Government of **Western Australia**
Department of **Water and Environmental Regulation**

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2019 Western Australian air monitoring report

Annual report under the National Environment Protection (Ambient Air Quality) Measure

October 2020

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Summary

As a signatory to the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM), Western Australia (WA) is required to report annually on results of air monitoring.

The Department of Water and Environmental Regulation (the department) is responsible for the operation and maintenance of 15 air quality monitoring sites in WA with a total capital cost of over $2.1 million. Nine of these sites – Caversham (Ca), Duncraig (Du), Mandurah (Ma), Quinns Rocks (QR), Rolling Green (RG), Rockingham (Ro), South Lake (SL), Swanbourne (Sw) and Wattleup (Wt) – are within the Greater Perth Region and the remaining six are regionally located in Albany (Al), Bunbury (Bn), Busselton (Bs), Collie (Co), Geraldton (Ge) and Kalgoorlie (Kg).

While the QR site was decommissioned in early 2017 because of redevelopment of the area, the department has recommissioned the site at another suitable location during 2020.

Mandurah was commissioned in November 2019. While any exceedances recorded at the site during November and December have been included within this report, other annual and trend statistics have not been included because of the absence of data for the first 10 months of 2019.

A new site will be established south of Perth in Armadale in 2020. The site will contain instruments to monitor PM_{10} and $PM_{2.5}$ particles and will be included in future reports.

During calendar year 2019 the AAQ NEPM goal was not met for PM_{10} particles at Collie, Geraldton and Kalgoorlie. $PM_{2.5}$ particles did not meet the AAQ NEPM goal at Kalgoorlie.

Across all monitoring sites there were 47 exceedances in 2019, comprising 26 exceedances of PM_{10} particles (including 16 exceptional events) and 19 of $PM_{2.5}$ particles (including 18 exceptional events).

Of the 34 particle exceedances that were classed as exceptional events, 14 were because of prescribed burning activities, 14 because of bushfires and six because of windborne dust. These ‘exceptional event’ exceedances are not included in the AAQ NEPM goal assessment.

The carbon monoxide, ozone, nitrogen dioxide and sulfur dioxide goals of no more than one exceedance per site per calendar year were met for all averaging periods.

Annual averages were met for all pollutants other than $PM_{2.5}$ particles at Caversham, South Lake, Bunbury and Busselton.

A. Monitoring summary

A.1 Current monitoring stations

The department monitoring network shown in Figure A1 was the subject of careful design for the purposes of the Perth Photochemical Smog Study, the Perth Haze Study and the management of pollutants in the Kwinana area.

The network's design was based on the knowledge of emissions sources, pollutant chemistry and important features of the meteorology.

Commonwealth Scientific and Industrial Research Organisation (CSIRO) Atmospheric Research provided advice on monitoring site locations for the Perth Photochemical Smog Study and Perth Haze Study.

The Bunbury station shown in Figure A2 was established in the South West of the state to monitor fuel reduction burns, and stations in Busselton, Collie and Albany were also in operation for that purpose.

The Geraldton station shown in Figure A2 was established in the Mid West of the state to monitor windblown crustal material and smoke from bushfires, hazard reduction or stubble burning and possibly wood-fired home heaters. Kalgoorlie is to monitor primarily particles and sulfur dioxide. Table A1 is a list of pollutants monitored at each site.

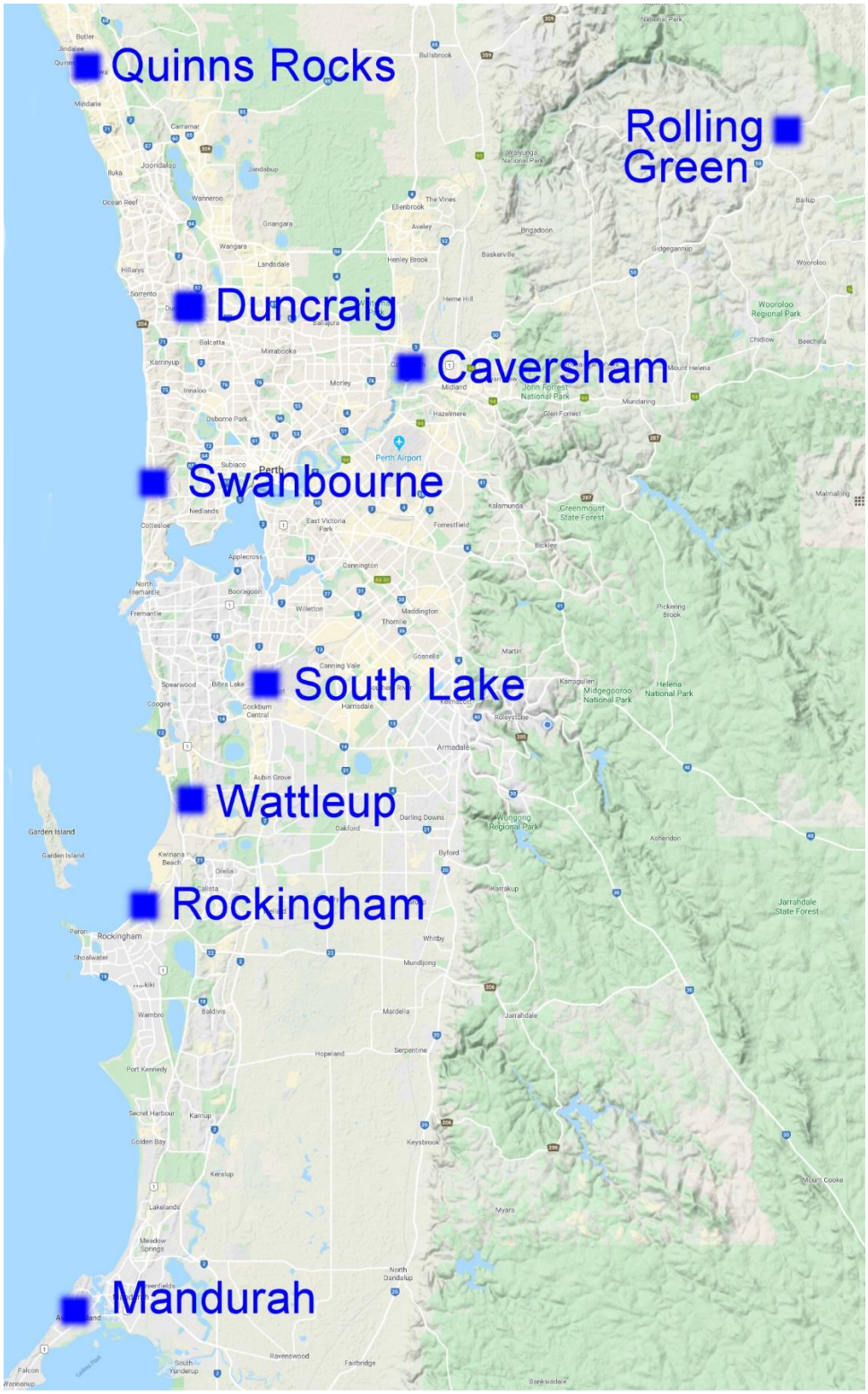


Figure A1 Department of Water and Environmental Regulation air quality monitoring stations operating in the Perth Metropolitan and Mandurah Regions

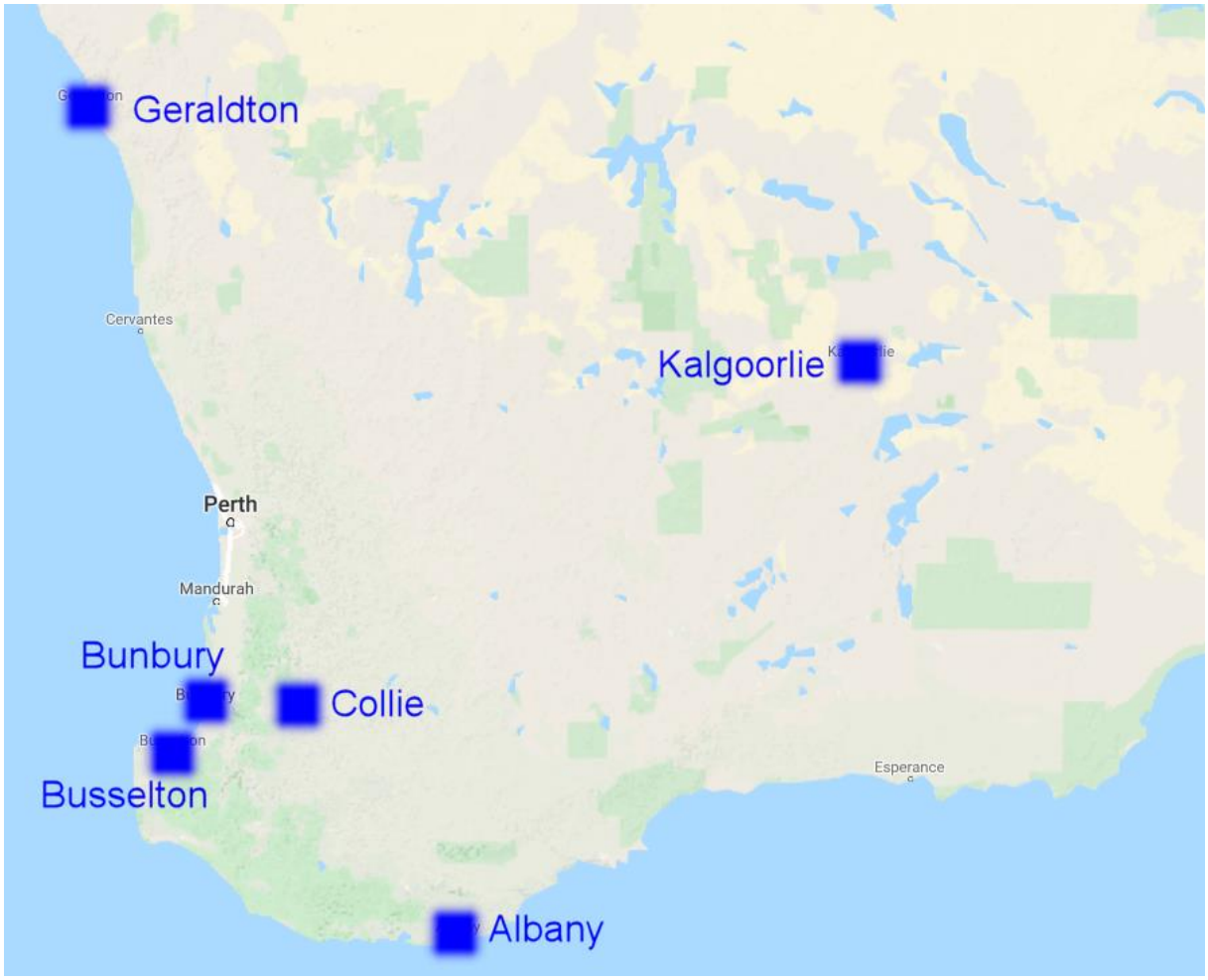


Figure A2 Department of Water and Environmental Regulation air quality monitoring stations operating in regional WA

Table A1 Air quality parameters measured at Department of Water and Environmental Regulation monitoring stations

Monitoring site		CO (month/year)	O_3 (month/year)	NO_2 (month/year)	SO_2 (month/year)	PM_{10} TEOM (month/year)	$PM_{2.5}$ TEOM (month/year)
Al Albany						07/06 to present	
Bn Bunbury						06/99 to present	04/97 to present
Bs Busselton							11/06 to present
Ca Caversham		08/93 to present	11/89 to present	09/90 to present		01/04 to present	03/94 to present
Co Collie						02/08 to present	
Du Duncraig		08/95 to present		08/95 to present		06/96 to present	01/95 to present
Ge Geraldton						09/05 to present	01/19 to present
Kg# Kalgoorlie		12/17 to present			12/17 to present	12/17 to present#	12/17 to present
Ma# Mandurah		10/19 to present	10/19 to present	10/19 to present		10/19 to present	10/19 to present
QR* Quinns Rocks			11/92 to 03/17	11/92 to 03/17			07/06 to 03/17
Ro Rockingham			12/95 to present	12/95 to present	07/88 to present		
RG Rolling Green			01/93 to present	01/93 to present			
SL South Lake		03/00 to present	03/00 to present	03/00 to present	03/00 to present	03/00 to present	04/06 to present
Sw Swanbourne			01/93 to present	03/93 to present			
Wt Wattleup					01/88 to present		

* Quinns Rocks was decommissioned in March 2017 but has been re-established at a new location in 2020
# Kalgoorlie and Mandurah tapered element oscillating microbalances (TEOMs) are fitted with filter dynamic measurement systems (FDMS)

The department has, from time to time, performed campaign monitoring for various projects.
While some of these short-term projects are not reported within this document, detailed reports and/or data can be obtained from www.dwer.wa.gov.au, by emailing airquality@dwer.wa.gov.au or by telephoning 08 6364 7000.

Table A2 Methods used to monitor air quality at departmental monitoring stations

Pollutant	Standard	Method
Carbon monoxide	AS/NZS 3580.7.1 2011 – Methods for sampling and analysis of ambient air – Determination of carbon monoxide – Direct-reading instrumental method	Gas filter correlation spectrophotometry
Ozone	AS 3580.6.1 2011 – Methods for sampling and analysis of ambient air – Determination of ozone – Direct-reading instrumental method	Ultraviolet absorption
Nitrogen dioxide	AS 3580.5.1 2011 – Methods for sampling and analysis of ambient air – Determination of oxides of nitrogen – Chemiluminescence method	Chemiluminescence
Sulfur dioxide	AS 3580.4.1 2008 – Methods for sampling and analysis of ambient air – Determination of sulfur dioxide – Direct-reading instrumental method	Ultraviolet fluorescence
Particles as PM_{10}	AS 3580.9.8 2008 – Methods for sampling and analysis of ambient air – Determination of suspended particulate matter – PM_{10} continuous direct mass method using a tapered element oscillating microbalance (TEOM) analyser	Tapered element oscillating microbalance*
Particles as $PM_{2.5}$	AS/NZS 3580.9.13 2013 – Methods for sampling and analysis of ambient air – Determination of suspended particulate matter – $PM_{2.5}$ continuous direct mass method using a tapered element oscillating microbalance analyser	Tapered element oscillating microbalance*

* The TEOMs at Kalgoorlie and Mandurah are fitted with a filter dynamic measurement system (FDMS) while TEOMs in the remainder of the network are not. A replacement program is currently underway to include FDMS on all existing TEOMs.

Table A3 Monitoring in Western Australia

Site	CO	O_3	NO_2	SO_2	PM_{10}	$PM_{2.5}$
Al – Albany					P/T	
Bn – Bunbury					P/T	P/T
Bs – Busselton						DWER
Ca – Caversham	DWER	P/T	P/T		P/T	P/T
Co – Collie					DWER	
Du – Duncraig	P/T		DWER		P/T	P/T
Ge – Geraldton					P/T	P/T
Kg – Kalgoorlie	C				P/T	P/T
Ma – Mandurah	P/T	P/T	P/T		P/T	P/T
QR – Quinns Rocks		DWER	DWER			DWER
RG – Rolling Green		DWER	DWER			
Ro – Rockingham		DWER	DWER	DWER		
SL – South Lake	P/T	P/T	P/T	P	P/T	P/T
Sw – Swanbourne		P/T	P/T			
Wt – Wattleup				DWER		

Key to symbols:

P Performance monitoring station
T Trend performance monitoring station
C Campaign Monitoring
DWER Instrument will be maintained by the Department of Water and Environmental Regulation for the foreseeable future

Table A4 Standards for pollutants

Pollutant	Averaging period	Maximum concentration standard	Maximum allowable exceedances (goals)
Carbon monoxide	8 hours	9.0 ppm	1 day a year
Nitrogen dioxide	1 hour 1 year	0.12 ppm 0.03 ppm	1 day a year None
Photochemical oxidants (as ozone)	1 hour 4 hours	0.10 ppm 0.08 ppm	1 day a year 1 day a year
Sulfur dioxide	1 hour 1 day 1 year	0.20 ppm 0.08 ppm 0.02 ppm	1 day a year 1 day a year None
Lead	1 year	0.05 µg/m^3	None
Particles as PM_{10}	1 day 1 year	50 µg/m^3 25 µg/m^3	None None
Particles as $PM_{2.5}$	1 day 1 year	25 µg/m^3 8 µg/m^3	None None

Table A5 Monitoring site description

Site	Description
Al – Albany	Large rural town 380 km south-south-west of Perth with moderate-density housing.
Bn – Bunbury	Large rural town 145 km south of Perth with moderate-density housing.
Bs – Busselton	Small rural town 185 km south of Perth with moderate-density housing.
Ca – Caversham	Semi-rural north-east metropolitan suburb in the Swan Valley – a grape-growing region next to the Perth foothills – 14 km north-east of the Perth CBD. The region mainly comprises low-density housing and paddocks. Some brick manufacturing.
Co – Collie	Small rural town within a forested region 152 km south of Perth with moderate-density housing and typical traffic flows. Coal mining and power-generation industries.
Du – Duncraig	North metropolitan suburb 16 km north-north-west of the Perth CBD with moderate/high-density housing and moderate-to-high traffic flow. The site is 200 m west of the Mitchell freeway, a main north–south arterial road carrying about 98,000 vehicles daily.
Ge – Geraldton	Large rural town 377 km north of Perth in the Mid West with moderate-density housing.
Kg – Kalgoorlie	Large rural town 500 km east-north-east of Perth in the goldfields with dry climate, moderate-density housing.
Ma – Mandurah	City on the south-west coast of Western Australia 70 km south of Perth. It is the State's second-largest city and has a Mediterranean climate. The site is about 100 m from the coast and is affected by marine aerosols.
QR – Quinns Rocks	Outer-north coastal suburb 35 km north of Perth with moderate-density housing.
RG – Rolling Green	Outer-east rural suburb 56 km north-east of Perth with low-density rural housing and low traffic flows. The closest road is 80 m east of the site with 3,200 vehicles per day.
Ro – Rockingham	South-coastal site 35 km south of Perth with moderate-density housing and typical traffic flows, and adjacent to the southern border of the Kwinana Industrial Area. A major arterial road carrying 34,700 vehicles per day runs 1 km east of the site.
SL – South Lake	South-east metropolitan site 17 km south of Perth with moderate/high-density housing and moderate-to-high traffic flow. The site is 1.6 km west of the Kwinana freeway, a main north–south arterial road carrying about 87,000 vehicles daily, and is 4 km north-east of the northern border of the Kwinana Industrial Area.
Sw – Swanbourne	An inner-coastal site on coastal sand dunes 9 km west of the Perth CBD, and 150 m west of a major north–south arterial road carrying about 27,200 vehicles per day.
Wt – Wattleup	A south metropolitan site 25 km south of Perth within a defined buffer area for the Kwinana Industrial Area. Surrounding land uses are retail outlets and market gardens.

Table A6 Screening procedures are used to demonstrate if pollutants are consistently below standards

Screening procedures
A. Campaign monitoring at a Generally Representative Upper Bound (GRUB or upper bound) monitoring location (with no significant deterioration expected over 5–10 years)
B. Use of historical data within a region which will contain one or more GRUB monitoring stations to demonstrate the full number of stations is not required, either to detect exceedances or gain a more representative depiction of pollutant distribution
C. Use of modelling within a region which will contain one or more GRUB monitoring stations to demonstrate the full number of stations is not required, either to detect exceedances or gain a more representative depiction of pollutant distribution
D. In a region with no performance monitoring, use of validated (1) modelling with detailed and reliable estimates of emissions and meteorological data
E. In a region with no performance monitoring, and in the absence of emissions and detailed meteorological data, use of generic model results based on gross emissions estimates, 'worst case' meteorology estimates, and other conservative assumptions
F. In a region with no performance monitoring, comparison with a NEPM-compliant region with greater population, emissions and pollution potential
P. Performance monitoring
T. Trend monitoring
M. Campaign monitoring

Table A7 Screening procedures satisfied at each station

Site	Pop'n[a]	CO	O_3	NO_2	SO_2	Pb	PM_{10}
Perth and Rockingham	1,944,000				B&C	B	
Mandurah[b]	80,800				F	F	
Albany	29,400	F	F	F	F	F	
Bunbury	71,000	A&F	E&F	E&F	D&F	F	
Kalgoorlie-Boulder[c]	29,900	M	E&F	E&F		F	
Geraldton	32,000	F	E&F	E&F	D&F	F	

Grey shaded cells represent performance, trend or campaign sites where monitoring is currently underway.

a. 2016 data (www.censusdata.abs.gov.au)
b. Mandurah station was commissioned in November 2019
c. Kalgoorlie station was commissioned in December 2017

Details of screening procedures are given in the monitoring plan available at: www.nepc.gov.au/resource/ephc-archive-ambient-air-quality-nepm

Table A8 Station site compliance with AS/NZ 3580.1.1 – 2007

	Height above ground	Minimum distance to support structures	Clear sky angle of 120°	Unrestricted airflow of 270°/360°	20m from trees	No extraneous sources nearby	Minimum distance from road or traffic	Sample line material	Sample line length	Comments
Perth region										
Caversham	☑	☑	☑	☑	☑	☑	☑	☑	☑	
Duncraig	☑	☑	☒	☑	☒	☑	☑	☑	☑	6 m to medium-sized trees and presence of power pole.
Rockingham	☑	☑	☑	☑	☒	☑	☑	☑	☑	12 m to trees. Northern vector dominated by grain storage facility.
Rolling Green	☑	☑	☑	☑	☑	☑	☑	☑	☑	
South Lake	☑	☑	☑	☑	☑	☑	☑	☑	☑	
Swanbourne	☑	☑	☑	☑	☑	☑	☑	☑	☑	
Wattleup	☑	☑	☑	☑	☑	☑	☑	☑	☑	
Mandurah Region										
Mandurah	☑	☑	☑	☑	☑	☑	☑	☑	☑	
Southwest region										
Albany	☑	☑	☑	☑	☑	☑	☑	☑	☑	
Bunbury	☑	☑	☑	☑	☒	☑	☑	☑	☑	15 m to small to medium-sized eucalyptus trees.
Busselton	☑	☑	☑	☑	☒	☑	☑	☑	☑	5 m to small to medium-sized eucalyptus trees.
Collie	☑	☑	☒	☑	☒	☑	☑	☑	☑	Some trees and shipping containers nearby
Midwest region										
Geraldton	☑	☑	☑	☑	☑	☑	☑	☑	☑	
Goldfields region										
Kalgoorlie	☑	☑	☑	☑	☑	☑	☑	☑	☑	

A.2 Carbon monoxide (CO)

Duncraig monitoring station is an upper-bound site for monitoring the combined effects of emissions from vehicles on the nearby Mitchell Freeway, and from domestic wood fires. The site is about 200 m west of the Mitchell freeway, so it is well beyond the distance of roadside measurement. By Perth's standards the site is representative of dense population, and lies in a depression through which the freeway passes, hence the effect of stable air pooling in the depression is likely to lead to elevated concentrations. This feature would be found in many other places across the coastal plain.

South Lake monitoring station lies in a growing urban area and is likely to see moderate levels of CO from wood fires in particular. It is not as close to major roads as the Duncraig site, and is therefore more typical of a population-average site.

The concentration of CO caused by motor vehicles at Mandurah is expected to be low; however, there is expected to be some level of contribution from wood fires and controlled burns.

Caversham monitoring station is in a region of low population density and is therefore not considered a performance monitoring station.

In summary, WA maintained performance monitoring of CO at the nominated trend stations of Duncraig and South Lake.

Trend analysis for each of these sites shows that, overall, the maximum of the eight-hourly averages at each site have consistently declined between 0.1 and 0.03 ppm per year as shown in Figure A3. Distinct seasonal influences can be seen in Figure A3 with CO concentrations peaking during winter months and falling during summer.

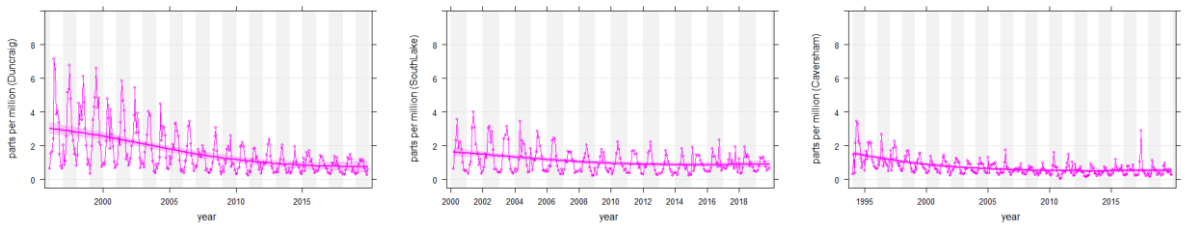


Figure A3 Smoothed trend (dark lines) for CO at Duncraig (left), South Lake (centre) and Caversham (right).

During the 2017/18 National Pollutant Inventory reporting year, CO emissions were mainly distributed between motor vehicles (0.25 million tonnes (MT)) and combustion products from fuel-reduction burns and wildfires (1.7 MT)[1]. These two sources account for over 90 per cent of the CO emissions, with the next highest emissions from metal ore mining 0.047 MT and domestic solid fuel burning at 0.041 MT per annum.

[1] http://www.npi.gov.au/npidata/action/load/emission-by-source-result/criteria/substance/20/destination/AIR/source-type/ALL/subthreshold-data/Yes/substance-name/Carbon%2Bmonoxide/state/WA/year/2019

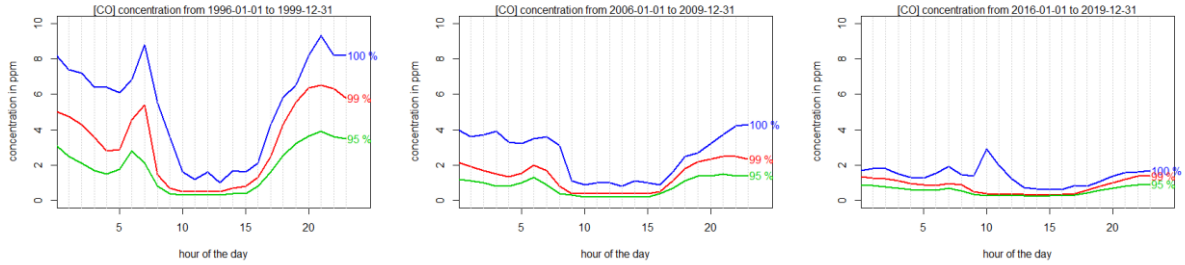


Figure A4 The CO maximum (blue), 99th (red) and 95th (green) percentiles for each hour of the day at Duncraig over four year periods 1996–99 (left), 2006–0 9 (centre) and 2016–19 (right)

Percentile concentrations for CO for each hour of the day during three separate four-year periods at Duncraig are shown in Figure A4. The CO profile shows a marked decrease in overnight concentrations over a 24-year timespan. One possible reason for this is the introduction of the Environmental Protection (Domestic Solid Fuel Burning Appliances and Firewood Supply) Regulations 1998 which require heating appliances (wood heaters) sold to meet emission standards set out in the relevant Australian and New Zealand Standard (AS/NZS4013:1999) and regulate the moisture content of wood sold as firewood.

Over the same period motor vehicle engine technologies have also improved, reducing the emissions of harmful exhaust products and further driving the overall reduction of CO concentrations.

A.3 Photochemical oxidants as ozone (O_3)

Statistics for the coastal sites of Quinns Rocks, Swanbourne and Rockingham indicate there is little difference between ozone levels at each station over the long-term. Swanbourne was selected as a performance monitoring station, while monitoring stations at Quinns Rocks and at or near Rockingham were maintained to provide additional information on ozone events.

Given its location, there is reason to be confident that Caversham monitoring station represents an upper-bound, middle-distance, inland site. Accordingly, Caversham was selected as a performance monitoring station site.

A third performance monitoring station was at South Lake. It has the following desirable attributes in that:

- it provides spatial spread of stations (it will measure ozone returning on shore in the southern part of the metropolitan area)
- it is a moderate distance inland in a growing urban area, hence it is well classed as a population average station
- it may occasionally detect the interactions of ozone (O_3) rich air with the nitrogen oxides (NO_x) rich plumes from Kwinana industry (potentially giving elevated nitrogen dioxide (NO_2) concentrations).

Caversham, Swanbourne and South Lake sites are all nominated as Trend stations.

The department will continue to maintain the stations at Rockingham, Quinns Rocks and Rolling Green as part of its wider ozone network to enable a better understanding of ozone events.

Long-term analysis is presented in Figure A5. The number of periods when the one-hour ozone concentration exceeded the long-term average at the coastal site of Swanbourne has increased for every five-year period analysed.

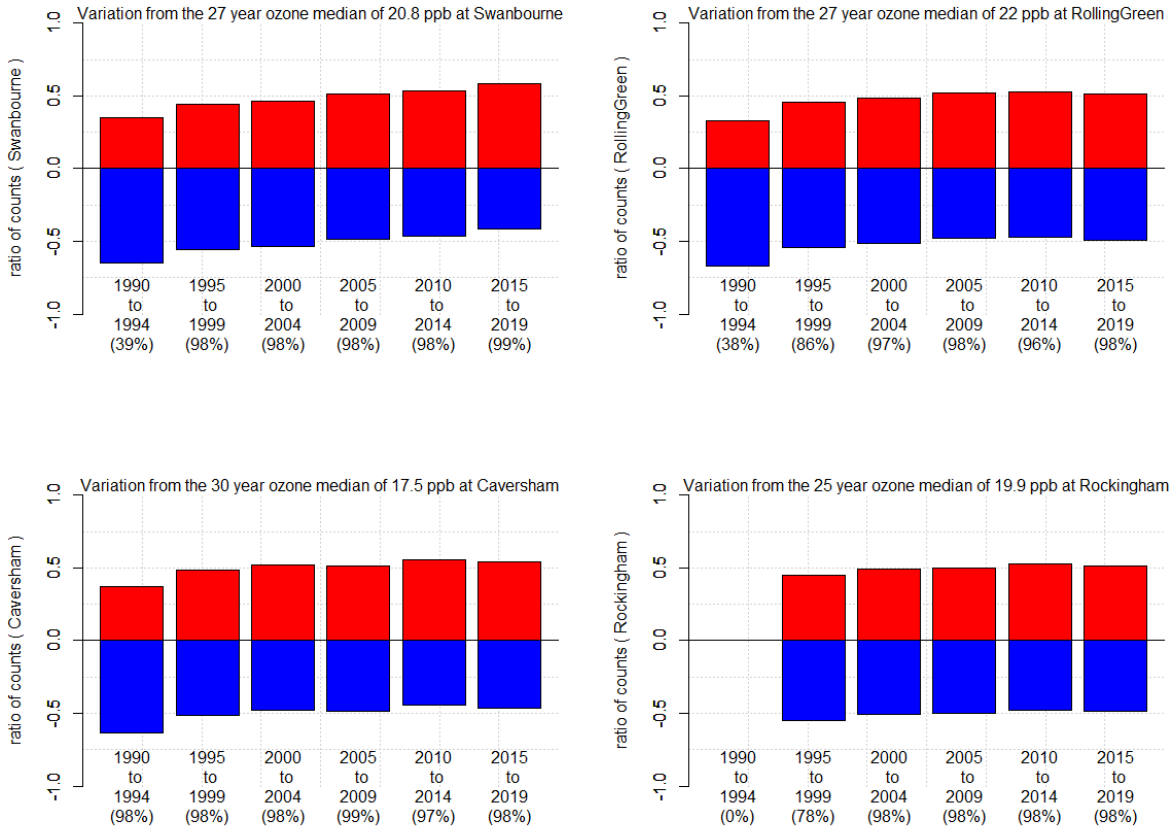


Figure A5 *Ratio of the number of hourly averaged ozone concentrations at Swanbourne and Rolling Green (top panel) and, Caversham and Rockingham (lower panel) that was higher (red) or equal to or lower (blue) than the long-term average concentration for that site (bracketed percentages indicate data recovery for the nominated period.)*

A similar increasing pattern is not as evident at the other southern coastal site of Rockingham. The inland sites of Caversham and Rolling Green have a less distinct pattern.

A.4 Nitrogen dioxide (NO_2)

Owing to the close chemical reactivity relationship, NO_2 is currently being monitored at all stations where O_3 is monitored. Caversham, Swanbourne and South Lake sites were chosen as performance monitoring stations for NO_2 as they provided a good spatial distribution. Caversham, Swanbourne and South Lake sites are also trend stations.

The department will continue to measure NO_2 at Quinns Rocks, Rolling Green and Duncraig as part of its wider network to enable a better understanding of photochemical smog formation.

Figure A6 demonstrates how nitrogen oxides ($NO + NO_2$) monthly means have decreased at all sites. The monthly NO has also seen a general decrease over time, with Duncraig experiencing an average of 0.65 ppb per annum decrease since 1996.

A possibly unintended result of these decreasing concentrations of oxides of nitrogen is the inability to fully suppress ozone formation by (typically) producing NO_2 ($NO + O_3 \rightarrow NO_2 + O_2$). The general build-up in O_3 therefore commences earlier (and consequently closer to populated areas) than it otherwise would[2].

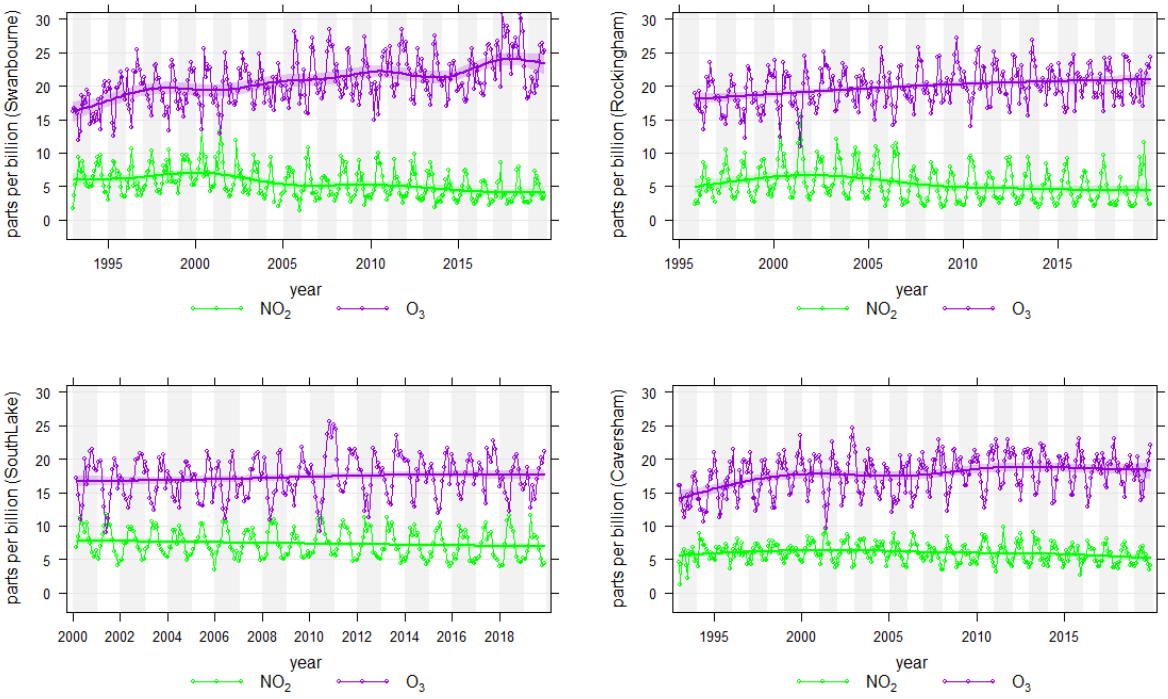


Figure A6 *Smoothed trend (dark lines) at Swanbourne and Rockingham (top panel) and South Lake and Caversham (lower panel) using the monthly mean concentration of NO_2 (green) and O_3 (violet)*

A.5 Sulfur dioxide

The department operates one performance monitoring station at South Lake for sulfur dioxide, while maintaining a source management network which includes Wattleup and Rockingham monitoring stations.

South Lake site is an upper-bound performance monitoring station for sulfur dioxide, and a trend station. South Lake is near the southern extent of the main urban population and downwind of Kwinana in sea breeze conditions.

Heavy industries in Kwinana are the only significant sources of sulfur dioxide in the Perth/Kwinana/Rockingham region. Concentrations of sulfur dioxide have reduced

[2] D.H.Stedman, *Environ. Chem.* 2004, 1, 65-66

markedly since the late 1970s because of the conversion from high- to low-sulfur fuels and the installation of sulfur dioxide control technologies. Emissions are controlled through conditions of licences issued by the department under Part V of the *Environmental Protection Act 1986,* in concert with the Environmental Protection (Kwinana) (Atmospheric Wastes) Policy 1999 (EPP), to ensure ambient concentrations do not exceed ambient standards set in the EPP.

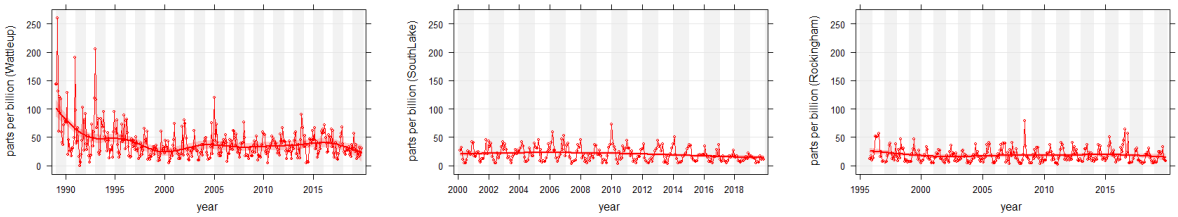


Figure A7 *Trend line for maximum hourly averaged sulfur dioxide concentration at Wattleup, within the Kwinana Industrial Buffer (left), South Lake (centre) and Rockingham (right)*

A.6 Lead

Since 1995, lead levels within the Perth CBD have been below 60 per cent of the 0.5 µg/m^3 annual AAQ NEPM standard. In 2001, the average lead level in Perth was 0.022 µg/m^3, less than 5 per cent of the AAQ NEPM standard.

In accordance with AAQ NEPM Technical Paper No. 4, Screening Procedures, and the WA Monitoring Plan, a performance monitoring station for lead has not been maintained since 2001.

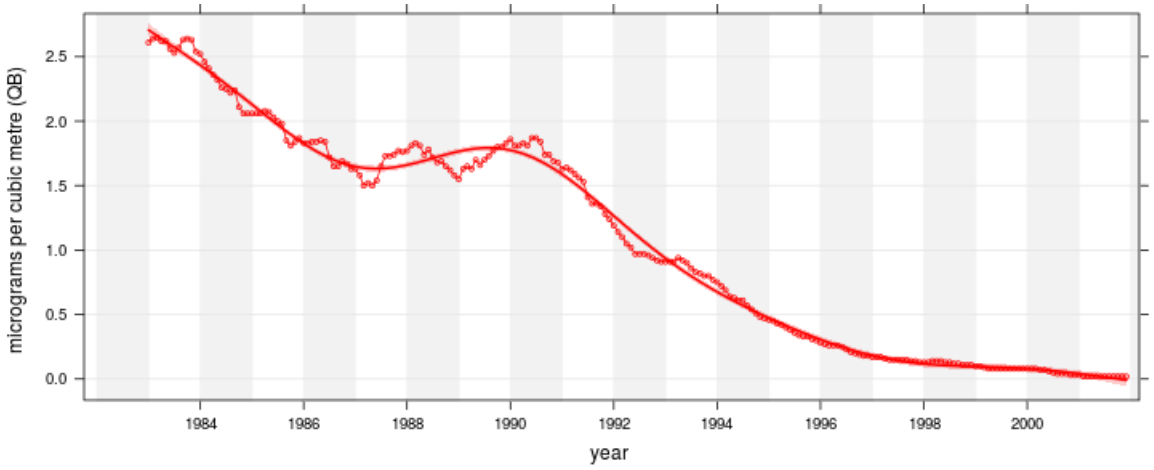


Figure A8 *Trend line for annual moving averaged lead concentration within the Perth CBD*

A.7 Particles as PM_{10}

The Duncraig site is an upper-bound performance monitoring station site for PM_{10}. High levels of PM_{10} here are caused by a combination of vehicle and domestic wood heater emissions during strongly stable meteorological conditions.

Likewise, the site at South Lake measures significant PM_{10} concentrations arising from wood fires and some industrial emissions.

Duncraig and South Lake sites are both nominated as Trend stations.

Monitoring stations were established at Geraldton in 2005, Albany in 2006, Collie in 2008, Kalgoorlie in 2017 and Mandurah in 2019.

All TEOMs used by the department are operated continuously and unadjusted for temperature. All TEOM Model 1400AB data presented in this report has the manufacturer's recommended equivalency factor of 1.03x + 3.00 applied. A TEOM Model 1405DF is in operation at Kalgoorlie and Mandurah and, as per manufacturer's instructions, has no equivalency factors applied.

