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

2020 Western Australian air monitoring report

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

Department of Water and Environmental Regulation

October 2021

Department of Water and Environmental Regulation
Prime House, 8 Davidson Terrace
Joondalup Western Australia 6027
Locked Bag 10 Joondalup DC WA 6919

Telephone +61 8 6364 7000
Facsimile +61 8 6364 7001
National Relay Service 13 36 77
www.dwer.wa.gov.au

FIRST 115950

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Summary

Western Australia (WA) is a signatory to the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) and is required to report annually on the results of air quality monitoring undertaken by the Department of Water and Environmental Regulation (the department). This report has been prepared to comply with these AAQ NEPM reporting requirements.

The department is responsible for the operation and maintenance of 16 air quality monitoring sites in WA, with a total capital cost of over $4 million. Ten of these sites – Armadale, Caversham, Duncraig, Mandurah, Quinns Rocks, Rolling Green, Rockingham, South Lake, Swanbourne and Wattleup – are within the Greater Perth region. The remaining six sites are located regionally in Albany, Bunbury, Busselton, Collie, Geraldton and Kalgoorlie.

This report is based on the 2016 AAQ NEPM available at legislation.gov.au. The AAQ NEPM was amended in 2021 and will form the basis of future reports.

The Armadale site was commissioned in July 2020 to monitor PM_{10} and $PM_{2.5}$ particles. Exceedances recorded at this site during November and December have been included in this report; however, annual and trend statistics have not been included because there are only six months of data for 2020.

The Busselton site was decommissioned and rebuilt with a new enclosure, instruments and meteorological mast during the second quarter of 2020.

During calendar year 2020, the AAQ NEPM annual average standard for PM_{10} particles was not met at Mandurah.

The AAQ NEPM goal for PM_{10} particles was not met at:

- Caversham
- Geraldton
- Kalgoorlie
- Mandurah

The AAQ NEPM goal for $PM_{2.5}$ particles was not met at:

- Bunbury
- Caversham
- Kalgoorlie
- Mandurah
- Quinns Rocks
- South Lake

The AAQ NEPM annual average standards were met for all other pollutants.

Across all monitoring sites, there were 89 AAQ NEPM standard exceedances in 2020, comprising 48 exceedances of the PM_{10} particles standard (including 17 exceptional events) and 41 of the $PM_{2.5}$ particles standard (including 28 exceptional events).

Of the 45 PM_{10} and $PM_{2.5}$ particle exceedances that were classed as exceptional events:

- 33 were due to prescribed burning activities
- two were due to bushfires
- three were a combination of bushfires and prescribed burning activities
- seven were due to windborne dust.

These ‘exceptional event’ exceedances are not included in the AAQ NEPM goal assessment, in accordance with AAQ NEPM protocols.

A. Monitoring summary

This section summarises pollution data collected from each air quality monitoring site.

A.1 Current monitoring sites

The department's urban monitoring network shown in Figure A1 was originally designed for the purposes of the Perth Photochemical Smog Study, the Perth Haze Study and the management of pollutants in the Kwinana area.

The then Commonwealth Scientific and Industrial Research Organisation (CSIRO) Division of Atmospheric Research provided advice on monitoring site locations for the two studies. The network's design was based on the knowledge of emissions sources, pollutant chemistry and meteorological features.

More recently, new urban sites have been established at Armadale and Mandurah.

Regional monitoring sites at Bunbury, Busselton, Collie and Albany (as shown in Figure A2) were established to monitor smoke from fuel reduction burns. The Geraldton site (Figure A2) was established in the mid-west of the state to monitor windblown crustal material and smoke from bushfires, prescribed burns, agricultural stubble burning and wood-fired home heaters. The Kalgoorlie monitoring site was established to monitor particles from windblown crustal material and smoke, and sulfur dioxide from industry.

Tables A1 to A8 present summaries of site locations, monitoring methods and other information relating to the monitoring network.

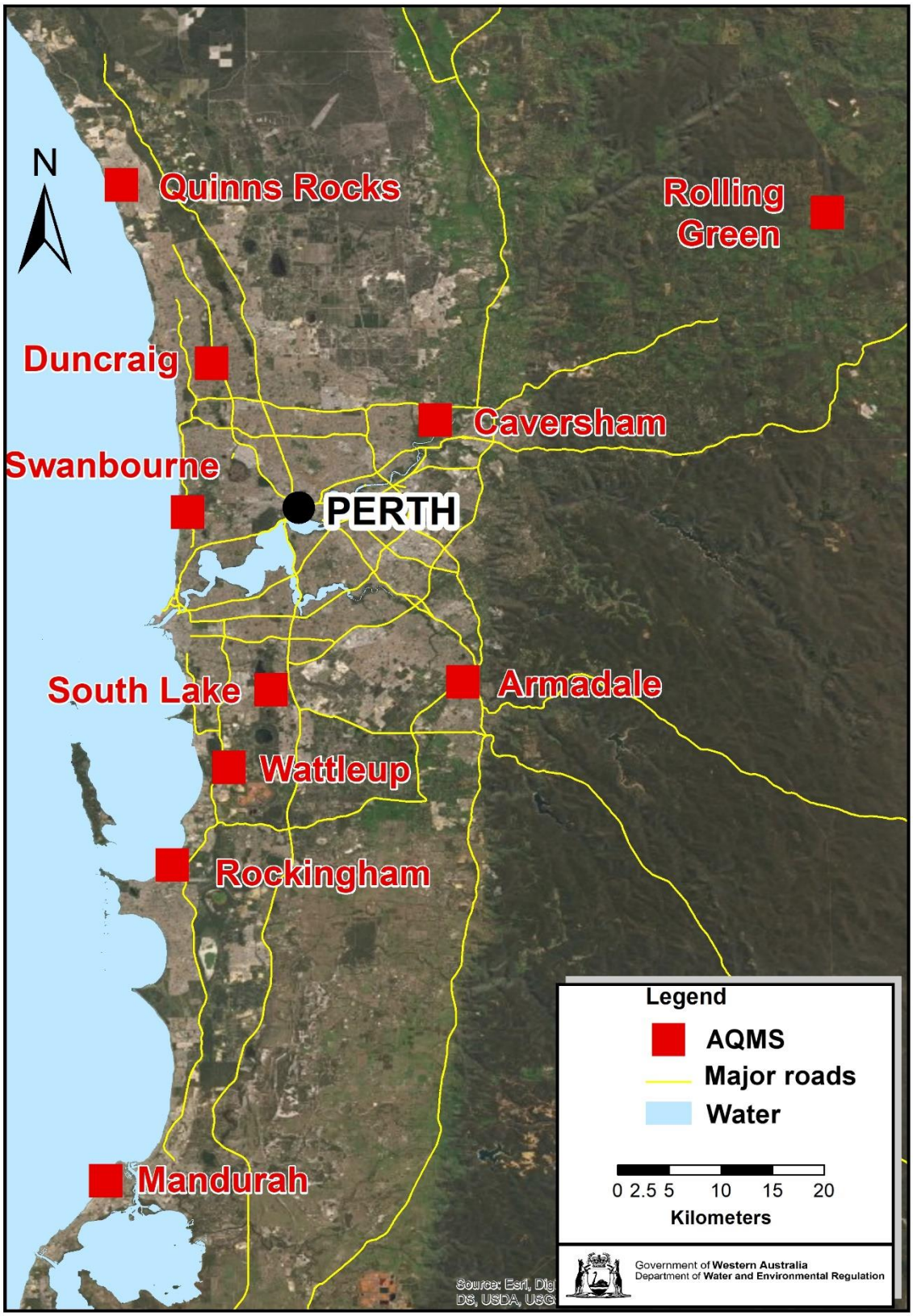


Figure A1 Department air quality monitoring sites in the Perth Metropolitan and Peel Regions.

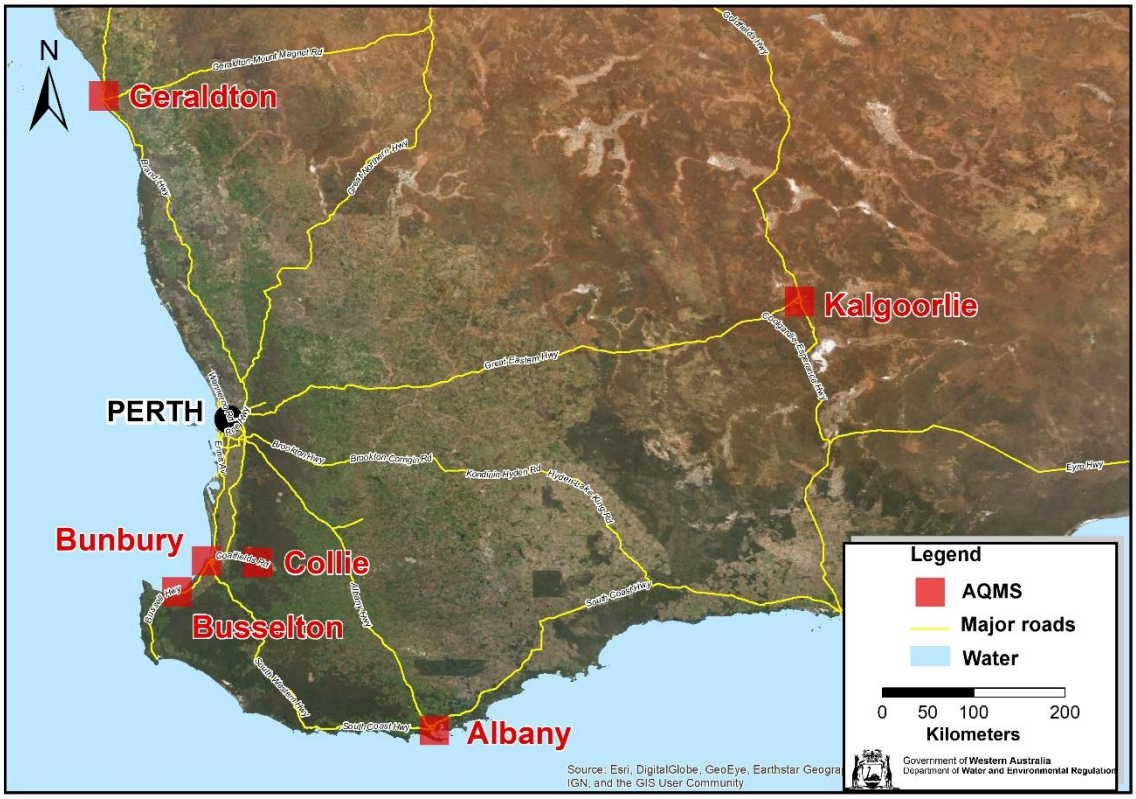


Figure A2 Department air quality monitoring sites in regional WA.

