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Prepared for: Technical Committee
Activity: Environmental - Ambient Air Quality Monitoring & Reporting
Prepared by: Deborah Mills, Environmental Scientist
Date: 7 November 2017

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1. Précis

State of the Environment (SoE) ambient air quality monitoring of PM_{10}[1] continued this year at eight towns across Otago. Continuous, year-round monitoring was performed in four towns: Alexandra, Arrowtown, Mosgiel and Central Dunedin. Monitoring was performed from 1 May through to 31 August in Balclutha, Milton, Clyde and Cromwell.

Monitoring shows that, except for the Central Dunedin airshed, ambient air quality did not meet the National Environmental Standards for Air Quality 2016 compliance targets for particulates. Table 1 shows the number of days during 2017 when average daily PM_{10} exceeded the NESAQ threshold in each monitored town, and provides comparison to the typical number (average of 2014-2016) of exceedances.

Table 1: Number of exceedances recorded at Otago PM_{10} monitoring sites.

Location	Number of exceedance days - (2017)	Number of exceedance days - (2014-2016)
Alexandra	43	34
Arrowtown	42	36
Balclutha	14	8
Clyde	23	16
Cromwell	42	36
Dunedin	0	0
Milton	48	26
Mosgiel	7	7

This paper describes the state of Otago air quality this year using key air quality indicators assessed against current standards. The status of the NESAQ review is also discussed.

2. Background

2a. Air quality assessment criteria and reporting

In 2004, the Ministry for the Environment (MfE) introduced national environmental standards for ambient air quality which, among other things, set threshold concentrations of PM_{10}. The limits set in the NESAQ were, at the time, considered minimum requirements for providing a nationally consistent level of protection for human health and the environment. The National Ambient Air Quality Guidelines (1994, revised 2002) were the pre-cursor to the NESAQ and provide additional assessment guidelines for PM_{10}.

[1] Particulate matter with an aerodynamic diameter of less than 10 micrometres.

Additional assessments of air quality can be made against the World Health Organisation (WHO) guidelines[1] which establish recommended levels of both short-term (daily) and long-term (annual) PM_{10} and $PM_{2.5}$[2].

The Otago Regional Plan: Air (Air Plan) sets a daily average PM_{10} guideline value of 35µg/m^3, known as the Otago Goal Level.

Current standards and guidelines related to particulate matter are shown in Table 2.

Table 2: Current standards and guidelines related to particulate matter.

Indicator	Standard/Guideline	Threshold concentration (µg/m^3)	Averaging period	Allowable exceedances per annum
PM_{10}	NESAQ standard	50	24-hour	1
PM_{10}	Otago guideline	35	24-hour	n/a
PM_{10}	NAAQG guideline	20	Annual	n/a
$PM_{2.5}$	WHO guideline	25	24-hour	3
$PM_{2.5}$	WHO guideline	10	Annual	n/a

2b. Monitoring network

PM_{10} monitoring began in 1997 in Alexandra, Mosgiel and Central Dunedin with samples taken every third day. These centres represent three distinct climatic regions in Otago.

In 2004 the ORC gazetted 23 towns into four airsheds, fulfilling a requirement of the NESAQ. Decisions on towns' designations were based on evaluations of their climatology and topography and the expected level of air quality. Airshed 1 towns were to represent the poorest winter air quality, and Airshed 4 towns were expected to have the best air quality.

In response to the NESAQ requirement for daily monitoring, the three original sites were upgraded to continuous, MfE-approved monitors from MetOne Instruments and a fourth such monitor was added to Arrowtown. These sites fulfil the requirements of the NESAQ to monitor in airsheds where ambient air quality is not expected to meet standards.

In 2008 the network was expanded to include several other towns; these sites typically run during winter months. Results of monitoring have been used to gain information regarding the ambient air quality levels in 10 towns around the region.

The current ORC network consists of eight continuous PM_{10} monitors in towns across the region. Four monitors (Alexandra, Arrowtown, Central Dunedin, and Mosgiel) run year-round and four monitors (Balclutha, Clyde, Cromwell, and Milton) operate during winter (May – August) months. Results from all monitors are used to track long-term trends in air quality.