A frequency distribution of hourly particle concentrations, such as that shown in Figure A9 for three metropolitan sites and one regional site for the 10-year period 2010-19, can indicate differences in the ratio of $PM_{2.5}$:PM_{10}, and also provides some insight as to the source of the pollutant. A high ratio of $PM_{2.5}$:PM_{10} indicates a high proportion of smaller particles and is generally caused by particles originating from smoke or fumes, while a lower ratio of $PM_{2.5}$:PM_{10} may indicate anthropogenic dust or crustal materials.

The blue plots in Figure A9 represent periods where the one-hour averaged PM_{10} exceeded an arbitrary concentration of 50 µg/m^3. This cut-off was chosen to limit the analysis to those concentrations at the higher end of the spectrum. While Duncraig exhibits a lower overall number, both Duncraig and Bunbury exhibit a slightly higher proportion of high-ratio events, and both Caversham and South Lake display a larger number of low-ratio events.

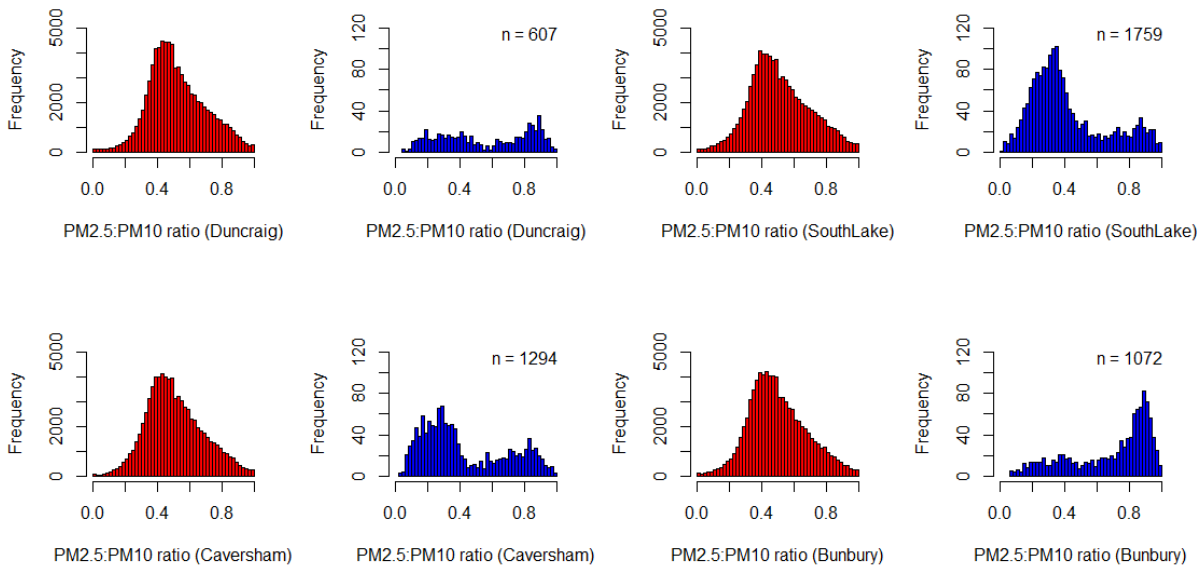


Figure A9 *Frequency distribution of $PM_{2.5}$:PM_{10} ratios of hourly averages at Duncraig (top left), South Lake (top right), Caversham (lower left) and Bunbury (lower right) for 10-year period 2010–1 9 using all data (red) and data where hourly averaged PM_{10} was greater than, or equal to 50 µg/m³ (blue)*

These differences can be explained based on the site locations. Duncraig is 3.5 km from the coast within a moderate/high-density housing area with no industry close by and will therefore be predominantly influenced by vehicles, sea salt and smoke from the occasional bushfire or prescribed burn and, to a lesser extent, domestic wood heater emissions. One therefore expects to see a higher $PM_{2.5}$:PM_{10} ratio which is characteristic of combustion products. Bunbury is a large coastal town in the south-west of the state which has surrounding bushlands which are subjected to controlled burns and occasional bushfires. Caversham is in a semi-rural setting north-east of Perth CBD and has a number of vineyards and some brick manufacturing. These two industries are more likely to produce coarse fraction particles producing a lower $PM_{2.5}$:PM_{10} ratio. South Lake, within a moderate/high-density housing area, is close to the Kwinana Industrial Area, market gardens, new housing developments and a cement manufacturing plant, providing more opportunity to be influenced by lower $PM_{2.5}$:PM_{10} ratios.

A.8 Particles as $PM_{2.5}$

To make assessments against the AAQ NEPM standard, $PM_{2.5}$ TEOMs have been installed in the greater Perth Metropolitan Region Area at Quinns Rocks, Caversham, Duncraig, South Lake and Mandurah and in Bunbury, Busselton and Kalgoorlie. All will remain in use at these locations indefinitely with the intention of developing trend data.

All TEOMs used by the department are operated continuously (unadjusted for temperature).

All TEOM Model 1400AB data presented in this report has the manufacturer's recommended equivalency factor of 1.03x + 3.00 applied. A TEOM Model 1405DF is in operation at Kalgoorlie and Mandurah and, as per manufacturer's instructions, has no equivalency factors applied.

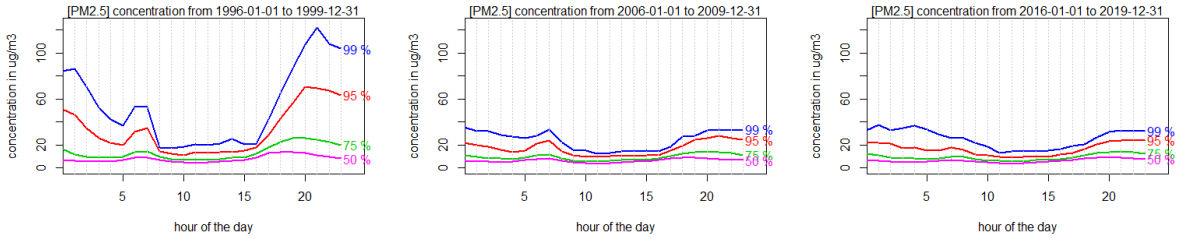


Figure A10 The $PM_{2.5}$ 99th (blue), 95th (red), 75th (green) and 50th (mauve) percentiles for each hour of the day at Duncraig over winter months spanning four-year periods 1996–99 (left), 2006–09 (centre) and 2016–19 (right).

Percentile concentrations for $PM_{2.5}$ for each hour of the day over winter months during three four-year periods at Duncraig are shown in Figure A10. The $PM_{2.5}$ profile shows a marked decrease in overnight concentrations over the initial 10-year timespan with a much smaller improvement over the second decade. As indicated in section A2 on carbon monoxide, one possible reason for this initial and dramatic decrease in fine particle concentrations during winter is the introduction of the Environmental Protection (Domestic Solid Fuel Burning Appliances and Firewood Supply) Regulations 1998 which require heating appliances (wood heaters) sold to meet emission standards set out in the relevant Australian and New Zealand Standard (AS/NZS4013:1999) and regulate the moisture content of wood sold as firewood.

In addition, in 2006 and 2007 wood heater replacement programs were conducted by the then Department of Environment and Conservation, which offered up to $600 as an economic incentive to encourage people using wood heaters or fireplaces as the main source of heating in their homes to convert to an alternative heating source.

A.9 Population exposure

The requirement for an annual assessment of population exposure to particles as $PM_{2.5}$ was made in the AAQ NEPM variation[3] on 26 February 2016.

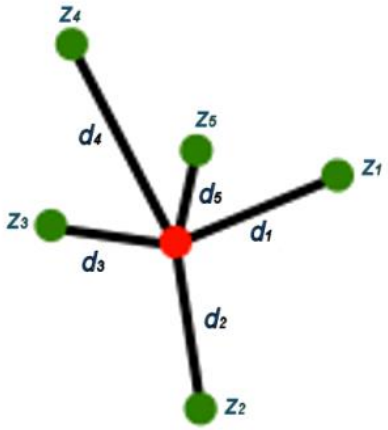
[3] www.legislation.gov.au/Details/F2016C00215

Pending a nationally consistent method to assess population exposures for $PM_{2.5}$, the department has used a simple inverse distance weighing (IDW) method.

$$Z(x) = \frac{\sum w_i z_i}{\sum w_i}$$

where

$$w_i = \frac{1}{d(x, x_i)^2}$$



In this simple IDW function, $Z(x)$ represents a known location for which a $PM_{2.5}$ concentration needs to be estimated, z_i represents known locations for which $PM_{2.5}$ concentrations are available while $d(x, x_i)$ is the distance from a point x_i for which we have a known concentration to a point x where the concentration estimate is needed.

$$Population\ Exposure = \sum \frac{Z(x)P_x}{P_{total}}$$

where

$$P_x = population\ at\ each\ Z(x)\ or\ suburb$$

It is important to note that this method uses a very simple interpolation and does not take into account land-use or terrain effects but simply causes concentrations of nearer sites to have a significantly greater effect on the estimated concentration than more distant sites.

In 2019, metropolitan $PM_{2.5}$ particle data was collected from three metropolitan sites, Caversham, Duncraig and South Lake and three regional sites of Bunbury, Busselton and Kalgoorlie. Using the centroid of each suburb in metropolitan Perth and their associated population data, the population weighted average $PM_{2.5}$ particle concentration for the Perth region in 2019 was calculated.

It is important to recognise that all concentrations used in calculating population exposure concentration are from TEOM particle monitors Model 1400AB which have had the following adjustments made as recommended by the manufacturers in the most recent TEOM operating manual[4]:

> *This is done using the formula Y=A+Bx, where Y is the adjusted mass concentration, x is the unadjusted mass concentration, A (Const A) is the intercept factor and B (Const B) is the slope factor. The values of A and B must be set to their default values of 3.000 and 1.030, respectively, for the Series 1400a Monitor to be used as a U.S. EPA equivalent method for PM-10 measurements. These adjustment factors were determined at sites where non-volatile particulate matter dominated and, therefore, the adjustment factors reflect the filter character more than they reflect the particulate matter.*
>
> *For PM-2.5 measurements, it is justifiable to use the original constants (3.000 and 1.030), because the technical rationale may still apply. The other option is to use no adjustment for PM-2.5, by setting the constants to values of 0.000 (Const A) and 1.000 (Const B). In either case, the adjustment factors used may be revisited later as more information becomes*

[4] Operating Manual TEOM® SERIES 1400a Ambient Particulate (PM-10) Monitor (AB serial numbers) June 2004, Revision B, R&P Part Number 42-003347

> *available on the best approach. Because the adjustment is attained by a simple linear transformation, it is possible to recalculate the mass concentration values later based upon new information.*

A March 2003 AAQ NEPM technical paper on Monitoring for Particles as $PM_{2.5}$[5] advised the following course for $PM_{2.5}$ particle concentrations using a TEOM:

> *When the monitor is operated as an equivalent PM10 monitor, the values of A and B are set to 3.0 and 1.03 respectively. For operation as a PM2.5 monitor for the equivalency program the values for A and B must be set to 0 and 1.0 respectively (R&P Operating Manual TEOM Series 1400a Ambient Particulate (PM10) Monitor (AB serial Numbers) December 1995 Revision B Section 4.7 Setting Other Hardware Parameters).*

All data collected using a 1400AB TEOM particle monitor presented in this report has had the manufacturer's recommended adjustment applied to both PM_{10} and $PM_{2.5}$ data. To ensure that equitable comparisons of population exposure can be made with other jurisdictions, the population exposure using both methods of calculating $PM_{2.5}$ are presented below.

Table A9 Population exposure for particles as $PM_{2.5}$

Data adjustment method	Population Exposure (Perth Metro)
Data with manufacturers recommended adjustment factor ($Y = 3.0 + 1.03x$)	8.0µg/m^3
Unadjusted data ($Y = 0.0 + 1.00x$)	4.8µg/m^3

A.10 Variation to the AAQ NEPM

In February 2016, the AAQ NEPM was varied to, among other things:

- provide for a PM_{10} annual standard of 25 µg/m^3
- create two standards for $PM_{2.5}$ of 25 µg/m^3 averaged over 24 hours, and 8 µg/m^3 averaged over one year
- include an aim to move to annual average and 24-hour $PM_{2.5}$ standards of 7 µg/m^3 and 20 µg/m^3 respectively by 2025
- remove the five allowable exceedances for PM_{10} one-day average standards when determining compliance with the AAQ NEPM goal
- allow for exceptional events when determining compliance for one-day PM_{10} and $PM_{2.5}$ with the AAQ NEPM goal. An exceptional event means a fire or dust occurrence that adversely affects air quality at a particular location, and causes an exceedance of one-day average standards in excess of normal historical fluctuations and background levels, and is directly related to: bushfire; jurisdiction authorised hazard reduction burning; or continental scale windblown dust. For the purpose of reporting compliance against PM_{10} and $PM_{2.5}$ one-day average standards, jurisdictions are required to exclude monitoring data that has been determined as being directly associated with an

[5] http://www.nepc.gov.au/system/files/resources/9947318f-af8c-0b24-d928-04e4d3a4b25c/files/aaq-pm25-tp-technical-paper-monitoring-particles-final-200303.pdf

exceptional event. For the purpose of reporting compliance against PM_{10} and $PM_{2.5,}$ one-year average standards, jurisdictions are required to include all measured data, including monitoring data that is directly associated with an exceptional event

- require that each jurisdiction must evaluate and report population exposures for particles as $PM_{2.5}$ annually from June 2018.

This report has been prepared to comply with these AAQ NEPM reporting requirements.

A.11 Exceedance summary

There were a number of exceedances of $PM_{2.5}$ and PM_{10} in 2019. The AAQ NEPM goal for particles was not met at Collie, Geraldton and Kalgoorlie. Detailed summaries of all exceedances are provided in Section F.

Table A10 AAQ NEPM standard exceedances recorded during 2019

Site	Pollutant	Concentration[1,2,3]	Date	Cause	Type	
Albany	PM_{10}	128.5 µg/m^3	06/06/2019	WD	EE	
Bunbury	$PM_{2.5}$	28.1 µg/m^3	11/05/2019	PB	EE	
Bunbury	$PM_{2.5}$	26.7 µg/m^3	12/05/2019	PB	EE	
Bunbury	$PM_{2.5}$	28.9 µg/m^3	14/05/2019	PB	EE	
Bunbury	PM_{10}	92.7 µg/m^3	15/05/2019	PB	EE	
Bunbury	$PM_{2.5}$	76.8 µg/m^3	15/05/2019	PB	EE	
Bunbury	PM_{10}	81.6 µg/m^3	06/06/2019	WD	EE	
Bunbury	$PM_{2.5}$	26.2 µg/m^3	19/11/2019	PB	EE	
Bunbury	PM_{10}	131.0 µg/m^3	15/12/2019	PB	EE	
Bunbury	$PM_{2.5}$	118.2 µg/m^3	15/12/2019	PB	EE	
Busselton	$PM_{2.5}$	30.9 µg/m^3	25/04/2019	PB	EE	
Busselton	$PM_{2.5}$	33.7 µg/m^3	12/05/2019	PB	EE	
Busselton	$PM_{2.5}$	78.5 µg/m^3	15/05/2019	PB	EE	
Busselton	$PM_{2.5}$	28.1 µg/m^3	19/11/2019	PB	EE	
Busselton	$PM_{2.5}$	39.6 µg/m^3	15/12/2019	BF	EE	
Caversham	$PM_{2.5}$	25.4 µg/m^3	14/05/2019	PB	EE	
Caversham	PM_{10}	107.7 µg/m^3	06/06/2019	WD	EE	
Collie	PM_{10}	76.6 µg/m^3	12/05/2019	PB	EE	
Collie	PM_{10}	83.5 µg/m^3	14/05/2019	PB	EE	
Collie	PM_{10}	77.9 µg/m^3	15/05/2019	PB	EE	
Collie	PM_{10}	53.4 µg/m^3	28/05/2019	LB		AS
Collie	PM_{10}	59.4 µg/m^3	04/06/2019	WH		AS
Collie	PM_{10}	50.4 µg/m^3	19/06/2019	WH		AS
Collie	PM_{10}	62.1 µg/m^3	15/12/2019	BF	EE	
Duncraig	PM_{10}	68.1 µg/m^3	06/06/2019	WD	EE	
Geraldton	PM_{10}	88.4 µg/m^3	02/05/2019	WD		AS
Geraldton	PM_{10}	72.7 µg/m^3	10/05/2019	WD		AS
Geraldton	PM_{10}	52.9 µg/m^3	30/05/2019	WD		AS
Geraldton	PM_{10}	88.1 µg/m^3	06/06/2019	WD	EE	
Geraldton	PM_{10}	50.5 µg/m^3	29/11/2019	WD		AS
Geraldton	PM_{10}	50.8 µg/m^3	11/12/2019	WD		AS
Kalgoorlie	PM_{10}	50.3 µg/m^3	23/02/2019	BF	EE	
Kalgoorlie	$PM_{2.5}$	29.7 µg/m^3	23/02/2019	BF	EE	
Kalgoorlie	$PM_{2.5}$	26.6 µg/m^3	24/07/2019	WH		AS
Kalgoorlie	PM_{10}	58.7 µg/m^3	19/11/2019	WD		AS
Kalgoorlie	PM_{10}	64.5 µg/m^3	24/11/2019	WD		AS
Kalgoorlie	PM_{10}	67.6 µg/m^3	23/12/2019	BF	EE	
Kalgoorlie	$PM_{2.5}$	40.8 µg/m^3	23/12/2019	BF	EE	
Mandurah	$PM_{2.5}$	25.4 µg/m^3	27/11/2019	BF	EE	
Mandurah	PM_{10}	59.1 µg/m^3	16/12/2019	BF	EE	
Mandurah	$PM_{2.5}$	48.1 µg/m^3	16/12/2019	BF	EE	
Rolling Green	O_3 (1 hr)	0.100 ppm	27/02/2019 1600	-		AS
Rolling Green	O_3 (4 hr)	0.087 ppm	27/02/2019 1800	-		AS
South Lake	PM_{10}	98.8 µg/m^3	06/06/2019	WD	EE	
South Lake	$PM_{2.5}$	26.5 µg/m^3	27/11/2019	BF	EE	
South Lake	PM_{10}	51.3 µg/m^3	16/12/2019	BF	EE	
South Lake	$PM_{2.5}$	28.9 µg/m^3	16/12/2019	BF	EE	

1. All concentrations are 24-hour averages (midnight to midnight) unless otherwise stated.

2. All Model 1400AB TEOMs used by DWER are operated continuously (unadjusted for temperature) and have the manufacturer's recommended equivalency factor of 1.03x + 3.00 applied. All particle concentrations are displayed as a daily average.

3. Kalgoorlie and Mandurah have a Model 1405DF TEOM which does not require an equivalency factor to be applied.

AS	Assessable event	LB	Local Burn
BF	Bushfire	WD	Windborne dust
EE	Exceptional event	WH	Woodheater
	Prescribed burning activities		

B. Assessment of compliance with standards and goals

Table B1 2019 compliance summary for carbon monoxide

AAQ NEPM standard
9.0 ppm (eight-hour average)

Regional performance monitoring station	Data availability rates (% of hours)					Number of exceedances (days)	Performance against the standards and goal
	Q1	Q2	Q3	Q4	Annual		
Perth region							
Caversham (Northeast Metro)	96.9	97.7	94.1	97.7	96.6	0	met
Duncraig (North Metro)	99.9	93.9	98.0	97.7	97.4	0	met
South Lake (Southeast Metro)	99.9	94.1	98.0	97.4	97.3	0	met
Goldfields Region							
Kalgoorlie	95.5	95.0	94.7	96.7	95.5	0	met

Performance against the standards and goal: “met”, “not met”, “not demonstrated”.

Table B2 2019 compliance summary for nitrogen dioxide

AAQ NEPM standard
0.12 ppm (one-hour average)
0.03 ppm (one-year average)

Regional performance monitoring station	Data availability rates (% of hours)					Annual mean	Number of exceedances	Performance against the standards and goal	
	Q1	Q2	Q3	Q4	Annual	(ppm)	(days)	1-hour	1-year
Perth region									
Caversham (Northeast Metro)	99.4	96.3	98.6	99.4	98.4	0.005	0	met	met
Duncraig (North Metro)	92.3	94.1	99.1	98.1	95.9	0.006	0	met	met
Quinns Rocks (Outer North Coast)	-	-	-	-	-	-	0	ND	ND
Rockingham (South Coast)	99.6	92.8	84.6	96.6	93.4	0.005	0	met	met
Rolling Green (Outer East Rural)	99.8	99.8	99.3	99.5	99.6	0.002	0	met	met
South Lake (Southeast Metro)	98.1	95.0	99.0	99.4	97.9	0.007	0	met	met
Swanbourne (Inner West Coast)	99.8	97.3	98.5	99.9	98.9	0.004	0	met	met

Performance against the standards and goal: “met”, “not met”, “not demonstrated” (ND)

Table B3 2019 compliance summary for ozone

AAQ NEPM standard
0.10 ppm (one-hour average)
0.08 ppm (four-hour average)

Regional performance monitoring station	Data availability rates (% of hours)					Number of exceedances (days)		Performance against the standards and goal	
	Q1	Q2	Q3	Q4	Annual	1-hour	4-hour	1-hour	4-hour
Perth region									
Caversham (Northeast Metro)	96.3	99.8	98.7	99.7	98.6	0	0	met	met
Quinns Rocks (Outer North Coast)	-	-	-	-	-	0	0	ND	ND
Rockingham (South Coast)	99.9	91.9	97.5	99.6	97.2	0	0	met	met
Rolling Green (Outer East Rural)	93.1	99.5	99.2	99.5	97.9	1	1	met	met
South Lake (Southeast Metro)	99.8	94.0	99.0	99.6	98.1	0	0	met	met
Swanbourne (Inner West Coast)	100	98.0	98.6	99.0	98.7	0	0	met	met

Performance against the standards and goal: “met”, “not met”, “not demonstrated (ND)”.

Table B4 2019 compliance summary for sulfur dioxide

AAQ NEPM standard
0.20 ppm (one-hour average)
0.08 ppm (24-hour average)
0.02 ppm (one-year average)

Regional performance monitoring station	Data availability rates (% of hours)					Annual mean	Number of exceedances (days)		Performance against the standards and goal		
	Q1	Q2	Q3	Q4	Annual	(ppm)	1-hour	24-hour	1-hour	24-hour	1-year
Perth region											
Rockingham (South Coast)	97.4	92	94.7	94.9	94.7	0.001	0	0	met	met	met
South Lake (Southeast Metro)	97.6	94.5	97.6	99.4	97.3	0.002	0	0	met	met	met
Wattleup (South Metro)	96.4	97.4	95.5	91.5	95.2	0.002	0	0	met	met	met
Goldfields region											
Kalgoorlie	95.5	94.9	95	97.3	95.7	0.001	0	0	met	met	met

Performance against the standards and goal: “met”, “not met”, “not demonstrated”.

Table B5 2019 compliance summary for particles as PM_{10}

AAQ NEPM standard
50 µg/m^3 (24-hour average)
25 µg/m^3 (annual average)

Regional performance monitoring station	Data availability rates (% of days)					Number of exceedances	Performance against the standards and goal	
	Q1	Q2	Q3	Q4	Annual	(days)	24-hour	Annual
Perth region								
Caversham (Northeast Metro)	99.1	98.2	32.3	99.5	82.1	1	Met	Met
Duncraig (North Metro)	99.9	91.4	93.3	99.3	96	1	Met	Met
South Lake (Southeast Metro)	99.6	96.6	99	99.3	98.6	2	Met	Met
Southwest region								
Albany	99.8	97.9	95.3	99.8	98.2	1	Met	Met
Bunbury	99.7	99.8	97.5	98.8	98.9	3	Met	Met
Collie	99.8	99.7	99.5	99.7	99.7	7	Not met	Met
Midwest region								
Geraldton	99.8	99.5	99.8	99.0	99.5	6	Not met	Met
Goldfields region								
Kalgoorlie	97.8	97.2	96.6	99.3	97.7	4	Not met	Met

Performance against the standards and goal: “met”, “not met”, “not demonstrated”.

Table B6 2019 compliance summary for particles as $PM_{2.5}$

AAQ NEPM standard
25 µg/m^3 (24-hour average)
8 µg/m^3 (annual average)

Regional performance monitoring station	Data availability rates (% of days)					Number of exceedances	Performance against the standards and goal	
	Q1	Q2	Q3	Q4	Annual	(Days)	24-hour	annual
Perth region								
Caversham (Northeast Metro)	99.4	97.8	32.3	99.5	82.1	1	Met	Not met
Duncraig (North Metro)	99.9	91.6	98.2	99.3	97.3	0	Met	Met
Quinns Rocks (Outer North Coast)	-	-	-	-	-	0	ND	ND
South Lake (Southeast Metro)	99.6	96.5	99.1	99.4	98.7	2	Met	Not met
Southwest region								
Bunbury	99.9	99.9	97.6	98.8	99.0	6	Met	Not met
Busselton	99.8	96.1	99.8	95.7	97.8	5	Met	Not met
Goldfields region								
Kalgoorlie	97.8	97.2	96.6	99.3	97.7	3	Not met	Met

Performance against the standards and goal: “met”, “not met”, “not demonstrated” (ND)

C. Analysis of air quality monitoring

C.1 Carbon monoxide

The AAQ NEPM standard for carbon monoxide of 9.0 ppm averaged over eight hours was not exceeded at any site during 2019. The AAQ NEPM goal of no more than one exceedance at each site was met. Table C1 contains the summary statistics for daily peak eight-hour carbon monoxide in Western Australia.

Table C1 2019 summary statistics for daily peak eight-hour carbon monoxide

AAQ NEPM standard
9.0 ppm (eight-hour average)

Regional performance monitoring station	Data availability rates (%)	Highest (ppm)	Highest (date)	Highest (time)	2nd highest (ppm)	2nd highest (date)	2nd highest (time)
Perth region							
Caversham (Northeast Metro)	96.6	1.0	17/05/2019	0900	0.8	26/04/2019	0600
Duncraig (North Metro)	97.4	1.2	24/05/2019	0600	1.2	17/07/2019	0500
South Lake (Southeast Metro)	97.3	1.4	17/07/2019	0300	1.3	18/05/2019	0300
Goldfields region							
Kalgoorlie	95.5	2.1	09/07/2019	0400	1.5	25/06/2019	0400

C.2 Nitrogen dioxide

The AAQ NEPM standard for nitrogen dioxide of 0.12 ppm averaged over one hour and the 0.03 ppm annual average were not exceeded at any site during 2019. The AAQ NEPM goal of no more than one exceedance at each site was met. Table C2 contains the summary statistics for daily peak one-hour nitrogen dioxide in Western Australia.

Table C2 2019 summary statistics for daily peak one-hour nitrogen dioxide

AAQ NEPM standard
0.12 ppm (one-hour average)

Regional performance monitoring station	Data availability rates (%)	Highest (ppm)	Highest (date)	Highest (time)	2nd highest (ppm)	2nd highest (date)	2nd highest (time)
Perth region							
Caversham (Northeast Metro)	98.4	0.039	09/04/2019	2000	0.031	09/09/2019	2100
Duncraig (North Metro)	95.9	0.037	27/08/2019	2000	0.035	14/05/2019	2000
Rockingham (South Coast)	93.4	0.107	27/08/2019	0900	0.076	20/08/2019	1000
Rolling Green (Outer East Rural)	99.6	0.023	17/04/2019	1900	0.019	23/04/2019	2000
South Lake (Southeast Metro)	97.9	0.036	14/05/2019	1900	0.033	09/09/2019	2000
Swanbourne (Inner West Coast)	98.9	0.037	13/05/2019	1600	0.032	20/08/2019	2200

The AAQ NEPM standard for nitrogen dioxide of 0.03 ppm averaged over one year was not exceeded at any site during 2019. Table C2a contains the summary statistics for annual nitrogen dioxide in WA.

Table C2a 2019 summary statistics for annual nitrogen dioxide.

AAQ NEPM standard
0.03 ppm (annual average)

Regional performance monitoring station	Data availability rates (%)	Annual average (ppm)
Perth region		
Caversham (Northeast Metro)	98.4	0.005
Duncraig (North Metro)	95.9	0.006
Rockingham (South Coast)	93.4	0.005
Rolling Green (Outer East Rural)	99.6	0.002
South Lake (Southeast Metro)	97.9	0.007
Swanbourne (Inner West Coast)	98.9	0.004

C.3 Photochemical smog as ozone

The AAQ NEPM standard for ozone of 0.10 ppm averaged over one hour was exceeded at Rolling Green during 2019. The AAQ NEPM goal of no more than one exceedance was met at all sites. Table C3 contains the summary statistics for daily peak one-hour ozone in Western Australia.

Table C3 2019 summary statistics for daily peak one-hour ozone

AAQ NEPM standard
0.10 ppm (one-hour average)

Regional performance monitoring station	Data availability rates (%)	Highest (ppm)	Highest (date)	Highest (time)	2nd highest (ppm)	2nd highest (date)	2nd highest (time)
Perth region							
Caversham (Northeast Metro)	98.6	0.082	16/12/2019	1300	0.075	26/02/2019	1400
Quinns Rocks (Outer North Coast)	-	-	-	-	-	-	-
Rockingham (South Coast)	97.2	0.079	16/12/2019	1200	0.069	06/12/2019	1300
Rolling Green (Outer East Rural)	97.9	0.100*	27/02/2019	1600	0.088	17/12/2019	1500
South Lake (South East Metro)	98.1	0.083	14/12/2019	1400	0.076	16/11/2019	1400
Swanbourne (Inner West Coast)	98.7	0.070	14/12/2019	1400	0.067	16/11/2019	1400

* Actual concentration was 0.1001 ppm which makes this event an AAQ NEPM exceedance

The AAQ NEPM standard for ozone of 0.08 ppm averaged over four hours was exceeded at Rolling Green during 2019. The AAQ NEPM goal of no more than one exceedance was met at all sites. Table C4 contains the summary statistics for daily peak four-hour ozone in Western Australia.

Table C4 2019 summary statistics for daily peak four-hour ozone

AAQ NEPM standard
0.08 ppm (four-hour average)

Regional performance monitoring station	Data availability rates (%)	Highest (ppm)	Highest (date)	Highest (time)	2nd highest (ppm)	2nd highest (date)	2nd highest (time)
Perth region							
Caversham (Northeast Metro)	98.6	0.065	27/02/2019	1500	0.065	26/02/2019	1600
Quinns Rocks (Outer North Coast)	-	-	-	-	-	-	-
Rockingham (South Coast)	97.2	0.067	16/12/2019	1400	0.064	06/12/2019	1500
Rolling Green (Outer East Rural)	97.9	0.087	27/02/2019	1800	0.075	17/12/2019	1700
South Lake (South East Metro)	98.1	0.076	14/12/2019	1500	0.065	16/11/2019	1500
Swanbourne (Inner West Coast)	98.7	0.066	14/12/2019	1500	0.062	16/12/2019	1400

C.4 Sulfur dioxide

The AAQ NEPM standard for sulfur dioxide of 0.20 ppm averaged over one hour was not exceeded at any site during 2019. The AAQ NEPM goal of no more than one exceedance at each site was met. Table C5 contains the summary statistics for daily peak one-hour sulfur dioxide in Western Australia.

Table C5 2019 summary statistics for daily peak one-hour sulfur dioxide

AAQ NEPM standard
0.20 ppm (one-hour average)

Regional performance monitoring station	Data availability rates (%)	Highest (ppm)	Highest (date)	Highest (time)	2nd highest (ppm)	2nd highest (date)	2nd highest (time)
Perth region							
Rockingham (South Coast)	94.7	0.034	01/09/2019	0900	0.025	06/06/2019	1400
South Lake (Southeast Metro)	97.3	0.019	31/01/2019	1800	0.017	06/02/2019	1500
Wattleup (South Metro)	95.2	0.057	26/02/2019	1600	0.038	13/05/2019	1700
Goldfields region							
Kalgoorlie	95.7	0.082	16/02/2019	1100	0.079	05/11/2019	0800

The AAQ NEPM standard for sulfur dioxide of 0.08 ppm averaged over 24 hours was not exceeded at any site during 2019. The AAQ NEPM goal of no more than one exceedance at each site was met. Table C6 contains the summary statistics for daily peak 24-hour sulfur dioxide in Western Australia.

Table C6 2019 summary statistics for 24-hour sulfur dioxide

AAQ NEPM standard
0.08 ppm (24-hour average)

Regional performance monitoring station	Data availability rates (%)	Highest (ppm)	Highest (date)	Highest (time)	2nd highest (ppm)	2nd highest (date)	2nd highest (time)
Perth region							
Rockingham (South Coast)	94.7	0.009	06/06/2019	2400	0.008	22/06/2019	2400
South Lake (Southeast Metro)	97.3	0.006	27/03/2019	2400	0.006	15/12/2019	2400
Wattleup (South Metro)	95.2	0.008	26/02/2019	2400	0.006	27/03/2019	2400
Goldfields region							
Kalgoorlie	95.7	0.012	16/02/2019	2400	0.007	24/03/2019	2400

The AAQ NEPM standard for sulfur dioxide of 0.02 ppm averaged over one year was not exceeded at any site during 2019. Table C7 contains the summary statistics for annual sulfur dioxide in Western Australia.

Table C7 2019 summary statistics for annual sulfur dioxide

AAQ NEPM standard
0.02 ppm (annual average)

Regional performance monitoring station	Data availability rates (%)	Annual average (ppm)
Perth region		
Rockingham (South Coast)	94.7	0.001
South Lake (Southeast Metro)	97.3	0.002
Wattleup (South Metro)	95.2	0.002
Goldfields region		
Kalgoorlie	95.7	0.001

C.5 Particles as PM_{10}

The AAQ NEPM standard for particles as PM_{10} of 50 µg/m^3 averaged over 24 hours was exceeded a number of times during 2019, as detailed in Table A10. The AAQ NEPM goal was not met at Collie, Geraldton and Kalgoorlie. Table C8 contains the summary statistics for daily peak 24-hour PM_{10} in Western Australia.

Table C8 2019 summary statistics for 24-hour particles as PM_{10}

AAQ NEPM Standard
50 µg/m^3 (24-hour average)

Regional performance monitoring station	Data availability rates (%)	Highest (µg/m^3)	Highest (date)	Highest (time)	6th Highest (µg/m^3)	6th Highest (date)	6th Highest (time)
Perth region							
Caversham[1] (Northeast Metro)	82.1	**107.7**	06/06/2019	2400	38.7	05/06/2019	2400
Duncraig[1] (North Metro)	96.0	**68.1**	06/06/2019	2400	30.1	14/05/2019	2400
South Lake[1] (Southeast Metro)	98.6	**98.8**	06/06/2019	2400	38.8	26/02/2019	2400
Southwest region							
Albany[1]	98.2	**128.5**	06/06/2019	2400	33.5	22/12/2019	2400
Bunbury[1]	98.9	**131.0**	15/12/2019	2400	36.4	12/05/2019	2400
Collie[1]	99.7	**83.5**	14/05/2019	2400	**53.4**	28/05/2019	2400
Midwest region							
Geraldton[1]	99.5	**88.4**	02/05/2019	2400	**50.5**	29/11/2019	2400
Goldfields region							
Kalgoorlie[2]	97.7	**67.6**	23/12/2019	2400	43.0	22/01/2019	2400

1. Model 1400AB TEOM operating continuously (unadjusted for temperature) and includes the manufacturer's recommended equivalency factor of 1.03x + 3.00

2. Model 1405DF TEOM operating continuously (unadjusted for temperature) with no equivalency factor

Bold numerals indicate where a relevant standard has been exceeded.

The AAQ NEPM standard for particles as PM_{10} of 25 micrograms per cubic metre averaged over one year was met at all sites during 2019. Table C9 contains the summary statistics for annual PM_{10} in Western Australia.

Table C9 2019 summary statistics for annual particles as PM_{10}

Regional performance monitoring station	Data availability rates (%)	Annual average (µg/m³)
	AAQ NEPM standard	25 µg/m³ (annual average)
Perth region		
Caversham[1] (Northeast Metro)	82.1	18.7
Duncraig[1] (North Metro)	96.0	14.8
South Lake[1] (Southeast Metro)	98.6	17.7
Southwest region		
Albany[1]	98.2	15.3
Bunbury[1]	98.9	16.6
Collie[1]	99.7	22.0
Midwest region		
Geraldton[1]	99.5	22.2
Goldfields region		
Kalgoorlie[2]	97.7	15.2

1. TEOM operating continuously (unadjusted for temperature) and includes the manufacturer's recommended equivalency factor of 1.03x + 3.00

2. Model 1405DF TEOM operating continuously (unadjusted for temperature) with no equivalency factor

C.6 Particles as $PM_{2.5}$

The AAQ NEPM standard for particles as $PM_{2.5}$ of 25 micrograms per cubic metre averaged over 24 hours was exceeded a number of times as detailed in Table A10 during 2019. The AAQ NEPM goal was not met at Kalgoorlie. Table C10 contains the summary statistics for daily peak 24-hour $PM_{2.5}$ in Western Australia.

Table C10 2019 summary statistics for 24-hour particles as $PM_{2.5}$

AAQ NEPM standard
25 µg/m^3 (24-hour average)

Regional Performance Monitoring Station	Data availability rates (%)	Highest (µg/m^3)	Highest (date)	Highest (time)	6th highest (µg/m^3)	6th highest (date)	6th highest (time)
Perth region							
Caversham[1] (Northeast Metro)	82.1	**25.4**	14/05/2019	2400	17.7	18/06/2019	2400
Duncraig[1] (North Metro)	97.3	25.0	16/12/2019	2400	19.1	18/06/2019	2400
Quinns Rocks[1] (Outer North Coast)	-	**-**	-	-	-	-	-
South Lake[1] (Southeast Metro)	98.7	**28.9**	16/12/2019	2400	16.7	19/05/2019	2400
Southwest region							
Bunbury[1]	99.0	**118.2**	15/12/2019	2400	**26.2**	19/11/2019	2400
Busselton[1]	97.8	**78.5**	15/05/2019	2400	24.4	11/05/2019	2400
Goldfields region							
Kalgoorlie[2]	97.7	**40.8**	23/12/2019	2400	23.1	16/02/2019	2400

1. TEOM operating continuously (unadjusted for temperature) and includes the manufacturer's recommended equivalency factor of 1.03x + 3.00

2. Model 1405DF TEOM operating continuously (unadjusted for temperature) with no equivalency factor.

Bold numerals indicate where a relevant standard has been exceeded.

The AAQ NEPM standard for particles as $PM_{2.5}$ of 8 micrograms per cubic metre averaged over one year was not met at several sites during 2019. Table C11 contains the summary statistics for annual $PM_{2.5}$ in Western Australia.

Table C11 2019 summary statistics for annual particles as $PM_{2.5}$

Regional performance monitoring station	Data availability rates (%)	Annual average (µg/m³)
		AAQ NEPM standard 8 µg/m³ (annual average)
Perth region		
Caversham[1] (Northeast Metro)	82.1	**8.3**
Duncraig[1] (North Metro)	97.3	7.4
Quinns Rocks[1] (Outer North Coast)	-	-
South Lake[1] (Southeast Metro)	98.7	**8.2**
Southwest region		
Bunbury[1]	99.0	**8.5**
Busselton[1]	97.8	**8.1**
Goldfields region		
Kalgoorlie[2]	97.7	5.6

1. TEOM operating continuously (unadjusted for temperature) and includes the manufacturer's recommended equivalency factor of 1.03x + 3.00

2. Model 1405DF TEOM operating continuously (unadjusted for temperature) with no equivalency factor.

Bold numerals indicate where a relevant standard has been exceeded.