Table A1 Monitoring sites, air pollutants measured and periods of operation

Monitoring site	CO	O_3	NO_2	SO_2	PM_{10}	$PM_{2.5}$
Al Albany					07/2006 to present	
Ar Armadale					07/2020 to present	07/2020 to present
Bn Bunbury					06/1999 to present	04/1997 to present
Bs# Busselton					05/2020 to present	11/2006 to present
Ca Caversham	08/1993 to present	11/1989 to present	09/1990 to present		01/2004 to present	03/1994 to present
Co Collie					02/2008 to present	
Du Duncraig	08/1995 to present		08/1995 to present		06/1996 to present	01/1995 to present
Ge Geraldton					09/2005 to present	01/2019 to present
Kg Kalgoorlie	12/2017 to present			12/2017 to present	12/2017 to present	12/2017 to present
Ma Mandurah	10/2019 to present	10/2019 to present	10/2019 to present		10/2019 to present	10/2019 to present
QR* Quinns Rocks		11/1992 to present*	11/1992 to present*		04/2020 to present	07/2006 to present*
Ro Rockingham		12/1995 to present	12/1995 to present	07/1988 to present		
RG Rolling Green		01/1993 to present	01/1993 to present			
SL South Lake	03/2000 to present	03/2000 to present	03/2000 to present	03/2000 to present	03/2000 to present	04/2006 to present
Sw Swanbourne		01/1993 to present	03/1993 to present			
Wt Wattleup				01/1988 to present		

* The Quinns Rocks site was decommissioned in March 2017 and re-established at a new location in April 2020

The Busselton site was decommissioned in April 2020 and rebuilt with the addition of PM_{10} monitoring in May 2020

Table A2 Monitoring site descriptions

Site	Description
Albany	Large rural town 380 km south-south-west of Perth with medium-density housing.
Armadale	South-east metropolitan site 22 km south-east of Perth with medium-density housing and moderate traffic flow. The site is 200 m east of the Tonkin Highway, a main north–south arterial road carrying about 27,000 vehicles daily.
Bunbury	Large rural town 145 km south of Perth with medium-density housing.
Busselton	Small rural town 185 km south of Perth with medium-density housing.
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.
Collie	Small rural town within a forested region 152 km south of Perth with medium-density housing and typical traffic flows. Coal mining and power-generation industries.
Duncraig	North metropolitan suburb 16 km north-north-west of the Perth CBD with medium-density housing and moderate-to-high traffic flows. The site is 200 m west of the Mitchell freeway, a main north–south arterial road carrying about 98,000 vehicles daily.
Geraldton	Large rural town 377 km north of Perth in the mid-west with medium-density housing.
Kalgoorlie	Large rural town 500 km east-north-east of Perth in the goldfields with a dry climate and medium-density housing.
Mandurah	City on the south-west coast of WA, 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 during westerly winds.
Quinns Rocks	Outer-north coastal suburb 35 km north of Perth with medium-density housing.
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.
Rockingham	South-coastal site 35 km south of Perth with medium-density housing and typical traffic flows, situated 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.
South Lake	South-east metropolitan site 17 km south of Perth with medium-density housing and moderate-to-high traffic flows. 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.
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.
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 A3 Monitoring site classification

Site	CO	O_3	NO_2	SO_2	PM_{10}	$PM_{2.5}$
Albany					P/T	
Armadale					P/T	P/T
Bunbury					P/T	P/T
Busselton						DWER
Caversham	DWER	P/T	P/T		P/T	P/T
Collie					DWER	
Duncraig	P/T		DWER		P/T	P/T
Geraldton					P/T	P/T
Kalgoorlie	M				P/T	P/T
Mandurah	P/T	P/T	P/T		P/T	P/T
Quinns Rocks		DWER	DWER			DWER
Rolling Green		DWER	DWER			
Rockingham		DWER	DWER	DWER		
South Lake	P/T	P/T	P/T	P	P/T	P/T
Swanbourne		P/T	P/T			
Wattleup				DWER		

Key:

P	Performance monitoring site
T	Trend performance monitoring site
M	Campaign monitoring
DWER	Instrument will be maintained by the department for the foreseeable future

Table A4 Screening procedures to demonstrate if monitoring is required

Notation	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 sites to demonstrate the full number of sites 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 sites to demonstrate the full number of sites 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 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 a greater population, emissions and pollution potential.
P	Performance monitoring.
T	Trend monitoring.
M	Campaign monitoring.

Table A5 Screening procedures satisfied at each site

Site	Pop'n*	CO	O_3	NO_2	SO_2	Pb	Particles
Perth and Rockingham	1,944,000	P/T/M	P/T/M	P/T/M	B&C	B	P/T/M
Mandurah	80,800	P/T/M	P/T/M	P/T/M	F	F	P/T
Albany	29,400	F	F	F	F	F	P/T
Bunbury	71,000	A&F	E&F	E&F	D&F	F	P/T
Kalgoorlie-Boulder	29,900	M	E&F	E&F	P/T	F	P/T
Geraldton	32,000	F	E&F	E&F	D&F	F	P/T

* Population based on 2016 data (www.censusdata.abs.gov.au).

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

Table A6 Monitoring methods used

Pollutant	Standard	Method
Carbon monoxide	AS/NZS 3580.7.1 Determination of carbon monoxide – direct-reading instrumental method.	Gas filter correlation spectrophotometry.
Ozone	AS 3580.6.1 Determination of ozone – direct-reading instrumental method.	Ultraviolet absorption.
Nitrogen dioxide	AS 3580.5.1 Determination of oxides of nitrogen – chemiluminescence method.	Chemiluminescence.
Sulfur dioxide	AS 3580.4.1 Determination of sulfur dioxide – direct-reading instrumental method.	Ultraviolet fluorescence.
Particles as PM_{10}	AS 3580.9.8 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 Determination of suspended particulate matter – $PM_{2.5}$ continuous direct mass method using a tapered element oscillating microbalance analyser.	Tapered element oscillating microbalance.
Particles as $PM_{2.5}$ and PM_{10}	AS/NZS 3580.9.7 Determination of suspended particulate matter – dichotomous sampler (PM_{10}, coarse PM and PM2.5) – gravimetric method.	Dichotomous FDMS
	AS/NZS 3580.9.16 PM_{10} continuous direct mass method using a tapered element oscillating microbalance monitor incorporating a filter dynamic measurement system (FDMS) unit.	Tapered element oscillating microbalance.

Table A7 Site compliance with AS/NZ 3580.1.1

	Height above ground	Minimum distance to support structures	Clear sky angle of 120°	Unrestricted airflow of 270°/360°	20 m from trees	No extraneous sources nearby	Minimum distance from road or traffic	Sample line material	Sample line length	Comments
Perth region										
Armadale	☑	☑	☑	☑	☑	☑	☑	☑	☑	
Caversham	☑	☑	☑	☑	☑	☑	☑	☑	☑	
Duncraig	☑	☑	☒	☑	☒	☑	☑	☑	☑	6 m to medium-sized trees and presence of power pole.
Quinns Rocks	☑	☑	☑	☑	☒	☑	☑	☑	☑	
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 from small to medium-sized eucalyptus trees.
Busselton	☑	☑	☑	☑	☒	☑	☑	☑	☑	5 m from small to medium-sized eucalyptus trees.
Collie	☑	☑	☒	☑	☒	☑	☑	☑	☑	Some trees and shipping containers nearby.
Mid West region										
Geraldton	☑	☑	☑	☑	☑	☑	☑	☑	☑	
Goldfields region										
Kalgoorlie	☑	☑	☑	☑	☑	☑	☑	☑	☑	

Table A8 AAQ NEPM standards and goals for criteria 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	0.50 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

A.2 Carbon monoxide

This section summarises carbon monoxide (CO) monitoring performed in WA.

WA maintained performance monitoring of CO at the nominated trend sites of Duncraig and South Lake. CO is also monitored at Mandurah and Caversham.

The Duncraig monitoring site 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 200 m west of the Mitchell freeway and lies in a depression through which the freeway passes. The effect of stable air pooling in the depression is likely to lead to elevated CO concentrations. This geographic feature is found in many other places across the Perth coastal plain. The site is representative of a medium-density suburb.

The South Lake monitoring site is in an urban area and has previously recorded moderate levels of CO from domestic wood fires. 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 the Mandurah monitoring site is expected to be low; however, there is likely to be some contribution from wood fires and controlled burns. Data has only been collected from Mandurah since October 2019, and so trend analysis is not possible at this time.

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

Trend analysis for each site shows that the maximum of the eight-hourly averages has 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.