This year it was necessary to move the long-standing Alexandra monitor due to a change in property ownership. The permanent monitor was re-located to grounds belonging to the Alexandra Primary School, approximately ¾ km closer to the town centre from the original site. A temporary monitor was set up over winter at the original site in order to obtain co-location data.

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[1] Guidelines are considered recommended values, as opposed to standards which require compliance.

[2] Particulate matter with an aerodynamic diameter of less than 2.5 micrometres.

Monitoring locations are shown in Figure 1.

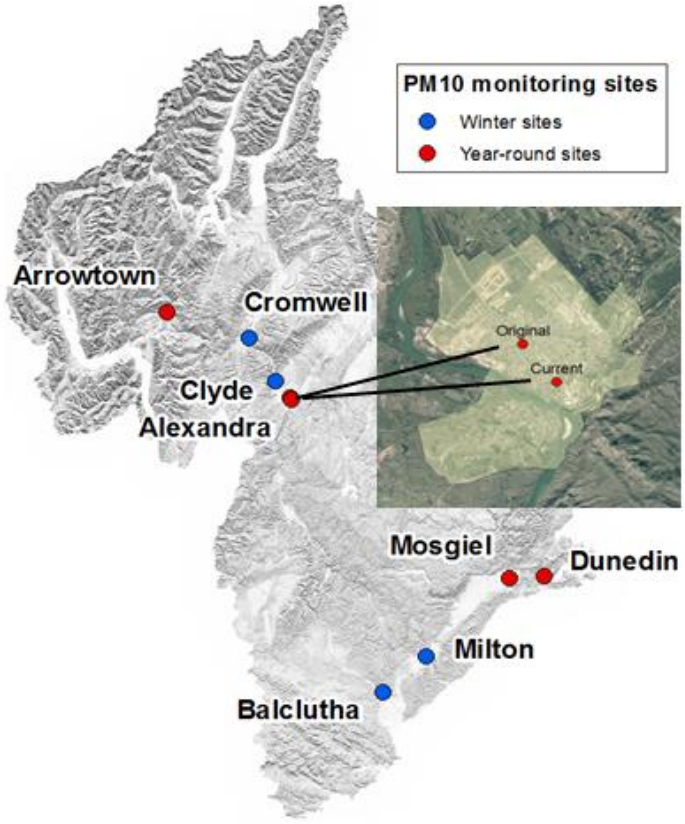

Figure 1: Monitoring locations for 2017; inset indicates the current and original Alexandra sites.

3. Key results

Results of provisional data for key indicators of PM_{10} during winter months (May-August) are given in Table 3. For sites with less than 75% data capture for the season, an average is considered not applicable. This situation occurred in Alexandra this winter due to the re-location of the monitor.

Table 3: Key indicators of air quality during winter 2017 in Otago. Except where noted, all values are µg/m^3.

	Maximum One-day average PM_{10}	Winter Mean PM_{10}	Average of 10 highest days	Days > 50µg/m^3 (# of days)	Days > 35µg/m^3 (# of days)
Alexandra – Original	96	n/a	88	35	51
Alexandra – Current	70	n/a	52	4	22
Arrowtown	146	44	113	42	63
Balclutha	93	33	67	14	45
Clyde	66	32	60	23	46

Cromwell	123	43	96	42	67
Dunedin	42	17	32	0	2
Milton	154	47	101	48	73
Mosgiel	89	26	63	7	20

By most metrics, Milton experienced the poorest air quality of all monitored sites this winter with 48 days breaching NESAQ limits. Arrowtown, Cromwell and Alexandra all recorded at least 35 days when PM_{10} breached the NESAQ limit. The maximum PM_{10} levels in these towns were two-to-three times the national limit.

National standards were also not met in Balclutha, Clyde, and Mosgiel but to a lesser degree. Central Dunedin continued to meet national standards and recorded just two days above the Otago Goal Level of 35µg/m^3; this is the best result to date for the Central Dunedin airshed.