D. Data analysis

D.1 Maxima and percentiles by pollutant in 2019

Table D1 2019 percentiles of daily peak eight-hour carbon monoxide concentrations

AAQ NEPM standard
9.0 ppm (eight-hour average)

Regional performance monitoring station	Data availability rates (%)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)	75th percentile (ppm)	50th percentile (ppm)
Perth region								
Caversham (Northeast Metro)	96.6	1.0	0.7	0.6	0.5	0.4	0.3	0.2
Duncraig (North Metro)	97.4	1.2	1.1	1.0	0.8	0.6	0.4	0.3
South Lake (Southeast Metro)	97.3	1.4	1.2	1.2	1.0	0.8	0.5	0.3
Goldfields region								
Kalgoorlie	95.5	2.1	1.1	1.0	0.8	0.5	0.2	0.2

Table D2 2019 percentiles of daily peak one-hour nitrogen dioxide concentrations

AAQ NEPM standard
0.12 ppm (one-hour average)

Regional performance monitoring station	Data availability rates (%)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)	75th percentile (ppm)	50th percentile (ppm)
Perth region								
Caversham (Northeast Metro)	98.4	0.039	0.030	0.028	0.025	0.023	0.018	0.014
Duncraig (North Metro)	95.9	0.037	0.033	0.031	0.028	0.025	0.021	0.015
Quinns Rocks (Outer North Coast)	-	-	-	-	-	-	-	-
Rockingham (South Coast)	93.4	0.107	0.059	0.042	0.029	0.025	0.018	0.011
Rolling Green (Outer East Rural)	99.6	0.023	0.015	0.015	0.012	0.011	0.008	0.005
South Lake (Southeast Metro)	97.9	0.036	0.031	0.030	0.028	0.026	0.021	0.016
Swanbourne (Inner West Coast)	98.9	0.037	0.031	0.029	0.026	0.022	0.015	0.011

Table D3 2019 percentiles of daily peak one-hour ozone concentrations

AAQ NEPM standard
0.10 ppm (one-hour average)

Regional performance monitoring station	Data availability rates (%)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)	75th percentile (ppm)	50th percentile (ppm)
Perth region								
Caversham (Northeast Metro)	98.6	0.082	0.073	0.068	0.057	0.047	0.036	0.030
Quinns Rocks (Outer North Coast)	-	-	-	-	-	-	-	-
Rockingham (South Coast)	97.2	0.079	0.062	0.058	0.050	0.043	0.035	0.031
Rolling Green (Outer East Rural)	97.9	0.100	0.079	0.072	0.063	0.055	0.040	0.034
South Lake (Southeast Metro)	98.1	0.083	0.062	0.057	0.047	0.040	0.033	0.029
Swanbourne (Inner West Coast)	98.7	0.070	0.064	0.058	0.052	0.046	0.036	0.032

Table D4 2019 percentiles of daily peak four-hour ozone concentrations

AAQ NEPM standard
0.08 ppm (four-hour average)

Regional performance monitoring station	Data availability rates (%)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)	75th percentile (ppm)	50th percentile (ppm)
Perth region								
Caversham (Northeast Metro)	98.6	0.065	0.061	0.057	0.049	0.042	0.033	0.028
Quinns Rocks (Outer North Coast)	-	-	-	-	-	-	-	-
Rockingham (South Coast)	97.2	0.067	0.058	0.053	0.044	0.039	0.034	0.030
Rolling Green (Outer East Rural)	97.9	0.087	0.067	0.063	0.055	0.049	0.037	0.032
South Lake (Southeast Metro)	98.1	0.076	0.056	0.051	0.042	0.037	0.031	0.027
Swanbourne (Inner West Coast)	98.7	0.066	0.055	0.051	0.047	0.042	0.035	0.031

Table D5 2019 percentiles of daily peak one-hour sulfur dioxide concentrations

AAQ NEPM standard
0.20 ppm (one-hour average)

Regional performance monitoring station	Data availability rates (%)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)	75th percentile (ppm)	50th percentile (ppm)
Perth region								
Rockingham (South Coast)	94.7	0.034	0.023	0.020	0.015	0.011	0.004	0.002
South Lake (Southeast Metro)	97.3	0.019	0.016	0.014	0.012	0.010	0.006	0.004
Wattleup (South Metro)	95.2	0.057	0.031	0.029	0.023	0.018	0.011	0.005
.								
Goldfields region								
Kalgoorlie	95.7	0.082	0.053	0.038	0.020	0.012	0.003	0.001

Table D6 2019 percentiles of daily peak 24-hour sulfur dioxide concentrations

AAQ NEPM standard
0.08 ppm (24-hour average)

Regional performance monitoring station	Data availability rates (%)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)	75th percentile (ppm)	50th percentile (ppm)
Perth region								
Rockingham (South Coast)	94.7	0.009	0.005	0.004	0.003	0.002	0.002	0.001
South Lake (Southeast Metro)	97.3	0.006	0.005	0.005	0.004	0.004	0.003	0.002
Wattleup (South Metro)	95.2	0.008	0.005	0.005	0.004	0.003	0.002	0.001
Goldfields region								
Kalgoorlie	95.7	0.012	0.005	0.004	0.003	0.002	0.001	0.001

Table D7 2019 percentiles of daily peak 24-hour particles as PM_{10} concentrations

AAQ NEPM standard
50 µg/m³ (24-hour average)

Regional performance monitoring station	Data availability rates (%)	Max conc. (µg/m³)	99th percentile (µg/m³)	98th percentile (µg/m³)	95th percentile (µg/m³)	90th percentile (µg/m³)	75th percentile (µg/m³)	50th percentile (µg/m³)
Perth region								
Caversham (Northeast Metro)	82.1	**107.7**	42.1	38.1	29.6	27.0	23.0	17.7
Duncraig (North Metro)	96.0	**68.1**	30.7	27.2	23.7	22.2	18.2	14.1
South Lake (Southeast Metro)	98.6	**98.8**	40.4	37.0	30.7	26.7	21.6	16.7
Southwest region								
Albany	98.2	**128.5**	35.5	30.9	27.1	22.5	17.5	14.1
Bunbury	98.9	**131.0**	38.4	31.8	26.8	23.6	18.5	15.3
Collie	99.7	**83.5**	**60.4**	48.6	39.5	33.9	26.7	20.2
Midwest region								
Geraldton	99.5	**88.4**	**51.5**	46.0	39.4	35.2	29.2	20.2
Goldfields region								
Kalgoorlie	97.7	**67.6**	46.6	41.4	31.8	27.2	18.8	12.8

Bold numerals indicate where a relevant standard has been exceeded.

Table D8 2019 percentiles of daily peak 24-hour particles as $PM_{2.5}$ concentrations

AAQ NEPM standard
25 µg/m³ (24-hour average)

Regional performance monitoring station	Data availability rates (%)	Max conc. (µg/m³)	99th percentile (µg/m³)	98th percentile (µg/m³)	95th percentile (µg/m³)	90th percentile (µg/m³)	75th percentile (µg/m³)	50th percentile (µg/m³)
Perth region								
Caversham (Northeast Metro)	82.1	**25.4**	18.2	17.3	15.2	12.4	9.9	7.4
Duncraig (North Metro)	97.3	25.0*	20.2	15.9	13.9	11.6	9.2	7.0
Quinns Rocks (Outer North Coast)	-	**-**	-	-	-	-	-	-
South Lake (Southeast Metro)	98.7	**28.9**	18.0	16.0	13.5	12.4	9.8	7.8
Southwest region								
Bunbury	99.0	**118.2**	**27.3**	22.5	14.2	12.1	9.3	7.3
Busselton	97.8	**78.5**	**29.4**	21.6	13.2	11.0	8.9	7.3
Goldfields region								
Kalgoorlie	97.7	**40.8**	24.1	22.1	16.6	12.8	6.1	3.8

Bold numerals indicate where a relevant standard has been exceeded.
* Actual concentration was 24.954 µg/m³ which is not a NEPM exceedance

D.2 Maxima and percentiles by site 2010–19

Table D9 Daily peak eight-hour carbon monoxide at Caversham (2010–19)
Trend station/region: Caversham

AAQ NEPM standard
9.0 ppm (eight-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	85.0	0	1.6	0.8	0.7	0.6	0.5
2011	98.2	0	1.5	1.2	1.0	0.6	0.5
2012	98.0	0	0.9	0.7	0.6	0.5	0.4
2013	97.5	0	0.9	0.7	0.6	0.5	0.4
2014	96.1	0	0.7	0.7	0.6	0.5	0.4
2015	94.1	0	1.2	0.8	0.7	0.6	0.5
2016	99.2	0	0.9	0.6	0.6	0.5	0.4
2017	97.5	0	2.9	1.1	0.8	0.5	0.4
2018	97.4	0	1.1	0.7	0.6	0.5	0.4
2019	96.6	0	1.0	0.7	0.6	0.5	0.4

Table D10 Daily peak eight-hour carbon monoxide at Duncraig (2010–19)
Trend station/region: Duncraig

AAQ NEPM standard
9.0 ppm (eight-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	87.5	0	2.3	2.0	1.8	1.5	1.1
2011	99.3	0	1.9	1.3	1.2	1.0	0.7
2012	99.5	0	2.4	1.9	1.5	1.1	0.9
2013	99.5	0	2.1	1.8	1.6	1.2	0.8
2014	99.7	0	1.9	1.4	1.0	0.8	0.7
2015	99.5	0	1.7	1.4	1.3	1.0	0.7
2016	99.8	0	1.4	1.2	1.1	0.8	0.7
2017	96.9	0	1.4	1.1	0.9	0.8	0.6
2018	98.7	0	1.5	1.2	1.0	0.8	0.7
2019	97.4	0	1.2	1.1	1.0	0.8	0.6

Table D11 Daily peak eight-hour carbon monoxide at South Lake (2010–19)

Trend station/region: South Lake

AAQ NEPM standard
9.0 ppm (eight-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	87.8	0	2.2	1.6	1.5	1.2	0.9
2011	98.3	0	1.7	1.5	1.3	1.0	0.8
2012	98.9	0	2.2	1.6	1.4	1.0	0.8
2013	98.5	0	1.7	1.3	1.2	1.0	0.6
2014	99.5	0	1.8	1.4	1.0	0.8	0.7
2015	98.5	0	1.9	1.3	1.2	0.9	0.8
2016	99.8	0	2.3	1.3	1.1	0.9	0.7
2017	98.6	0	1.9	1.4	1.3	1.0	0.7
2018	99.7	0	1.9	1.3	1.3	1.0	0.9
2019	97.3	0	1.4	1.2	1.2	1.0	0.8

Table D12 Daily peak eight-hour carbon monoxide at Kalgoorlie (2010–19)

Campaign station/region: Kalgoorlie

AAQ NEPM standard
9.0 ppm (eight-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	86.9	0	1.9	0.9	0.8	0.5	0.4
2019	95.5	0	2.1	1.1	1.0	0.8	0.5

Table D13 Daily peak one-hour nitrogen dioxide at Caversham (2010–19)

Trend station/region: Caversham

AAQ NEPM standard
0.12 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	84.9	0	0.054	0.040	0.037	0.032	0.029
2011	99.5	0	0.035	0.031	0.029	0.027	0.025
2012	97.0	0	0.037	0.033	0.032	0.029	0.025
2013	97.5	0	0.043	0.034	0.032	0.029	0.025
2014	94.2	0	0.033	0.031	0.030	0.026	0.024
2015	94.6	0	0.041	0.035	0.032	0.027	0.025
2016	99.5	0	0.036	0.032	0.030	0.026	0.024
2017	95.3	0	0.042	0.032	0.031	0.028	0.025
2018	98.6	0	0.034	0.029	0.028	0.026	0.024
2019	98.4	0	0.039	0.030	0.028	0.025	0.023

Table D14 Daily peak one-hour nitrogen dioxide at Duncraig (2010–19)

Trend station/region: Duncraig

AAQ NEPM standard
0.12 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	87.5	0	0.038	0.035	0.033	0.030	0.028
2011	99.3	0	0.035	0.032	0.030	0.028	0.027
2012	96.8	0	0.047	0.037	0.033	0.030	0.027
2013	97.9	0	0.040	0.031	0.030	0.028	0.026
2014	99.3	0	0.048	0.029	0.028	0.026	0.024
2015	98.2	0	0.036	0.034	0.032	0.028	0.026
2016	99.8	0	0.033	0.029	0.028	0.026	0.024
2017	98.2	0	0.032	0.031	0.030	0.027	0.026
2018	97.1	0	0.036	0.031	0.030	0.027	0.025
2019	95.9	0	0.037	0.033	0.031	0.028	0.025

Table D15 Daily peak one-hour nitrogen dioxide at Quinns Rocks (2010–19)

Trend station/region: Quinns Rocks

AAQ NEPM standard
0.12 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	88.8	0	0.040	0.032	0.032	0.030	0.027
2011	99.0	0	0.031	0.028	0.027	0.025	0.022
2012	97.3	0	0.041	0.032	0.031	0.027	0.024
2013	97.9	0	0.032	0.026	0.026	0.023	0.020
2014	99.6	0	0.031	0.026	0.024	0.020	0.017
2015	98.8	0	0.030	0.028	0.026	0.024	0.020
2016	97.8	0	0.029	0.026	0.024	0.022	0.020
2017	21.5	0	0.019	0.017	0.016	0.015	0.014
2018	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-

Table D16 Daily peak one-hour nitrogen dioxide at Rockingham (2010–19)

Trend station/region: Rockingham

AAQ NEPM standard
0.12 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	88.7	0	0.036	0.032	0.030	0.028	0.026
2011	96.6	0	0.034	0.028	0.027	0.025	0.022
2012	96.4	0	0.053	0.030	0.030	0.027	0.024
2013	97.8	0	0.035	0.031	0.029	0.027	0.025
2014	98.7	0	0.034	0.027	0.026	0.024	0.021
2015	98.8	0	0.062	0.032	0.029	0.026	0.023
2016	99.3	0	0.029	0.027	0.026	0.024	0.022
2017	93.4	0	0.074	0.047	0.034	0.026	0.023
2018	82.2	0	0.029	0.026	0.025	0.023	0.020
2019	93.4	0	0.107	0.059	0.042	0.029	0.025

Table D17 Daily peak one-hour nitrogen dioxide at Rolling Green (2010–19)

Trend station/region: Rolling Green

AAQ NEPM standard

0.12 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	87.5	0	0.030	0.022	0.019	0.017	0.016
2011	97.1	0	0.023	0.019	0.018	0.015	0.013
2012	91.9	0	0.029	0.019	0.017	0.016	0.014
2013	96.5	0	0.030	0.018	0.017	0.015	0.013
2014	97.2	0	0.021	0.017	0.015	0.013	0.013
2015	98.0	0	0.023	0.018	0.017	0.016	0.013
2016	97.5	0	0.023	0.016	0.016	0.013	0.012
2017	99.1	0	0.018	0.017	0.016	0.014	0.013
2018	99.8	0	0.023	0.018	0.016	0.014	0.012
2019	99.6	0	0.023	0.015	0.015	0.012	0.011

Table D18 Daily peak one-hour nitrogen dioxide at South Lake (2010–19)

Trend station/region: South Lake

AAQ NEPM standard

0.12 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	87.8	0	0.058	0.045	0.040	0.036	0.030
2011	96.1	0	0.041	0.033	0.032	0.030	0.028
2012	98.7	0	0.046	0.038	0.035	0.031	0.028
2013	97.1	0	0.043	0.037	0.033	0.031	0.027
2014	99.5	0	0.034	0.032	0.029	0.028	0.026
2015	98.7	0	0.043	0.034	0.031	0.028	0.026
2016	95.0	0	0.038	0.030	0.029	0.027	0.025
2017	97.3	0	0.045	0.034	0.030	0.028	0.026
2018	98.9	0	0.047	0.035	0.033	0.029	0.027
2019	97.9	0	0.036	0.031	0.030	0.028	0.026

Table D19 Daily peak one-hour nitrogen dioxide at Swanbourne (2010–19)

Trend station/region: Swanbourne

AAQ NEPM standard

0.12 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	86.6	0	0.038	0.033	0.032	0.031	0.029
2011	99.4	0	0.032	0.029	0.028	0.026	0.024
2012	98.4	0	0.045	0.033	0.032	0.030	0.027
2013	99.6	0	0.037	0.033	0.031	0.027	0.025
2014	99.8	0	0.036	0.029	0.028	0.024	0.022
2015	99.5	0	0.036	0.034	0.030	0.027	0.023
2016	96.1	0	0.030	0.028	0.026	0.024	0.020
2017	99.8	0	0.033	0.032	0.030	0.026	0.022
2018	99.3	0	0.039	0.031	0.029	0.026	0.021
2019	98.9	0	0.037	0.031	0.029	0.026	0.022

Table D20 Daily peak one-hour ozone at Caversham (2010–19)

Trend station/region: Caversham

AAQ NEPM standard
0.10 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	84.5	0	0.082	0.069	0.059	0.055	0.046
2011	99.2	0	0.077	0.070	0.067	0.054	0.045
2012	97.5	0	0.098	0.078	0.064	0.052	0.047
2013	95.7	1	**0.101**	0.074	0.070	0.056	0.051
2014	96.3	0	0.091	0.065	0.058	0.052	0.047
2015	95.4	1	**0.103**	0.080	0.077	0.062	0.052
2016	99.6	0	0.096	0.066	0.062	0.053	0.046
2017	98.7	0	0.099	0.077	0.069	0.059	0.049
2018	99.8	0	0.067	0.059	0.056	0.049	0.045
2019	98.6	0	0.082	0.073	0.068	0.057	0.047

Bold numerals indicate where a relevant standard has been exceeded.

Table D21 Daily peak one-hour ozone at Quinns Rocks (2010–19)

Trend station/region: Quinns Rocks

AAQ NEPM standard
0.10 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	88.7	0	0.091	0.061	0.058	0.054	0.048
2011	99.1	0	0.083	0.068	0.057	0.051	0.045
2012	95.7	1	**0.130**	0.073	0.069	0.058	0.048
2013	99.2	0	0.087	0.077	0.066	0.058	0.050
2014	99.3	0	0.073	0.065	0.062	0.052	0.045
2015	98.9	0	0.083	0.070	0.064	0.057	0.049
2016	98.7	0	0.089	0.066	0.061	0.056	0.048
2017	21.5	0	0.066	0.064	0.061	0.056	0.051
2018	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-

Table D22 Daily peak one-hour ozone at Rockingham (2010–19)

Trend station/region: Rockingham

AAQ NEPM standard
0.10 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	88.2	0	0.067	0.060	0.057	0.052	0.044
2011	94.9	0	0.065	0.062	0.057	0.048	0.043
2012	99.0	0	0.095	0.073	0.064	0.053	0.044
2013	98.8	0	0.084	0.068	0.065	0.052	0.044
2014	99.0	0	0.076	0.060	0.053	0.047	0.039
2015	98.9	0	0.069	0.062	0.061	0.052	0.045
2016	98.8	0	0.087	0.064	0.060	0.051	0.044
2017	99.1	0	0.069	0.060	0.058	0.051	0.042
2018	99.8	0	0.061	0.049	0.045	0.042	0.038
2019	97.2	0	0.079	0.062	0.058	0.050	0.043

Table D23 Daily peak one-hour ozone at Rolling Green (2010–19)

Trend station/region: Rolling Green

AAQ NEPM standard
0.10 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	85.6	0	0.088	0.077	0.070	0.056	0.046
2011	95.9	0	0.073	0.068	0.060	0.052	0.043
2012	91.8	1	**0.103**	0.074	0.066	0.055	0.045
2013	96.8	0	0.099	0.078	0.071	0.061	0.049
2014	98.1	0	0.080	0.069	0.063	0.056	0.047
2015	99.2	1	**0.105**	0.078	0.073	0.062	0.055
2016	97.5	0	0.075	0.070	0.063	0.053	0.047
2017	98.6	0	0.069	0.064	0.058	0.052	0.043
2018	98.0	0	0.075	0.063	0.062	0.055	0.049
2019	97.9	1	**0.100***	0.079	0.072	0.063	0.055

Bold numerals indicate where a relevant standard has been exceeded.
* Actual concentration was 0.1001ppm which makes this event a NEPM exceedance

Table D24 Daily peak one-hour ozone at South Lake (2010–19)

Trend station/region: South Lake

AAQ NEPM standard
0.10 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	88.0	0	0.070	0.067	0.062	0.052	0.045
2011	99.4	0	0.076	0.064	0.057	0.050	0.044
2012	98.2	0	0.085	0.065	0.062	0.051	0.041
2013	98.6	0	0.087	0.074	0.062	0.054	0.043
2014	99.4	0	0.065	0.059	0.056	0.046	0.041
2015	98.8	0	0.067	0.063	0.060	0.051	0.042
2016	99.6	0	0.091	0.065	0.056	0.050	0.043
2017	98.5	0	0.074	0.061	0.058	0.050	0.043
2018	99.6	0	0.061	0.048	0.044	0.039	0.035
2019	98.1	0	0.083	0.062	0.057	0.047	0.040

Table D25 Daily peak one-hour ozone at Swanbourne (2010–19)

Trend station/region: Swanbourne

AAQ NEPM standard
0.10 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	86.6	0	0.066	0.059	0.056	0.050	0.044
2011	99.6	0	0.085	0.069	0.061	0.051	0.046
2012	98.2	1	**0.128**	0.074	0.067	0.056	0.047
2013	99.8	0	0.083	0.069	0.064	0.052	0.045
2014	97.8	0	0.066	0.056	0.053	0.048	0.042
2015	99.9	0	0.074	0.066	0.061	0.056	0.044
2016	98.7	1	**0.103**	0.067	0.064	0.054	0.046
2017	99.5	0	0.079	0.074	0.064	0.056	0.049
2018	99.8	0	0.075	0.054	0.050	0.046	0.044
2019	98.7	0	0.070	0.064	0.058	0.052	0.046

Bold numerals indicate where a relevant standard has been exceeded.

Table D26 Daily peak four-hour ozone at Caversham (2010–19)

Trend station/region: Caversham

AAQ NEPM standard

0.08 ppm (four-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	84.5	0	0.072	0.056	0.052	0.047	0.041
2011	99.2	0	0.063	0.061	0.056	0.049	0.041
2012	97.5	2	**0.086**	0.070	0.056	0.047	0.041
2013	95.7	0	0.075	0.065	0.060	0.049	0.044
2014	96.3	0	0.073	0.055	0.050	0.046	0.041
2015	95.4	1	**0.084**	0.070	0.067	0.054	0.046
2016	99.6	1	**0.085**	0.062	0.053	0.046	0.042
2017	98.7	0	0.077	0.068	0.060	0.050	0.044
2018	99.8	0	0.056	0.052	0.050	0.044	0.040
2019	98.6	0	0.065	0.061	0.057	0.049	0.042

Bold numerals indicate where a relevant standard has been exceeded.

Table D27 Daily peak four-hour ozone at Quinns Rocks (2010–19)

Trend station/region: Quinns Rocks

AAQ NEPM standard

0.08 ppm (four-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	88.7	0	0.065	0.056	0.052	0.048	0.042
2011	99.1	0	0.075	0.060	0.052	0.047	0.041
2012	95.7	2	**0.108**	0.065	0.061	0.051	0.043
2013	99.2	0	0.079	0.068	0.061	0.051	0.045
2014	99.3	0	0.062	0.057	0.051	0.046	0.042
2015	98.9	0	0.071	0.063	0.059	0.053	0.042
2016	98.7	0	0.079	0.060	0.058	0.050	0.044
2017	21.5	0	0.062	0.058	0.054	0.049	0.047
2018	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-

Bold numerals indicate where a relevant standard has been exceeded.

Table D28 Daily peak four-hour ozone at Rockingham (2010–19)

Trend station/region: Rockingham

AAQ NEPM standard

0.08 ppm (four-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	88.2	0	0.064	0.054	0.053	0.046	0.041
2011	94.9	0	0.061	0.058	0.053	0.045	0.040
2012	99.0	0	0.079	0.065	0.060	0.048	0.040
2013	98.8	0	0.075	0.064	0.057	0.047	0.042
2014	99.0	0	0.067	0.051	0.048	0.043	0.037
2015	98.9	0	0.064	0.056	0.055	0.047	0.041
2016	98.8	0	0.079	0.060	0.057	0.048	0.041
2017	99.1	0	0.062	0.057	0.053	0.046	0.039
2018	99.8	0	0.057	0.045	0.043	0.038	0.036
2019	97.2	0	0.067	0.058	0.053	0.044	0.039

Table D29 Daily peak four-hour ozone at Rolling Green (2010–19)

Trend station/region: Rolling Green

AAQ NEPM standard
0.08 ppm (four-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	85.6	0	0.080	0.065	0.056	0.049	0.042
2011	95.9	0	0.061	0.055	0.051	0.045	0.040
2012	91.8	1	**0.081**	0.064	0.058	0.049	0.042
2013	96.8	1	**0.083**	0.065	0.059	0.051	0.045
2014	98.1	0	0.070	0.058	0.054	0.048	0.042
2015	99.2	1	**0.093**	0.068	0.063	0.054	0.049
2016	97.5	0	0.066	0.059	0.056	0.047	0.042
2017	98.6	0	0.064	0.057	0.051	0.045	0.039
2018	98.0	0	0.067	0.057	0.053	0.048	0.043
2019	97.9	1	**0.087**	0.067	0.063	0.055	0.049

Bold numerals indicate where a relevant standard has been exceeded.

Table D30 Daily peak four-hour ozone at South Lake (2010–19)

Trend station/region: South Lake

AAQ NEPM standard
0.08 ppm (four-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	88.0	0	0.061	0.055	0.053	0.046	0.042
2011	99.4	0	0.064	0.056	0.051	0.046	0.039
2012	98.2	0	0.080	0.060	0.054	0.046	0.037
2013	98.6	0	0.074	0.063	0.057	0.048	0.039
2014	99.4	0	0.058	0.053	0.049	0.042	0.037
2015	98.8	0	0.060	0.055	0.053	0.045	0.037
2016	99.6	0	0.080	0.054	0.051	0.044	0.038
2017	98.5	0	0.067	0.055	0.052	0.045	0.038
2018	99.6	0	0.053	0.043	0.040	0.035	0.032
2019	98.1	0	0.076	0.056	0.051	0.042	0.037

Table D31 Daily peak four-hour ozone at Swanbourne (2010–19)

Trend station/region: Swanbourne

AAQ NEPM standard
0.08 ppm (four-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	86.6	0	0.055	0.053	0.050	0.044	0.040
2011	99.6	0	0.073	0.059	0.056	0.047	0.043
2012	98.2	1	**0.108**	0.064	0.061	0.051	0.042
2013	99.8	0	0.068	0.063	0.056	0.048	0.042
2014	97.8	0	0.057	0.050	0.049	0.043	0.038
2015	99.9	0	0.067	0.058	0.056	0.049	0.039
2016	98.7	1	**0.081**	0.062	0.057	0.050	0.042
2017	99.5	0	0.070	0.060	0.057	0.051	0.046
2018	99.8	0	0.063	0.051	0.047	0.043	0.041
2019	98.7	0	0.066	0.055	0.051	0.047	0.042

Bold numerals indicate where a relevant standard has been exceeded.

Table D32 Daily peak one-hour sulfur dioxide at Rockingham (2010–19)

Trend station/region: Rockingham

AAQ NEPM standard

0.20 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	89.9	0	0.037	0.022	0.019	0.013	0.009
2011	93.7	0	0.040	0.029	0.024	0.017	0.010
2012	94.4	0	0.040	0.020	0.018	0.011	0.008
2013	94.5	0	0.037	0.028	0.022	0.016	0.011
2014	93.9	0	0.036	0.024	0.021	0.013	0.008
2015	94.6	0	0.051	0.033	0.023	0.018	0.012
2016	96.1	0	0.064	0.041	0.035	0.020	0.013
2017	95.8	0	0.030	0.024	0.017	0.012	0.008
2018	95.4	0	0.031	0.021	0.019	0.013	0.008
2019	94.7	0	0.034	0.023	0.020	0.015	0.011

Table D33 Daily peak one-hour sulfur dioxide at South Lake (2010–19)

Trend station/region: South Lake

AAQ NEPM standard

0.20 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	87.8	0	0.073	0.036	0.033	0.025	0.017
2011	95.7	0	0.044	0.029	0.026	0.017	0.012
2012	94.0	0	0.039	0.027	0.019	0.014	0.010
2013	93.3	0	0.044	0.034	0.031	0.020	0.015
2014	94.5	0	0.051	0.028	0.024	0.016	0.012
2015	95.5	0	0.037	0.031	0.029	0.020	0.016
2016	97.4	0	0.034	0.020	0.017	0.014	0.011
2017	95.2	0	0.037	0.023	0.019	0.017	0.013
2018	97.4	0	0.022	0.016	0.015	0.012	0.010
2019	97.3	0	0.019	0.016	0.014	0.012	0.010

Table D34 Daily peak one-hour sulfur dioxide at Wattleup (2010–19)

Trend station/region: Wattleup

AAQ NEPM standard

0.20 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	86.8	0	0.057	0.049	0.043	0.036	0.023
2011	94.3	0	0.067	0.049	0.042	0.032	0.026
2012	94.7	0	0.043	0.039	0.034	0.025	0.017
2013	92.5	0	0.090	0.059	0.047	0.037	0.027
2014	95.1	0	0.061	0.046	0.037	0.031	0.024
2015	95.6	0	0.067	0.046	0.045	0.039	0.031
2016	94.5	0	0.072	0.055	0.048	0.033	0.025
2017	96.3	0	0.068	0.051	0.036	0.026	0.021
2018	97.0	0	0.038	0.033	0.029	0.023	0.017
2019	95.2	0	0.057	0.031	0.029	0.023	0.018

Table D35 Daily peak one-hour sulfur dioxide at Kalgoorlie (2010–19)

Trend station/region: Goldfields

AAQ NEPM standard
0.20 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	92.2	0	0.106	0.060	0.038	0.019	0.014
2019	95.7	0	0.082	0.053	0.038	0.020	0.012

Table D36 Daily peak 24-hour sulfur dioxide at Rockingham (2010–19)

Trend station/region: Rockingham

AAQ NEPM standard
0.08 ppm (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	89.9	0	0.007	0.004	0.003	0.002	0.002
2011	93.7	0	0.008	0.006	0.006	0.003	0.002
2012	94.4	0	0.006	0.005	0.003	0.002	0.002
2013	94.5	0	0.007	0.005	0.004	0.003	0.002
2014	93.9	0	0.007	0.005	0.004	0.003	0.002
2015	94.6	0	0.013	0.007	0.006	0.004	0.003
2016	96.1	0	0.014	0.010	0.007	0.004	0.002
2017	95.8	0	0.009	0.004	0.003	0.003	0.002
2018	95.4	0	0.007	0.004	0.004	0.003	0.002
2019	94.7	0	0.009	0.005	0.004	0.003	0.002

Table D37 Daily peak 24-hour sulfur dioxide at South Lake (2010–19)

Trend station/region: South Lake

AAQ NEPM standard
0.08 ppm (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	87.8	0	0.009	0.005	0.004	0.003	0.002
2011	95.7	0	0.006	0.004	0.003	0.002	0.002
2012	94.0	0	0.006	0.004	0.003	0.003	0.002
2013	93.3	0	0.014	0.005	0.004	0.003	0.002
2014	94.5	0	0.010	0.005	0.004	0.003	0.003
2015	95.5	0	0.007	0.006	0.005	0.005	0.004
2016	97.4	0	0.010	0.007	0.007	0.006	0.005
2017	95.2	0	0.009	0.008	0.008	0.006	0.005
2018	97.4	0	0.005	0.004	0.004	0.004	0.003
2019	97.3	0	0.006	0.005	0.005	0.004	0.004

Table D38 Daily peak 24-hour sulfur dioxide at Wattleup (2010–19)

Trend station/region: Wattleup

AAQ NEPM standard
0.08 ppm (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	86.8	0	0.010	0.008	0.006	0.005	0.003
2011	94.3	0	0.008	0.006	0.005	0.004	0.003
2012	94.7	0	0.008	0.005	0.004	0.003	0.002
2013	92.5	0	0.010	0.008	0.006	0.005	0.004
2014	95.1	0	0.008	0.007	0.006	0.005	0.004
2015	95.6	0	0.009	0.007	0.006	0.006	0.005
2016	94.5	0	0.011	0.006	0.005	0.004	0.003
2017	96.3	0	0.007	0.005	0.005	0.004	0.003
2018	97.0	0	0.007	0.006	0.005	0.004	0.003
2019	95.2	0	0.008	0.005	0.005	0.004	0.003

Table D39 Daily peak 24-hour sulfur dioxide at Kalgoorlie (2010–19)

Trend station/region: Goldfields

AAQ NEPM standard
0.08 ppm (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2010	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	92.2	0	0.008	0.006	0.004	0.003	0.002
2019	95.7	0	0.012	0.005	0.004	0.003	0.002

Table D40 Daily peak 24-hour particles as PM_{10} at Caversham (2010–19)

Trend station/region: Caversham

AAQ NEPM standard
50 µg/m^3 (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (µg/m^3)	99th percentile (µg/m^3)	98th percentile (µg/m^3)	95th percentile (µg/m^3)	90th percentile (µg/m^3)
2010	99.5	1	**63.4**	40.7	36.1	30.5	26.3
2011	99.1	1	**76.1**	33.2	30.2	27.3	23.8
2012	97.8	4	**68.7**	49.2	36.7	27.2	24.4
2013	97.4	1	**62.4**	34.4	30.7	26.2	23.6
2014	97.2	1	**52.6**	37.3	34.5	27.2	24.8
2015	95.7	0	46.8	40.7	37.4	30.4	26.3
2016	99.1	0	38.1	33.7	31.5	26.4	22.8
2017	98.6	3	**79.2**	43.3	32.6	27.8	25.0
2018	98.9	2	**77.9**	36.1	33.2	27.8	25.0
2019	82.1	1	**107.7**	42.1	38.1	29.6	27.0

Bold numerals indicate where a relevant standard has been exceeded.

Table D41 Daily peak 24-hour particles as PM_{10} at Duncraig (2010–19)

Trend station/region: Duncraig

AAQ NEPM standard
50 µg/m^3 (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (µg/m^3)	99th percentile (µg/m^3)	98th percentile (µg/m^3)	95th percentile (µg/m^3)	90th percentile (µg/m^3)
2010	99.4	0	47.9	33.1	30.8	25.1	22.7
2011	99.3	1	**65.9**	30.1	29.5	25.7	23.2
2012	99.4	2	**89.5**	35.5	28.3	26.1	23.0
2013	99.3	0	37.6	32.1	28.1	25.6	22.8
2014	99.4	1	**53.0**	31.2	28.1	25.1	22.4
2015	99.4	1	**82.7**	40.1	36.7	28.0	25.2
2016	99.6	0	40.0	34.2	29.7	25.8	21.8
2017	98.4	1	**51.4**	33.4	30.1	26.4	22.5
2018	99.3	1	**61.3**	33.1	28.0	24.1	21.4
2019	96.0	1	**68.1**	30.7	27.2	23.7	22.2

Bold numerals indicate where a relevant standard has been exceeded.

Table D42 Daily peak 24-hour particles as PM_{10} at South Lake (2010–19)

Trend station/region: South Lake

AAQ NEPM standard
50 µg/m^3 (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (µg/m^3)	99th percentile (µg/m^3)	98th percentile (µg/m^3)	95th percentile (µg/m^3)	90th percentile (µg/m^3)
2010	99.7	4	**61.0**	46.7	39.8	33.9	28.5
2011	99.2	1	**66.2**	35.8	31.5	28.1	24.8
2012	99.1	2	**81.5**	36.6	30.3	28.5	24.1
2013	98.6	0	38.8	34.4	32.3	28.9	25.9
2014	99.4	0	44.5	38.2	34.0	29.4	26.3
2015	97.4	2	**53.3**	45.7	41.7	34.4	28.5
2016	99.5	0	47.0	38.7	33.4	28.9	24.3
2017	98.2	0	49.6	37.7	31.3	28.6	26.2
2018	99.6	1	**57.1**	40.7	34.3	26.7	23.7
2019	98.6	2	**98.8**	40.4	37.0	30.7	26.7

Bold numerals indicate where a relevant standard has been exceeded.

Table D43 Daily peak 24-hour particles as PM_{10} at Albany (2010–19)

Trend station/region: Albany

AAQ NEPM standard
50 µg/m^3 (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (µg/m^3)	99th percentile (µg/m^3)	98th percentile (µg/m^3)	95th percentile (µg/m^3)	90th percentile (µg/m^3)
2010	99.8	1	**52.5**	36.1	33.2	27.3	25.3
2011	99.3	0	37.3	33.6	30.6	26.3	22.0
2012	99.5	0	37.0	34.6	31.1	27.4	23.6
2013	98.1	3	**110.8**	43.3	36.0	29.1	23.8
2014	98.6	0	43.5	35.5	31.4	28.1	24.4
2015	99.1	2	**76.7**	37.3	34.7	28.4	24.5
2016	95.5	6	**94.9**	**56.5**	45.2	35.1	28.7
2017	99.5	2	**61.8**	46.7	41.4	30.7	25.8
2018	93.5	2	**89.6**	43.9	30.1	26.3	21.8
2019	98.2	1	**128.5**	35.5	30.9	27.1	22.5

Bold numerals indicate where a relevant standard has been exceeded.

Table D44 Daily peak 24-hour particles as PM_{10} at Bunbury (2010–19)

Trend station/region: Bunbury

AAQ NEPM standard
50 µg/m^3 (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (µg/m^3)	99th percentile (µg/m^3)	98th percentile (µg/m^3)	95th percentile (µg/m^3)	90th percentile (µg/m^3)
2010	99.1	2	**134.0**	37.6	36.0	29.3	25.3
2011	99.6	2	**68.4**	39.3	33.8	28.0	23.8
2012	99.5	2	**53.5**	40.0	32.9	26.5	24.1
2013	98.9	0	46.8	38.1	33.5	26.8	22.6
2014	98.1	0	44.5	31.7	26.2	24.6	22.8
2015	99.7	3	**62.9**	48.6	40.6	35.6	27.2
2016	97.5	2	**74.6**	44.4	33.0	28.6	24.9
2017	99.6	0	45.5	36.1	32.9	27.8	24.5
2018	99.6	1	**51.9**	37.8	35.2	27.8	24.4
2019	98.9	3	**131.0**	38.4	31.8	26.8	23.6

Bold numerals indicate where a relevant standard has been exceeded.

Table D45 Daily peak 24-hour particles as PM_{10} at Collie (2010–19)

Trend station/region: Collie

AAQ NEPM standard
50 µg/m^3 (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (µg/m^3)	99th percentile (µg/m^3)	98th percentile (µg/m^3)	95th percentile (µg/m^3)	90th percentile (µg/m^3)
2010	99.7	16	**163.0**	**86.7**	**67.3**	46.1	34.9
2011	97.6	4	**61.5**	**52.1**	40.4	32.0	29.2
2012	99.4	6	**91.7**	**54.9**	46.9	35.1	30.1
2013	99.0	3	**61.6**	46.0	41.3	36.0	32.0
2014	99.3	2	**73.3**	42.2	38.8	34.0	29.8
2015	99.0	10	**111.9**	**67.4**	**53.9**	41.9	37.8
2016	99.5	5	**89.9**	**51.0**	46.9	38.6	30.4
2017	96.8	11	**81.5**	**56.3**	**53.7**	42.5	33.7
2018	98.9	10	**84.6**	**57.4**	**52.4**	39.6	30.8
2019	99.7	7	**83.5**	**60.4**	48.6	39.5	33.9

Bold numerals indicate where a relevant standard has been exceeded.

Table D46 Daily peak 24-hour particles as PM_{10} at Geraldton (2010–19)

Trend station/region: Geraldton

AAQ NEPM standard
50 µg/m^3 (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (µg/m^3)	99th percentile (µg/m^3)	98th percentile (µg/m^3)	95th percentile (µg/m^3)	90th percentile (µg/m^3)
2010	97.7	4	**55.6**	49.3	47.8	41.6	37.9
2011	98.6	3	**63.0**	45.4	40.2	35.8	32.2
2012	99.6	3	**61.5**	47.0	45.3	40.2	33.8
2013	99.3	2	**63.1**	45.9	42.1	38.9	34.6
2014	98.8	4	**55.7**	49.7	47.1	41.4	37.5
2015	98.9	5	**68.1**	**54.5**	44.4	39.8	35.2
2016	96.7	3	**66.0**	49.3	42.1	37.3	32.1
2017	99.8	3	**73.5**	44.3	40.0	36.9	33.7
2018	96.0	3	**70.0**	42.2	41.0	36.7	31.8
2019	99.5	6	**88.4**	**51.5**	46.0	39.4	35.2

Bold numerals indicate where a relevant standard has been exceeded.

Table D47 Daily peak 24-hour particles as PM_{10} at Kalgoorlie (2010–19)
Trend station/region: Goldfields

AAQ NEPM standard
50 µg/m^3 (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (µg/m^3)	99th percentile (µg/m^3)	98th percentile (µg/m^3)	95th percentile (µg/m^3)	90th percentile (µg/m^3)
2010	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	93.6	1	**60.5**	31.8	29.3	22.8	20.6
2019	97.7	4	**67.6**	46.6	41.4	31.8	27.2

Bold numerals indicate where a relevant standard has been exceeded.

Table D48 Daily peak 24-hour particles as $PM_{2.5}$ at Caversham (2010–19)
Trend station/region: Caversham

AAQ NEPM standard
25 µg/m^3 (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (µg/m^3)	99th percentile (µg/m^3)	98th percentile (µg/m^3)	95th percentile (µg/m^3)	90th percentile (µg/m^3)
2010	99.1	3	**45.2**	21.9	16.2	13.7	12.1
2011	99.4	1	**41.5**	12.4	11.7	10.8	9.8
2012	96.9	3	**45.9**	19.2	15.9	12.3	10.6
2013	97.4	0	22.6	17.2	16.4	13.6	11.6
2014	97.0	1	**39.3**	16.2	15.2	14.1	11.9
2015	95.8	5	**30.0**	**27.2**	22.4	16.1	12.8
2016	99.5	0	24.1	17.0	14.2	12.6	10.9
2017	98.7	5	**65.9**	**31.3**	21.8	15.7	11.8
2018	99.5	2	**36.7**	20.6	17.3	14.8	11.6
2019	82.1	1	**25.4**	18.2	17.3	15.2	12.4

Bold numerals indicate where a relevant standard has been exceeded.