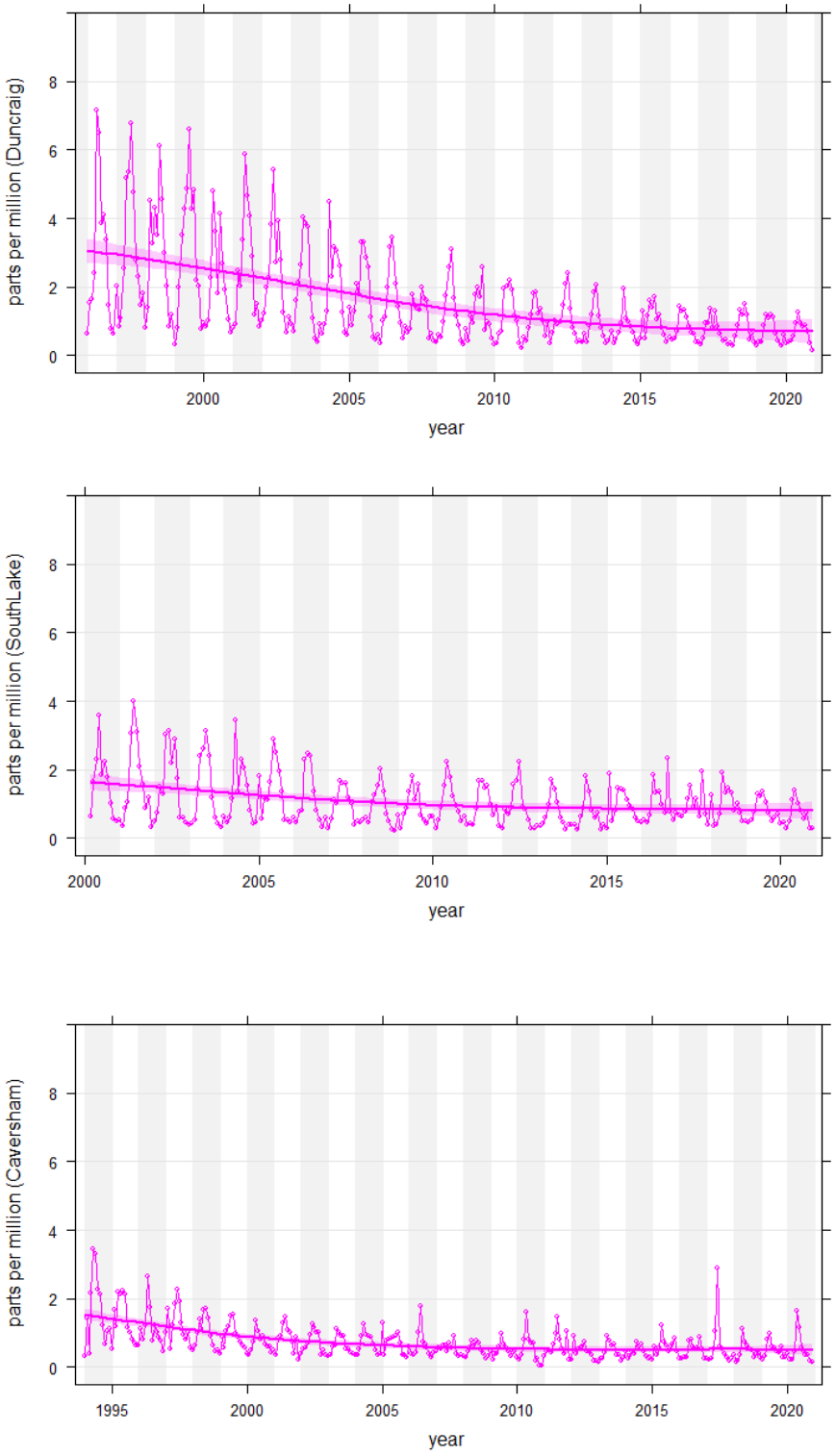


Figure A3 *Smoothed trend (dark lines) for CO at Duncraig (top), South Lake (centre) and Caversham (bottom).*

According to the National Pollutant Inventory, for the 2019–20 reporting year, over 90 per cent of the CO emissions were from motor vehicles (0.25 million tonnes [MT]) and combustion products from fuel-reduction burns and wildfires (1.7 MT). Metal ore mining (0.05 MT) and domestic solid fuel burning (0.041 MT) were the next highest contributors.

The CO maximum (blue), 99th (red) and 95th (green) concentration percentiles for each hour of the day at Duncraig over five-year periods 1996–2000, 2006–10 and 2016–20 are presented in Figure A4. The CO profile shows a marked decrease in overnight concentrations over the 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. These require heating appliances (wood heaters) for sale 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.

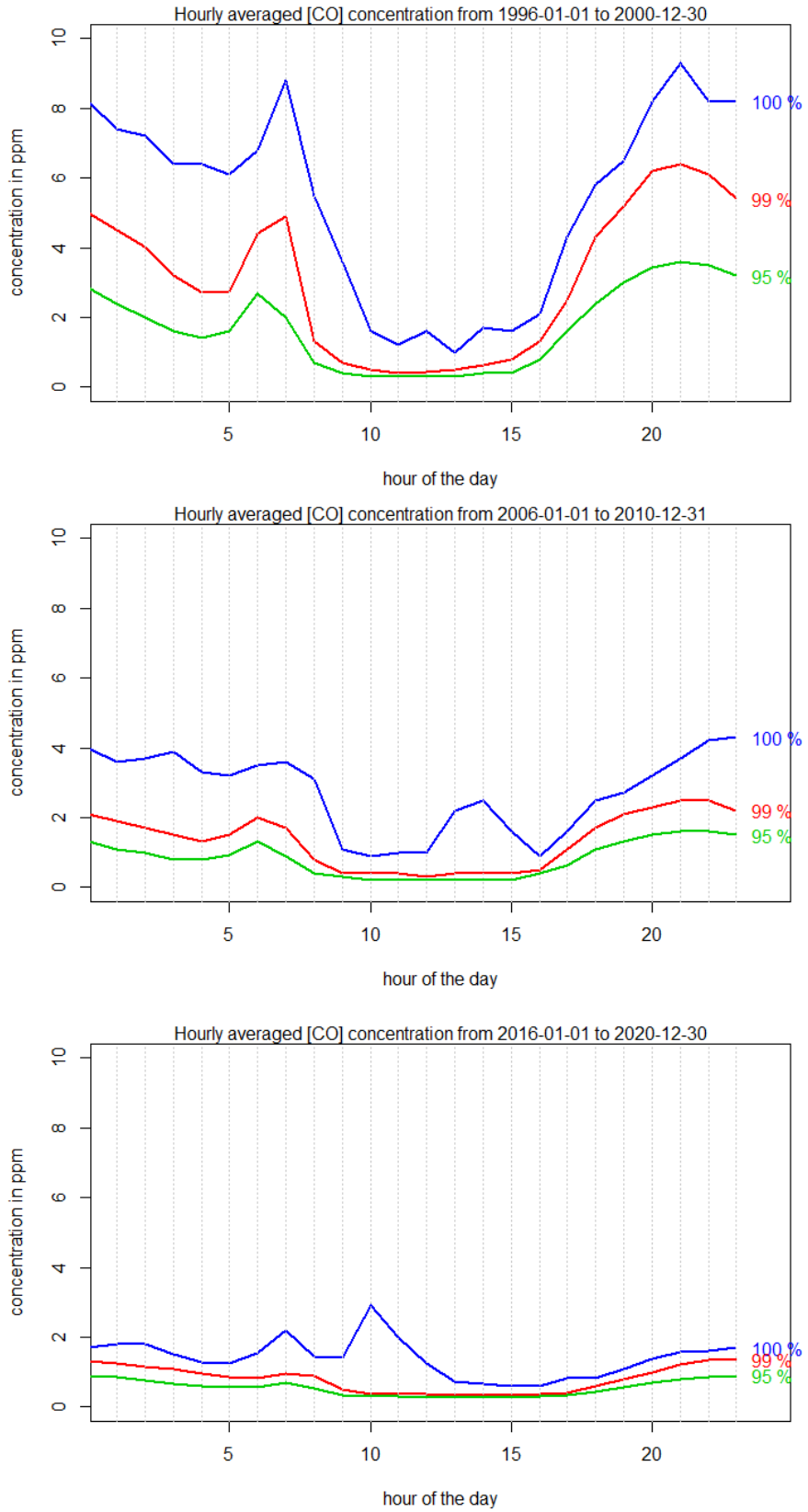


Figure A4 *The CO maximum (blue), 99th (red) and 95th (green) percentiles for each hour of the day at Duncraig over five-year periods 1996–2000 (top), 2006–10 (centre) and 2016–20 (bottom).*

A.3 Photochemical oxidants as ozone

This section describes ozone (O_3) monitoring performed in WA.

O_3 formation in metropolitan Perth occurs due to a complex interaction between nitrogen oxides, organic compounds, prevailing winds and relatively high levels of sunlight. This often occurs with easterly winds during the day, until an afternoon sea breeze pushes an ozone-rich plume back over the city.

Statistics for the coastal sites of Quinns Rocks, Swanbourne and Rockingham indicate there is little difference between O_3 levels at each site over the long term. Swanbourne was selected as a performance monitoring site, while monitoring sites at Quinns Rocks and Rockingham were maintained to provide additional information on O_3 events.

Given its location, the Caversham monitoring site represents an upper-bound, middle-distance inland site. Accordingly, Caversham was selected as a performance monitoring site.

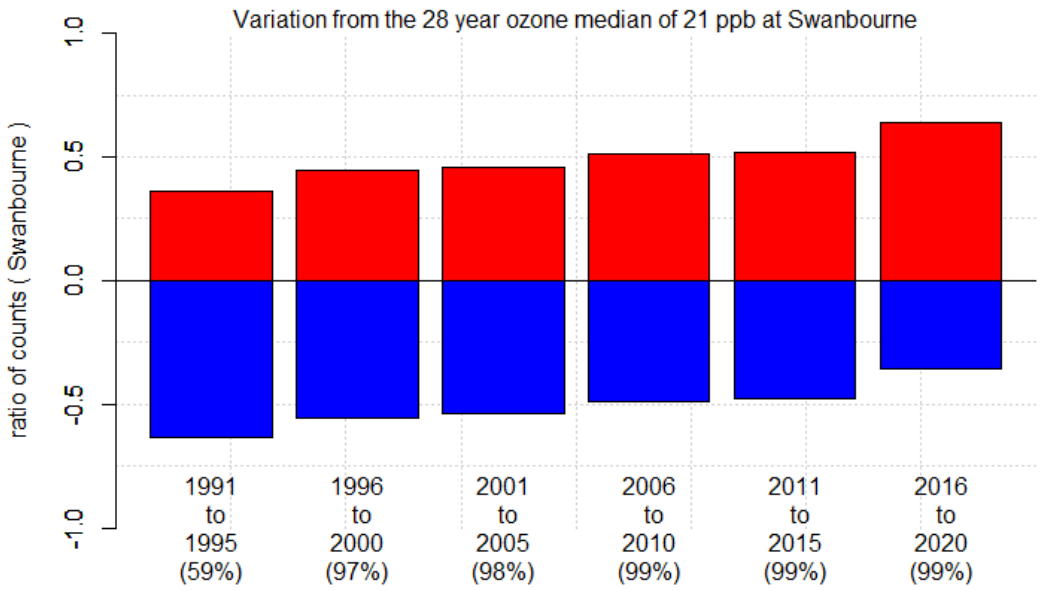
A third performance monitoring site was at South Lake. It was chosen because:

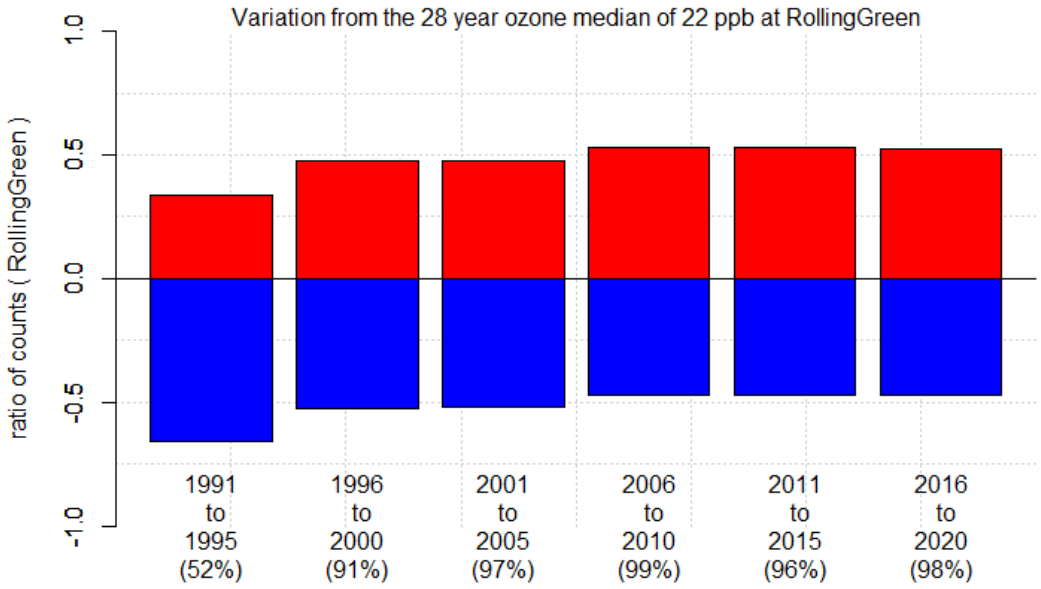
- it provides a good spatial spread of sites (it will measure ozone returning on shore in the southern part of the metropolitan area)
- it is a moderate distance inland in a growing urban area, so it is classified as a population-average site
- it may occasionally detect the interactions of O_3-rich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

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

The department will continue to maintain the sites at Rockingham, Quinns Rocks and Rolling Green as part of its wider ozone network to enable a better understanding of O_3 events.

Long-term analysis is presented in Figure A5. The number of times when the one-hour O_3 concentration exceeded the long-term average at the coastal site of Swanbourne has increased for every five-year period analysed.


Variation from the 28 year ozone median of 21 ppb at Swanbourne
ratio of counts (Swanbourne)
1.0
0.5
0.0
-0.5
-1.0
1991 to 1995 (59%)
1996 to 2000 (97%)
2001 to 2005 (98%)
2006 to 2010 (99%)
2011 to 2015 (99%)
2016 to 2020 (99%)


Variation from the 28 year ozone median of 22 ppb at RollingGreen
ratio of counts (RollingGreen)
1.0
0.5
0.0
-0.5
-1.0
1991 to 1995 (52%)
1996 to 2000 (91%)
2001 to 2005 (97%)
2006 to 2010 (99%)
2011 to 2015 (96%)
2016 to 2020 (98%)

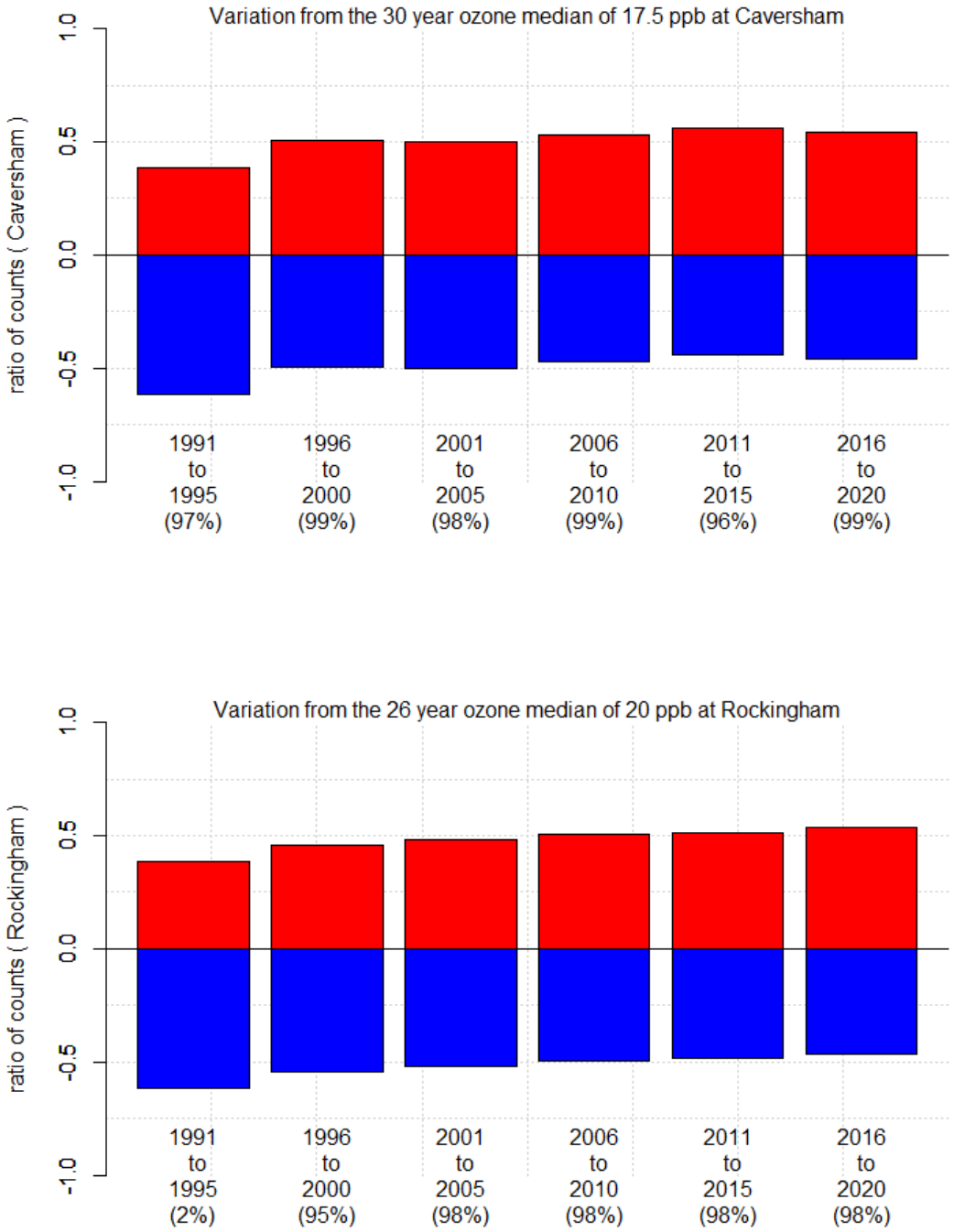


Figure A5 *Ratio of the number of hourly averaged ozone concentrations at Swanbourne (top panel), Rolling Green, Caversham and Rockingham (bottom panel) that was higher (red) or equal to or lower (blue) than the long-term average concentration for that site (bracketed percentages indicate data recovery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

A.4 Nitrogen dioxide

This section describes NO_2 monitoring performed in WA.

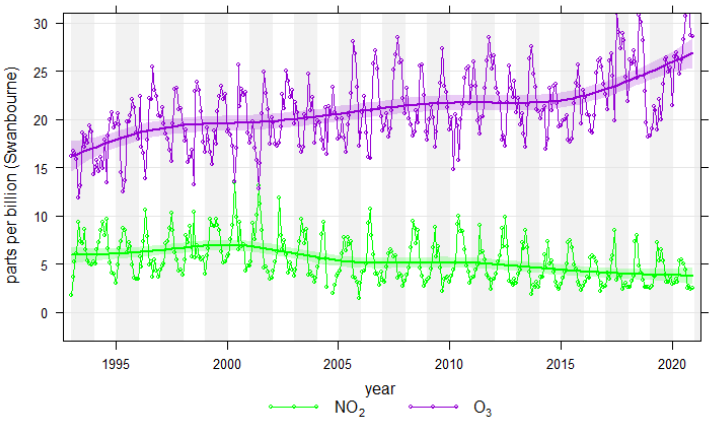
Nitrogen oxides (NO + NO_2) are primarily generated through vehicle use and industrial processes.

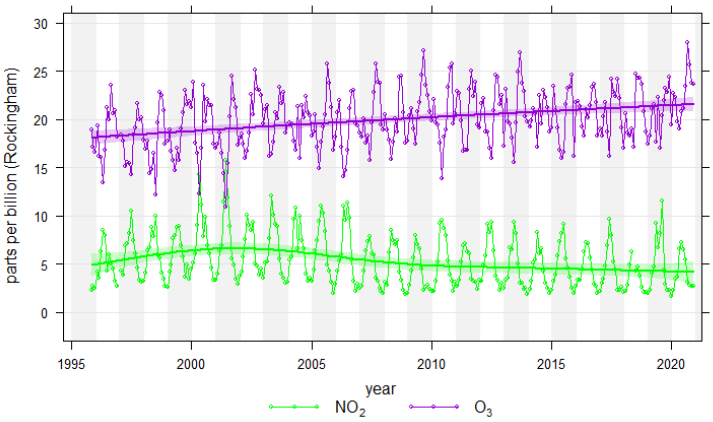
Owing to their close chemical reactivity relationship, NO_2 is currently being monitored at all sites where O_3 is monitored. Caversham, Swanbourne and South Lake sites were chosen as performance monitoring sites for NO_2 as they provided a good spatial distribution. Caversham, Swanbourne and South Lake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

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 the monthly averages for nitrogen oxides (NO + NO_2) have decreased at all sites. The monthly NO has also seen a general decrease over time, with Duncraig experiencing an average of 0.65 parts per billion (ppb) per annum decrease since 1996.

A possibly unintended consequence of these decreasing concentrations of nitroge oxies is the inability to suppress ozone formation fully by (typically) producing NO_2 (NO + O_3 → NO_2 + O_2). The general build-up in O_3 therefore starts earlier (and consequently closer to populated areas) than it otherwise would.[1]





[1] Stedman DH (2004) 'Photochemical ozone formation, simplified', *Environmental Chemistry* 1(2): 65-66.