4. Alexandra monitoring results

After 15 years of monitoring at 65 Ventry Street, the PM_{10} monitor had to be re-located this year due to a change in ownership of the section. The monitor was moved to 5 Ventry Street, approximately 750 metres to the southeast and closer to the centre of town. ORC was granted permission by the new owner of 65 Ventry Street to install a temporary monitor at the original site, thereby allowing us to obtain concurrent PM_{10} data for the winter months.

Differences in PM_{10} concentrations between the two sites were expected. Land use around the original site consists of older residential housing situated on relatively small sections; this results in relatively high-density particulate emissions from home heating appliances and, subsequently, high concentrations. In contrast, land use at the new site is mixed: there is commercial activity to the north and east, residential to the west, and school grounds to the south. This configuration yields lower emission amounts and densities and, subsequently, lower concentrations than the original site.

Results from a paired t-test indicate that the difference in daily PM_{10} concentrations between the two sites is statistically significant and that the concentrations between the two sites are highly correlated (R = 0.91). Figure 2 is a scatterplot of the daily values through winter showing the relationship between the two sites; the original site is shown along the horizontal axis. The linear trend line is represented by the equation:

PM_{10} at 5 Ventry St = 0.53 * (**PM_{10}** at 65 Ventry St) + 0.49

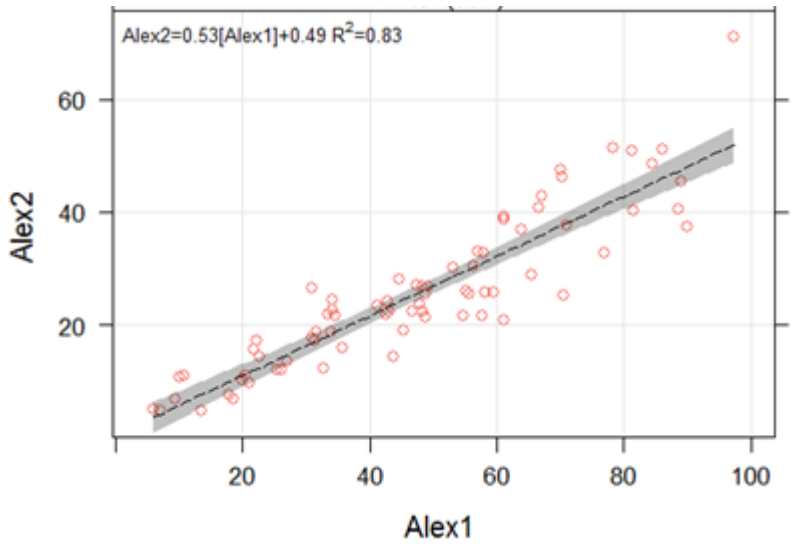

Figure 2: Scatterplot of winter daily PM_{10} concentrations at two sites in Alexandra. The original site is shown along the horizontal axis (Alex1) and the new site is shown on the vertical axis (Alex2).

Relevant metrics from the two sites are given in Table 4.

Table 4: Air quality metrics for two sites in Alexandra. All units are micrograms per cubic metre, except where noted.

PM_{10} metric	65 Ventry Street	5 Ventry Street
Mean	48	26
Minimum	7	5
Maximum	96	70
Median	47	23
95th percentile	90	49
99th percentile	92	68
# NES Exceedances	35 days	4 days

Key points of the winter monitoring in Alexandra are that:

1. The lower PM_{10} values at 5 Ventry do not necessarily indicate that there was a marked improvement in Alexandra's air quality from previous years.

2. Based on the results from the original site, air quality in town was comparable to previous years.

3. A designated airshed is not necessarily a homogeneous area of PM_{10} concentrations. Spatial studies have shown that previously, but this is the first time two monitors in one town have illustrated the point.