Table D49 Daily peak 24-hour particles as $PM_{2.5}$ at Duncraig (2010–19)
Trend station/region: Duncraig

AAQ NEPM standard
25 µg/m^3 (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (µg/m^3)	99th percentile (µg/m^3)	98th percentile (µg/m^3)	95th percentile (µg/m^3)	90th percentile (µg/m^3)
2010	99.3	3	**36.4**	20.1	15.9	13.7	12.0
2011	99.4	1	**52.1**	14.7	13.4	11.5	10.4
2012	97.5	3	**77.3**	22.0	14.4	12.7	11.0
2013	98.5	0	18.7	15.6	14.4	12.7	11.4
2014	99.7	1	**47.6**	16.8	15.3	13.0	11.0
2015	99.6	3	**35.8**	22.9	18.3	15.2	12.9
2016	99.4	1	**27.0**	15.9	15.4	12.0	10.9
2017	98.5	3	**40.5**	22.9	19.0	14.2	11.5
2018	99.4	1	**48.6**	19.3	15.6	12.9	11.1
2019	97.3	0	25.0	20.2	15.9	13.9	11.6

Bold numerals indicate where a relevant standard has been exceeded.

Table D50 Daily peak 24-hour particles as $PM_{2.5}$ at Quinns Rocks (2010–19)

Trend station/region: Quinns Rocks

AAQ NEPM standard
25 µg/m^3 (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (µg/m^3)	99th percentile (µg/m^3)	98th percentile (µg/m^3)	95th percentile (µg/m^3)	90th percentile (µg/m^3)
2010	99.6	3	**33.7**	17.6	14.5	12.0	10.9
2011	99.0	2	**43.2**	17.3	14.6	11.6	10.1
2012	96.5	4	**74.5**	22.7	14.3	11.9	10.6
2013	98.5	0	19.3	16.6	15.0	13.1	10.9
2014	98.8	2	**39.5**	15.8	14.5	13.4	11.7
2015	98.9	2	**37.9**	22.2	20.9	14.8	12.4
2016	98.7	2	**28.8**	18.4	14.8	12.7	10.8
2017	20.7	0	12.2	12.2	11.8	11.1	10.8
2018	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-

Bold numerals indicate where a relevant standard has been exceeded.

Table D51 Daily peak 24-hour particles as $PM_{2.5}$ at South Lake (2010–19)

Trend station/region: South Lake

AAQ NEPM standard
25 µg/m^3 (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (µg/m^3)	99th percentile (µg/m^3)	98th percentile (µg/m^3)	95th percentile (µg/m^3)	90th percentile (µg/m^3)
2010	99.5	2	**40.0**	22.0	19.2	15.9	13.2
2011	99.2	1	**48.2**	16.2	15.3	13.1	11.5
2012	99.0	4	**71.6**	25.0	19.3	14.6	13.2
2013	98.6	0	17.1	15.2	14.9	14.0	11.7
2014	98.7	2	**29.8**	17.7	15.0	13.4	11.5
2015	97.0	5	**34.5**	**29.8**	22.8	17.0	13.4
2016	99.6	3	**30.4**	17.2	15.3	13.1	11.6
2017	98.4	3	**46.6**	24.2	19.8	14.5	12.8
2018	99.7	5	**43.3**	**27.6**	20.2	15.0	12.3
2019	98.7	2	**28.9**	18.0	16.0	13.5	12.4

Bold numerals indicate where a relevant standard has been exceeded.

Table D52 Daily peak 24-hour particles as $PM_{2.5}$ at Bunbury (2010–19)

Trend station/region: Bunbury

AAQ NEPM standard
25 µg/m^3 (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (µg/m^3)	99th percentile (µg/m^3)	98th percentile (µg/m^3)	95th percentile (µg/m^3)	90th percentile (µg/m^3)
2010	98.6	7	**115.3**	**28.4**	24.2	14.8	12.2
2011	98.9	5	**45.5**	**26.6**	18.7	13.2	11.2
2012	99.6	7	**43.0**	**26.3**	21.0	14.9	12.8
2013	99.3	1	**38.3**	16.6	15.7	14.0	11.5
2014	98.4	1	**34.6**	16.1	15.0	13.3	11.7
2015	97.6	9	**52.1**	**35.0**	**30.2**	20.2	14.4
2016	99.7	6	**61.5**	**33.6**	22.4	14.9	12.2
2017	99.5	6	**33.9**	**27.2**	21.5	14.3	12.7
2018	99.7	5	**38.4**	**26.0**	22.2	17.2	12.5
2019	99.0	6	**118.2**	**27.3**	22.5	14.2	12.1

Bold numerals indicate where a relevant standard has been exceeded.

Table D53 Daily peak 24-hour particles as $PM_{2.5}$ at Busselton (2010–19)

Trend station/region: Busselton

AAQ NEPM standard
25 µg/m^3 (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (µg/m^3)	98th percentile (µg/m^3)	95th percentile (µg/m^3)	90th percentile (µg/m^3)
2010	99.4	7	**62.5**	**31.6**	22.9	15.7	11.6
2011	99.8	6	**85.2**	**36.7**	20.5	13.9	11.4
2012	99.6	5	**78.0**	**27.1**	21.4	13.4	11.8
2013	98.6	0	17.9	16.6	15.5	12.9	10.9
2014	99.6	1	25.1	13.2	12.4	11.1	10.2
2015	99.1	4	**37.8**	24.4	21.3	18.6	13.9
2016	99.5	4	**61.1**	22.8	17.5	13.7	11.3
2017	97.8	1	**28.8**	22.8	18.0	14.9	12.2
2018	97.0	7	**56.5**	**28.9**	22.2	16.4	11.3
2019	97.8	5	**78.5**	**29.4**	21.6	13.2	11.0

Bold numerals indicate where a relevant standard has been exceeded.

Table D54 Daily peak 24-hour particles as $PM_{2.5}$ at Kalgoorlie (2010–19)

Trend station/region: Goldfields

AAQ NEPM standard
25 µg/m^3 (24-hour average)

Year	Data recovery (%)	No. of exceedances (days)	Max conc. (ppm)	99th percentile (µg/m^3)	98th percentile (µg/m^3)	95th percentile (µg/m^3)	90th percentile (µg/m^3)
2010	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	93.6	1	**36.2**	16.4	14.0	10.2	8.2
2019	97.7	3	**40.8**	24.1	22.1	16.6	12.8

Bold numerals indicate where a relevant standard has been exceeded.

D.3 Maxima by pollutant 2010–19

Table D55 Peak eight-hour carbon monoxide concentrations (ppm) for 2010–19

AAQ NEPM standard
9.0 ppm (eight-hour average)

Regional performance monitoring station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Perth region										
Caversham (Northeast Metro)	1.6	1.5	0.9	0.9	0.7	1.2	0.9	2.9	1.1	1.0
Duncraig (North Metro)	2.3	1.9	2.4	2.1	1.9	1.7	1.4	1.4	1.5	1.2
South Lake (Southeast Metro)	2.2	1.7	2.2	1.7	1.8	1.9	2.3	1.9	1.9	1.4
Goldfields region										
Kalgoorlie	-	-	-	-	-	-	-	-	1.9	2.1

Table D56 Peak one-hour nitrogen dioxide concentrations (ppm) for 2010–19

AAQ NEPM standard
0.12 ppm (one-hour average)

Regional performance monitoring station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Perth region										
Caversham (Northeast Metro)	0.054	0.035	0.037	0.043	0.033	0.041	0.036	0.042	0.034	0.039
Duncraig (North Metro)	0.038	0.035	0.047	0.040	0.048	0.036	0.033	0.032	0.036	0.037
Quinns Rocks (Outer North Coast)	0.040	0.031	0.041	0.032	0.031	0.030	0.029	0.019	-	-
Rockingham (South Coast)	0.036	0.034	0.053	0.035	0.034	0.062	0.029	0.074	0.029	0.107
Rolling Green (Outer East Rural)	0.030	0.023	0.029	0.030	0.021	0.023	0.023	0.018	0.023	0.023
South Lake (South East Metro)	0.058	0.041	0.046	0.043	0.034	0.043	0.038	0.045	0.047	0.036
Swanbourne (Inner West Coast)	0.038	0.032	0.045	0.037	0.036	0.036	0.030	0.033	0.039	0.037

Table D57 Peak one-hour ozone concentrations (ppm) for 2010–19

AAQ NEPM standard
0.10 ppm (one-hour average)

Regional performance monitoring station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Perth region										
Caversham (Northeast Metro)	0.082	0.077	0.098	**0.101**	0.091	**0.103**	0.096	0.099	0.067	0.082
Quinns Rocks (Outer North Coast)	0.091	0.083	**0.130**	0.087	0.073	0.083	0.089	0.066	-	-
Rockingham (South Coast)	0.067	0.065	0.095	0.084	0.076	0.069	0.087	0.069	0.061	0.079
Rolling Green (Outer East Rural)	0.088	0.073	**0.103**	0.099	0.080	**0.105**	0.075	0.069	0.075	0.100
South Lake (South East Metro)	0.070	0.076	0.085	0.087	0.065	0.067	0.091	0.074	0.061	0.083
Swanbourne (Inner West Coast)	0.066	0.085	**0.128**	0.083	0.066	0.074	**0.103**	0.079	0.075	0.070

Bold numerals indicate where a relevant standard has been exceeded.

Table D58 Peak four-hour ozone concentrations (ppm) for 2010–19

AAQ NEPM standard
0.08 ppm (one-hour average)

Regional performance monitoring station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Perth region										
Caversham (Northeast Metro)	0.072	0.063	**0.086**	0.075	0.073	**0.084**	**0.085**	0.077	0.056	0.065
Quinns Rocks (Outer North Coast)	0.065	0.075	**0.108**	0.079	0.062	0.071	0.079	0.062	-	-
Rockingham (South Coast)	0.064	0.061	0.079	0.075	0.067	0.064	0.079	0.062	0.057	0.067
Rolling Green (Outer East Rural)	0.080	0.061	**0.081**	**0.083**	0.070	**0.093**	0.066	0.064	0.067	**0.087**
South Lake (South East Metro)	0.061	0.064	0.080	0.074	0.058	0.060	0.080	0.067	0.053	0.076
Swanbourne (Inner West Coast)	0.055	0.073	**0.108**	0.068	0.057	0.067	**0.081**	0.070	0.063	0.066

Bold numerals indicate where a relevant standard has been exceeded.

Table D59 Peak one-hour sulfur dioxide concentrations (ppm) for 2010–19

AAQ NEPM standard
0.20 ppm (one-hour average)

Regional performance monitoring station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Perth region										
Rockingham (South Coast)	0.037	0.040	0.040	0.037	0.036	0.051	0.064	0.030	0.031	0.034
South Lake (South East Metro)	0.073	0.044	0.039	0.044	0.051	0.037	0.034	0.037	0.022	0.019
Wattleup (South Metro)	0.057	0.067	0.043	0.090	0.061	0.067	0.072	0.068	0.038	0.057
Goldfields region										
Kalgoorlie	-	-	-	-	-	-	-	-	0.106	0.082

Table D60 Peak 24-hour sulfur dioxide concentrations (ppm) for 2010–19

AAQ NEPM standard
0.08 ppm (24-hour average)

Regional performance monitoring station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Perth region										
Rockingham (South Coast)	0.007	0.008	0.006	0.007	0.007	0.013	0.014	0.009	0.007	0.009
South Lake (South East Metro)	0.009	0.006	0.006	0.014	0.010	0.007	0.010	0.009	0.005	0.006
Wattleup (South Metro)	0.010	0.008	0.008	0.010	0.008	0.009	0.011	0.007	0.007	0.008
Goldfields region										
Kalgoorlie	-	-	-	-	-	-	-	-	0.008	0.012

Table D60a Annual averaged sulfur dioxide concentrations (ppm) for 2010–19

AAQ NEPM standard
0.02 ppm (annual average)

Regional performance monitoring station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Perth region										
Rockingham (South Coast)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
South Lake (South East Metro)	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.003	0.002	0.002
Wattleup (South Metro)	0.001	0.001	0.001	0.002	0.002	0.002	0.001	0.001	0.002	0.002
Goldfields region										
Kalgoorlie	-	-	-	-	-	-	-	-	0.001	0.001

Table D61 Peak 24-hour particles as PM_{10} concentrations ($\mu g/m^3$) for 2010–19

AAQ NEPM standard
50 $\mu g/m^3$ (24-hour average)

Regional performance monitoring station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Perth region										
Caversham (Northeast Metro)	**63.4**	**76.1**	**68.7**	**62.4**	**52.6**	46.8	38.1	**79.2**	**77.9**	**107.7**
Duncraig (North Metro)	47.9	**65.9**	**89.5**	37.6	**53.0**	**82.7**	40.0	**51.4**	**61.3**	**68.1**
South Lake (Southeast Metro)	**61.0**	**66.2**	**81.5**	38.8	44.5	**53.3**	47.0	49.6	**57.1**	**98.8**
Southwest region										
Bunbury	**134.0**	**68.4**	**53.5**	46.8	44.5	**62.9**	**74.6**	45.5	**51.9**	**131.0**
Collie	**163.0**	**61.5**	**91.7**	**61.6**	**73.3**	**111.9**	**89.9**	**81.5**	**84.6**	**83.5**
Albany	**52.5**	37.3	37.0	**110.8**	43.5	**76.7**	**94.9**	**61.8**	**89.6**	**128.5**
Midwest region										
Geraldton	**55.6**	**63.0**	**61.5**	**63.1**	**55.7**	**68.1**	**66.0**	**73.5**	**70.0**	**88.4**
Goldfields region										
Kalgoorlie	-	-	-	-	-	-	-	-	**60.5**	**67.6**

Bold numerals indicate where a relevant standard has been exceeded.
For explanation of this year's exceedances, please see Table A10 of this report.
For explanation of exceedances in previous years, please refer to the relevant year report.

Table D62 Peak 24-hour particles as $PM_{2.5}$ concentrations ($\mu g/m^3$) for 2010–19

AAQ NEPM standard
25 $\mu g/m^3$ (24-hour average)

Regional performance monitoring station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Perth region										
Caversham (Northeast Metro)	**45.2**	**41.5**	**45.9**	22.6	**39.3**	**30.0**	24.1	**65.9**	**36.7**	**25.4**
Duncraig (North Metro)	**36.4**	**52.1**	**77.3**	18.7	**47.6**	**35.8**	**27.0**	**40.5**	**48.6**	25.0
Quinns Rocks (Outer North Coast)	**33.7**	**43.2**	**74.5**	19.3	**39.5**	**37.9**	**28.8**	12.2	-	-
South Lake (Southeast Metro)	**40.0**	**48.2**	**71.6**	17.1	**29.8**	**34.5**	**30.4**	**46.6**	**43.3**	**28.9**
Southwest region										
Bunbury	**115.3**	**45.5**	**43.0**	**38.3**	**34.6**	**52.1**	**61.5**	**33.9**	**38.4**	**118.2**
Busselton	**62.5**	**85.2**	**78.0**	17.9	**25.1**	**37.8**	**61.1**	**28.8**	**56.5**	**78.5**
Goldfields region										
Kalgoorlie	-	-	-	-	-	-	-	-	**36.2**	**40.8**

Bold numerals indicate where a relevant standard has been exceeded.
For explanation of this year's exceedances, please see Table A10 of this report.
For explanation of exceedances in previous years, please refer to the relevant year report.

Table D63 Annual averaged particles as PM_{10} concentrations ($\mu g/m^3$) for 2010–19

AAQ NEPM standard
25 $\mu g/m^3$ (annual average)

Regional performance monitoring station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Perth region										
Caversham (Northeast Metro)	17.0	16.2	16.8	15.4	17.4	16.7	15.0	16.1	16.3	18.7
Duncraig (North Metro)	15.8	15.3	16.2	15.5	15.5	16.5	14.4	15.7	15.1	14.8
South Lake (Southeast Metro)	19.0	16.3	16.9	16.6	17.4	17.9	15.8	16.7	16.3	17.7
Southwest region										
Bunbury	17.6	17.0	17.5	16.8	16.1	17.5	16.5	16.5	16.1	16.6
Collie	22.8	19.6	20.0	20.1	19.2	22.4	19.3	21.7	19.3	22.0
Albany	15.9	14.5	15.0	15.4	16.0	15.9	17.5	16.6	14.6	15.3
Midwest region										
Geraldton	21.7	19.6	21.3	20.9	22.3	20.2	18.8	21.3	20.1	22.2
Goldfields region										
Kalgoorlie	-	-	-	-	-	-	-	-	12.8	15.2

Table D64: Annual averaged particles as $PM_{2.5}$ concentrations ($\mu g/m^3$) for 2010–19

AAQ NEPM standard
8 $\mu g/m^3$ (annual average)

Regional performance monitoring station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Perth region										
Caversham (Northeast Metro)	**8.2**	7.0	7.8	7.9	**8.1**	**8.5**	7.7	**8.5**	8.0	**8.3**
Duncraig (North Metro)	**8.2**	7.8	**8.2**	7.6	7.6	**8.4**	7.5	**8.2**	7.7	7.4
Quinns Rocks (Outer North Coast)	7.8	7.2	7.9	7.8	8.0	**8.3**	7.5	7.8	-	-
South Lake (Southeast Metro)	**8.7**	7.8	**8.9**	8.0	**8.1**	**8.8**	8.0	**8.7**	**8.4**	**8.2**
Southwest region										
Bunbury	**9.2**	8.0	**8.6**	7.8	7.8	**9.3**	**8.4**	**8.7**	**8.4**	**8.5**
Busselton	**8.5**	**8.5**	**8.6**	7.7	7.2	**8.6**	**8.1**	**8.2**	7.9	**8.1**
Goldfields region										
Kalgoorlie	-	-	-	-	-	-	-	-	5.1	5.6

Bold numerals indicate where a relevant standard has been exceeded.

E. Graphical trends

This section provides graphical representations of tables D9 to D54 of Section D.

Each graph shows the maximum, 99th percentile, 98th percentile, 95th percentile and 90th percentile of daily maximum concentration for all pollutants monitored by the department in Western Australia. The nominated percentiles can also be expressed as an Nth highest concentration.

Based on 100 per cent data recovery and a normal year (365 days), the following table gives each percentile an equivalent Nth highest ordinal value. The bracketed numbers represent the exact (as calculated) value of the ordinal number.

Percentile	Nth highest
100	1 (maximum)
99	5 (4.65)
98	8 (8.3)
95	19 (19.25)
90	38 (37.5)

E.1 Carbon monoxide

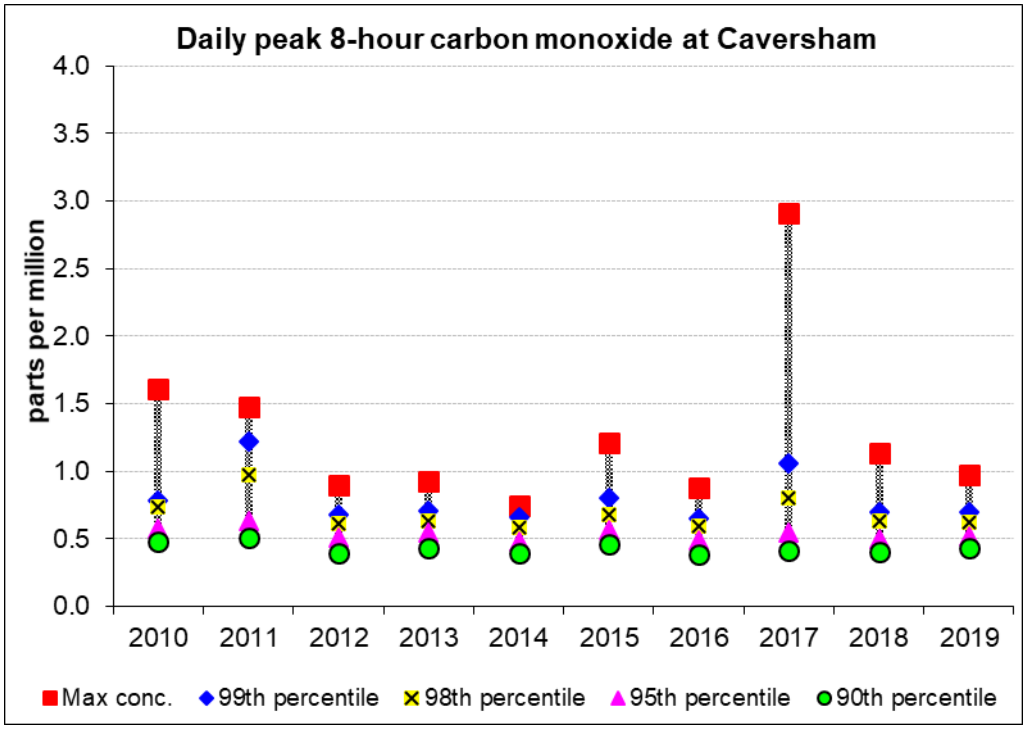


Figure E1-1: Eight-hour carbon monoxide at Caversham

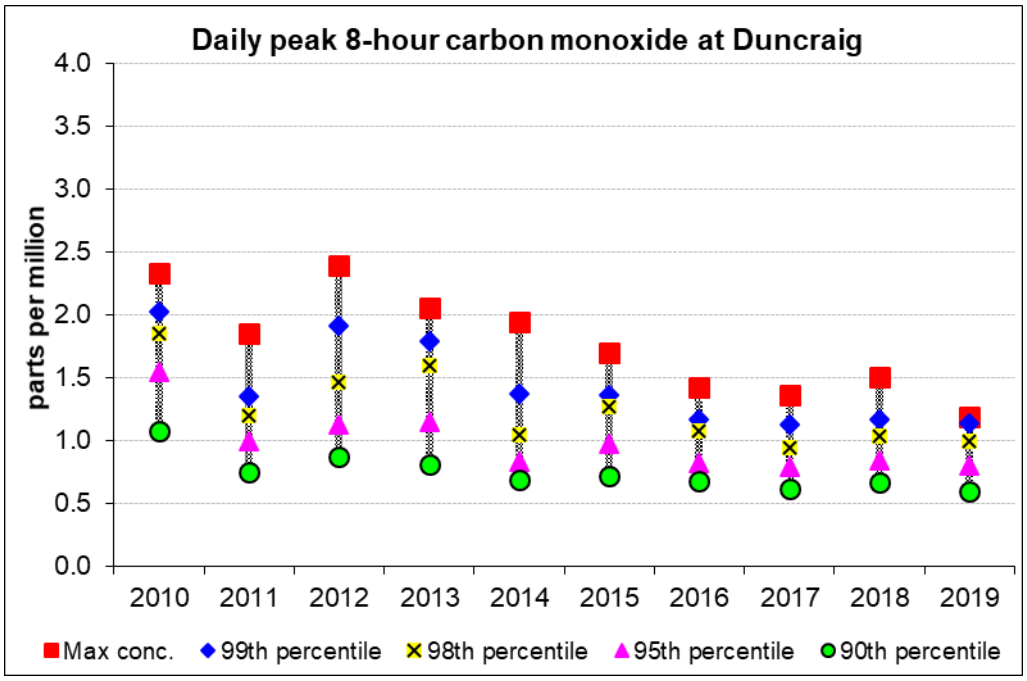


Figure E1-2: Eight-hour carbon monoxide at Duncraig

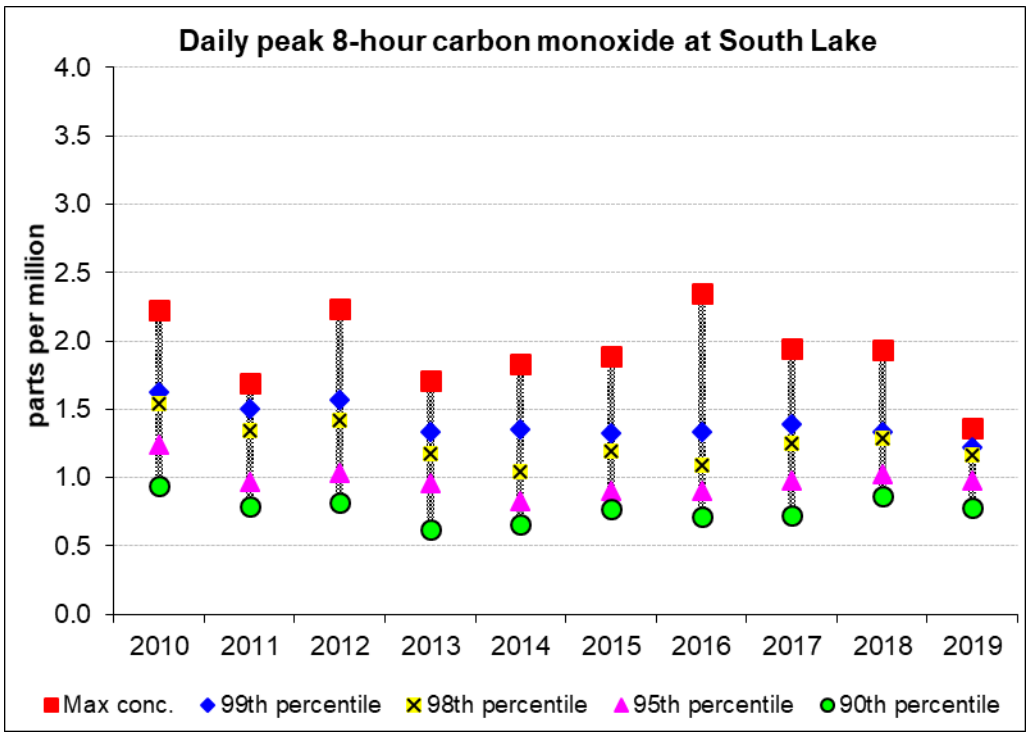


Figure E1-3: Eight-hour carbon monoxide at South Lake

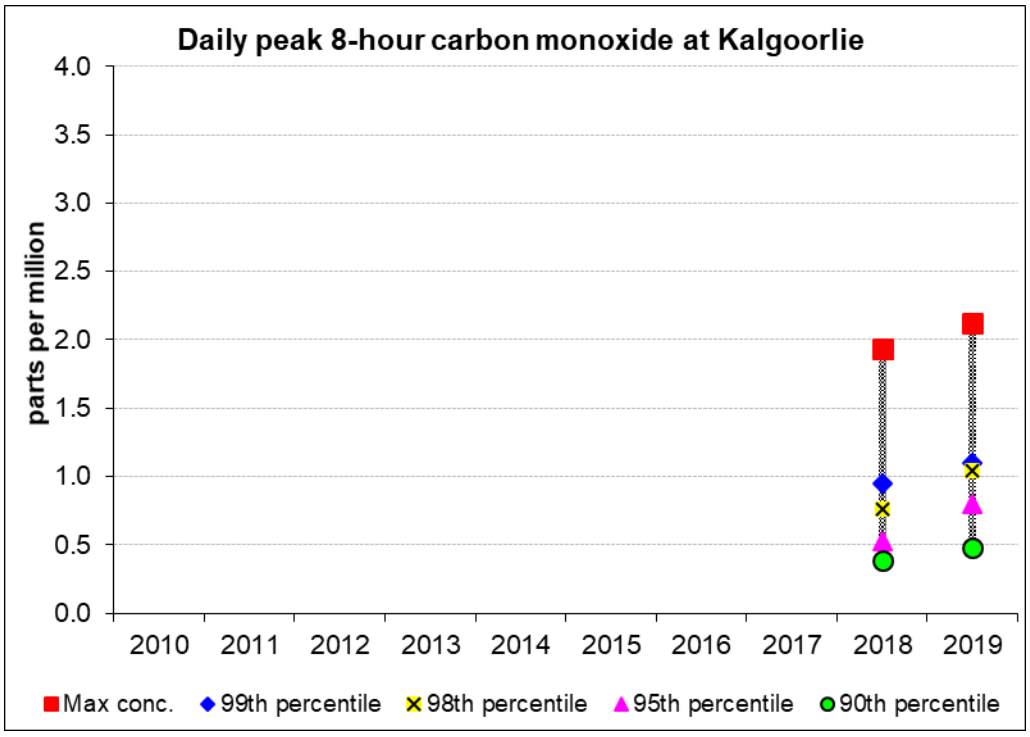


Figure E1-4: Eight-hour carbon monoxide at Kalgoorlie

E.2 Nitrogen dioxide

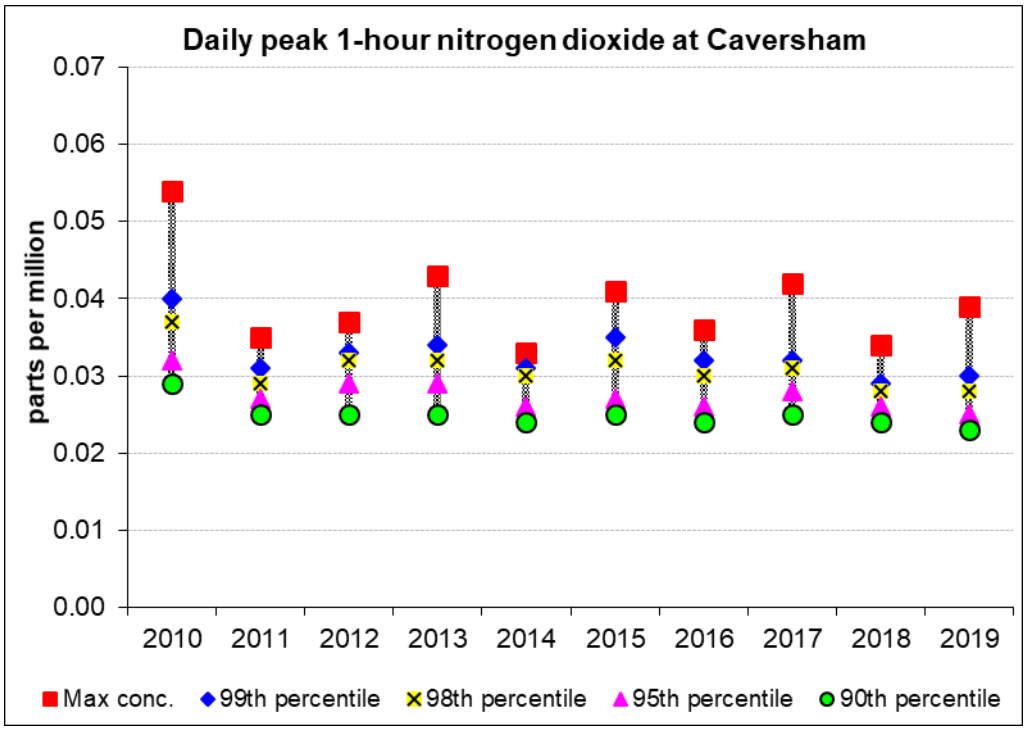


Figure E2-1: One-hour nitrogen dioxide at Caversham

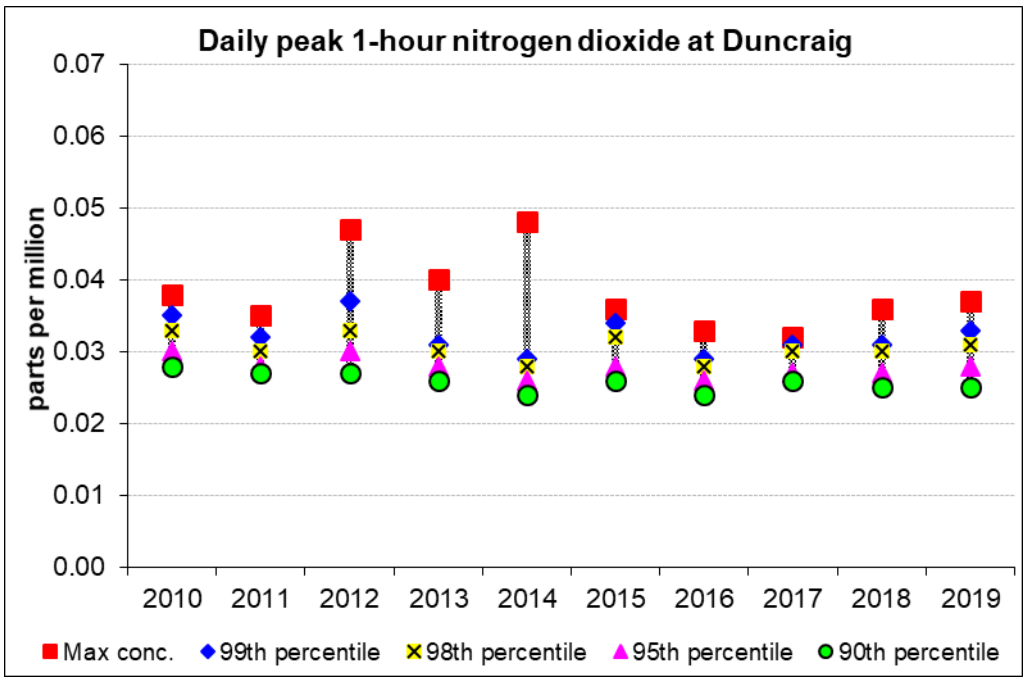


Figure E2-2: One-hour nitrogen dioxide at Duncraig

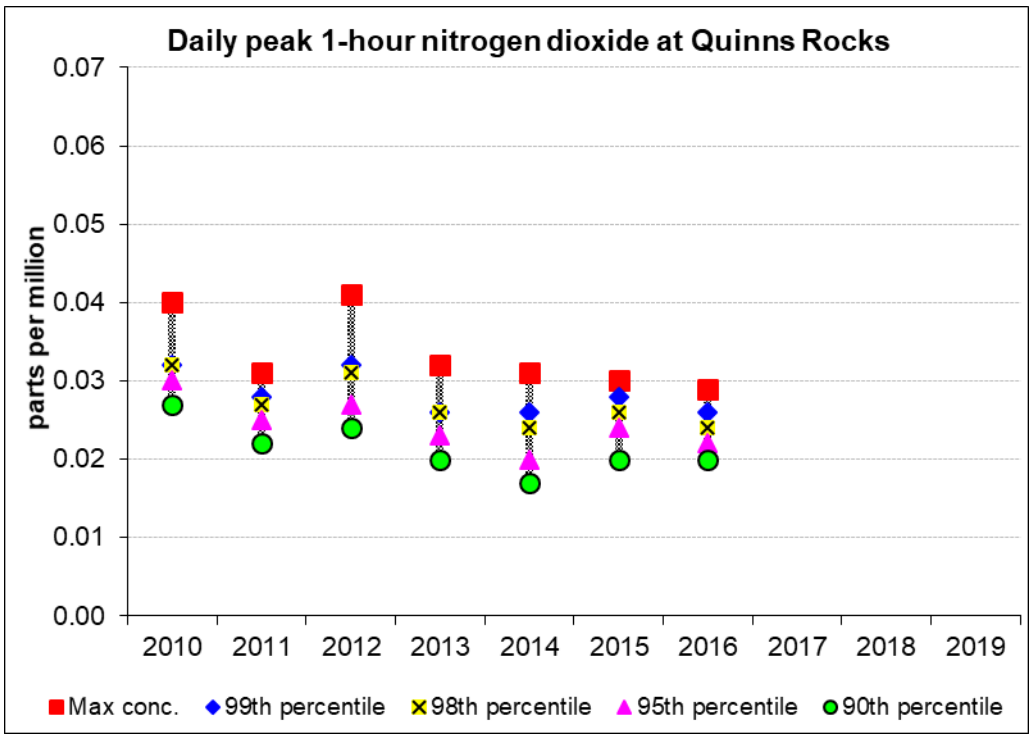


Figure E2-3: One-hour nitrogen dioxide at Quinns Rocks (2017–19 not included)