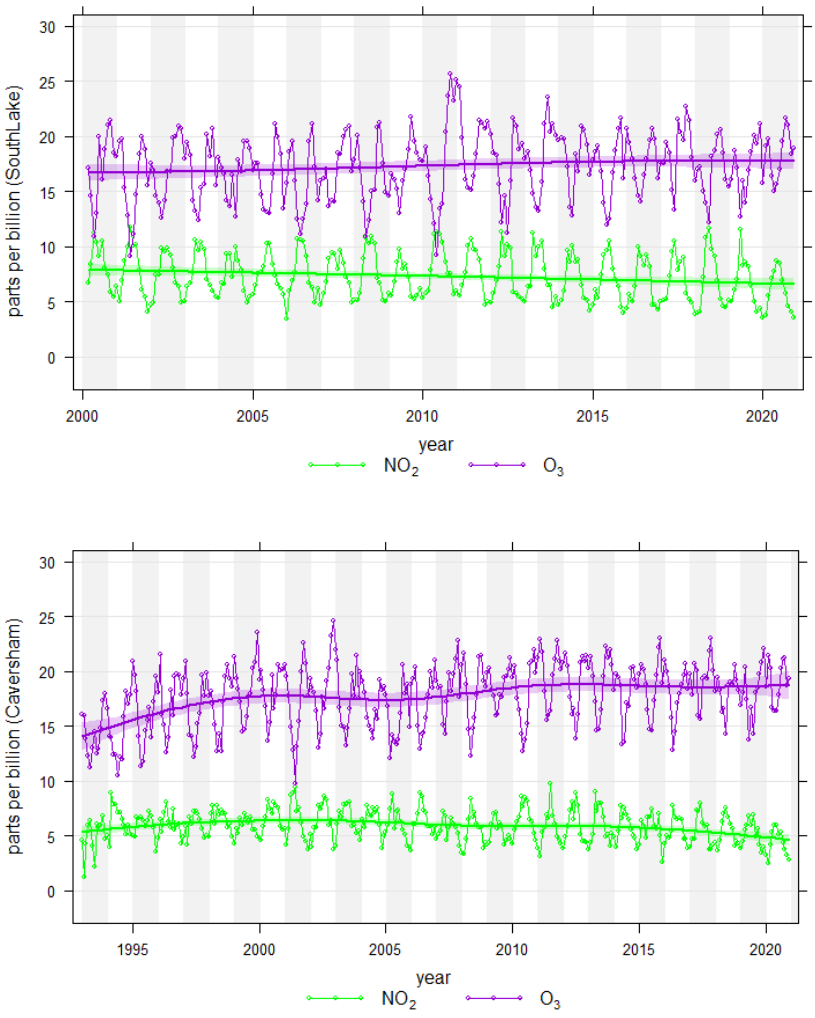


Figure A6 *Smoothed trend (dark lines) at Swanbourne (top panel), Rockingham, South Lake and Caversham (bottom panel) using the monthly average concentration of NO_2 (green) and O_3 (violet).*

A.5 Sulfur dioxide

This section describes sulfur dioxide monitoring performed in WA.

Heavy industry in the Kwinana Industrial Area (KIA) is the only significant source of sulfur dioxide in the Perth region. Concentrations of sulfur dioxide have reduced substantially since the late 1970s because of the transition from high to low-sulfur content fuels and the installation of sulfur dioxide emission control technologies. Emissions are controlled through conditions of licences issued by the department under Part V of the *Environmental Protection Act 1986*, together with the Environmental Protection (Kwinana) (Atmospheric Wastes) Policy 1999 (EPP), to ensure ambient concentrations do not exceed the standards and limits set in the EPP.

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

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

Long-term trends for sulfur dioxide are presented in Figure A7.

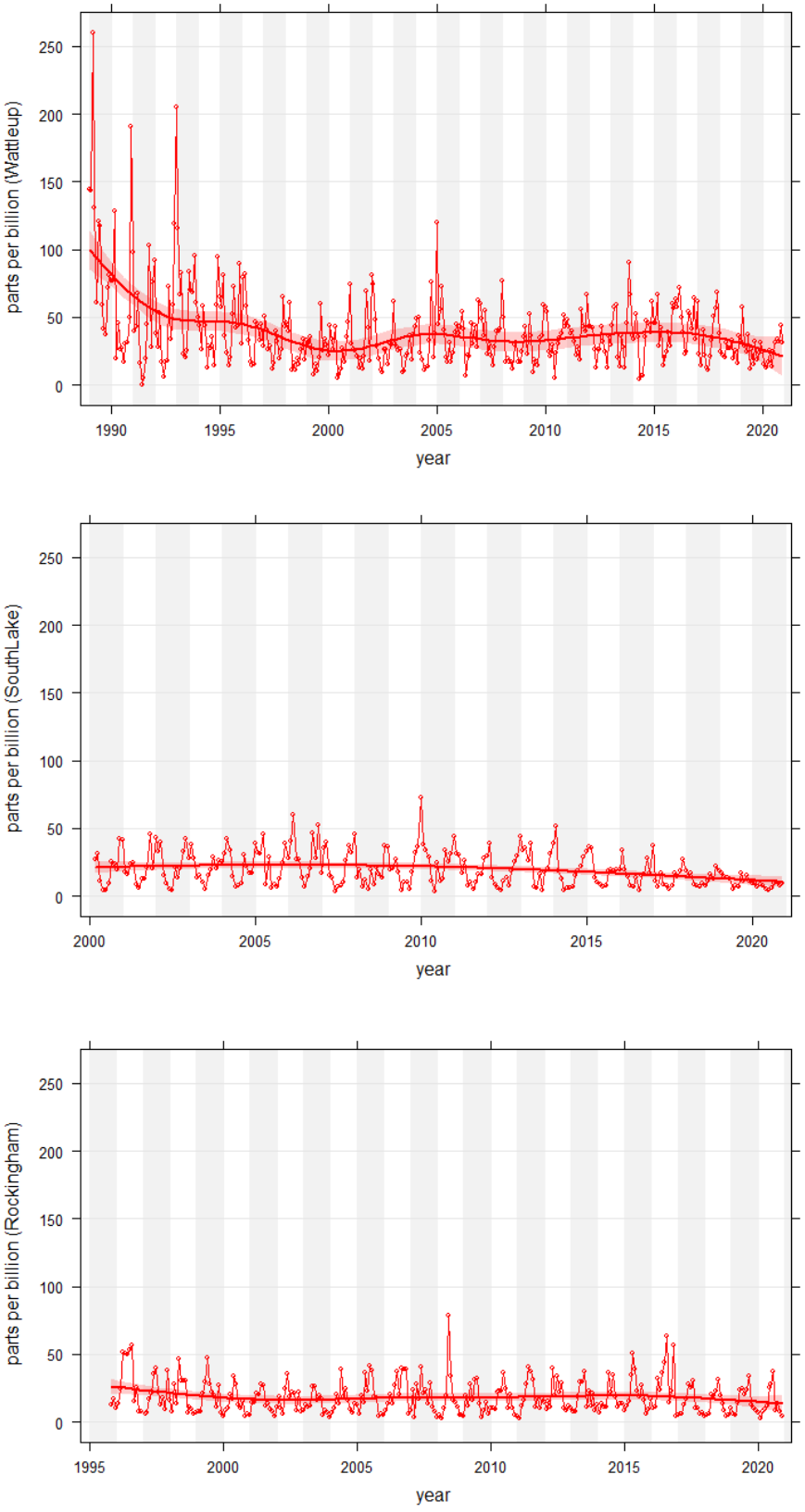


Figure A7 *Trend line for maximum hourly averaged sulfur dioxide concentration at Wattleup, within the Kwinana industrial buffer (top), South Lake (centre) and Rockingham (bottom).*

Sulphur dioxide is also monitored in Kalgoorlie; however, there is not enough data to allow any trend analysis.

A.6 Lead

This section describes lead monitoring previously performed in WA.

Since 1995, lead levels within the Perth CBD have been below 60 per cent of the AAQ NEPM annual standard of 0.5 particle micrograms per cubic metre (µg/m^3). In 2001, the average lead level in Perth was 0.022 µg/m^3, which is less than five per cent of the AAQ NEPM standard. The decreasing trend was the result of the phase out of leaded petrol.

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

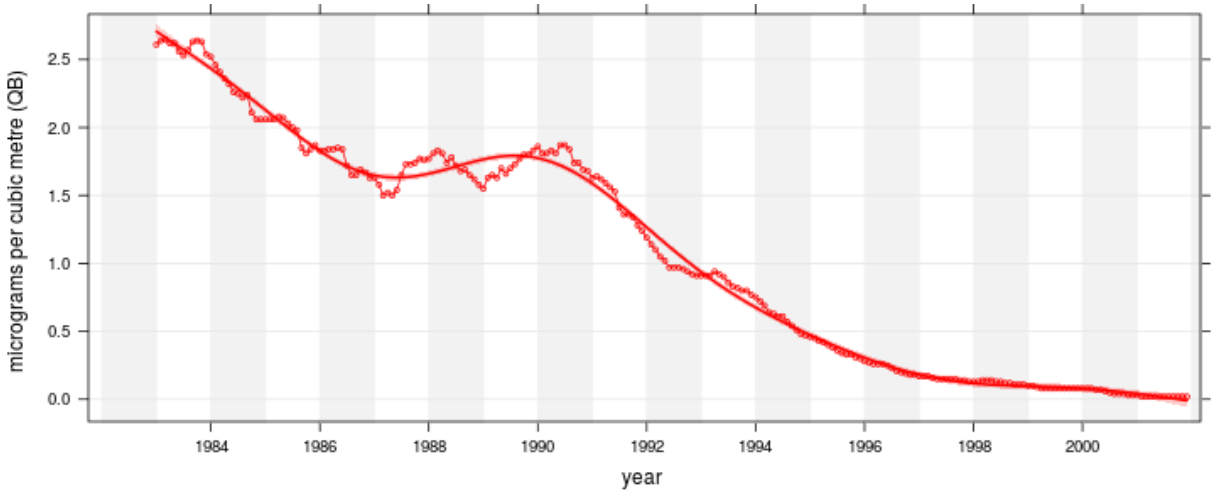


Figure A8 Trend line for annual moving average lead concentration within the Perth CBD.

A.7 Particles as PM_{10}

This section describes PM_{10} particle monitoring performed in WA.

The *Perth air emissions study 2011–12* estimated emissions from natural and man-made sources. Mining and quarries (46%), marine aerosols (21%), wind erosion (13%) and manufacturing (6%) were the biggest sources of particles as PM_{10} from an overall airshed perspective.

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

Similarly, South Lake measures significant PM_{10} concentrations arising from wood fires and some industrial emissions.