4. Daily PM_{10} concentrations at the new site are approximately half what they are at the original site.

   Most of that difference appears during the evening PM_{10} peak. Figure 3 represents a composite July day at both sites. A morning peak occurs at both sites at 9am and the evening experiences higher concentrations from about 7pm onwards. Both sites have good air quality during the early afternoon when the atmosphere is in its most unstable condition.

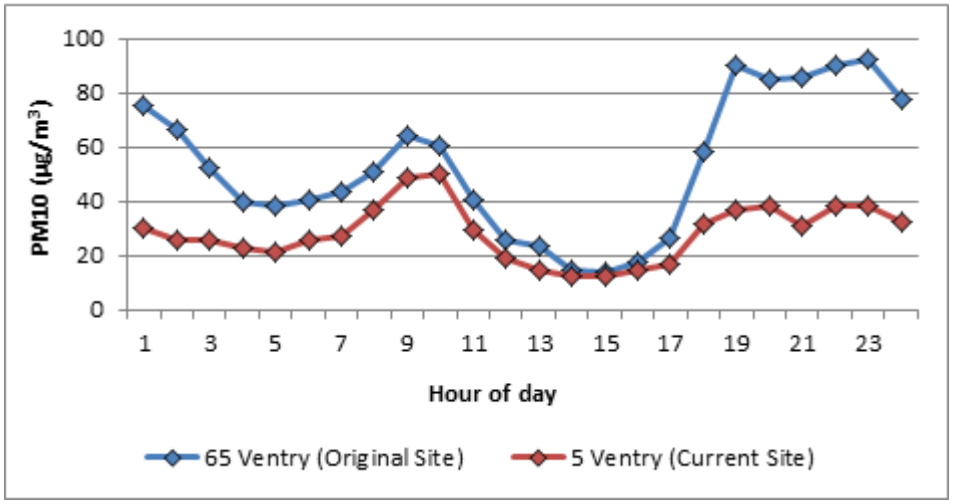

Figure 3: Composite diurnal trend during July for two sites in Alexandra.

The difference between the two sites can be addressed by:

- Developing a synthetic record for the original site, based on this winter's co-location relationship, and/or
- Deploying low-cost, temporary monitors at both sites during winter months to verify the co-location relationship and provide a complete dataset, or by
- Continuing to try to locate a viable site with similar characteristics to the original site.

5. Comparison to typical winter PM_{10} air quality

The typical air quality situation is described by aggregating statistics for the previous three years; in this case, an averaged dataset was created using data from 2014 through 2016. Using three years minimises the influence of annual climatic differences from year to year on air quality.

Two of the common metrics for assessing winter air quality are:

- Number of days that exceed the daily NESAQ standard of 50µg/m^3
- Winter average PM_{10} (May-August)

By both of these metrics, air quality this winter was worse than usual in most Otago towns. Figure 4 indicates that this year, except for Dunedin and Mosgiel, all other monitored centres had more exceedance days than usual. This result is consistent with the graph of winter average PM_{10} (Figure 5) which shows higher than normal winter PM_{10} in all monitored centres except for Dunedin and Mosgiel.

The exact cause of this result is not known. The fact that it was a region-wide effect points to the likelihood that a broad-scale climate setting played some part in the results.