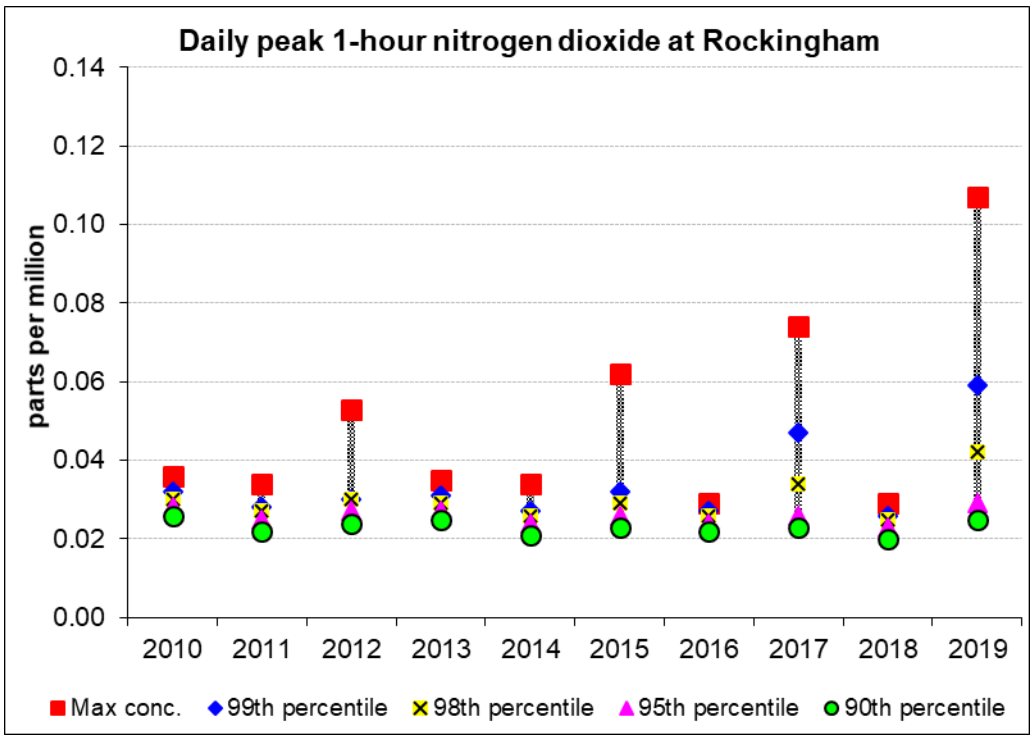


Figure E2-4: One-hour nitrogen dioxide at Rockingham

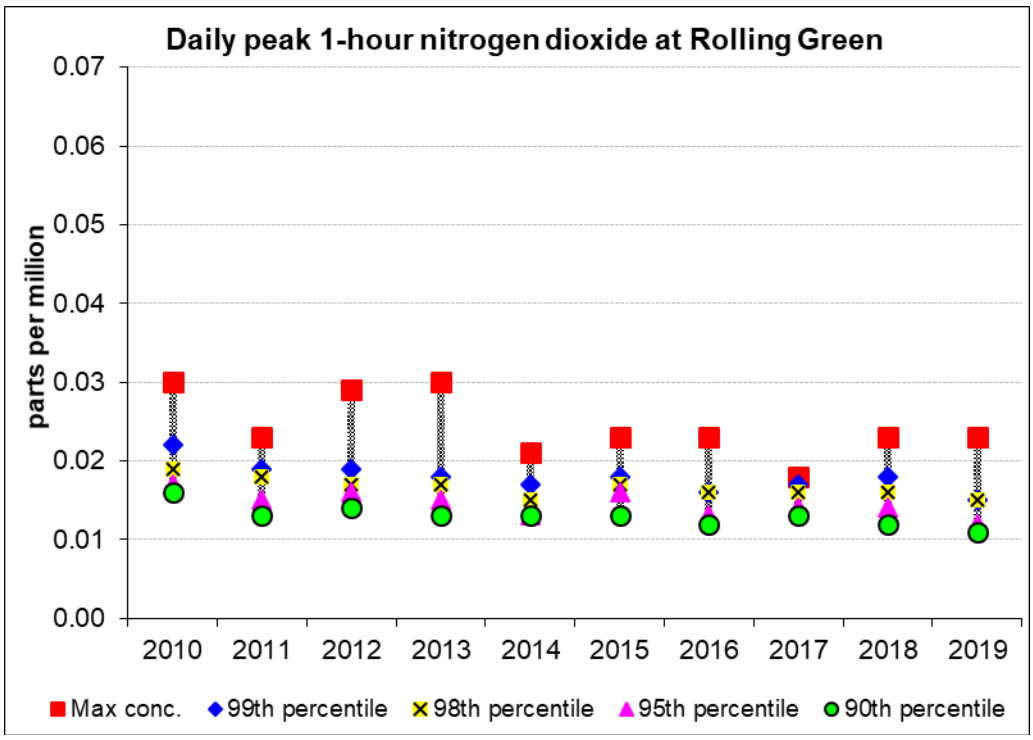


Figure E2-5: One-hour nitrogen dioxide at Rolling Green

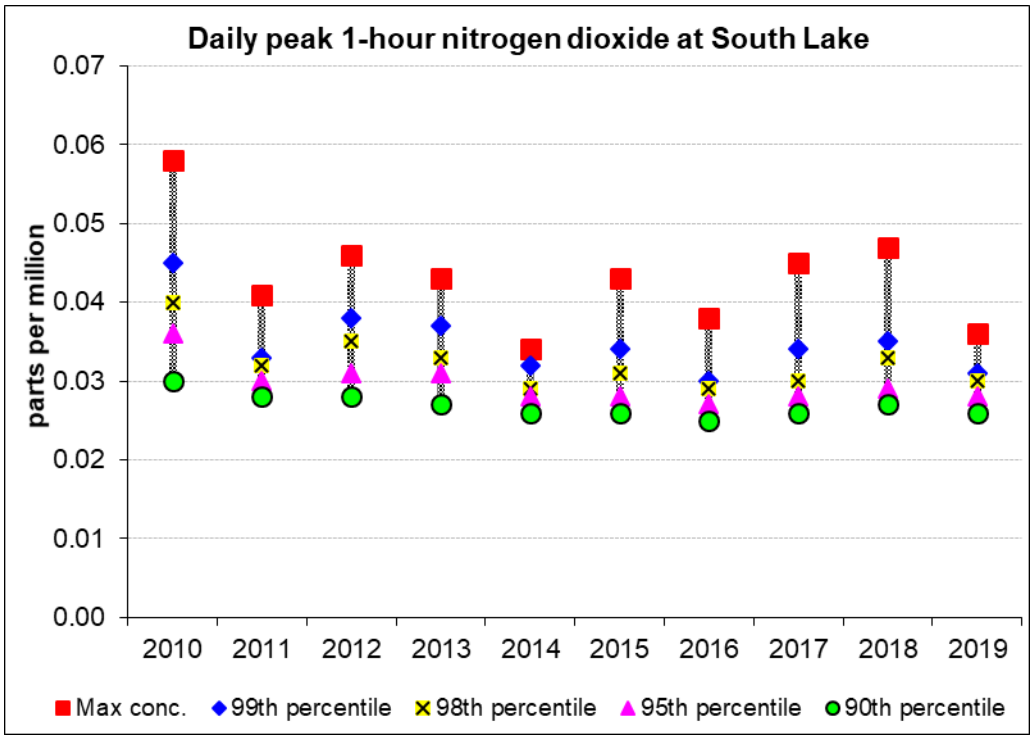


Figure E2-6: One-hour nitrogen dioxide at South Lake

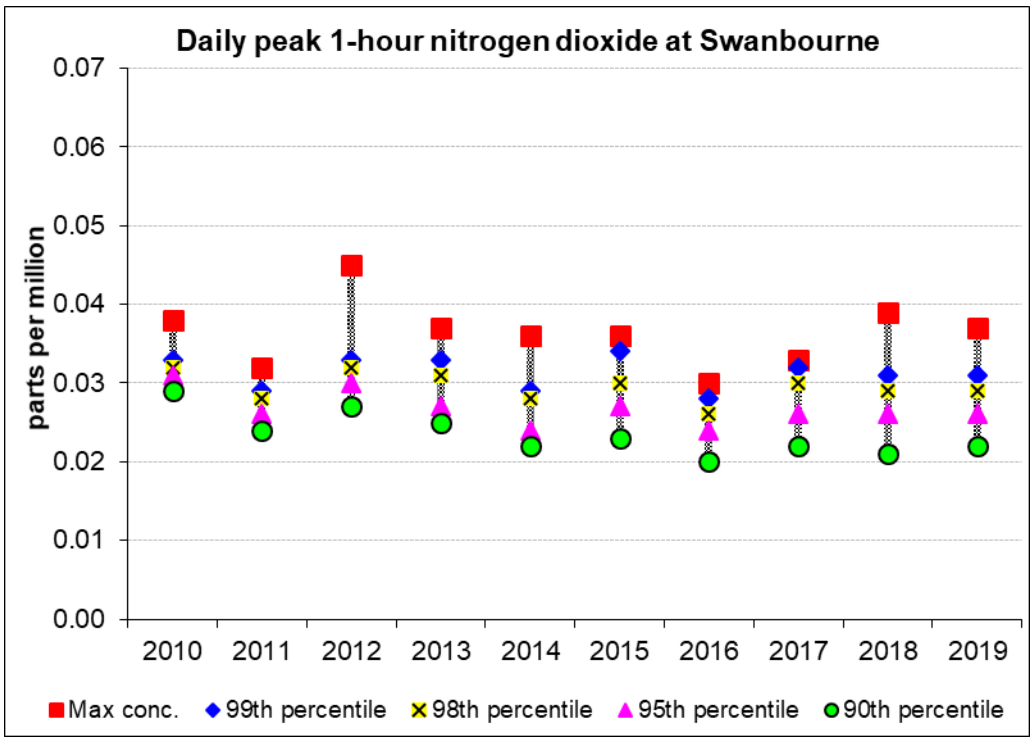


Figure E2-7: One-hour nitrogen dioxide at Swanbourne

E.3 Ozone

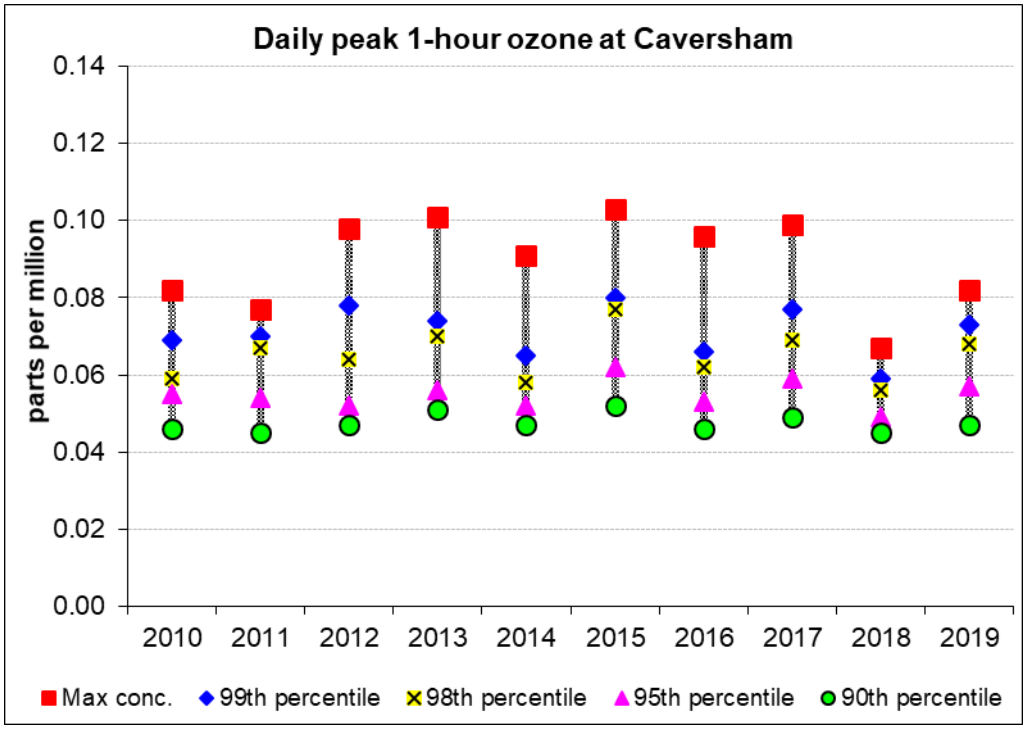


Figure E3-1: One-hour ozone at Caversham

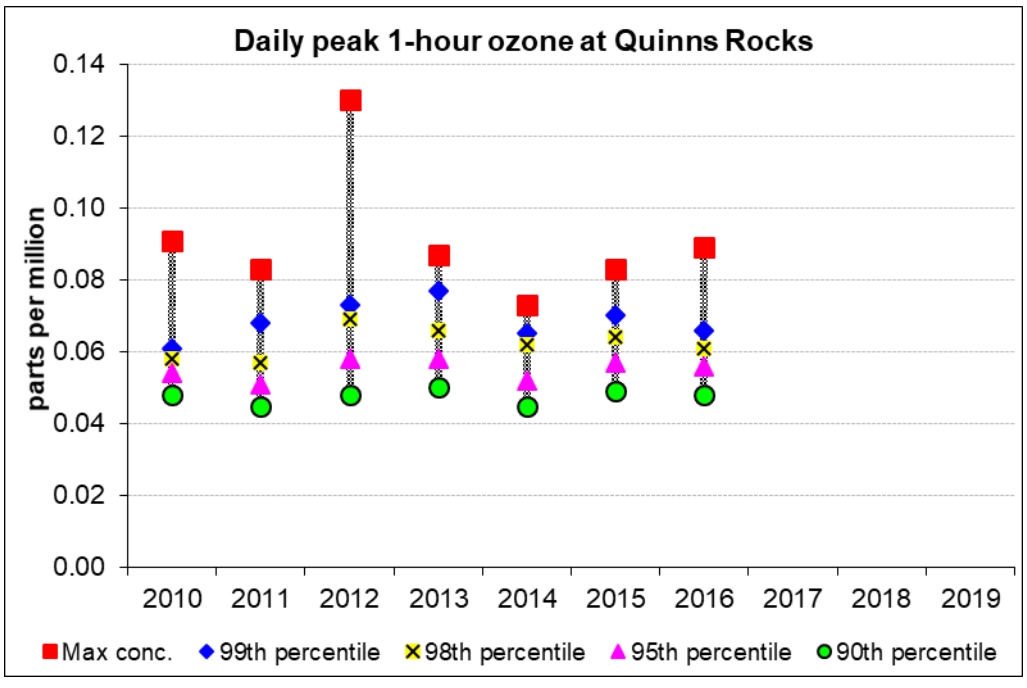


Figure E3-2: One-hour ozone at Quinns Rocks (2017–19 not included)

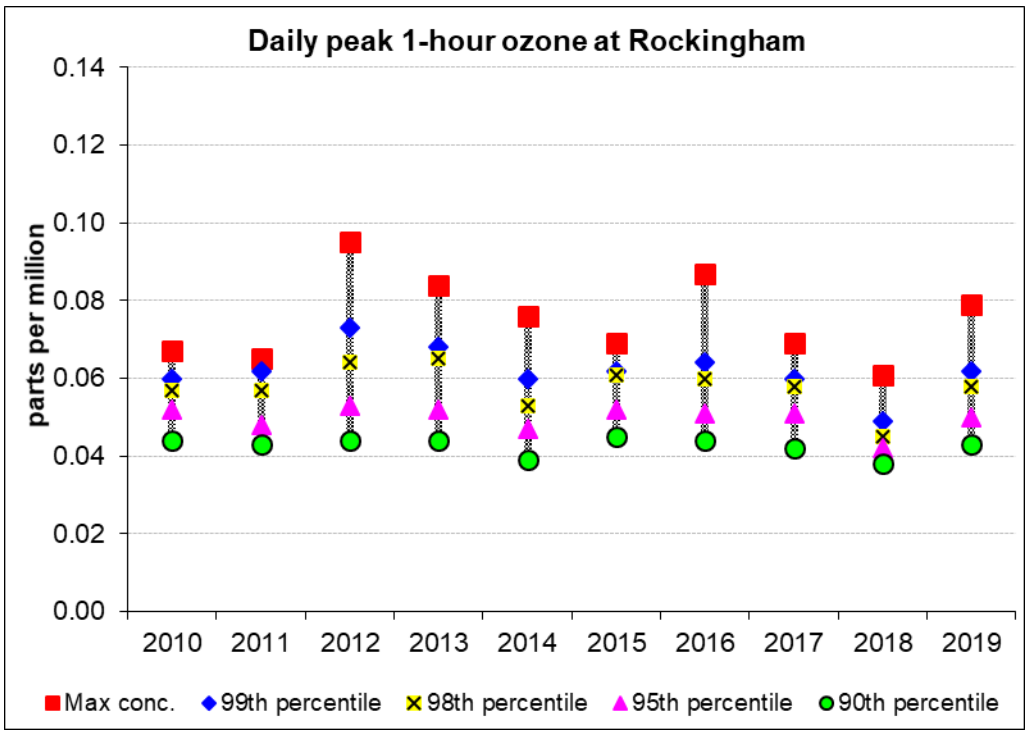


Figure E3-3: One-hour ozone at Rockingham

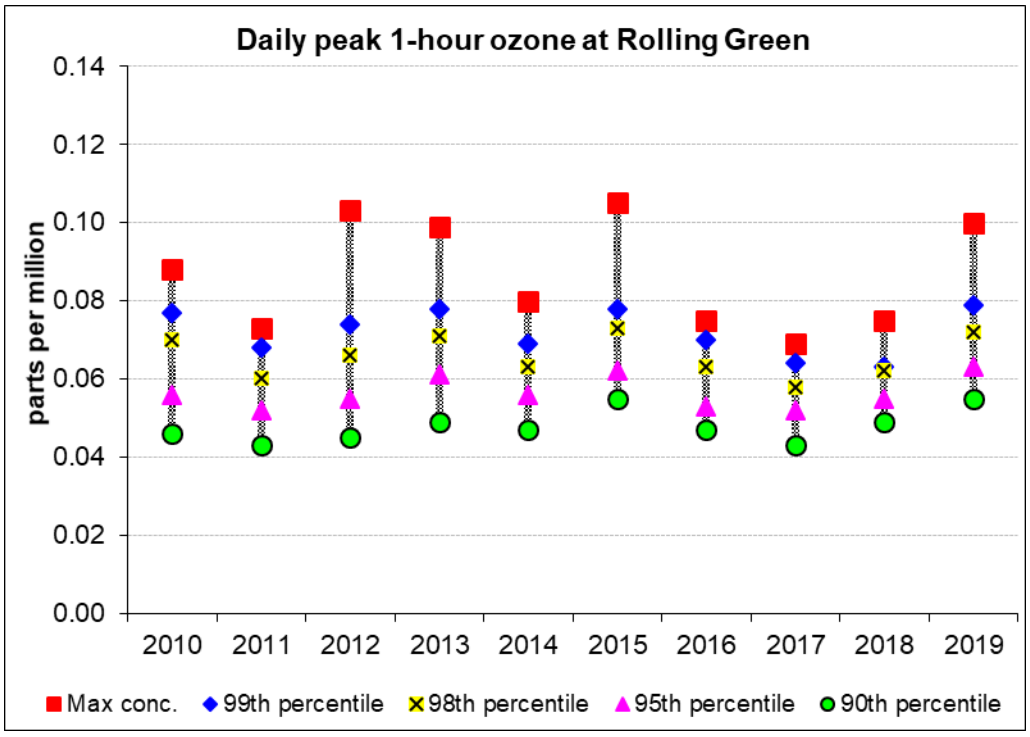


Figure E3-4: One-hour ozone at Rolling Green

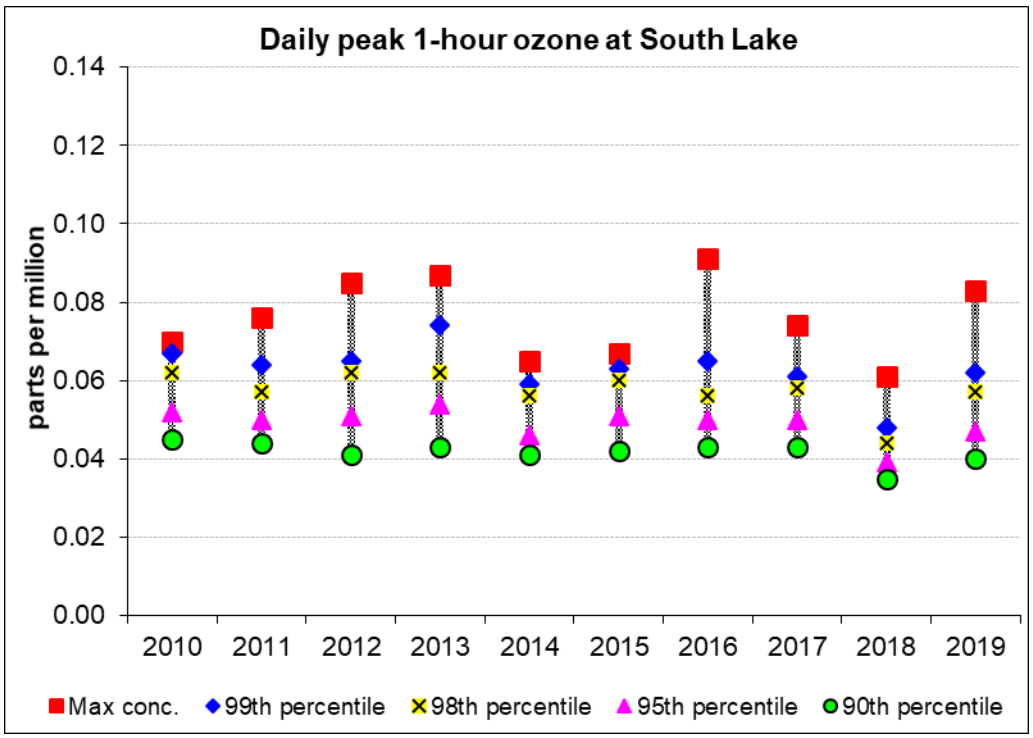


Figure E3-5: One-hour ozone at South Lake

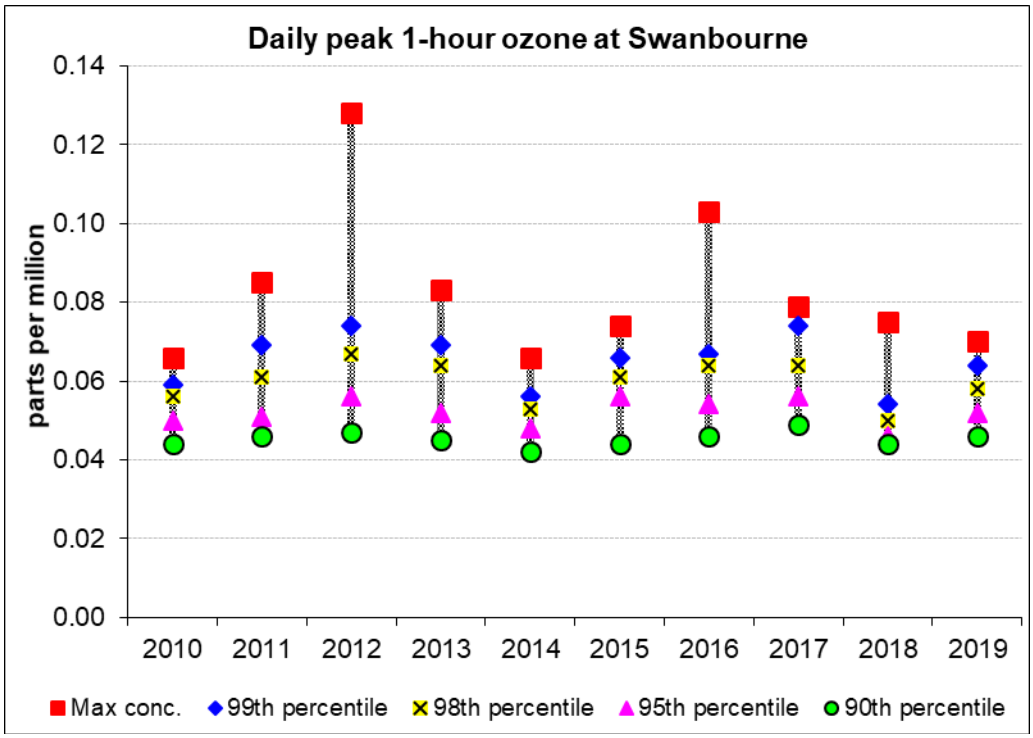


Figure E3-6: One-hour ozone at Swanbourne

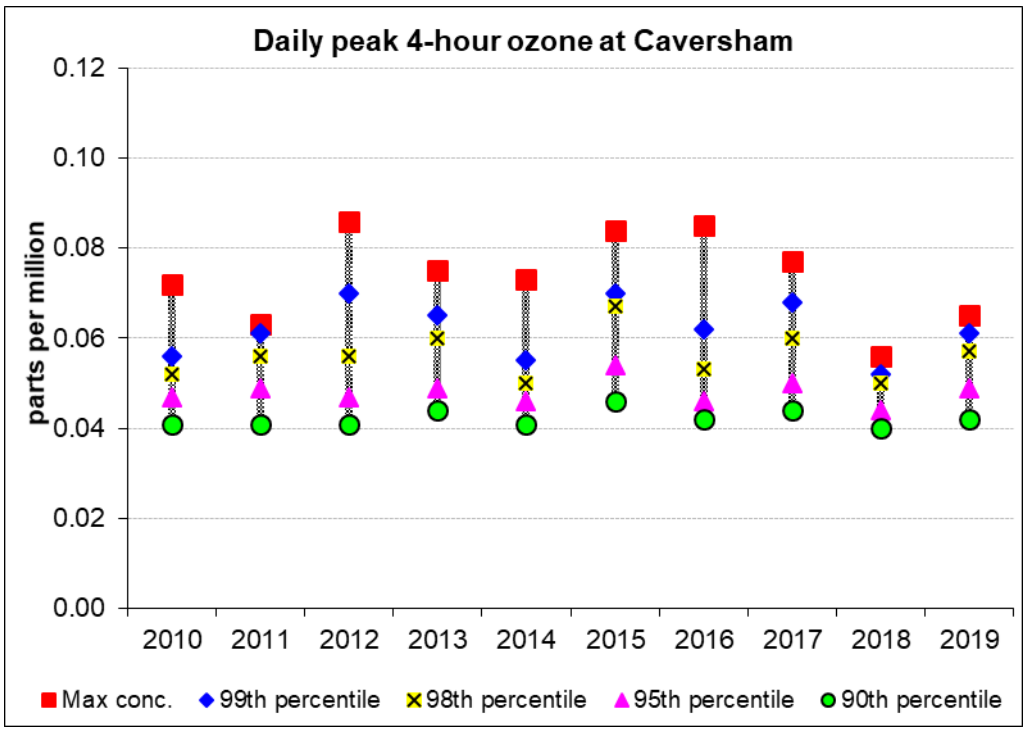


Figure E3-7: Four-hour ozone at Caversham

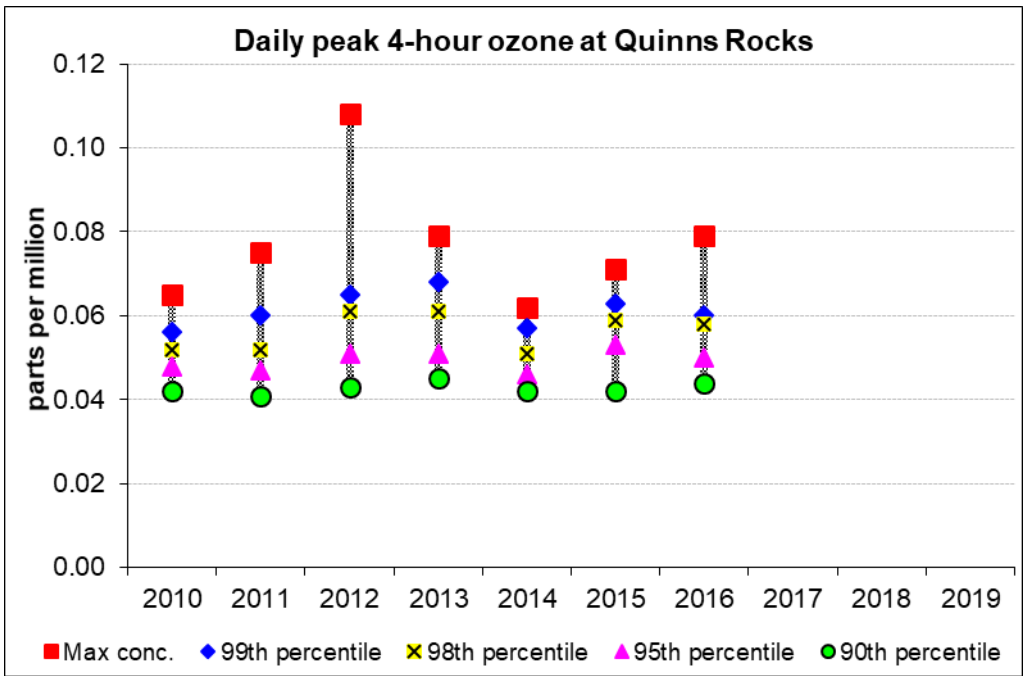


Figure E3-8: Four-hour ozone at Quinns Rocks (2017–19 not included)