Duncraig and South Lake are both nominated as trend sites.

Additional monitoring sites were established at Geraldton in 2005, Albany in 2006, Collie in 2008, Kalgoorlie in 2017, Mandurah in 2019 and Armadale in 2020.

A frequency distribution of hourly particle concentrations is shown in Figure A9 for three metropolitan sites and one regional site for the 10 years between 2011–20. It can demonstrate differences in the ratio of $PM_{2.5}$:PM_{10} and 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. A lower ratio 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 50µg/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.

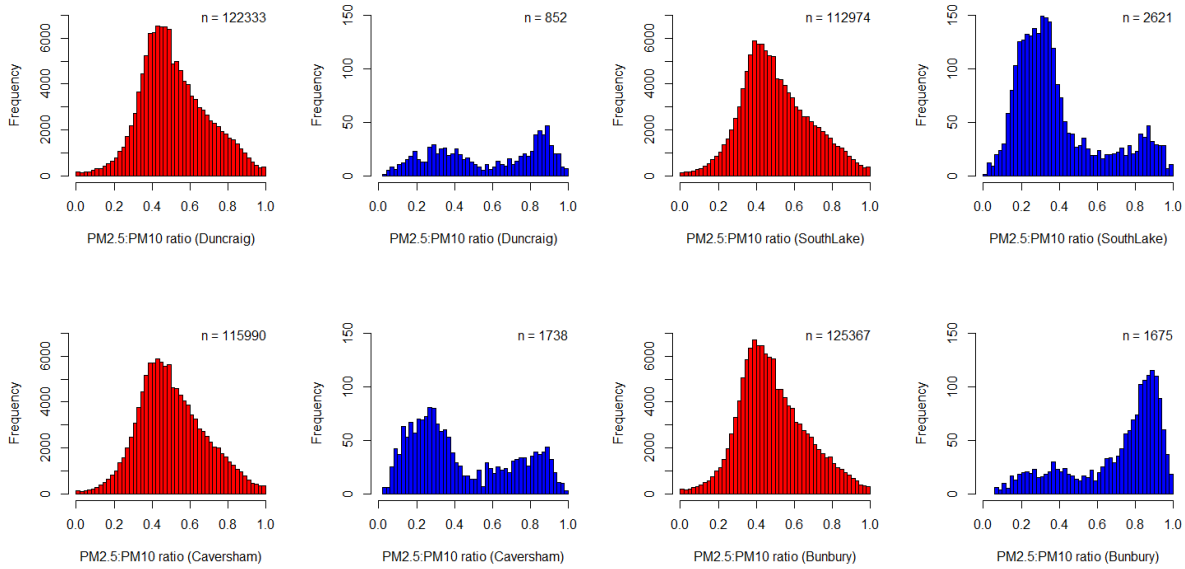


Figure A9 *Frequency distribution of $PM_{2.5}$:PM_{10} ratios of hourly averages at Duncraig (top left), South Lake (top right), Caversham (lower left) and Bunbury (lower right) for the 10-year period from 2011 to 2020 using all data (red) and data where hourly averaged PM_{10} was greater than or equal to 50µg/m³ (blue).*

These differences can be explained based on the site locations.

Duncraig is 3.5 km from the coast within a medium density housing area with no industry close by, so will be mainly influenced by vehicles, sea salt and smoke from the occasional bush fire or prescribed burn and, to a lesser extent, domestic wood heater emissions. Consequently, the site is likely to record a higher $PM_{2.5}$:PM_{10} ratio, which is characteristic of combustion products.

Bunbury is a small city in the south-west of the state surrounded by farms and bushland which are subjected to controlled burns and occasional bush fires. So, a higher $PM_{2.5}$:PM_{10} ratio characteristic of combustion products would be expected here too.

Caversham is in the semi-rural Swan Valley north-east of Perth CBD and has horticulture, viticulture and some brick manufacturing facilities. These two industries are more likely to produce coarse fraction particles producing a lower $PM_{2.5}$:PM_{10} ratio.

South Lake, within a medium density housing area, is close to the KIA, horticultural areas, new housing developments and a cement manufacturing plant. It is, therefore, more likely that $PM_{2.5}$:PM_{10} ratios will be lower.

A.8 Particles as $PM_{2.5}$

This section describes $PM_{2.5}$ particle monitoring performed in WA.

To make assessments against the AAQ NEPM standard, $PM_{2.5}$ tapered element oscillating microbalances (TEOMs) have been installed in the greater Perth Metropolitan and Peel regions at Quinns Rocks, Caversham, Duncraig, South Lake, Armadale and Mandurah, and in the rural locations of Bunbury, Busselton, Geraldton 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).

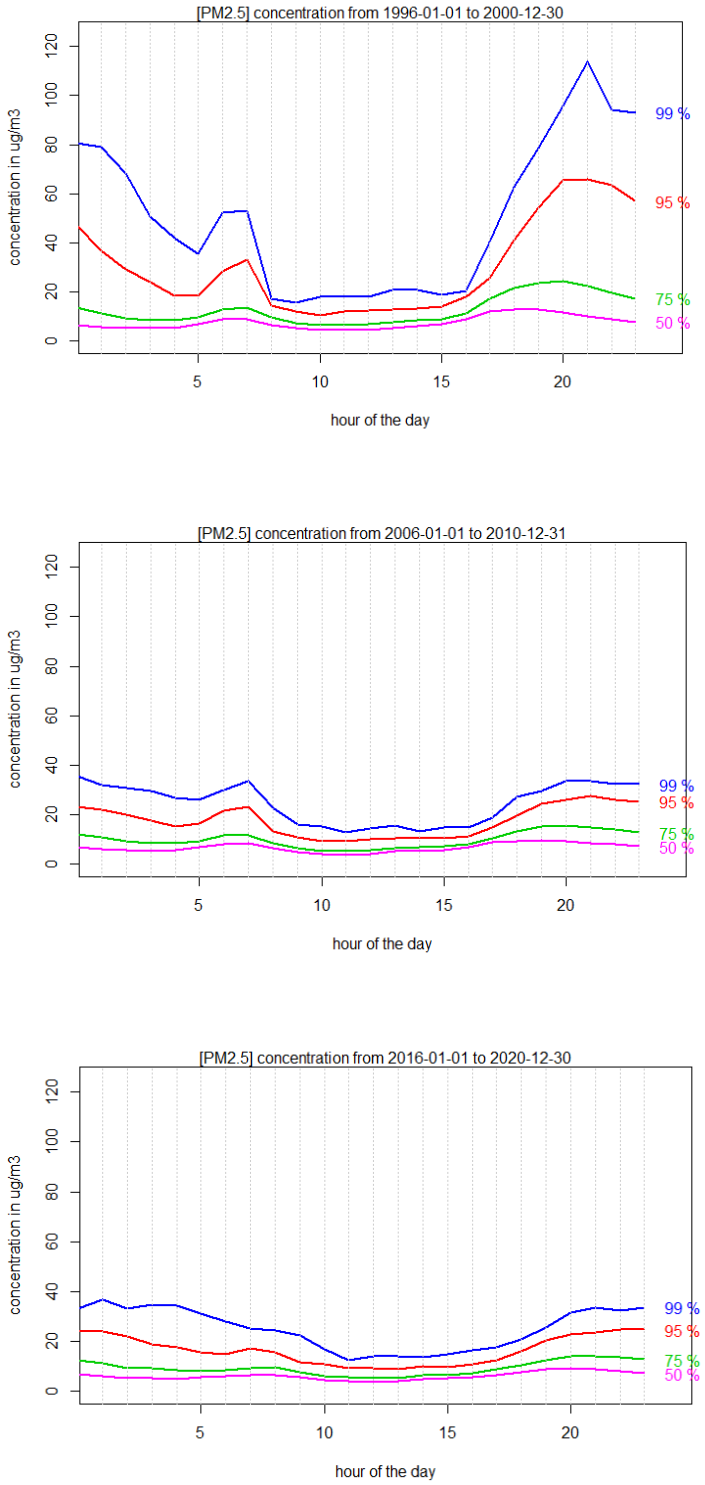


Figure A10 *The $PM_{2.5}$ 99th (blue), 95th (red), 75th (green) and 50th (mauve) percentiles for each hour of the day at Duncraig over winter months spanning the five-year periods 1996–2000 (top), 2006–2010 (centre) and 2016–2020 (bottom).*

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 (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) for sale 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 department, 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

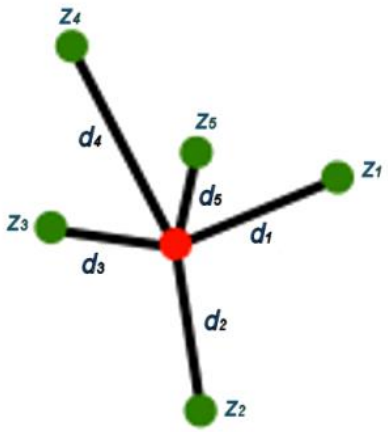
The requirement for an annual assessment of population exposure to particles as $PM_{2.5}$ was made in the AAQ NEPM variation on 26 February 2016.

Pending a nationally consistent method to assess population exposures for $PM_{2.5}$, the WA assessment 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 consider land-use or terrain effects. This results in the concentrations of nearer sites having a greater effect on the estimated concentration than more distant sites.

In 2020, metropolitan $PM_{2.5}$ particle data was collected from three metropolitan sites, namely Caversham, Duncraig, South Lake and Mandurah, and the three regional sites of Bunbury and Busselton. 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 2020 was 7.3µg/m^3.

A.10 COVID-19 and air quality

The first confirmed cases of COVID-19 in Australia were identified on 25 January 2020, in Victoria, where a man who had returned from Wuhan, China, tested positive for the virus. By 11 March 2020, the World Health Organisation declared COVID-19 to be a worldwide pandemic. To prevent the spread of this disease in Australia, the newly formed National Cabinet initially banned gatherings of over 500 people with further gradual tightening of restrictions on population movement, inter- and intrastate travel and the operation of non-essential venues. By 31 March 2020, gatherings of more than two people were banned, and people were encouraged to stay home.

In WA, the State Government introduced additional travel bans, border closures and school closures. The introduction of these measures saw a general drop in vehicle numbers with people increasingly choosing to work from home.