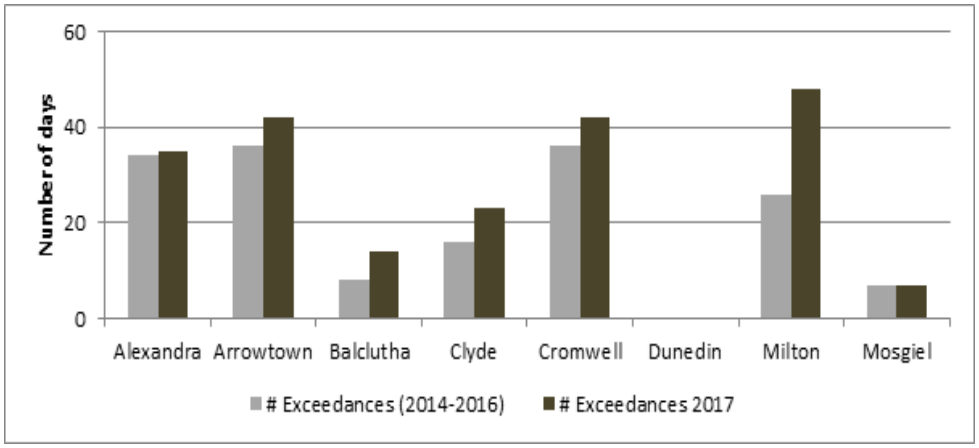

Figure 4: Number of exceedances in 2017 compared to the typical number

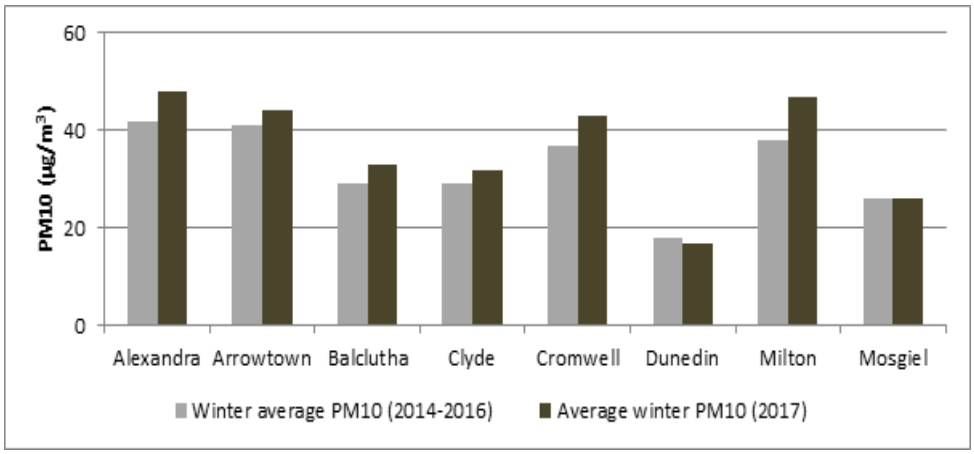

Figure 5: Average winter PM_{10} values in 2017 compared to the typical winter

6. NESAQ status

In 2015, the Parliamentary Commissioner for the Environment (Dr. Jan Wright) provided commentary[1] on the state of air quality in New Zealand as reported by MfE in their Domain Report – Air[2]. A significant recommendation of the commentary was that the MfE should review how particulate matter is managed. The review should determine:

1. Whether $PM_{2.5}$ should be measured in airsheds where it is likely to be a problem
2. The value of setting rules for $PM_{2.5}$, and for long-term (annual) exposure
3. Whether the PM_{10} short-term (daily) rule still has value
4. The impact of air quality rules on other public health issues
5. How air quality policies might be designed to achieve progressive improvement

In light of Dr. Wright's recommendations, the MfE initiated a review of the NESAQ. The outcome of the review has not yet been determined.

It is likely that a $PM_{2.5}$ standard will be included in a proposed NESAQ. What is still unknown is how other parameters of a $PM_{2.5}$ standard would be addressed. These include:

[1] Parliamentary Commissioner for the Environment (2015), *The state of air quality in New Zealand: Commentary by the Parliamentary Commissioner for the Environment on the 2014 Air Domain Report,* Wellington.

[2] Ministry for the Environment and Statistics New Zealand (2014), *New Zealand's Environmental Reporting Series: 2014 Air domain report.* Wellington.

- Averaging time – daily versus annual average standard.
- Threshold concentration – the limit that should not be exceeded
- Number of allowable exceedances
- Final compliance date
- Whether PM_{10} is still a viable standard

An analysis of the implications of a $PM_{2.5}$ standard on Otago's compliance is currently underway; a report will be forthcoming.

7. Recommendation

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a) *That this report be received.*
b) *That the state of air quality in Otago be noted.*
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Endorsed by: Gavin Palmer
Director Engineering, Hazards & Science

Attachments
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