7.3	09.07.2003	8.2
12.05.2003	12.5	12.06.2003	4.0	12.07.2003	2.2
15.05.2003	14.4	15.06.2003	16.0	15.07.2003	13.3
18.05.2003	21.1	18.06.2003	8.5	18.07.2003	9.4
21.05.2003	12.6	21.06.2003	9.8	21.07.2003	4.5
24.05.2003	6.1	24.06.2003	12.0	24.07.2003	13.7
27.05.2003	12.8	27.06.2003	5.0	27.07.2003	5.0
30.05.2003	18.2	30.06.2003	21.3	30.07.2003	8.7

	August	Date	September	Date	October
02.08.2003	0.7	01.09.2003	17.3	01.10.2003	13.6
05.08.2003	13.2	04.09.2003	16.2	04.10.2003	23.7
08.08.2003	11.5	07.09.2003	10.9	07.10.2003	21.4
11.08.2003	2.6	10.09.2003	0.6	10.10.2003	14.5
14.08.2003	7.5	13.09.2003	11.1	13.10.2003	12.3
17.08.2003	13.7	16.09.2003	25.9	16.10.2003	13.5
20.08.2003	4.2	19.09.2003	24.8	19.10.2003	13.7
23.08.2003	5.0	22.09.2003	4.0	22.10.2003	16.3
26.08.2003	7.1	25.09.2003	30.9	25.10.2003	12.7
29.08.2003	2.5	28.09.2003	N/R ¹	28.10.2003	24.6
				31.10.2003	N/R ¹

Table 8PM 10 results (µgm³) average over 24 hour.1.No result. Sample not analysed as filter damaged.

Appendix III

Wind rose and wind speed for duration of sampling


Graph 1 Wind rose for the whole monitoring period.



Graph 2 Wind speed (km/hr) at New Plymouth Wastewater Treatment Plant.

Appendix IV

Results and meteorology





Appendix V

Wind direction variability





Some examples of wind direction variability.

Appendix VI Correlation analysis

Entire Data set



Pearson Correlation matrix

	PM10	RAIN	SPEED	COLOR	DIRECTI ON
PM10	1.000				
RAIN	0.040	1.000			
SPEED	0.143	0.246	1.000		
COLOR	0.588	0.019	0.323	1.000	
DIRECTI ON	0.408	- 0.004	0.152	0.176	1.000

Prevailing offshore wind

Pearson correlation matrix							
	PM10	RAIN	SPEED	COLOR	DIRECTI ON		
PM10	1.000						
RAIN	- 0.039	1.000					
SPEED	0.218	0.274	1.000				
COLOR	0.618	- 0.076	- 0.477	1.000			
DIRECTI ON	0.197	0.082	0.083	0.016	1.000		



Prevailing onshore wind

Pearson correlation matrix

	PM10	RAIN	SPEED	COLOR	DIRECTI ON
PM10	1.000				
RAIN	0.150	1.000			
SPEED	0.420	0.092	1.000		
COLOR	0.582	0.407	0.132	1.000	
DIRECTI		-			
ON	0.541	0.149	0.112	0.384	1.000



Appendix VII

Speciation and source identification report from University of Auckland

29th January 2004

Johanna Symons Air Quality Technician Laboratory Services Watercare Services Limited 52 Aintree Avenue Airport Oaks Auckland

Re: Analysis of dust from air filters

Dear Ms Symons,

The samples supplied by you were 7 high volume filters used for ambient air quality monitoring, 6 had been exposed to air and 1 was a clean, control sample. Sections of each sample were cut and mounted using carbon adhesive tabs to aluminium pin stubs. Each sample was coated with platinum for 6 minutes using a high resolution sputter coater¹ then analysed using Scanning Electron Microscopy² (SEM) and Energy Dispersive Spectroscopy³ (EDS).

The results are presented in full in the following pages but are summarised here.

Control Sample 7261142

The filter material is clearly based on fibres of soda-lime-silica glass with traces of aluminium, potassium and magnesium.

Sample 7261136

Light coverage of particulate matter. Area analysis with EDS was dominated by the elemental signature of the filter material itself, this was true of all samples. Point analyses in individual particles also picked up this signature due to the depth of analysis inherent in the technique. Some pollen was present. Traces of iron were present in a small proportion of particles. Particulate matter was dominated by NaCl (salt), clearly formed from solution as crystals enclosed filter fibres. Implication that the filter was operating in moist marine air.