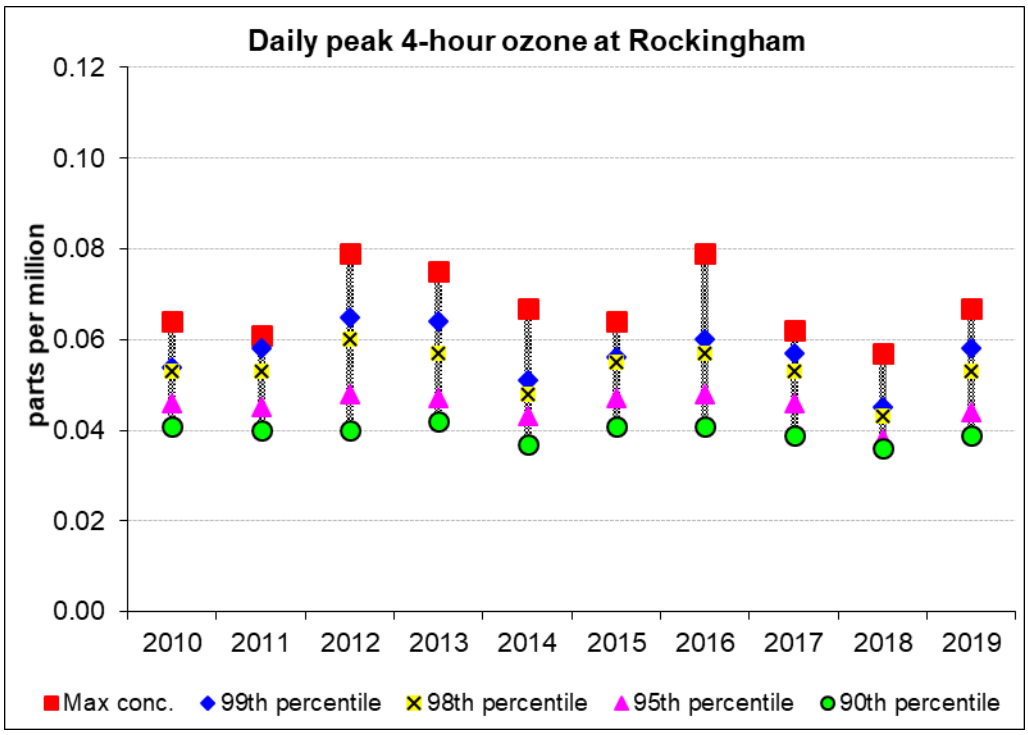


Figure E3-9: Four-hour ozone at Rockingham

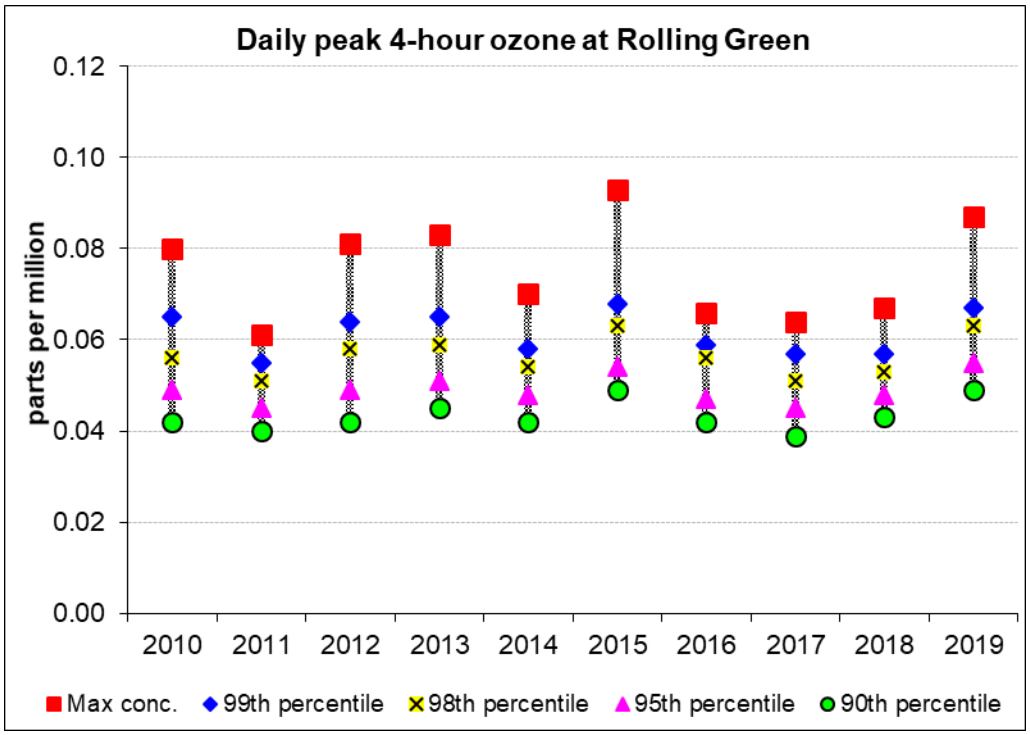


Figure E3-10: Four-hour ozone at Rolling Green

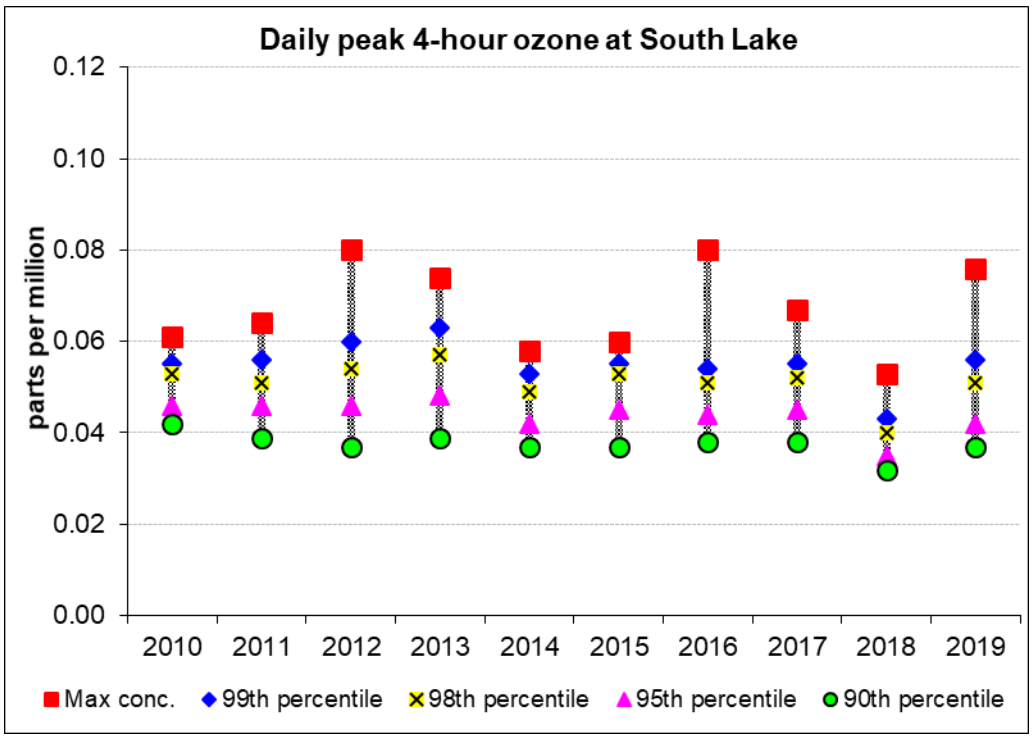


Figure E3-11: Four-hour ozone at South Lake

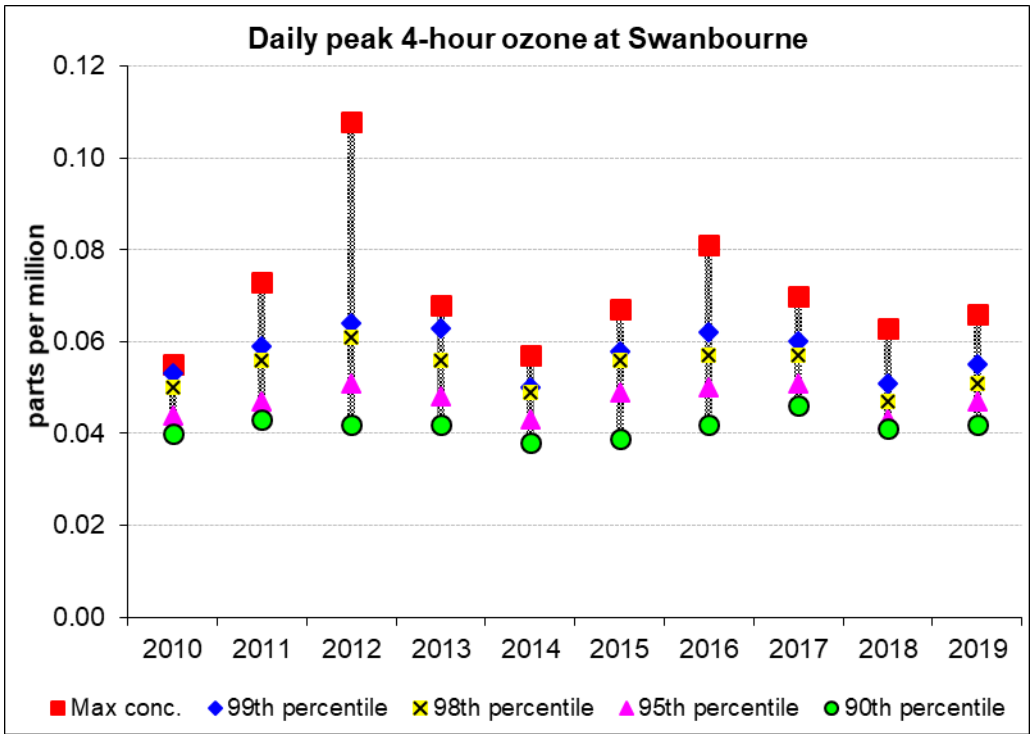


Figure E3-12: Four-hour ozone at Swanbourne

E.4 Sulfur dioxide

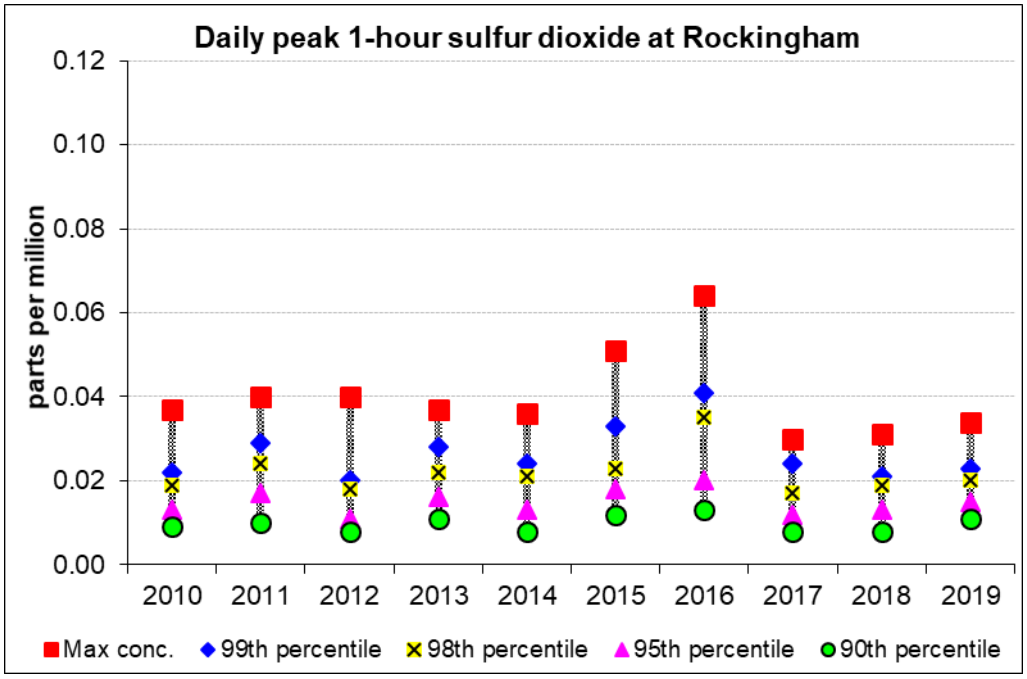


Figure E4-1: One-hour sulfur dioxide at Rockingham

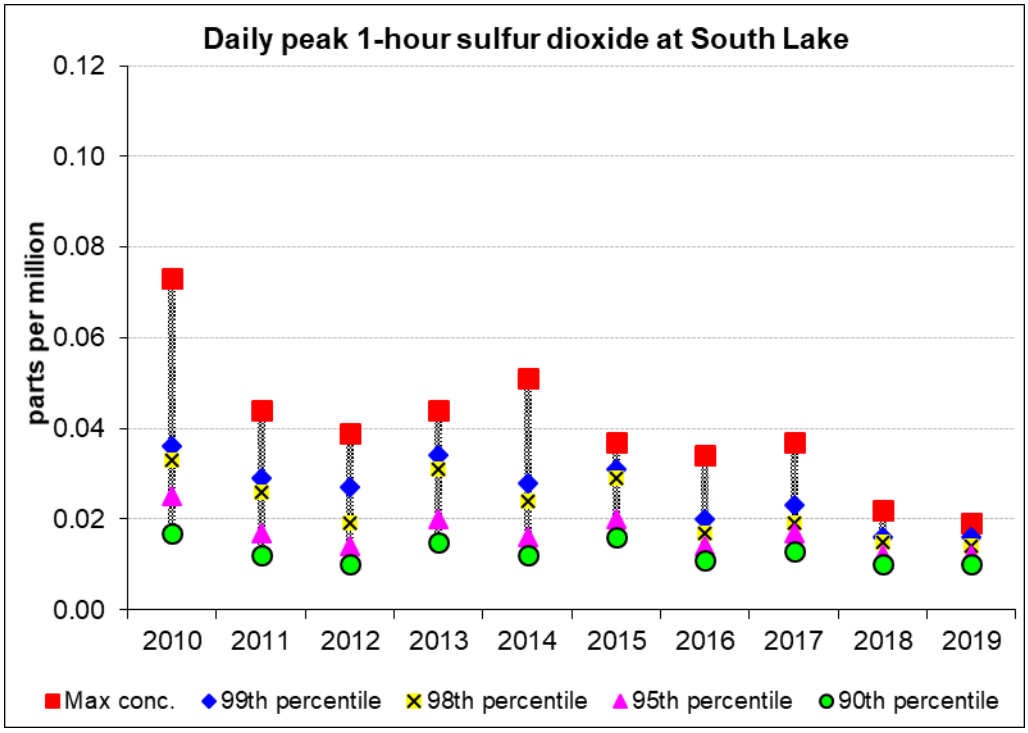


Figure E4-2: One-hour sulfur dioxide at South Lake

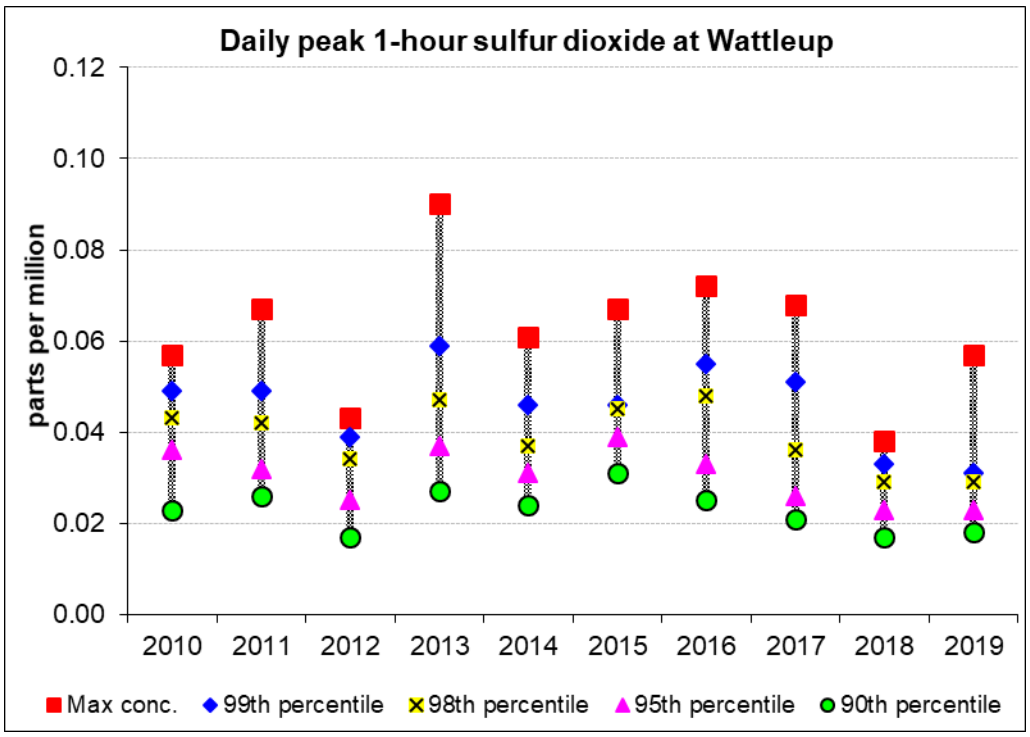


Figure E4-3: One-hour sulfur dioxide at Wattleup

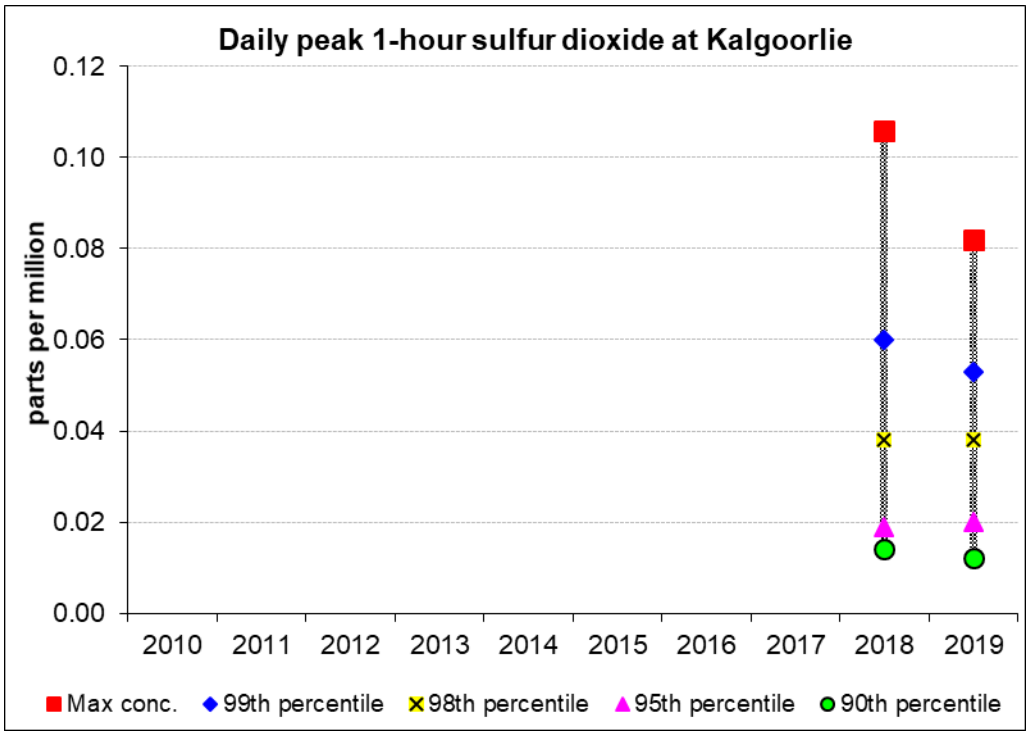


Figure E4-4: One-hour sulfur dioxide at Kalgoorlie

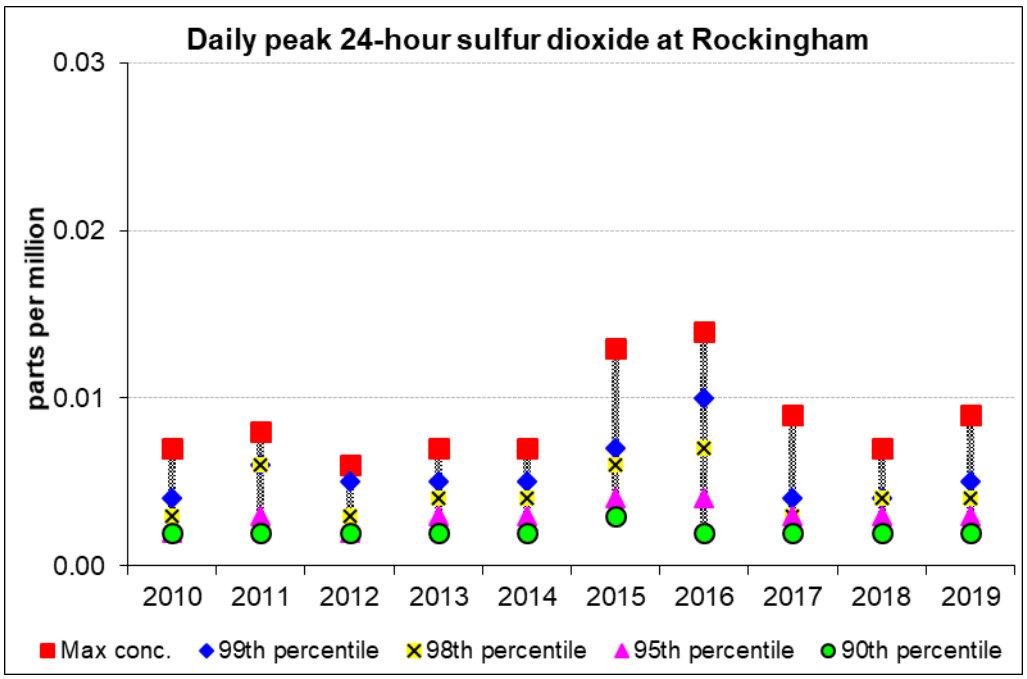


Figure E4-5: 24-hour sulfur dioxide at Rockingham

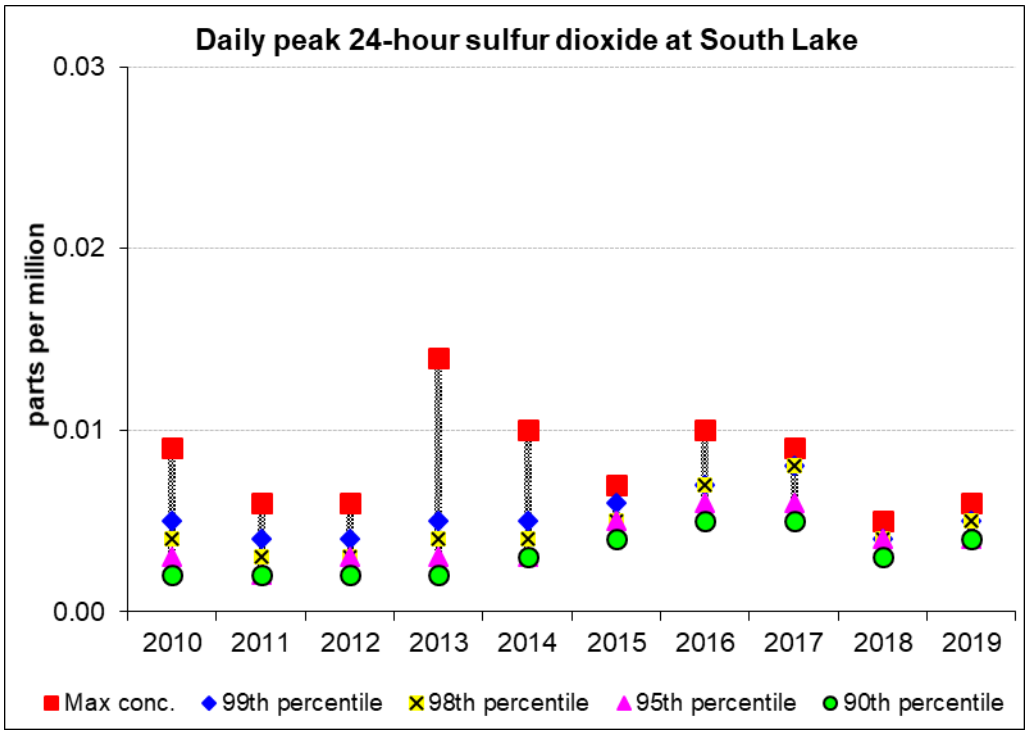


Figure E4-6: 24-hour sulfur dioxide at South Lake

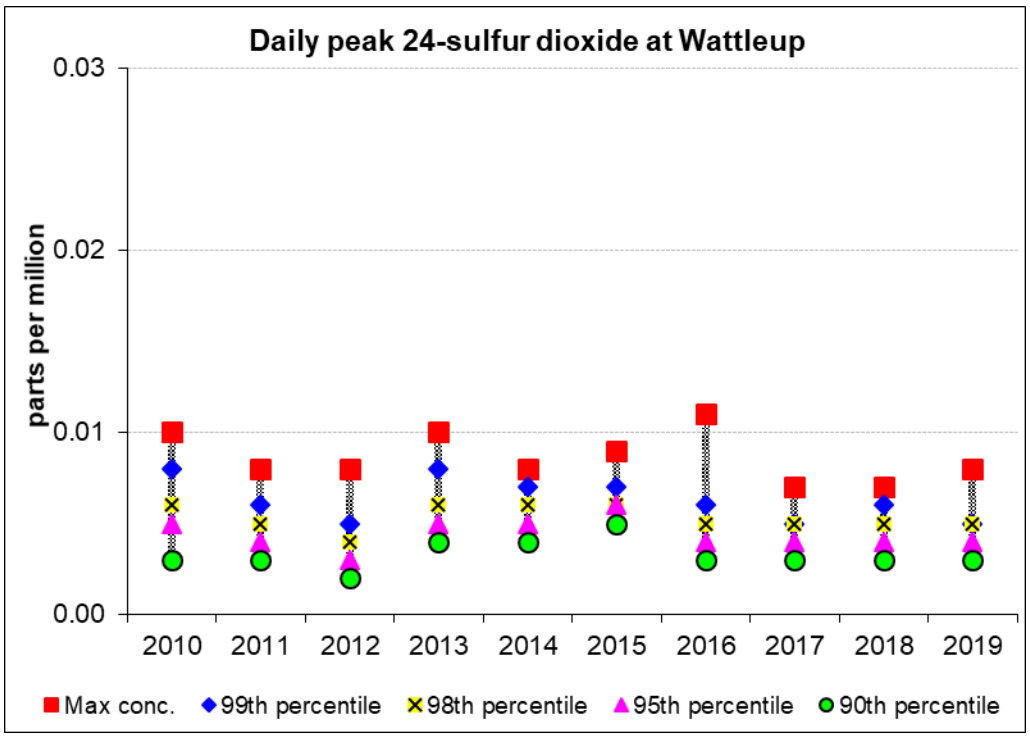


Figure E4-7: 24-hour sulfur dioxide at Wattleup

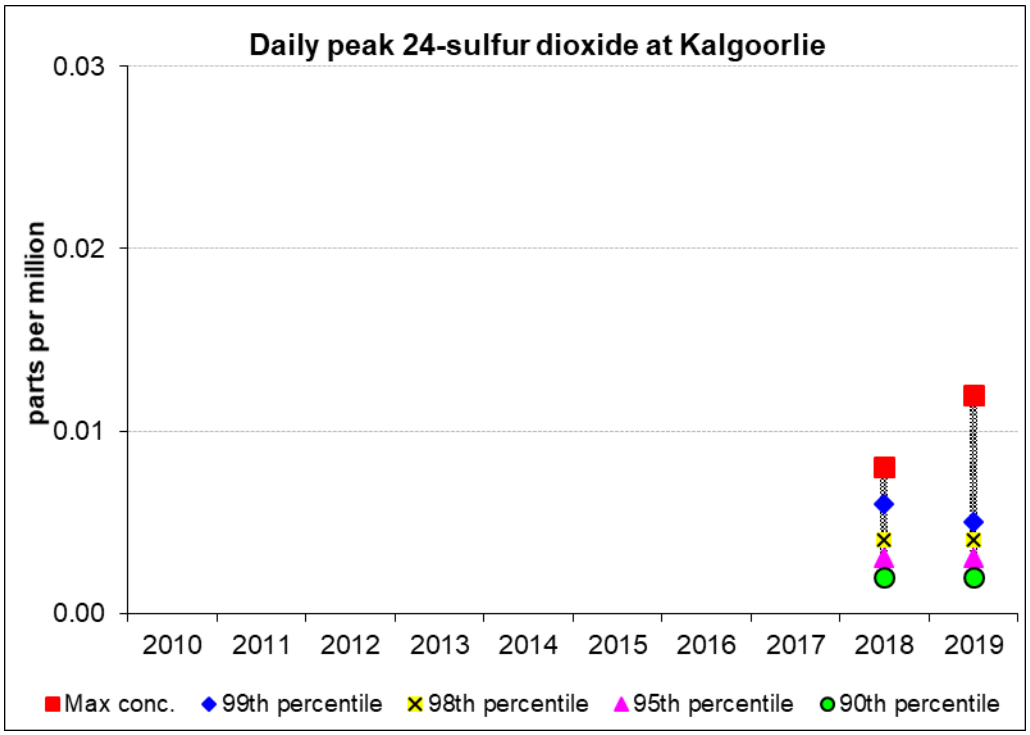


Figure E4-8: 24-hour sulfur dioxide at Kalgoorlie

E.5 Particles as PM_{10}

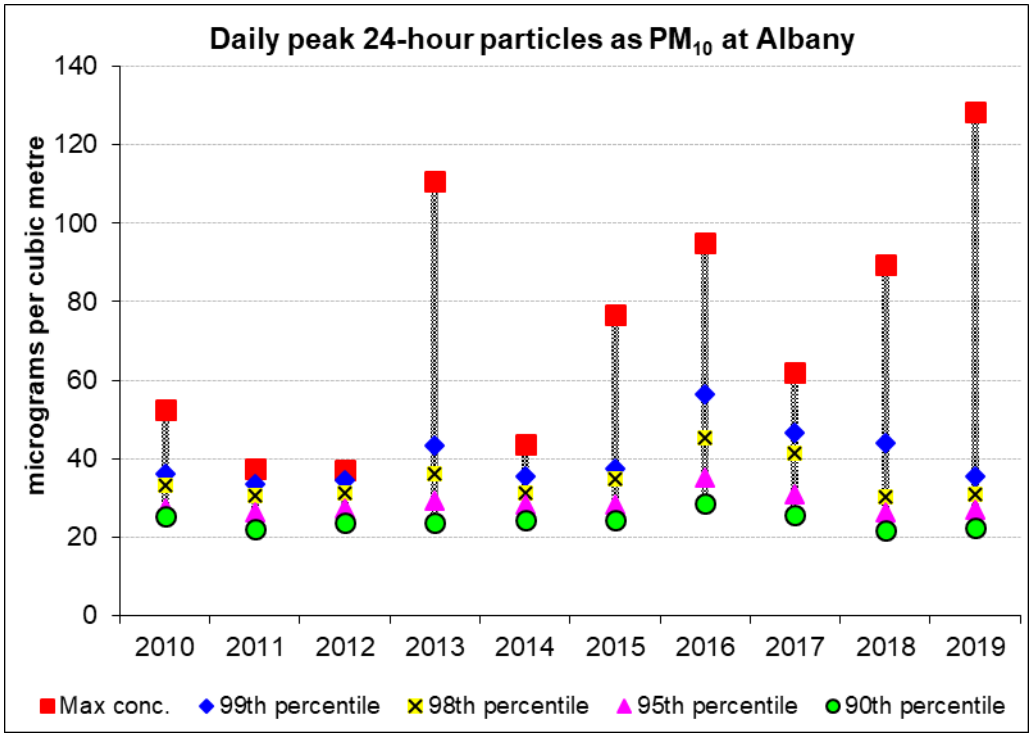


Figure E5-1: 24-hour PM_{10} at Albany

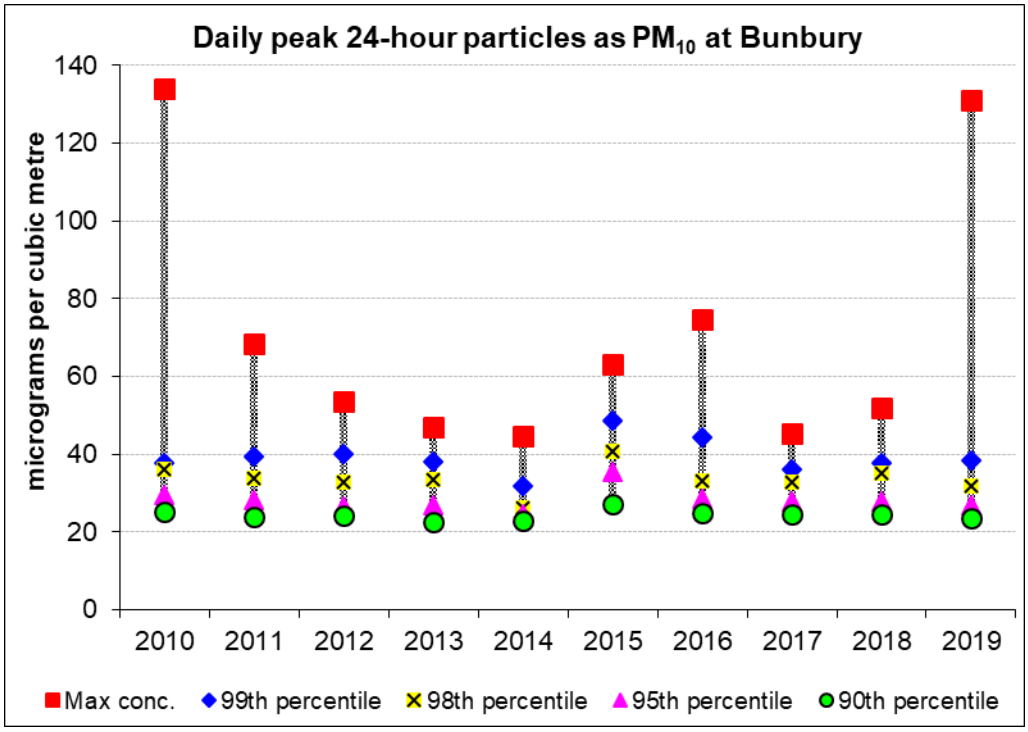


Figure E5-2: 24-hour PM_{10} at Bunbury

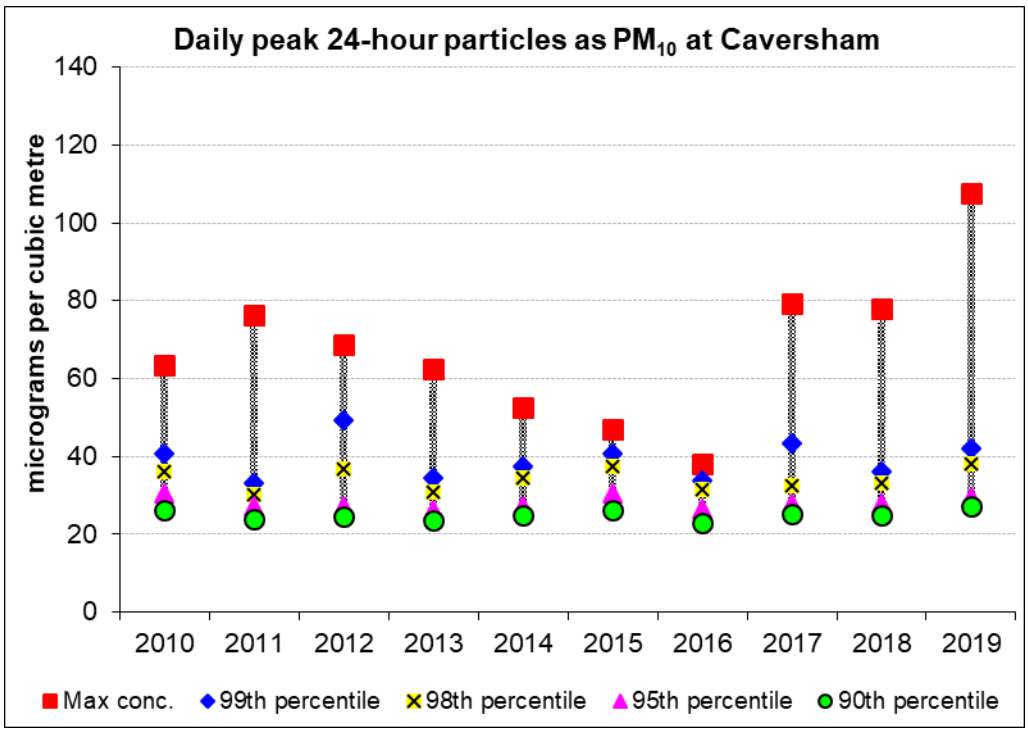


Figure E5-3: 24-hour PM_{10} at Caversham

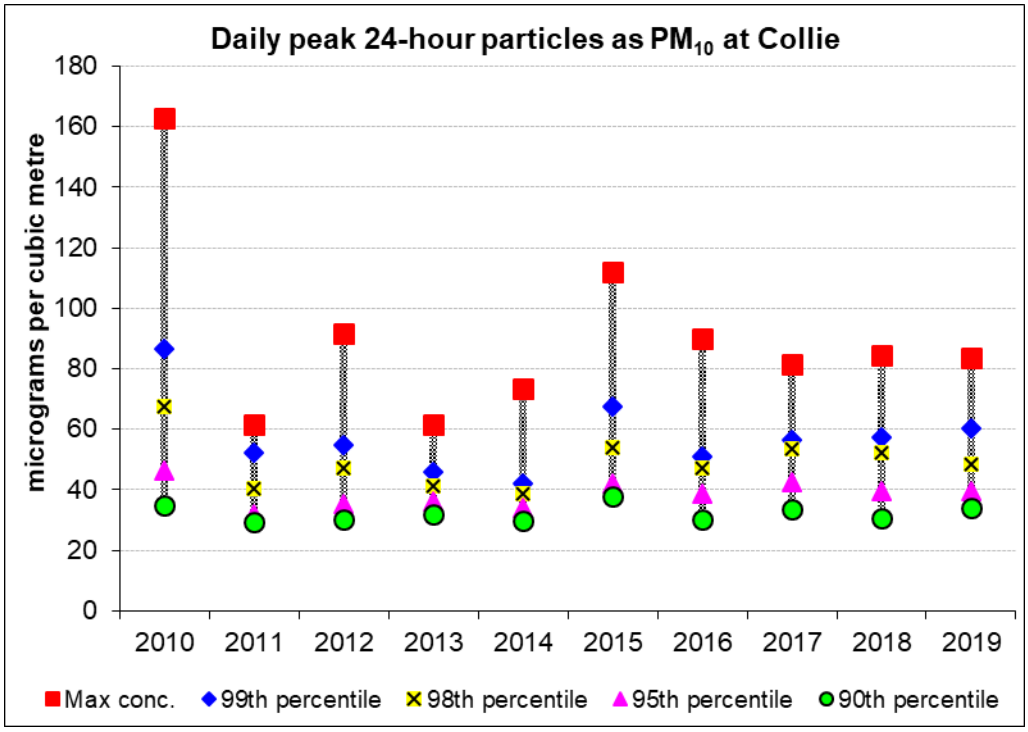


Figure E5-4: 24-hour PM_{10} at Collie

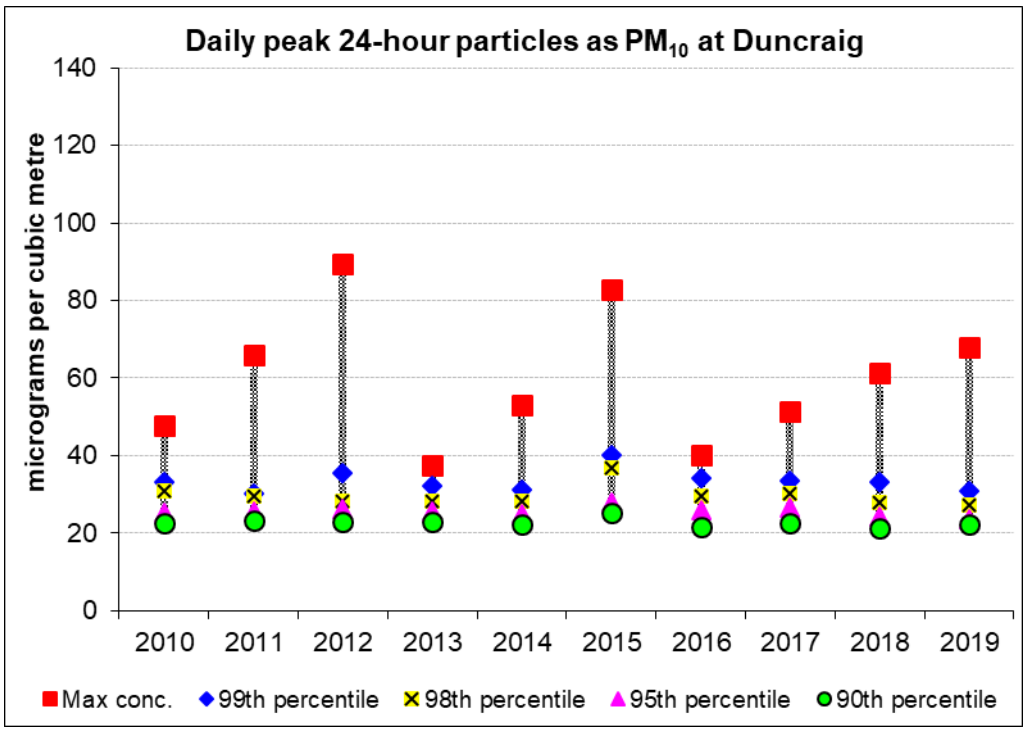


Figure E5-5: 24-hour PM_{10} at Duncraig

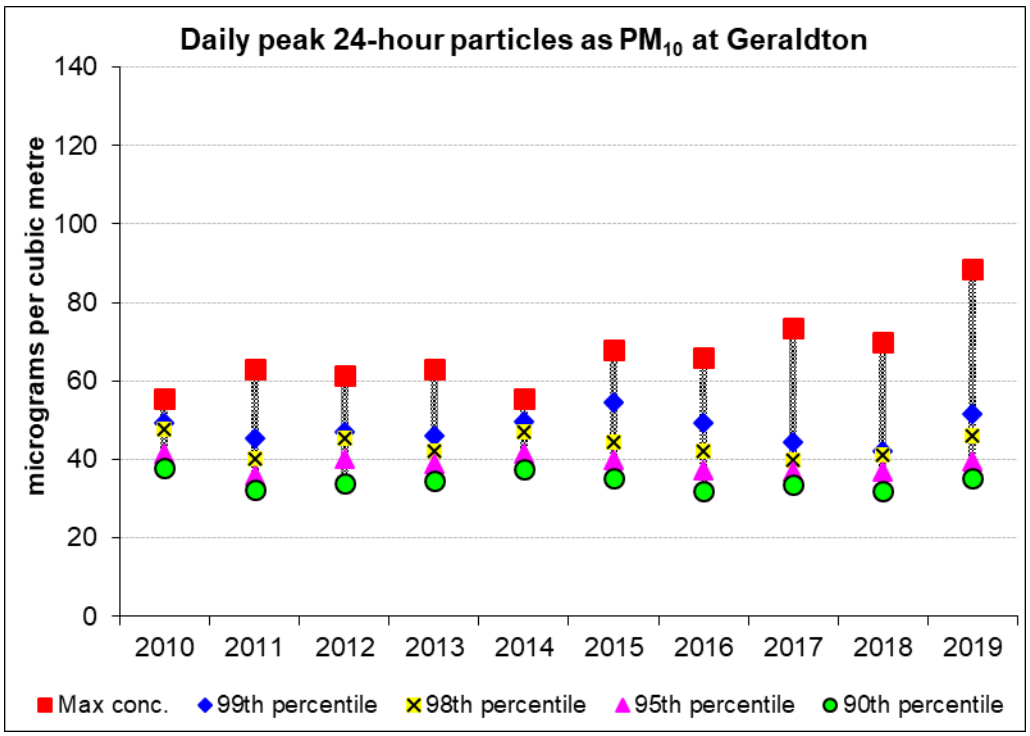


Figure E5-6: 24-hour PM_{10} at Geraldton

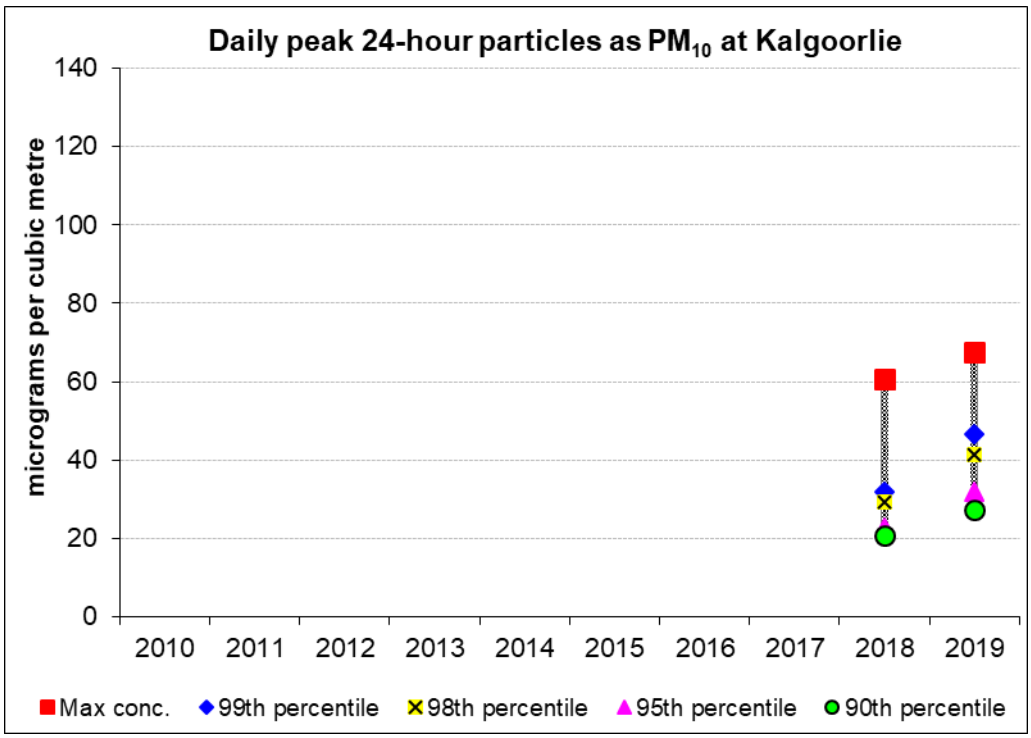


Figure E5-7: 24-hour PM_{10} at Kalgoorlie

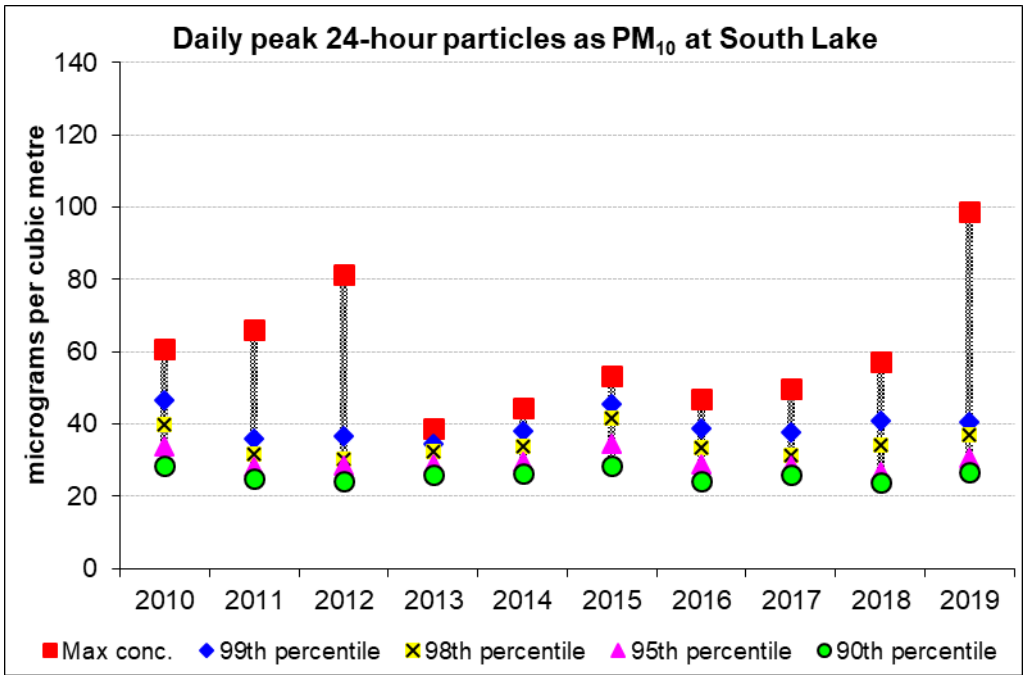


Figure E5-8: 24-hour PM_{10} at South Lake

E.6 Particles as $PM_{2.5}$

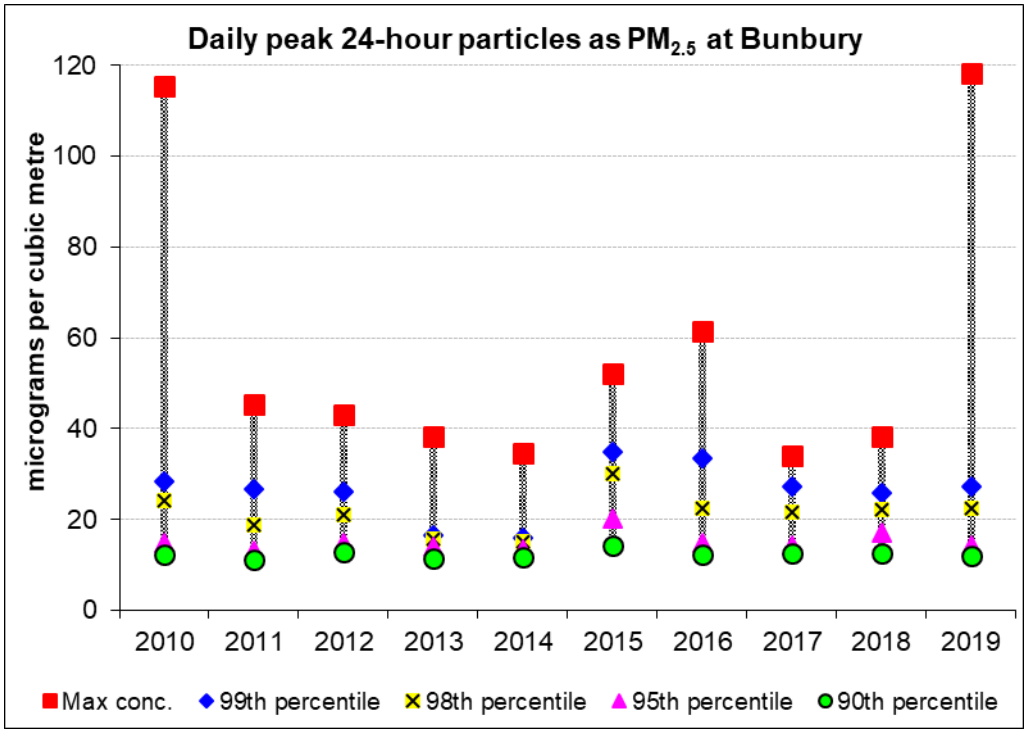


Figure E6-1: 24-hour $PM_{2.5}$ at Bunbury

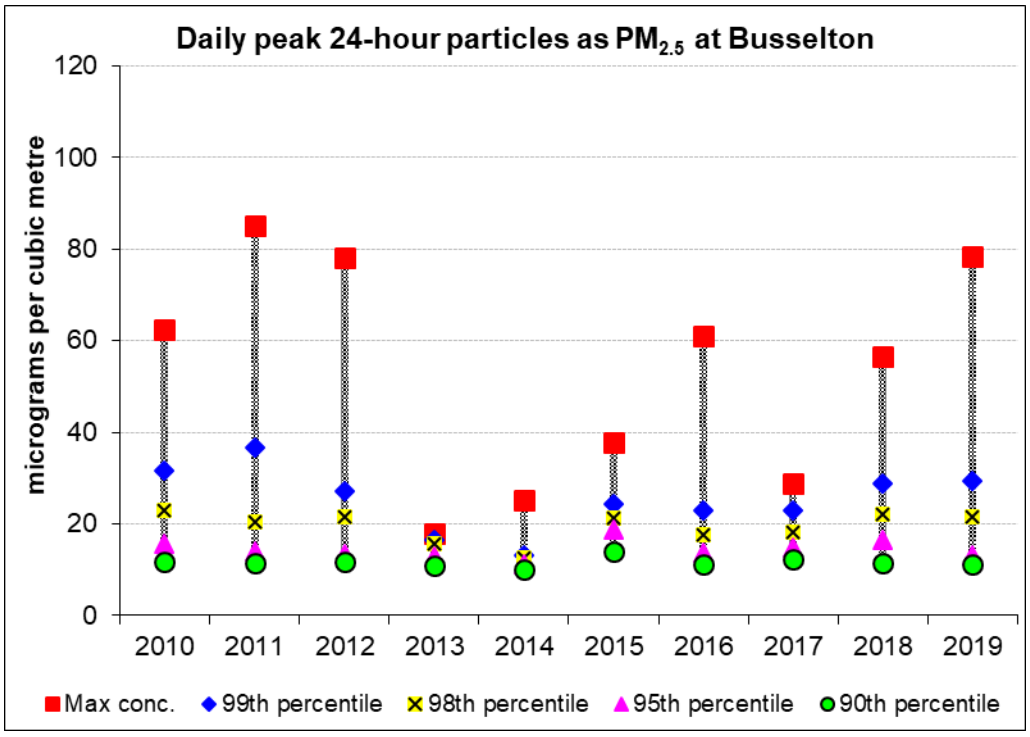


Figure E6-2: 24-hour $PM_{2.5}$ at Busselton

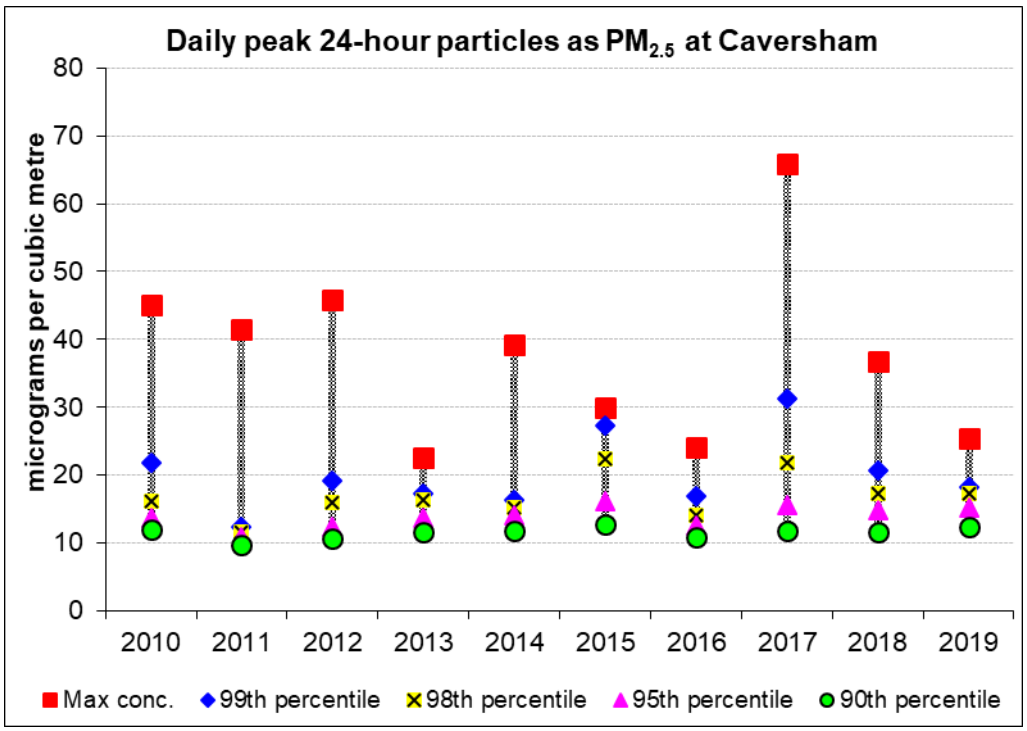


Figure E6-3: 24-hour $PM_{2.5}$ at Caversham

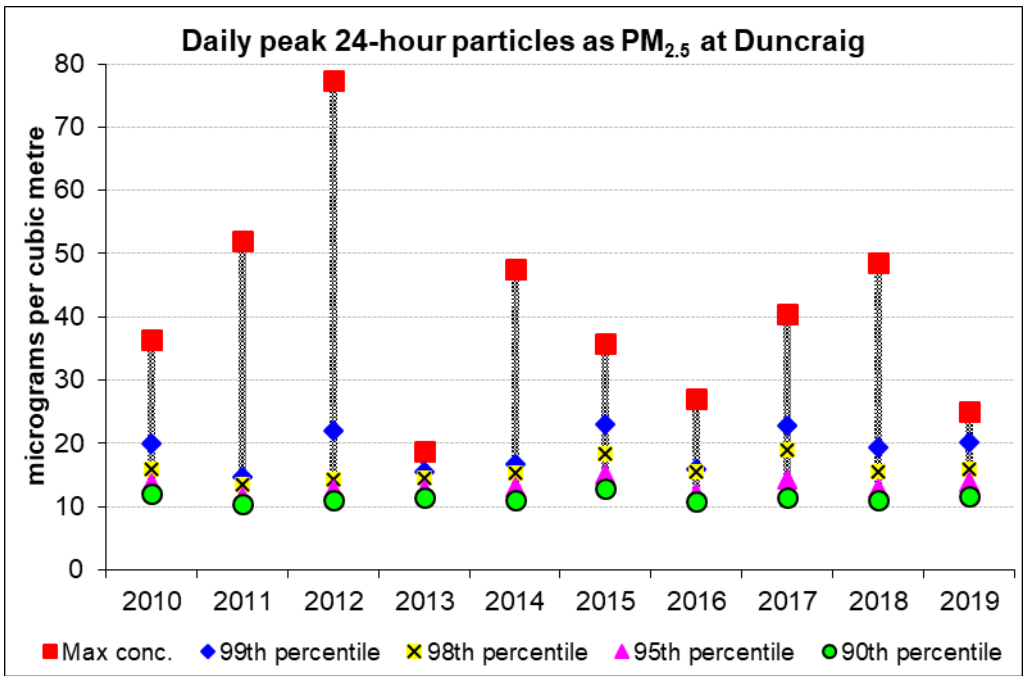


Figure E6-4: 24-hour $PM_{2.5}$ at Duncraig

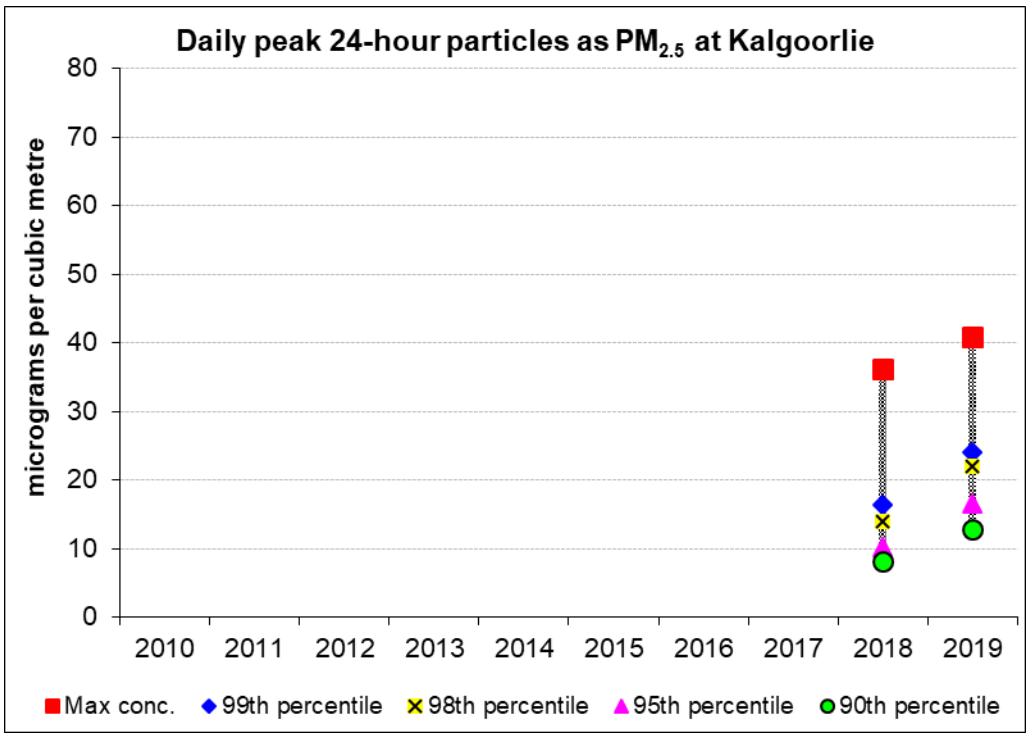


Figure E6-5: 24-hour $PM_{2.5}$ at Kalgoorlie

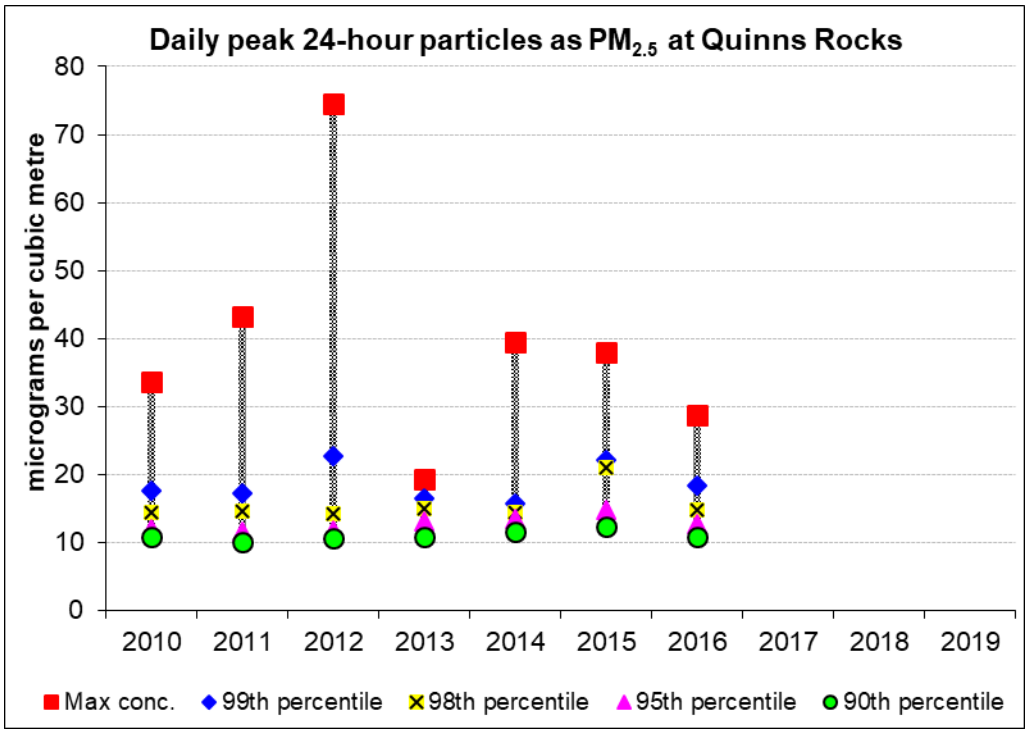


Figure E6-6: 24-hour $PM_{2.5}$ at Quinns Rocks (2017–19 not included)