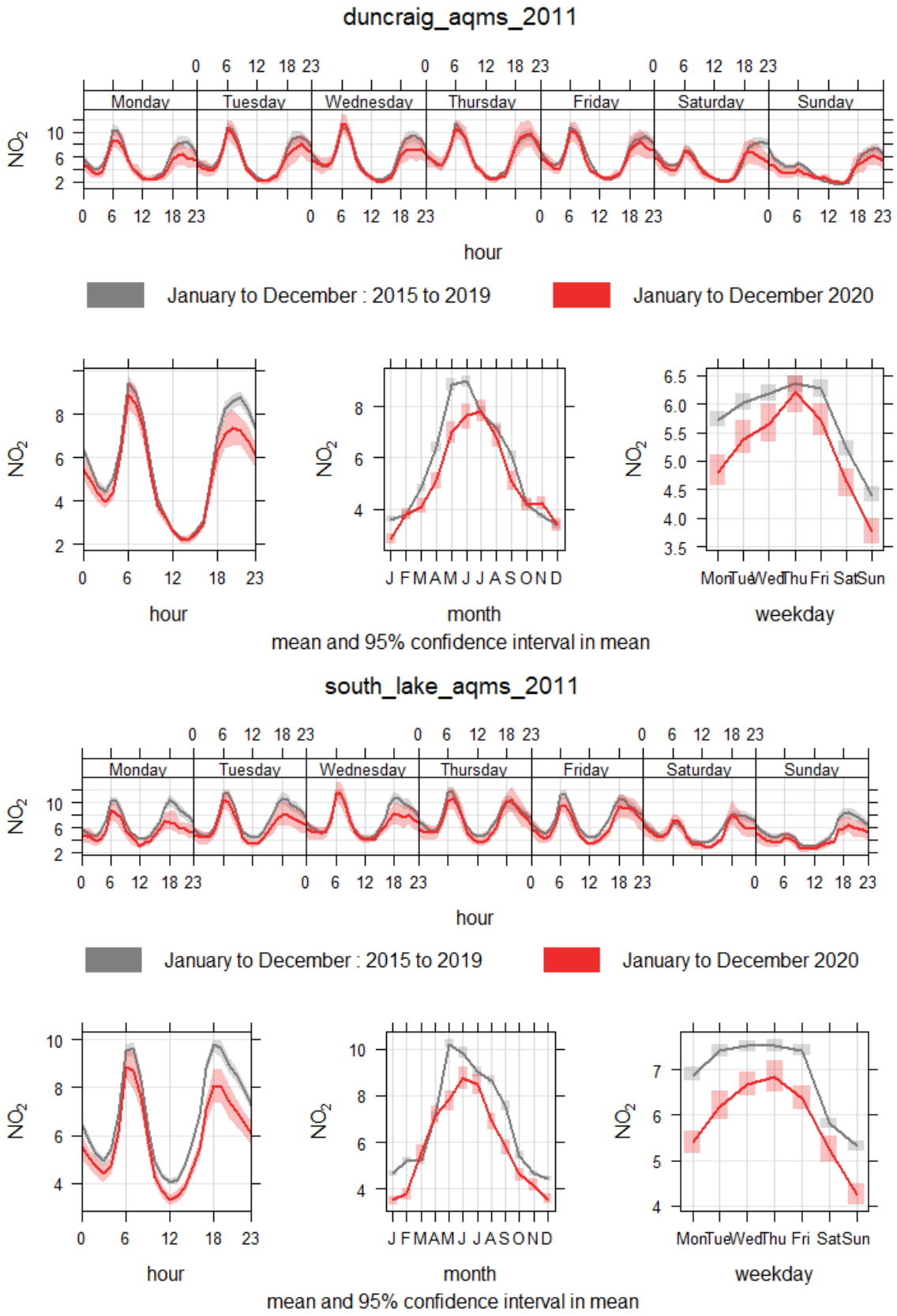


Figure A11 *Plots of nitrogen dioxide (NO_2) at Duncraig (upper) and South Lake (lower), before and during COVID.*

In Figure A11, plots of nitrogen dioxide at Duncraig and South Lake over the period 2015 to 2019 (grey) and 2020 (red) show the average variation in several temporal components. The shading shows the 95% confidence intervals of the average concentration.

The plot in the lower-left for each site panel shows the diurnal variation of concentrations. They clearly depict the bimodal pattern in concentrations at both sites where NO_2 increases during the early morning, reduces during the middle of the day and gradually increases to a second peak in the late afternoon. In both sites there is a drop in 2020 average concentrations during the peak-hour traffic times.

The plot at the lower-right for each site shows how concentrations vary by day of the week. Unsurprisingly, NO_2 concentrations on Sunday are lower than all other days, with a lower concentration over all days during 2020.

The upper plot for each site shows both sets of information together to provide an overview of how concentrations vary throughout the week.

Finally, the lower middle plot shows the reduction in concentration of NO_2 during all months in 2020, which coincides with the reduction in economic activity due to the COVID-19 pandemic. The reduction in concentrations was seen even though neither of the air monitoring sites were specifically located at roadside or industry monitoring sites.

Analysis of wind directions in South Lake showed a small decrease in the concentration densities for winds from the KIA. South Lake is 1.6 kilometres west of the Kwinana freeway, a main north–south arterial road carrying about 87,000 vehicles daily, and is about four kilometres north-east of the northern border of the KIA. Figure A12 shows this in a scatter plot of NO_2 and wind direction smoothed into a colour density image.

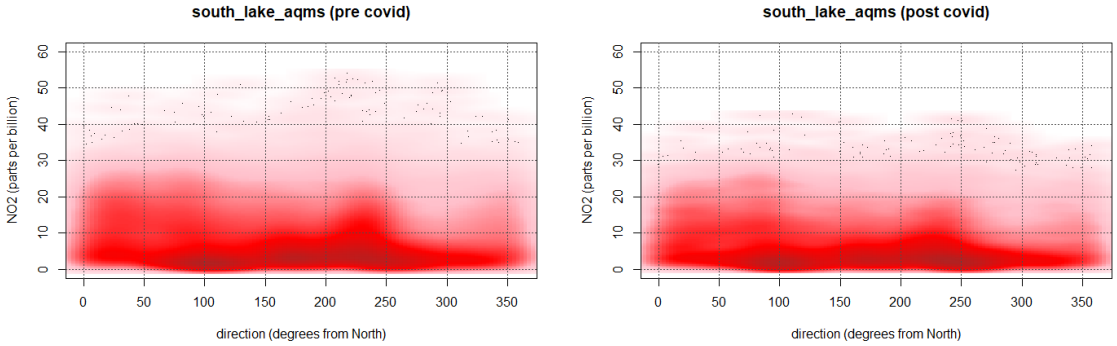


Figure A12 Smoothed scatterplots of South Lake NO_2 pre and post COVID.

Figure A12 shows that while there was a decrease in the NO_2 originating from the freeway (around 100 degrees) in 2020, there was a pronounced decrease in NO_2 from the direction of the KIA (240 degrees). Comparing individual pre-COVID years for each year spanning 2015 to 2019 produces similarly shaped pre-COVID plots, with each plot showing higher concentrations than 2020 regardless of which individual year is chosen.

Whether this reduction in NO_2 was due to a reduction in motor vehicle use, subdued industrial activity or some combination of both is unknown. Another possibility is the continuation of an overall year-to-year reduction in NO_2 concentrations, as discussed in Section A4. Further analysis will be required in future to determine whether these changes are a trend or related to COVID.

A.11 Mandurah and marine aerosols

The Monitoring Plan for WA (the plan), prepared in accordance with the AAQ NEPM in 2001, describes the monitoring required to determine compliance with the standards and goals of the AAQ NEPM. The plan identified that monitoring sites were required in Mandurah, Geraldton and Kalgoorlie-Boulder, based on population size.

In relation to Mandurah, the plan states:

> The preferred Mandurah monitoring site is close to the coast, in order to measure ozone concentrations before any significant titration with fresh nitric oxide occurs and before convective mixing over the land causes significant dilution … PM_{10} particles will be measured at Mandurah. Wood fires, wildfires and prescribed burning, sea salt and, to a lesser extent, vehicles are likely sources. Secondary particles in smog plumes from the Perth Region may also be measured.

The Mandurah air quality monitoring site was commissioned in November 2019 with the site located about 100 metres from the ocean in the suburb of Halls Head. Since installation, the Mandurah site has been recording a larger than expected number of PM_{10} particle exceedances of the AAQ NEPM standard. During the 2020 calendar year, 30 PM_{10} and five $PM_{2.5}$ particle exceedances were recorded at Mandurah. Of these, 25 PM_{10} exceedances were due to marine aerosols. There were no marine aerosol $PM_{2.5}$ exceedances.

Marine aerosols include all types of particles associated with ocean processes. These include particles generated mechanically at the sea surface, such as salt and other compounds, as well as compounds formed chemically from the atmospheric reactions of gases emitted from the sea surface.

The AAQ NEPM defines an 'exceptional event' as a fire or dust occurrence which adversely affects air quality at a particular location and causes an exceedance of daily standards in excess of normal historical fluctuations and background levels, and which is directly related to bushfire, jurisdiction-authorised hazard reduction burning or continental-scale windblown dust. Clause 18(3C) of the AAQ NEPM states:

> For the purpose of reporting compliance against PM_{10} and $PM_{2.5}$ 1-day average standards, jurisdictions shall exclude monitoring data that has been determined as being directly associated with an exceptional event.

As the Mandurah particle exceedances caused by marine aerosols cannot be defined as exceptional events, these exceedances are deemed assessable events and have been counted for the purposes of determining whether the AAQ NEPM PM_{10} goal of no allowable exceedances has been met at Mandurah.