Sample 7261134

Heavy coverage of particulate matter, again dominated by NaCl crystallised in situ (sufficient coverage that Cl was detected in the EDS area analysis). Some carbon was detectable.

Sample 7345455

Light coverage of particulate matter, slightly heavier than Sample 7261136, again dominated by NaCl crystals formed in situ. Some carbon was detectable.

¹ Polaron SC7640

² Philips XL-30 S-FEG SEM

³ Edax Phoenix EDS

Medium coverage of particulate matter, between Sample 7261136 and Sample 7261134. Large number of NaCl crystals as in the previous samples. Also particulate matter with a finely divided "fluffy" appearance. Carbon was present in the "fluffy" material.

Light coverage of particulate matter, as light as Sample 7261136. NaCl and carbon material as for Sample 7463416.

Sample 7470608

Light coverage of particulate matter, slightly heavier than 726113. Less NaCl present, some pollen. Particles dominated by inorganic materials, particular aluminosilicates and calcium silicates implying minerals.

There was no obvious "pairing" between the samples. The predominant particulate in all cases, except for 7470608, was NaCl with carbon based material also present. The "fluffy" morphology of the carbon based material did not suggest organic matter but could possibly be from vehicle emissions. Some pollen was present in the samples.

Full SEM micrographs and the associated EDS spectra are presented in the following pages. If you have any queries regarding these results please do not hesitate to contact me.

Yours sincerely,

Dr Bryony James Director, RCSMS

Control Sample 7261142





All samples

Each of these images is taken at the same magnification in order to illustrate the relative coverage of particulate matter.



Sample 7261136



Sample 7345455



Sample 7463425



Sample 77261134



Sample 7463416



Sample 7470608



Light coverage of particulate matter. The EDS analysis of an area (spectrum overleaf) such as this shows the elements present in the filter material rather than those present in the particles.



EDS analysis of points within particles (spectra overleaf) indicates the particles are predominantly sodium and chlorine, the morphology indicates that these elements are in the form of salt, NaCl



The salt clearly formed in situ on the filter, from a solution, as the crystals are formed around fibres of the filter.



Pollen was also present in a low amounts

Label A: sample 1 - 7261136 area scan



Label A: sample 1 - 7261136 particle



Label A: sample 1 - 7261136 particle



Label A: sample 1 - 7261136 particle





Heavy coverage of particulate matter dominated by NaCl formed in situ. The "fluffy" morphology material could potentially contain carbon, as is the case in Samples 7463416 and 7463425 but analysis depth means it is impossible to segregate this material in this sample. However, carbon was detected during point analyses in particles.

Label A: sample 2 - 7261134 area scan



Label A: sample 2 - 7261134 particle



Label A: sample 2 - 7261134 particle



Label A: sample 2 - 7261134 particle





Light coverage of particulate matter dominated by NaCl crystallised in situ. Some carbon present as above.

Label A: sample 3 - 77345455 area scan



Label A: sample 3 - 77345455 particle



Label A: sample 3 - 77345455 particle



Label A: sample 3 - 77345455 particle





Medium coverage of particulate matter. NaCl was again present as crystals formed in situ. A large quantity of "fluffy" matter was also present with a high proportion of carbon. The morphology did not suggest organic matter, rather it is possibly sourced from vehicle or industrial emissions.

Label A: sample 4 - 7463416 area



Label A: sample 4 - 7463416 particle



Label A: sample 4 - 7463416 particle



Label A: sample 4 - 7463416 particle





Light coverage of particulate matter. As for sample 7463425 NaCl was present and a high proportion of "fluffy" matter containing carbon.
Label A: sample 5 - 7463425 area



Label A: sample 5 - 7463425 particle



Label A: sample 5 - 7463425 particle



Label A: sample 5 - 7463425 particle



Sample 7470608



Light coverage of particulate matter, slightly heavier than 726113. Less NaCl present, some pollen. Particles dominated by inorganic materials containing Si, Ca, Al, Fe and O. These combinations imply aluminosilicates and calcium silicates and other mineral based materials such as clay, soil and rock dust.

Label A: sample 6 - 7470608 area



Label A: sample 6 - 7470608 particle



Label A: sample 6 - 7470608 particle



Label A: sample 6 - 7470608 particle



Label A: sample 6 - 7470608 particle



Label A: sample 6 - 7470608 particle



Label A: sample 6 - 7470608 particle



Label A: sample 6 - 7470608 particle