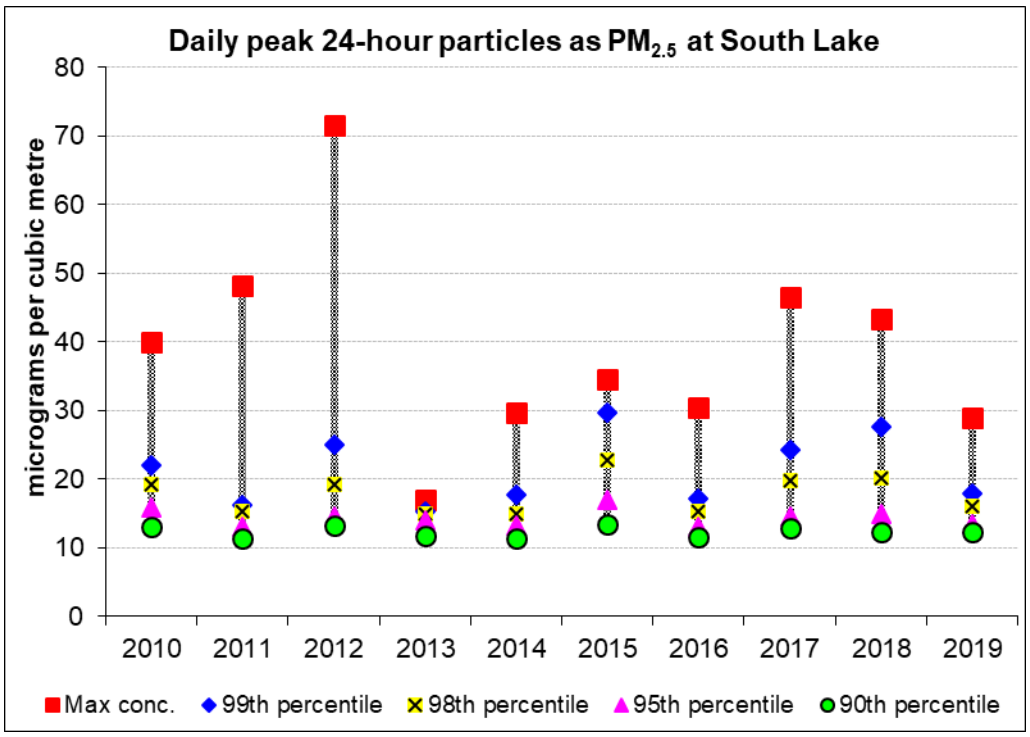


Figure E6-7: 24-hour $PM_{2.5}$ at South Lake

F. Exceedance analysis

This section contains information specific to each parameter exceeding the relevant AAQ NEPM standard during 2019. Each analysis is provided in date order and may include a satellite image of the region, a back trajectory, concentration and/or wind plots, together with information on the specific concentrations reached and possible sources.

Each back trajectory (where provided) is specific to one event and shows a possible path that a parcel of air may have taken through space to have arrived at a specific location at a certain time. A back trajectory does no more than use the wind speed and direction information recorded at various monitoring sites to track a simple path backwards to a possible origin site. Some major assumptions made in the calculation of these back trajectories, such as no air dispersion throughout the path, create large uncertainties in the indicated path and must be acknowledged. Notwithstanding, the back trajectories as calculated provide a reasonable first approximation for the possible path taken by an air parcel in arriving at its destination.

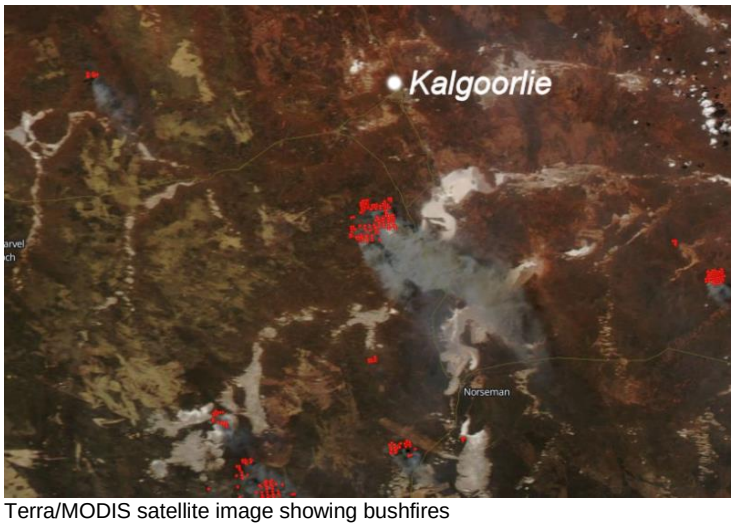
Satellite images are obtained from earthdata.nasa.gov/labs/worldview, where available and when cloud cover does not obscure the plume.

Abbreviations are occasionally used to represent air monitoring sites. The more common of these are:

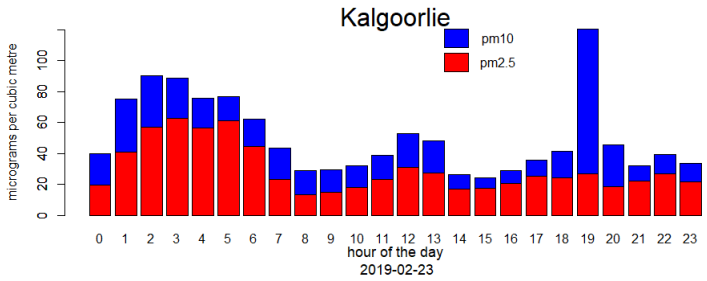
Metropolitan sites	
Ca	Caversham
Du	Duncraig
QR	Quinns Rocks
Ro	Rockingham
RG	Rolling Green
SL	South Lake
Sw	Swanbourne
Wt	Wattleup

Regional sites	
Al	Albany
Bn	Bunbury
Bs	Busselton
Co	Collie
Ge	Geraldton
Ma	Mandurah
Kg	Kalgoorlie

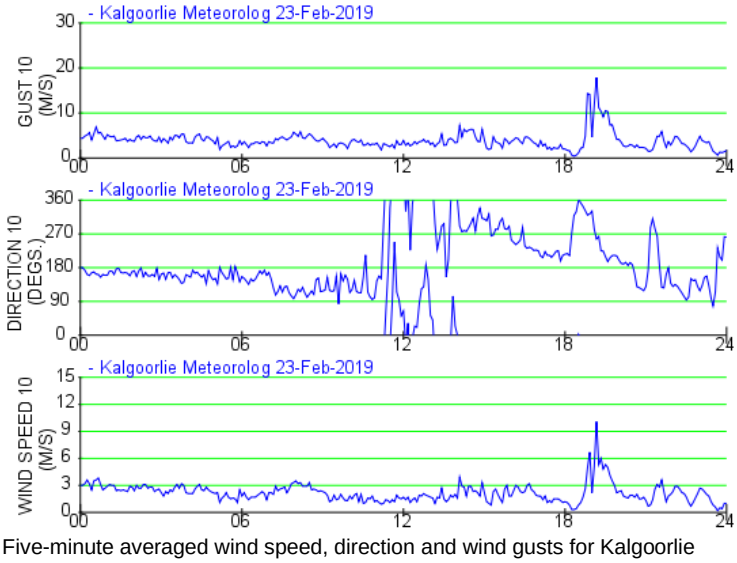
23 February 2019



Terra/MODIS satellite image showing bushfires



60-minute averaged PM_{10} (blue) and $PM_{2.5}$ (red) for Kalgoorlie



Five-minute averaged wind speed, direction and wind gusts for Kalgoorlie

Pollutant

PM_{10} & $PM_{2.5}$

Monitoring Site

Kalgoorlie

AAQ NEPM Standard

PM_{10} – 50 µg/m^3

$PM_{2.5}$ – 25 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

PM_{10} – 50.3 µg/m^3

$PM_{2.5}$ – 29.7 µg/m^3

Description of event

A number of bushfires were active on the 22nd and 23nd in the Goldfields region. No prescribed burns were known to be active at this time.

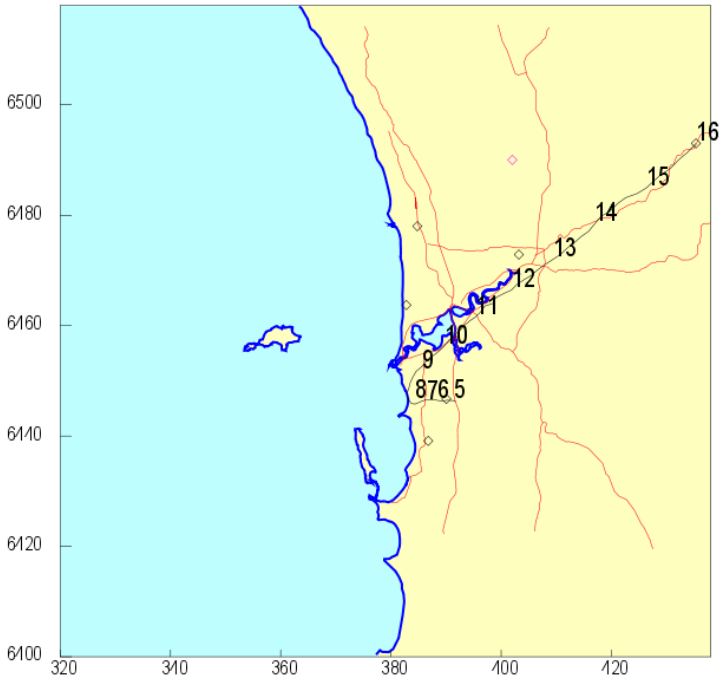
Morning particles were predominantly $PM_{2.5}$ while the afternoon particles were made up of coarser $PM_{10\text{-}2.5}$ particles.

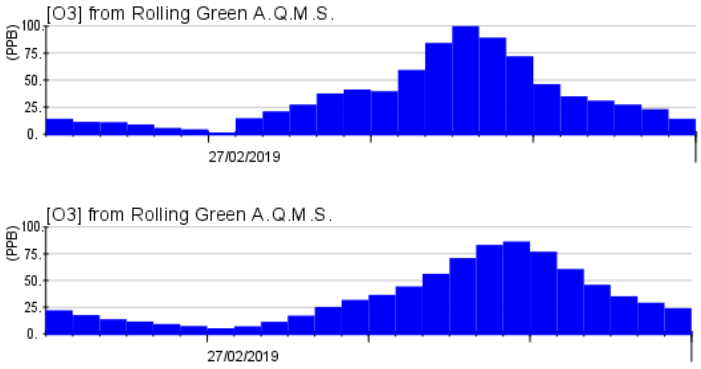
Wind speeds were low in the morning so the event was not windborne dust.

Afternoon winds were elevated for several hours which may have contributed to the dust levels.

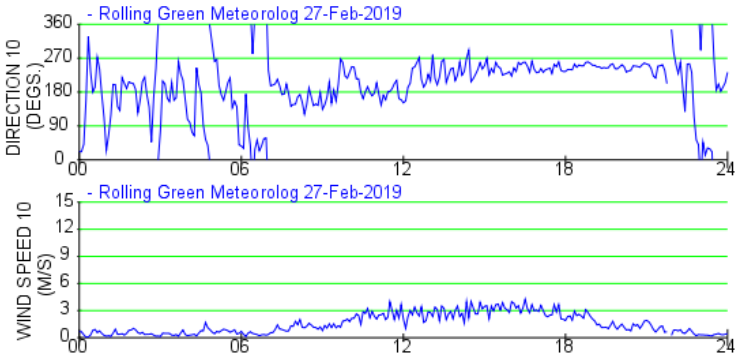
Exceptional event

27 February 2019





Hourly (top) and four-hourly (borttom) averaged ozone for Rolling Green



Five-minute averaged ozone, wind speed, direction and air temperature for Rolling Green

Pollutant

Ozone

Monitoring dite

Rolling Green

AAQ NEPM Standard

1 hour: 0.100 ppb

4 hour: 0.08 ppb

Concentration (µg/m^3)

1 hour 0.100 ppb (16:00)

4 hour 0.087 ppb (18:00)

Description of event

Temperatures during the day were in the high 30°Cs.

Urban emissions returned over the northern suburbs with Kwinana emissions returning over the main urban region.

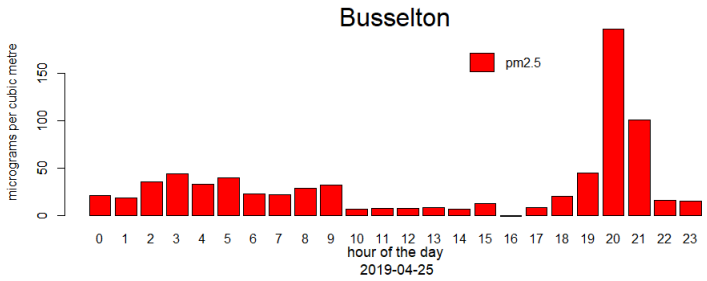
The ozone which formed in the metropolitan area is likely the product of emissions from both the Kwinana and Perth regions.

One-hour ozone levels were increased at Caversham (0.75 ppb) but the more northern site at Rolling Green received the highest hourly concentration of 0.100 ppb at 4pm and exceeded the four-hourly ozone standard, recording 0.087 ppb at 6pm.

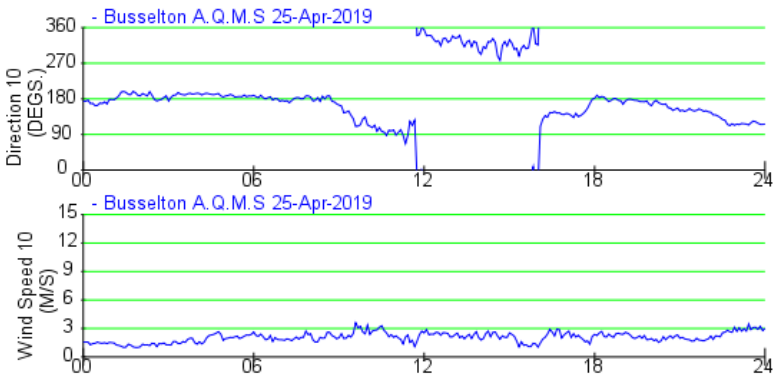
Assessable event

25 April 2019

Terra/MODIS satellite image showing prescribed burns



60-minute averaged PM2.5 particles for Busselton



Five-minute averaged wind speed and direction for Busselton

Pollutant

$PM_{2.5}$

Monitoring Site

Busselton

AAQ NEPM Standard

25 µg/m^3

Averaging Period

24 hours

Concentration (µg/m^3)

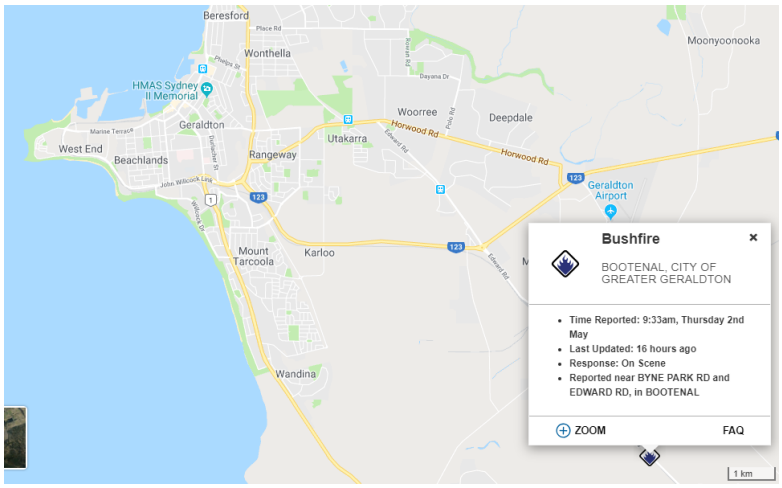
30.9 µg/m^3

Description of event

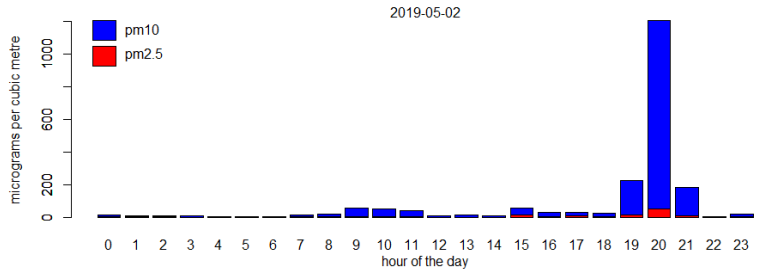
A number of prescribed burns were underway in the south-west of the state causing widespread smoke.

Exceptional event

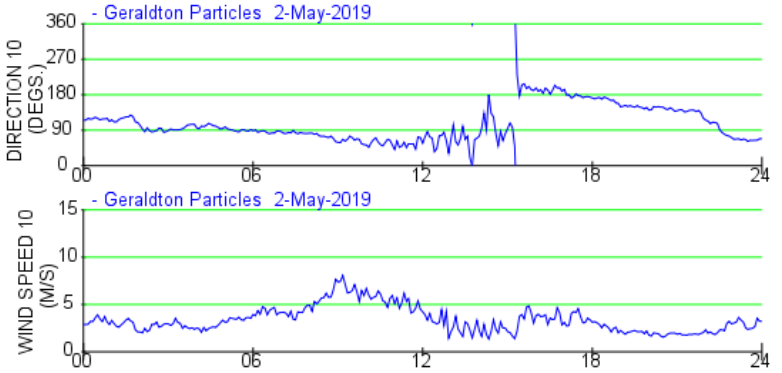
2 May 2019



Fire and emergency webpage:
www.emergency.wa.gov.au/#map/incident/1790267



60-minute averaged time series plot



Five-minute averaged time series plot of wind speed and direction at

Pollutant

PM_{10}

Monitoring Site

Geraldton

AAQ NEPM Standard

50 µg/m^3

Averaging Period

24 hours

Concentration (µg/m^3)

88.4 µg/m^3

Description of event

There were fires in the general vicinity of Geraldton but the very low $PM_{2.5}$:PM_{10} ratio indicates a very high proportion of larger material. The shape of the trace indicates a much localised nearby crustal event when winds were in a narrow band of between 140 and 150 degrees. Winds at the time were about 2 m/s.

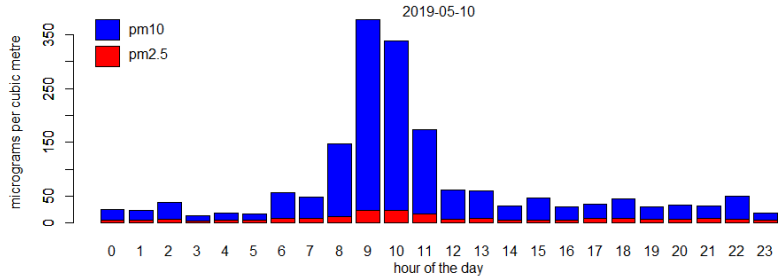
There are some unpaved areas 50 m to the south of the Geraldton site.

Aqua/MODIS satellite image showing fires

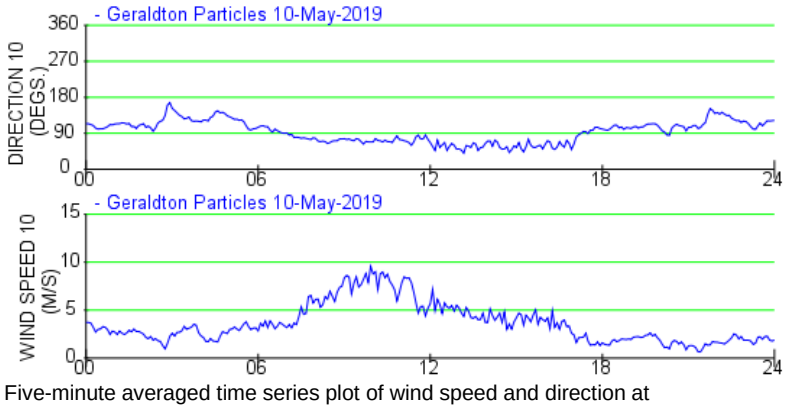
Assessable event

10 May 2019

Aqua/MODIS satellite image showing a local incident



60-minute averaged time series plot



Five-minute averaged time series plot of wind speed and direction at

Pollutant

PM_{10}

Monitoring Site

Geraldton

AAQ NEPM Standard

50 µg/m^3

Averaging Period

24 hours

Concentration (µg/m^3)

72.7 µg/m^3

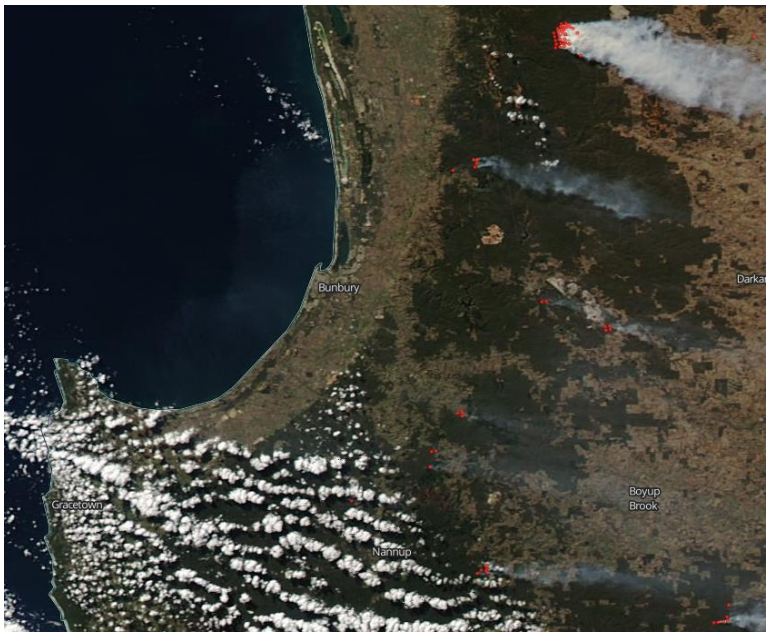
Description of event

No prescribed burns were active on the day. Low $PM_{2.5}$:PM_{10} ratio indicates crustal content.p

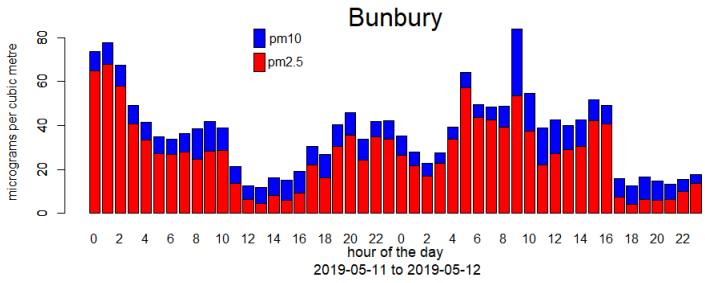
Possible some local smoke combined with dust in the area.

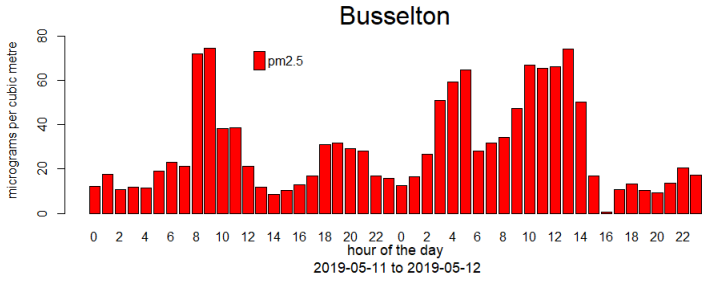
Assessable event

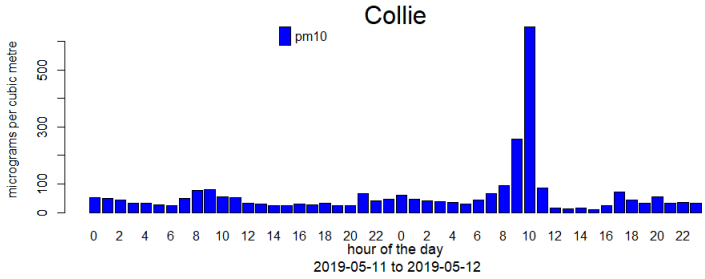
11 and 12 May 2019



Aqua/MODIS satellite image showing prescribed burns







60-minute averaged time series plot (Blue is PM10 Red is PM2.5)

Pollutant

PM_{10} & $PM_{2.5}$

Monitoring site

Bunbury, Busselton & Collie

AAQ NEPM Standard

PM_{10} 50 µg/m^3

$PM_{2.5}$ 25 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

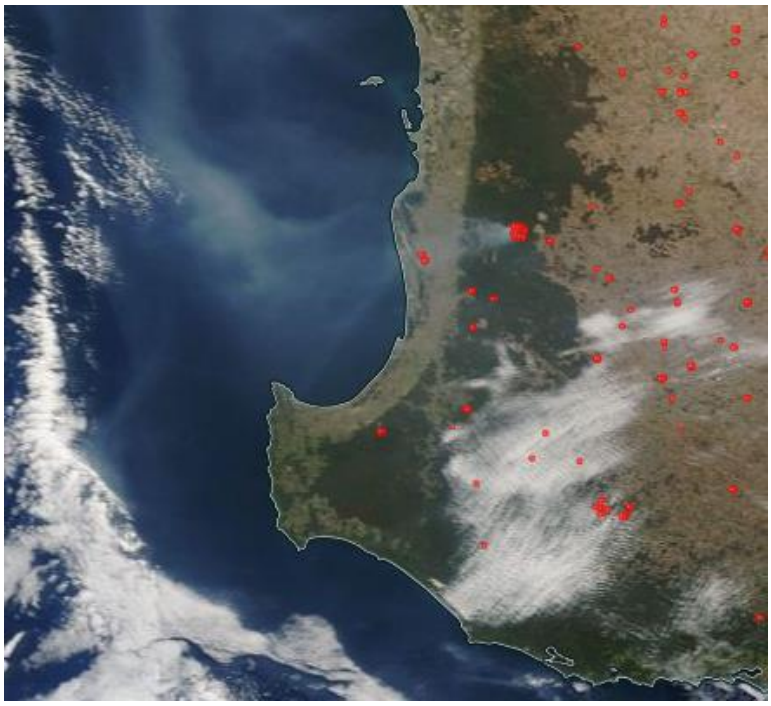
Location	11th	12th
Bunbury $PM_{2.5}$	**28.1**	**26.7**
Busselton $PM_{2.5}$	24.4	**33.7**
Collie PM_{10}	40.9	**76.6**

Description of event

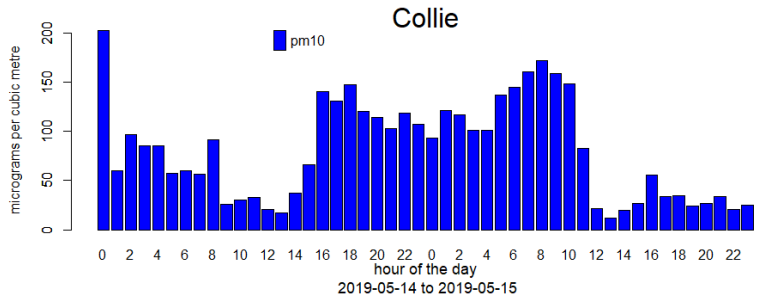
A number of prescribed burns were active in the south-west

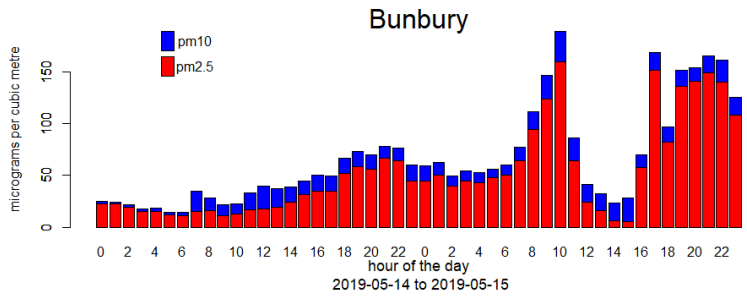
Exceptional event

14 and 15 May 2019



Terra/MODIS satellite image showing prescribed burns





60-minute averaged time series plot

Pollutant

PM_{10} and $PM_{2.5}$

Monitoring site

Caversham, Collie, Bunbury & Busselton

AAQ NEPM Standard

PM_{10} 50 µg/m^3

$PM_{2.5}$ 25 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

Location	14th	15th
Caversham $PM_{2.5}$	**25.4**	17.2
Collie PM_{10}	**83.5**	**77.9**
Bunbury PM_{10}	40.1	**92.7**
Bunbury $PM_{2.5}$	**28.9**	**76.8**
Busselton $PM_{2.5}$	21.4	**78.5**

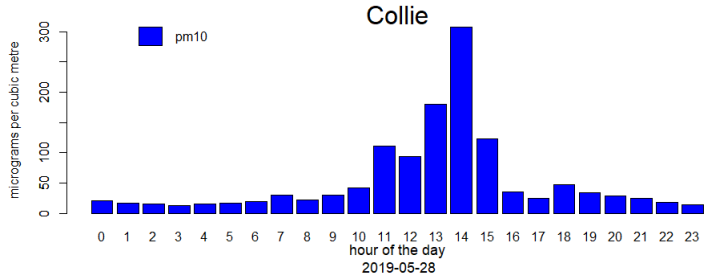
Description of event

A number of prescribed burns were active throughout the southern part of the state.

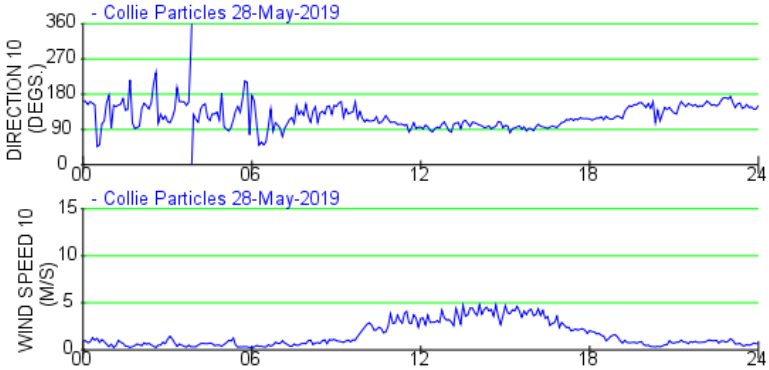
Exceptional event

28 May 2019

Aqua/MODIS satellite image showing prescribed burns



60-minute averaged time series plot



Five-minute averaged time series plot of wind speed and direction at Collie

Pollutant

PM_{10}

Monitoring site

Collie

AAQ NEPM Standard

50 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

53.4 µg/m^3

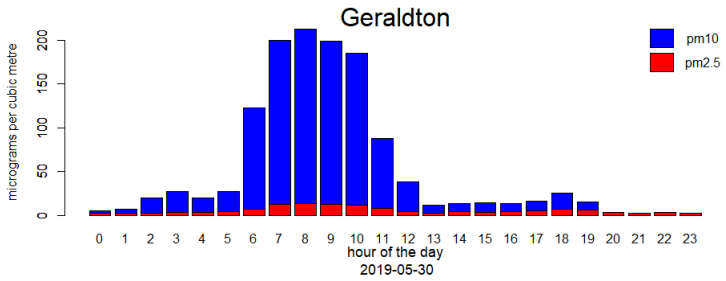
Description of event

Some prescribed burns were active in the region; however, the short-term nature of the plume indicates a possible local source.

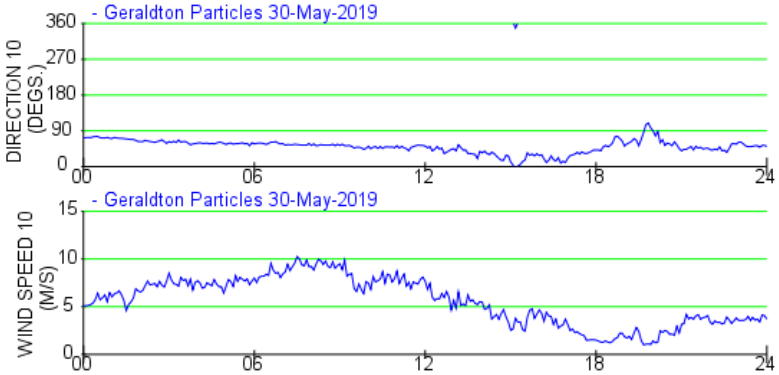
All other departmental PM_{10} sites recorded less than 20 µg/m^3

Assessable event

30 May 2019



60-minute averaged time series plot



Five-minute averaged time series plot of wind speed and direction at

Pollutant

PM_{10}

Monitoring site

Geraldton

AAQ NEPM Standard

50 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

52.9 µg/m^3

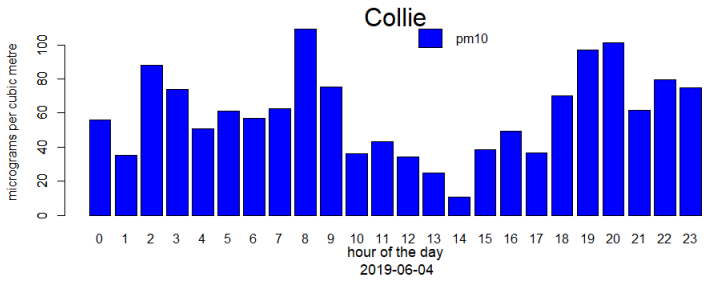
Description of event

No fires were reported in the vicinity of Geraldton. The ratio of $PM_{2.5}$ to PM_{10} and the high easterly winds suggests the cause to be from mainly crustal material.

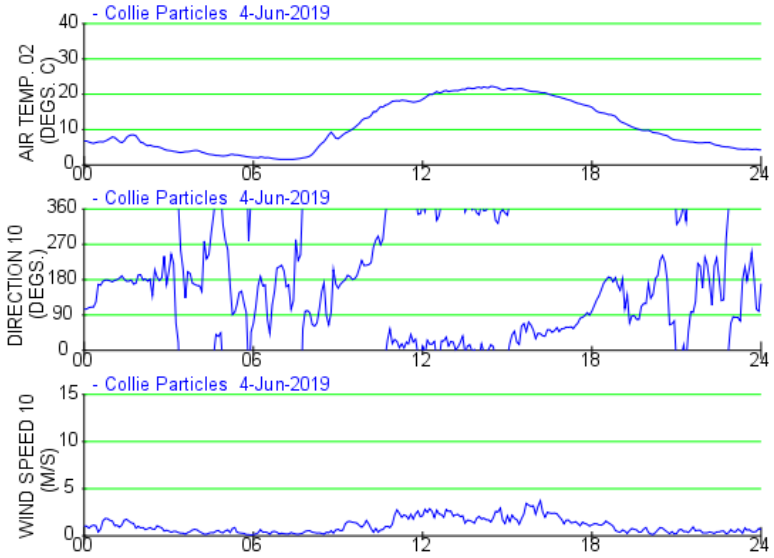
The duration and timing of the plume also suggest local activity was a possible cause.

Assessable event

4 June 2019



60-minute averaged time series plot



Five-minute averaged time series plot of wind speed and direction at Collie

Pollutant

PM_{10}

Monitoring site

Collie

AAQ NEPM Standard

50.0 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

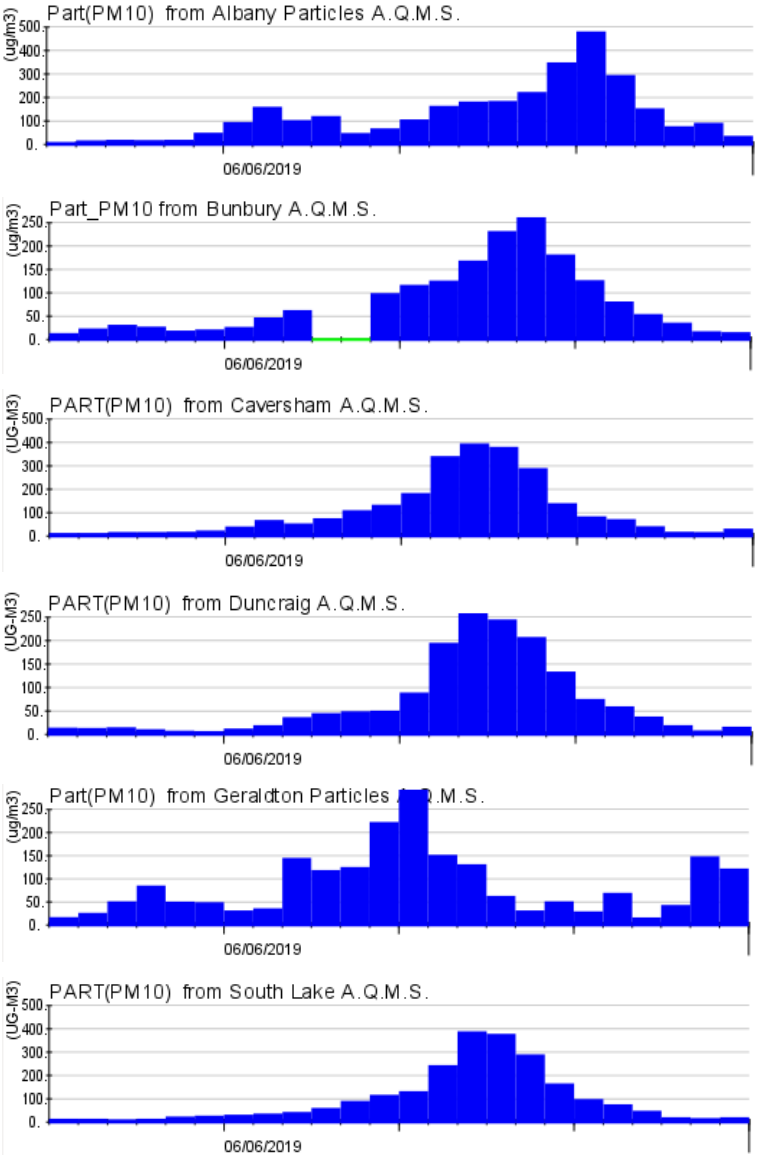
59.4 µg/m^3

Description of event

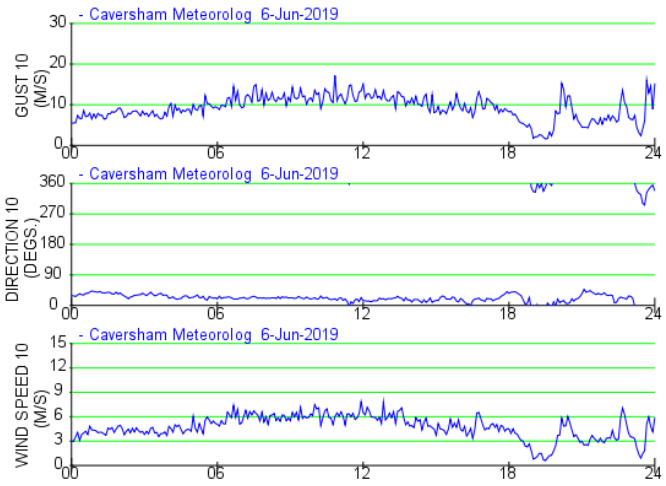
Low wind speeds and cool evenings resulted in an accumulation of wood heater smoke in Collie.

Assessable event

6 June 2019



60-minute averaged time series plot



Five minute averaged time series plot of wind speed and direction at Caversham

Pollutant

PM_{10}

Monitoring site

Albany, Bunbury, Caversham, Duncraig, Geraldton and South Lake.

AAQ NEPM Standard

50 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

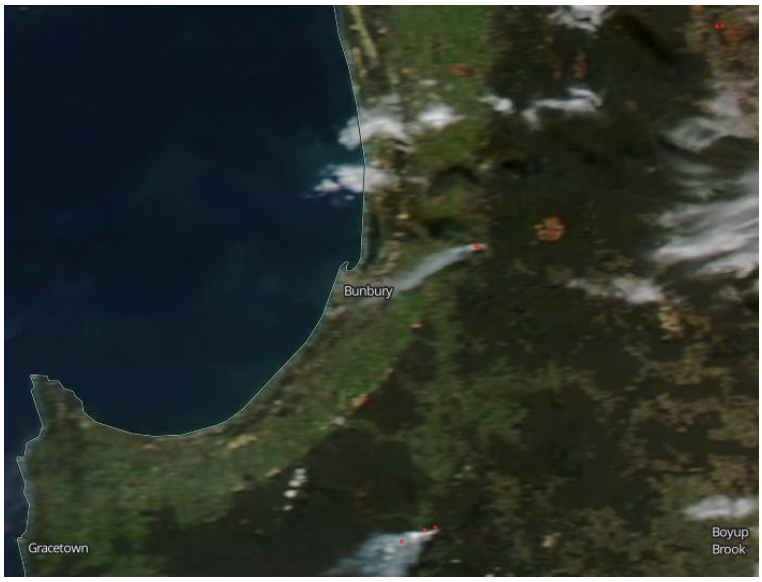
Location	PM_{10}	$PM_{2.5}$
Albany	**128.5**	NA
Bunbury	**81.6**	10.9
Caversham	**107.7**	11.2
Duncraig	**68.1**	9.1
Geraldton	**88.1**	8.5
Kalgoorlie	12.3	1.8
South Lake	**98.8**	11.6

Description of event

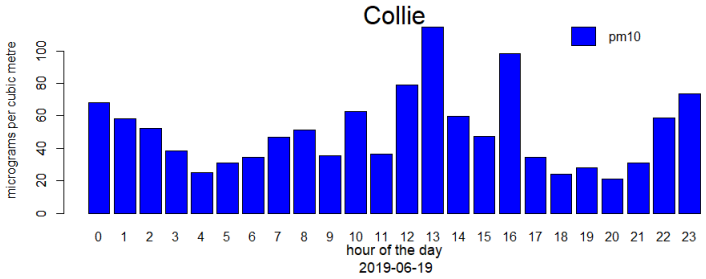
Eyewitness accounts, obtained from both north and south of the metropolitan area indicated the particles were dust (not smoke) and a light brown in colour. A possible cause of these exceedances is therefore likely to be dust from the Wheatbelt possibly combined with some private burn-offs started ahead of a cold-front forecast for the following day to bring heavy rain to Perth.

Exceptional event

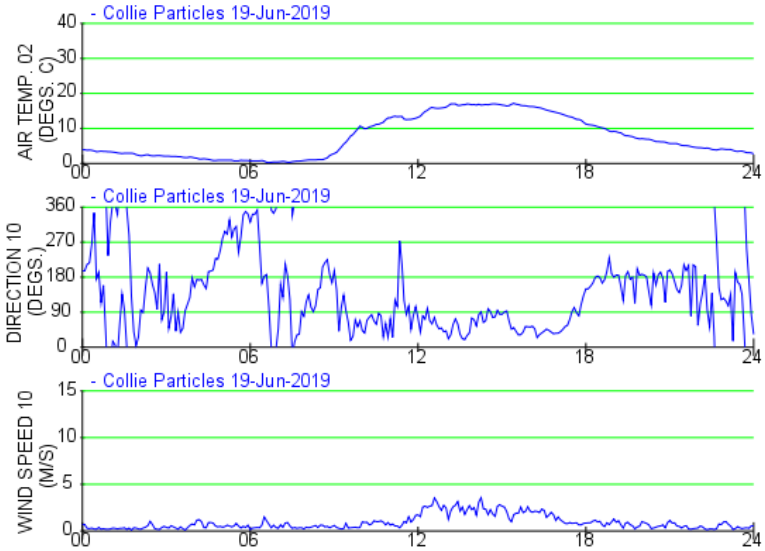
19 June 2019



Aqua/MODIS satellite image showing prescribed burns



60-minute averaged time series plot



Five-minute averaged time series plot of wind speed, direction and air temperature at Collie

Pollutant

PM_{10}

Monitoring site

Collie

AAQ NEPM Standard

50 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

50.4 µg/m^3

Description of event

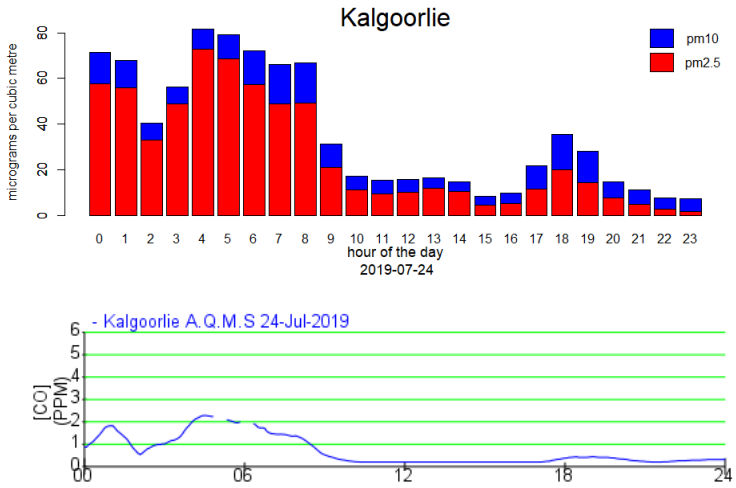
All other regional and metropolitan sites measured PM_{10} concentrations less than 25 µg/m^3. Bunbury PM_{10} recorded 22 µg/m^3.

Low temperatures and overnight peaks indicate possible wood heater contributions.

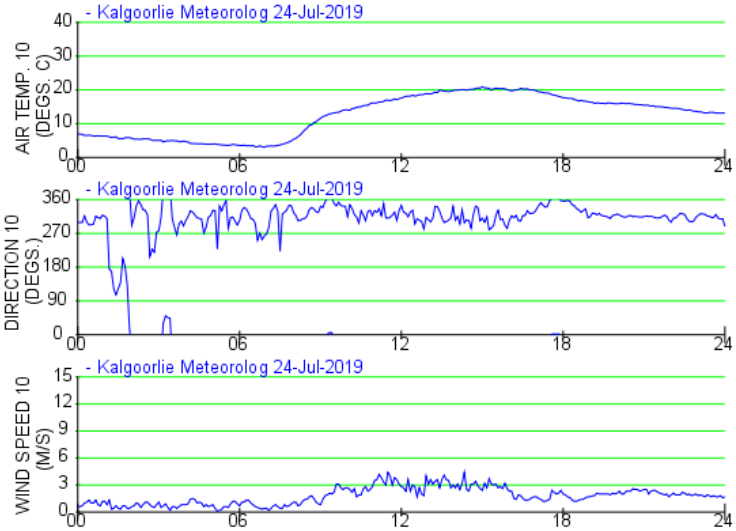
Some plantation debris prescribed burns were undertaken 20 km west of Collie but winds were very low and generally not from the west so would likely account for a small portion of the smoke.

Assessable event

24 July 2019



60-minute averaged time series plot for particles and carbon monoxide at Kalgoorlie



Five-minute averaged time series plot of air temperature, wind direction and wind seed at Kalgoorlie

Pollutant

$PM_{2.5}$

Monitoring site

Kalgoorlie

AAQ NEPM Standard

25 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

26.6 µg/m^3

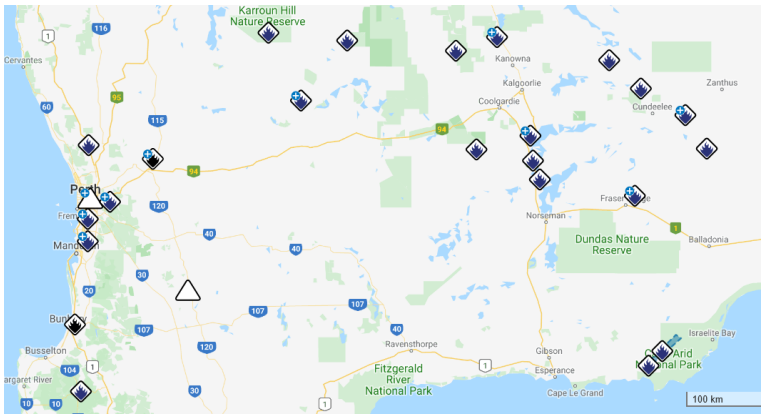
Description of event

Low overnight temperatures and low wind speeds caused an accumulation of wood-heater smoke at the site.

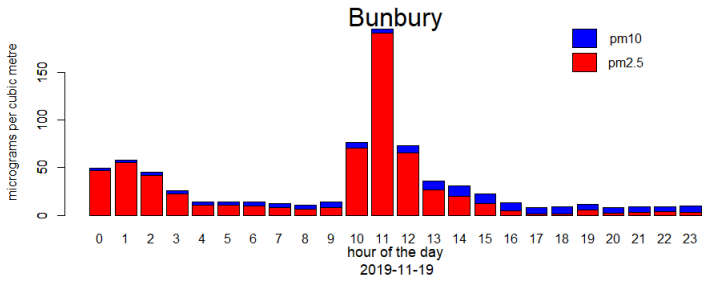
No prescribed burns were active in the area.

Assessable event

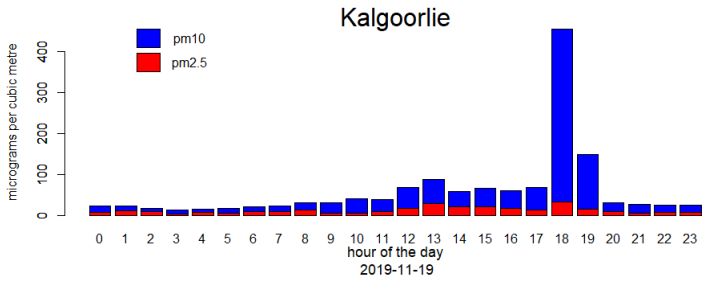
19 November 2019



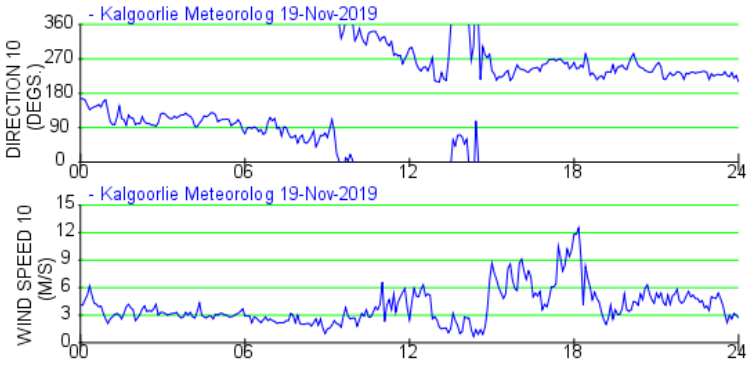
A number of bushfires and Prescribed burns in the south west (www.emergency.wa.gov.au/#)



60-minute averaged time series plot Bunbury PM10 (blue), PM2.5 (red) and Busselton PM2.5 (black)



60-minute averaged time series plot at Kalgoorlie PM10 (blue) and PM2.5 (red)



Five-minute averaged time series plot of wind speed and direction at Kalgoorlie

Pollutant

PM_{10} and $PM_{2.5}$

Monitoring sites

Kalgoorlie, Bunbury, Busselton

AAQ NEPM Standard

PM_{10} – 50 µg/m^3

$PM_{2.5}$ – 25 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

Location	PM_{10}	$PM_{2.5}$
Bunbury	31.9	**26.2**
Busselton	NA	**28.1**
Kalgoorlie	**58.7**	11.7

Description of event

Bunbury and Busselton events were caused by smoke from prescribed burns in the south-west.

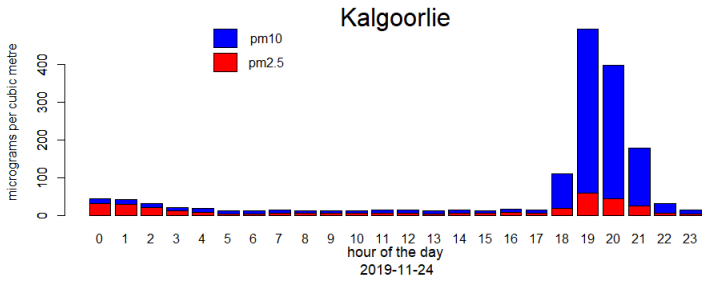
Exceptional event

No metropolitan sites exceeded the AAQ NEPM PM_{10} or $PM_{2.5}$ standard.

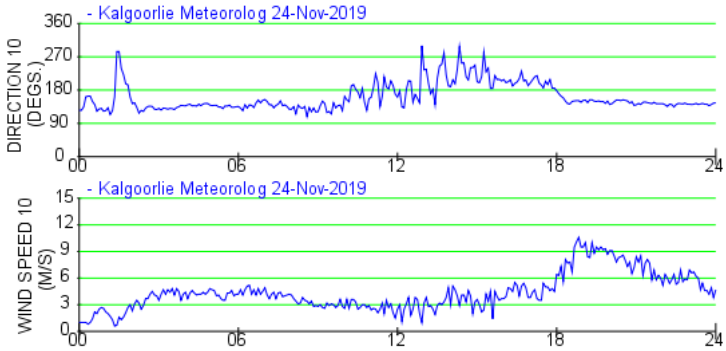
The low ratio of $PM_{2.5}/PM_{10}$ at Kalgoorlie indicates the PM_{10} exceedance was likely because of wind borne dust as winds were over 36 km/h during the event.

Assessable event

24 November 2019



60-minute averaged time series plot



Five-minute averaged time series plot of wind speed and direction at Kalgoorlie

Pollutant

PM_{10}

Monitoring site

Kalgoorlie

AAQ NEPM Standard

50 µg/m^3

Averaging Period

24 hours

Concentration (µg/m^3)

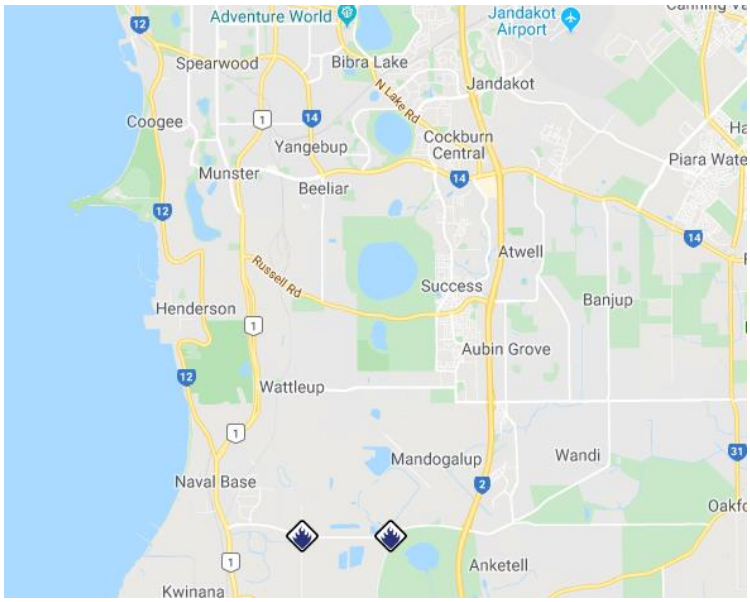
64.5 µg/m^3

Description of event

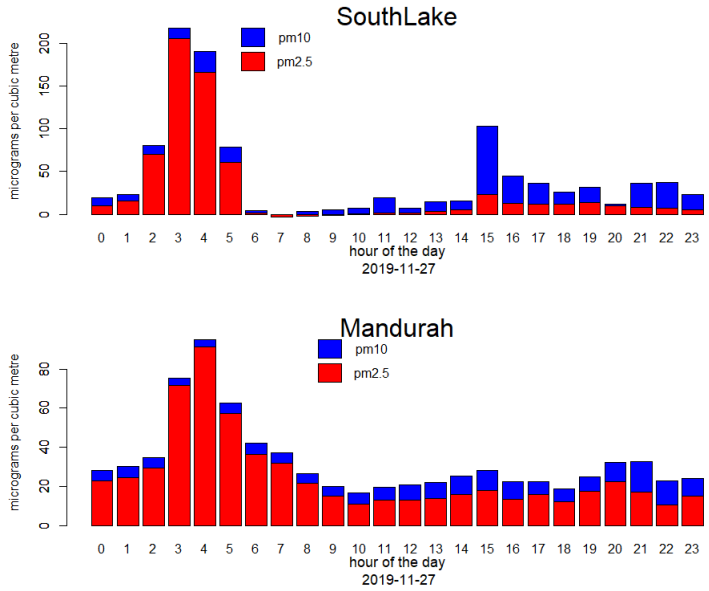
The low ratio of $PM_{2.5}$:PM_{10} at Kalgoorlie indicates the PM_{10} exceedance was likely due to wind borne dust as winds were over 32 km/h during the event.

Assessable event

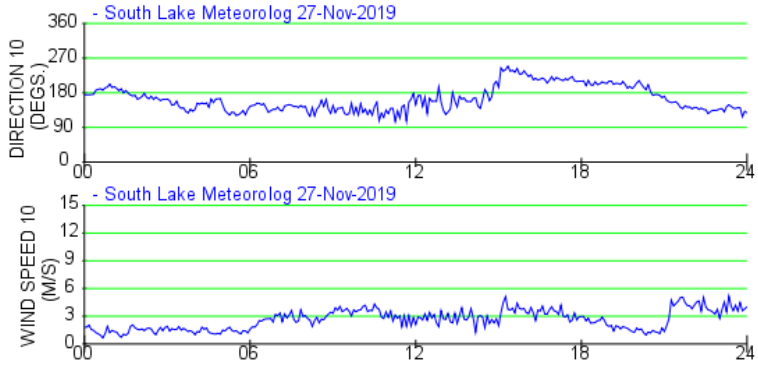
27 November 2019



Map obtained from www.emergency.wa.gov.au



60-minute averaged time series plot



Five-minute averaged time series plot of wind speed, direction and air temperature at South Lake

Pollutant

$PM_{2.5}$

Monitoring site

South Lake & Mandurah

AAQ NEPM Standard

25 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SL 26.5 µg/m^3

Ma 25.4 µg/m^3

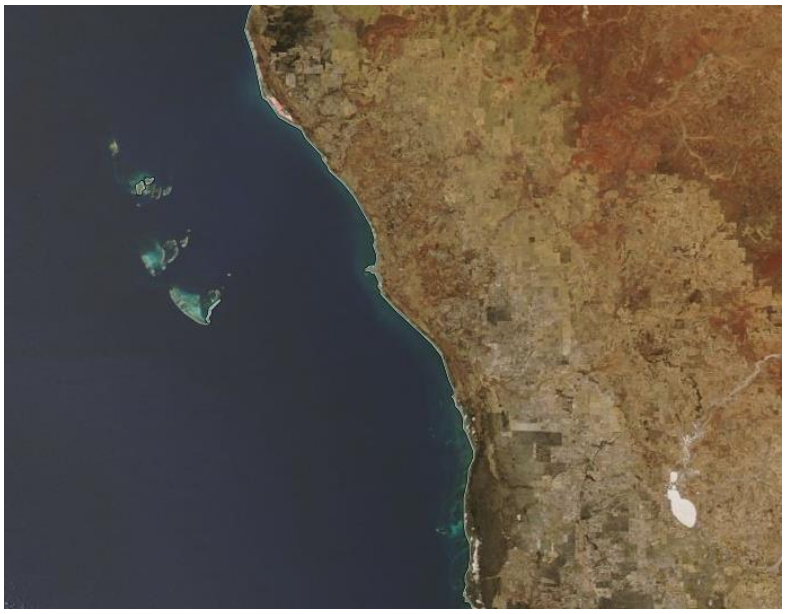
Description of event

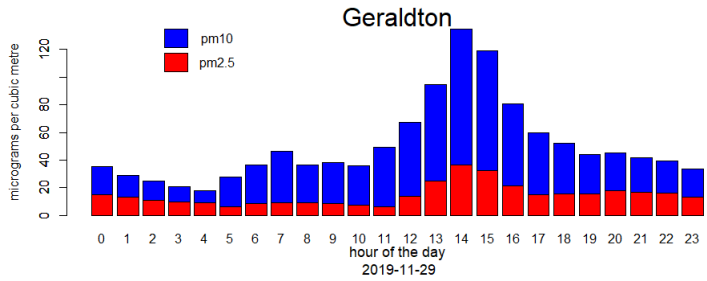
All other regional and metropolitan sites measured slightly elevated $PM_{2.5}$ concentrations but less than 25 µg/m^3.

Several bushfires burning in Hope Valley and Postans which are 15 km south of South Lake were the likely cause of the smoke.

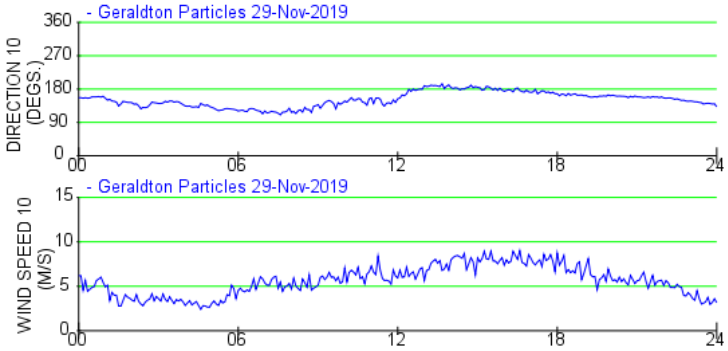
Exceptional event

29 November 2019





60-minute averaged time series plot



Five-minute averaged time series plot of wind speed, direction at Geraldton

Pollutant

PM_{10}

Monitoring site

Geraldton

AAQ NEPM Standard

50 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

50.5 µg/m^3

Description of event

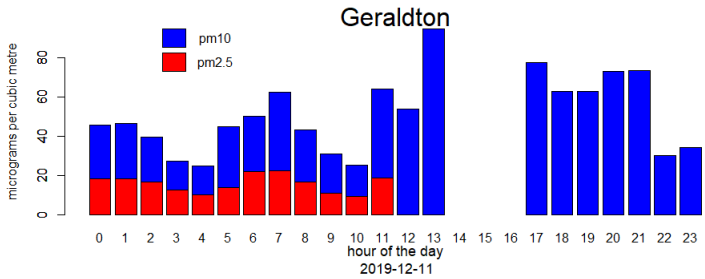
No fires or prescribed burns were known in the region.

The low ratio of $PM_{2.5}$:PM_{10} indicates the PM_{10} exceedance was likely because of wind borne dust as winds were over 30 km/h during the event.

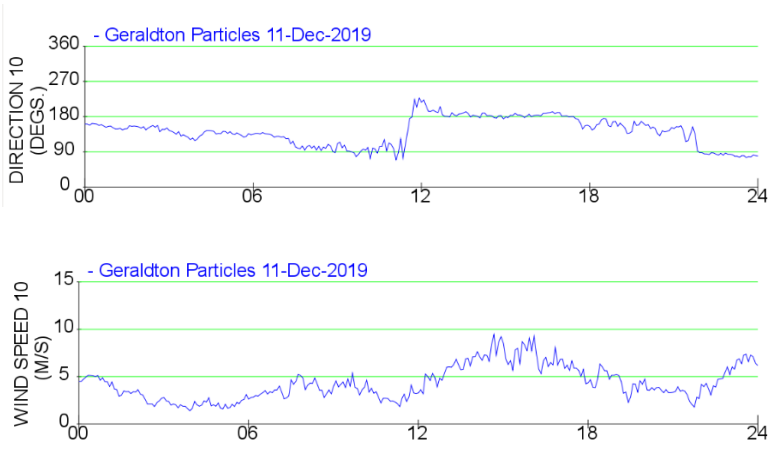
Assessable event

11 December 2019

Aqua/MODIS satellite image showing no bushfires or prescribed burns



60-minute averaged time series plot



Five-minute averaged time series plot of wind speed and direction.

Pollutant

PM_{10}

Monitoring site

Geraldton

AAQ NEPM Standard

50 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

50.8 µg/m^3

Description of event

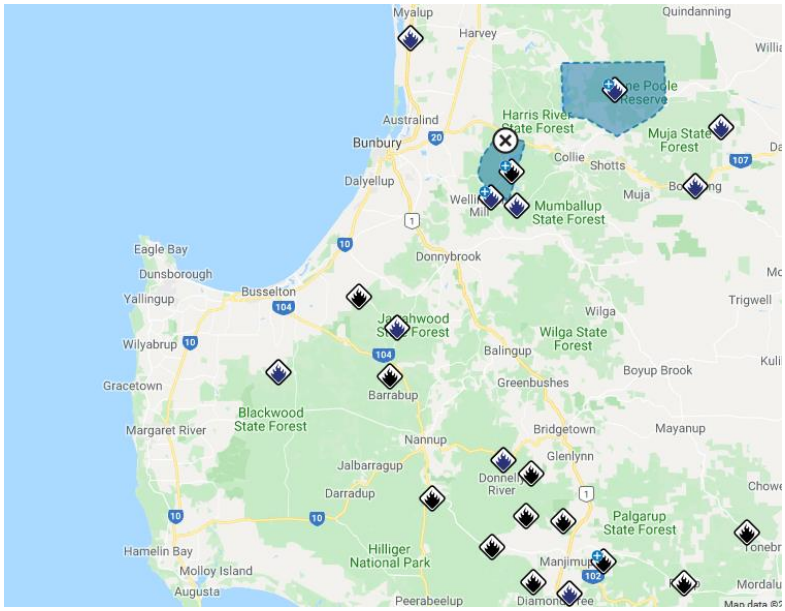
No prescribed burns or bushfires were active on the day. The elevated PM_{10} levels were most likely because of local crustal matter or a local fire. Maintenance was carried out on the PM_{10} and $PM_{2.5}$ monitors on the day; however, as there was greater than 75 per cent data recovery an assessment of PM_{10} concentration was possible. A departmental officer on site confirmed the presence of visible dust because of elevated winds.

$PM_{2.5}$ recording was offline for the majority of the day.

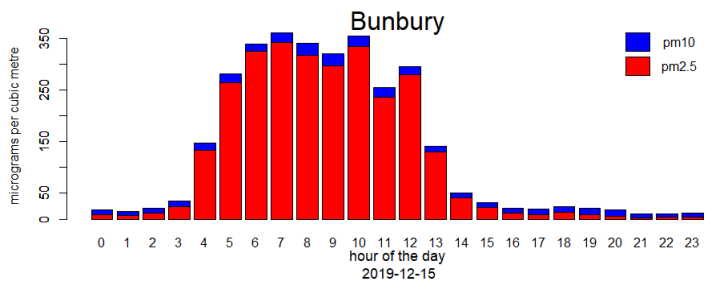
Assessable event

15 December 2019

Aqua/MODIS satellite image showing bushfires



A number of bushfires and Prescribed burns in the south west (www.emergency.wa.gov.au/#)



60-minute averaged time series plot

Pollutant

PM_{10} and $PM_{2.5}$

Monitoring site

Collie, Bunbury & Busselton

AAQ NEPM Standard

PM_{10} 50 µg/m^3

$PM_{2.5}$ 25 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

Location	15th
Collie PM_{10}	62.1
Bunbury PM_{10}	131.0
Bunbury $PM_{2.5}$	118.2
Busselton $PM_{2.5}$	39.6

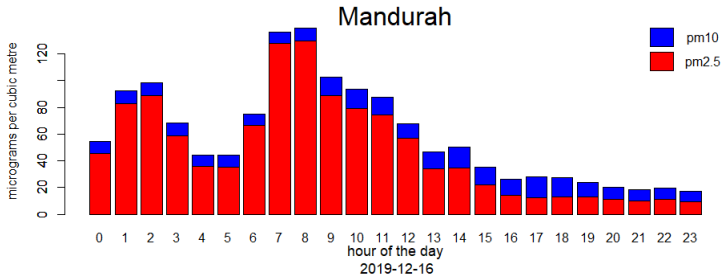
Description of event

A number of bushfires in Collie and surrounding areas were the likely cause of smoke.

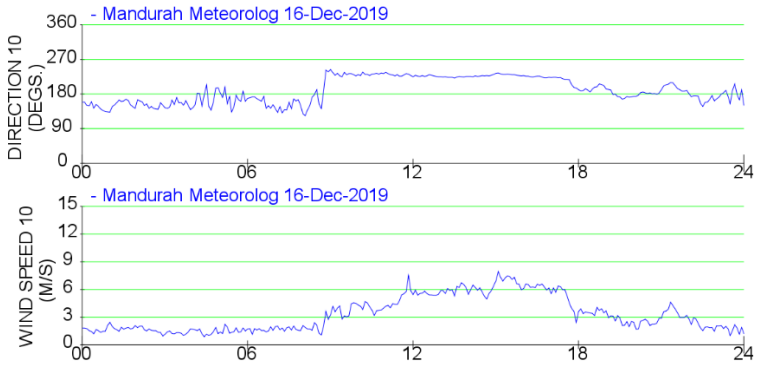
Exceptional event

16 December 2019

Terra/MODIS satellite image showing bushfires



60 minute averaged PM_{10} (blue) and $PM_{2.5}$ (red) for Mandurah.



Five-minute averaged wind direction and wind speed for Mandurah.

Pollutant

PM_{10} & $PM_{2.5}$

Monitoring site

Mandurah

AAQ NEPM Standard

PM_{10} – 50 µg/m^3

$PM_{2.5}$ – 25 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

PM_{10} – 59.1 µg/m^3

$PM_{2.5}$ – 48.1 µg/m^3

Description of event

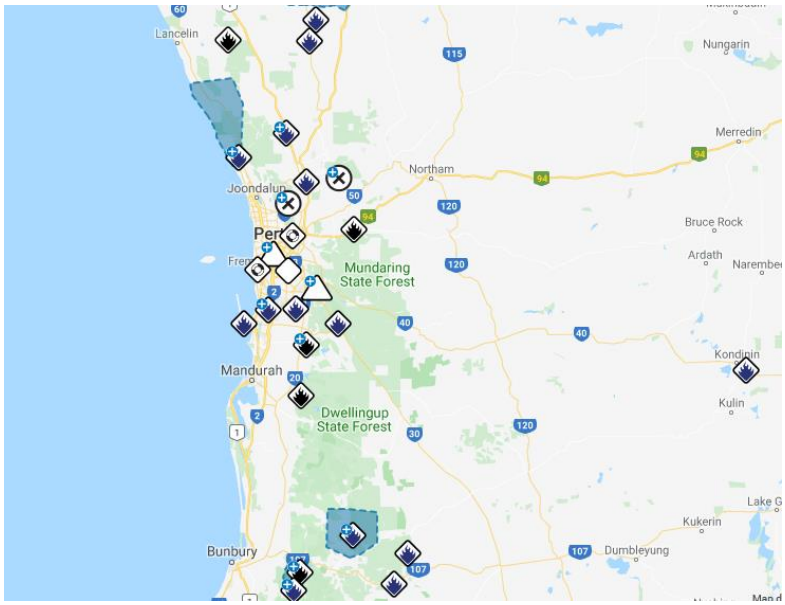
A number of bushfires were active 16 December in Collie and surrounding areas. Collie is about 120 km south-east of Mandurah.

The wind in the morning was from the SSE at a low speed.

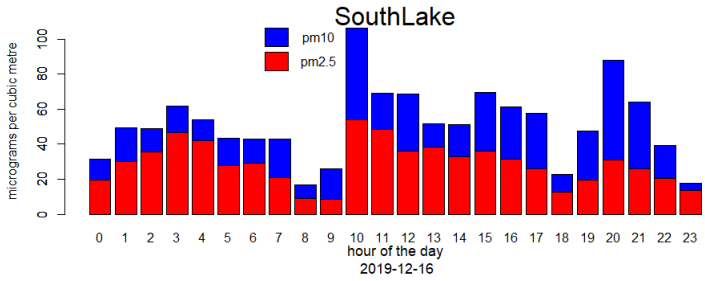
PM_{10} and $PM_{2.5}$ levels peaked at about 9am and decreased as the wind direction changed to south-westerly.

Exceptional event

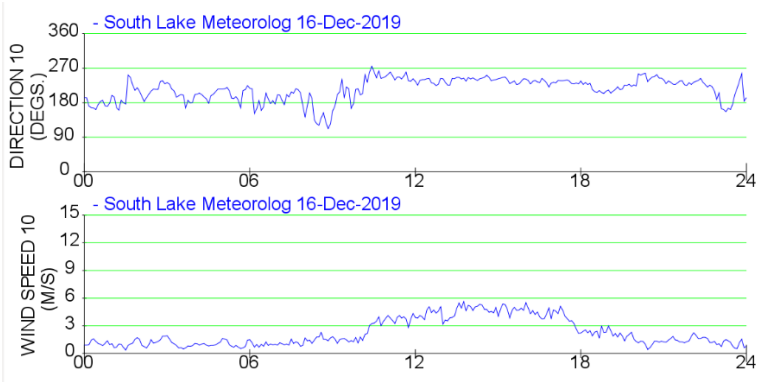
16 December 2019



A number of bushfires and Prescribed burns in Perth and the South West (www.emergency.wa.gov.au/#)



60-minute averaged PM_{10} and $PM_{2.5}$ for South Lake.



Five-minute averaged wind direction and wind speed for South Lake.

Pollutant

PM_{10} & $PM_{2.5}$

Monitoring site

South Lake

AAQ NEPM Standard

PM_{10} – 50 µg/m^3

$PM_{2.5}$ – 25 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

PM_{10} – 51.3 µg/m^3

$PM_{2.5}$ – 28.9 µg/m^3

Description of event

A number of bushfires were active 16 December in Perth and the south-west.

The wind in the morning was from the SSE at a low speed.

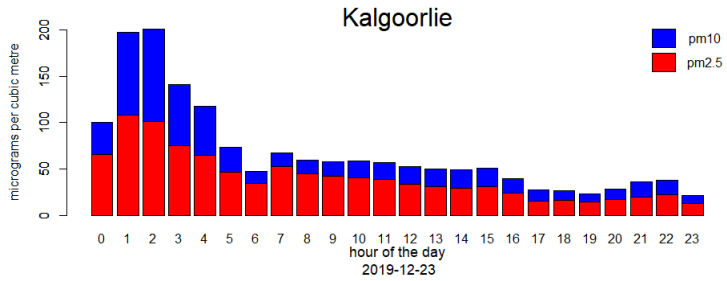
Elevated PM_{10} and $PM_{2.5}$ levels in the early morning were most likely because of to fires to the south of Perth.

As the wind changed to a south-westerly direction mid-morning there was an associated rise in PM_{10} and $PM_{2.5}$ levels.

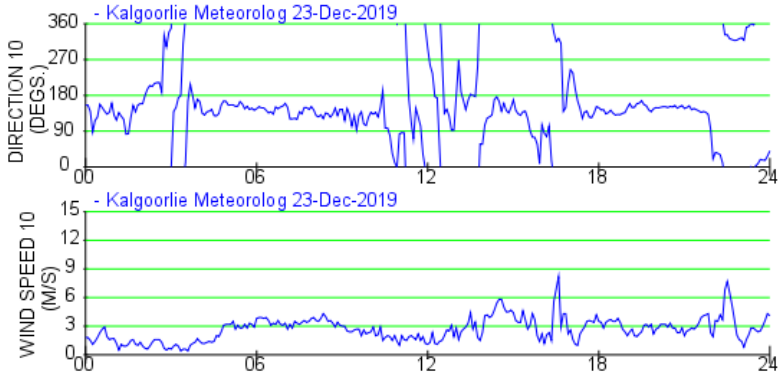
Exceptional event

23 December 2019

Map obtained from www.emergency.wa.gov.au



60 minute averaged time series plot of particles



Five minute averaged time series plot of wind speed and direction at Kalgoorlie

Pollutant

PM_{10} & $PM_{2.5}$

Monitoring site

Kalgoorlie

AAQ NEPM Standard

PM_{10} – 50 µg/m^3

$PM_{2.5}$ – 25 µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

PM_{10} – 67.6 µg/m^3

$PM_{2.5}$ – 40.8 µg/m^3

Description of event

A number of bushfires caused smoke in the region which impacted the Kalgoorlie site.

Exceptional event

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