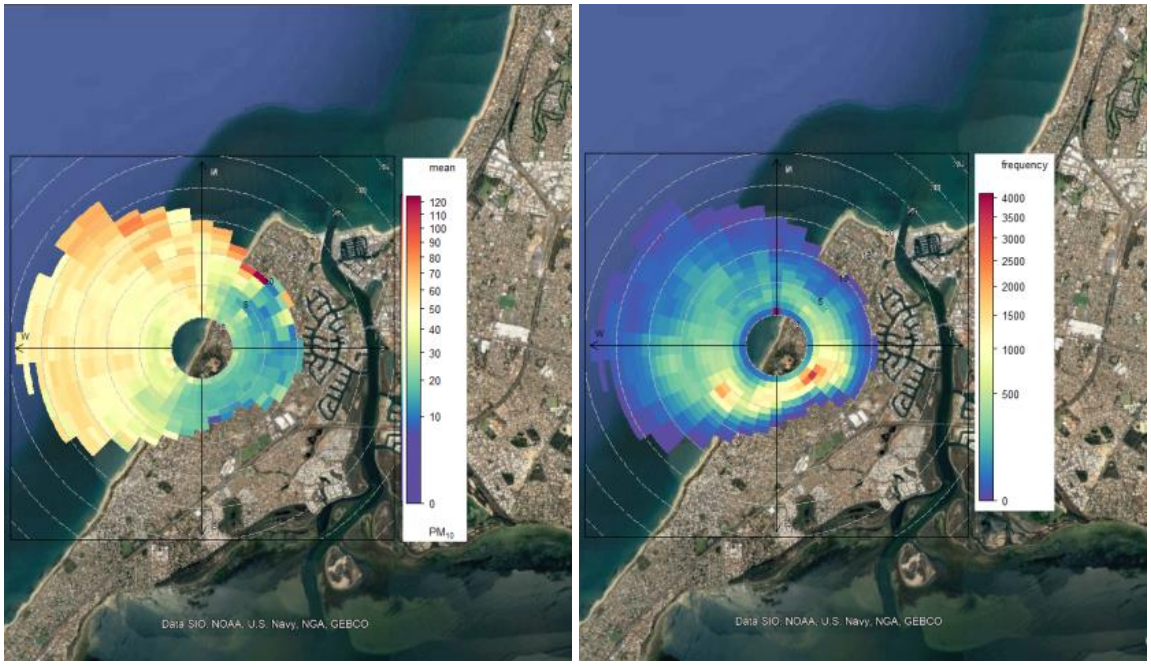


Figure A13 Polar plot for PM_{10} concentration (left) and frequency plot for winds (right) for 2020 at the Mandurah AQMS.

The left map in Figure A13 represents the average of all PM_{10} concentrations recorded at the Mandurah AQMS for every wind speed and direction during 2020. The image shows that when the winds are blowing from the ocean onto the land (onshore), the average concentration of PM_{10} is higher (shown as yellow/orange on the plot) than when the winds are blowing from the land onto the ocean (offshore) (shown as green/blue). The boundary of the yellow/orange (higher PM_{10}) and the green/blue

(lower PM_{10}) aligns precisely with the shoreline. Also noticeable is that average concentrations increase as you move towards the outer edge of the plot showing that higher winds produce more aerosols.

The right map in Figure A13 shows the frequency of winds coming from each wind speed/direction. This indicates that while the frequency or the number of times winds are onshore (blue/green) is less than when it is offshore (yellow/orange), the onshore winds generally have a much higher velocity.

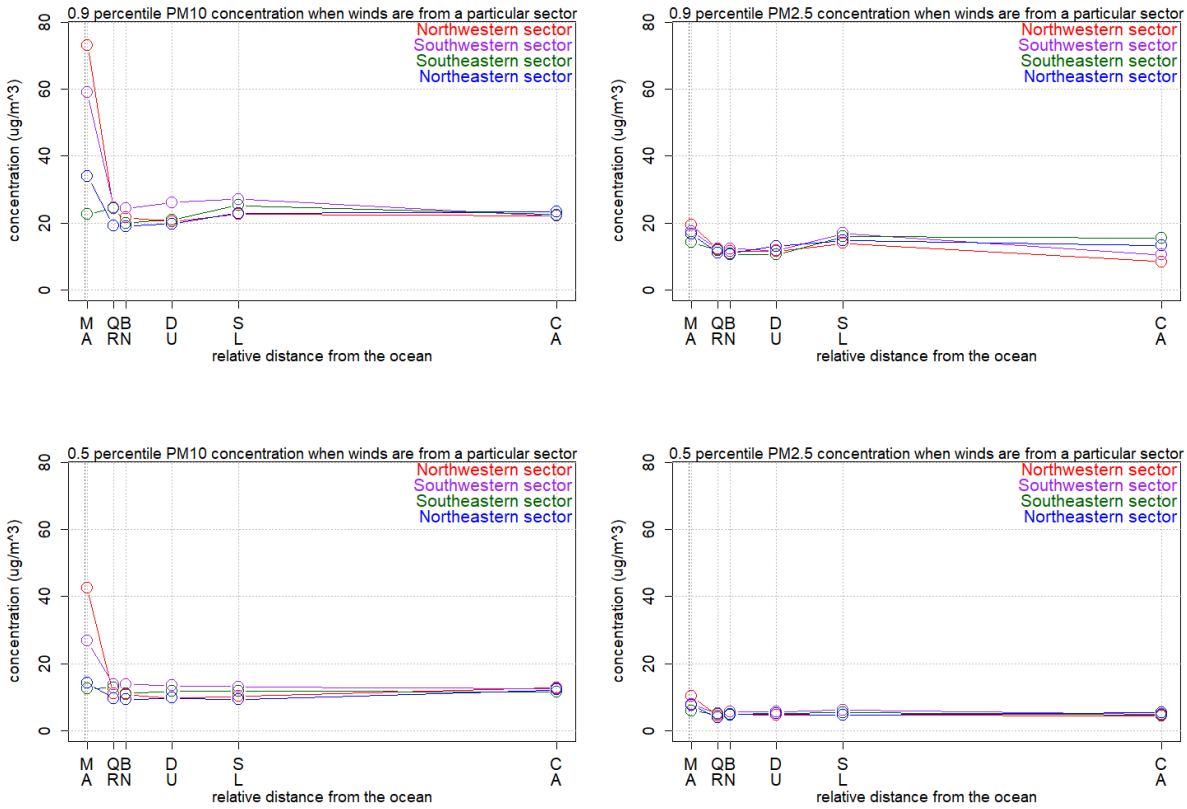


Figure A14 *90th percentile (upper) and 50th percentile (lower) 5-minute averaged concentrations at Mandurah for PM_{10} (left) and $PM_{2.5}$ (right).*

Figure A14 shows that PM_{10} is elevated at the Mandurah site during all winds with a westerly component at the 90th and 50th percentile concentration. This remains elevated but with a reduced magnitude as the percentiles reduce. This shows that for westerly winds, even relatively clean air (here represented by the 0.5 percentile) contains some proportion of PM_{10}, likely to be marine aerosols. This elevates the PM_{10} concentration above the corresponding PM_{10} from easterly winds at the same 0.5 percentile for other sites. The PM_{10} concentrations at Mandurah for western winds are higher than other sites at all the higher percentiles.

The annual average PM_{10} concentration at Mandurah for 2020 is 26.6 µg/m^3, which is six per cent higher than the NEPM standard. While Mandurah was the only site in the network to exceed the annual standard for PM_{10} in 2020, this can be attributed to the high number of these marine aerosol events.

The Department of Health has provided advice that inhaling ‘sea air’ or ‘ocean air’ is not harmful.

Mandurah $PM_{2.5}$ levels at all percentiles shows a similar concentration to all other metropolitan sites. The $PM_{2.5}$ concentrations at Mandurah seem to be unaffected by wind direction but remain slightly elevated compared with other sites throughout all percentiles. This is reflected in the annual average $PM_{2.5}$ concentration at Mandurah for 2020 of 10 µg/m^3, which is 20 per cent higher than the NEPM standard.

A.12 Variation to the AAQ NEPM

In February 2016, the AAQ NEPM was varied to:

- Provide for a PM_{10} annual standard of 25µg/m^3.
- Create two standards for $PM_{2.5}$ of 25µg/m^3 averaged over 24 hours, and 8µg/m^3 averaged over one year.
- Include an aim to move to annual average and 24-hour $PM_{2.5}$ standards of 7µg/m^3 and 20µg/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. For 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.

A.13 Exceedance summary

There were exceedances of the $PM_{2.5}$ and PM_{10} NEPM daily standards in 2020, which are listed in Table A10. The AAQ NEPM goal for particles was not met at Bunbury, Caversham, Duncraig, Geraldton, Kalgoorlie, Mandurah, Quinns Rock and South Lake. Detailed summaries of all exceedances are provided in Section F.

Table A10 AAQ NEPM standard exceedances recorded during 2020

Site	Pollutant	Concentration[1,2]	Date	Cause	Type
Armadale	PM2.5	26.2	07/10/2020	PB	EE
Bunbury	PM2.5	31.3	02/05/2020	PB	EE
Bunbury	PM2.5	31.4	03/05/2020	PB	EE
Bunbury	PM2.5	29.6	10/05/2020	WH	AE
Bunbury	PM2.5	40.3	14/05/2020	PB	EE
Bunbury	PM2.5	26.9	15/05/2020	PB	EE
Bunbury	PM2.5	26.3	21/05/2020	PB	EE
Bunbury	PM2.5	31.8	22/05/2020	PB	EE
Bunbury	PM2.5	28.4	21/06/2020	WH	AE
Bunbury	PM2.5	25.7	14/10/2020	PB/BF	EE
Bunbury	PM10	61.1	20/10/2020	PB	EE
Bunbury	PM2.5	55.5	20/10/2020	PB	EE
Bunbury	PM2.5	27.5	30/10/2020	LB	AE
Busselton	PM2.5	27.8	22/05/2020	PB	EE
Busselton	PM2.5	35.0	04/06/2020	PB	EE
Busselton	PM2.5	32.9	19/10/2020	PB	EE
Busselton	PM2.5	37.1	20/10/2020	PB	EE
Busselton	PM2.5	26.3	24/10/2020	PB	EE
Caversham	PM10	71.5	14/05/2020	PB	EE
Caversham	PM2.5	60.9	14/05/2020	PB	EE
Caversham	PM10	63.1	15/05/2020	PB	EE
Caversham	PM2.5	55.1	15/05/2020	PB	EE
Caversham	PM2.5	25.1	16/05/2020	PB	EE
Caversham	PM2.5	29.0	20/05/2020	PB	EE
Caversham	PM2.5	28.2	06/06/2020	LB	AE
Caversham	PM10	52.0	07/06/2020	LB	AE

Site	Pollutant	Concentration[1,2]	Date	Cause	Type
Caversham	PM2.5	45.1	07/06/2020	LB	AE
Caversham	PM2.5	33.1	09/06/2020	LB	AE
Caversham	PM2.5	28.2	10/06/2020	LB	AE
Caversham	PM2.5	28.4	31/12/2020	BF	EE
Collie	PM10	62.8	02/05/2020	PB	EE
Collie	PM10	52.6	03/05/2020	PB	EE
Collie	PM10	61.8	14/05/2020	PB	EE
Collie	PM10	75.4	23/05/2020	PB	EE
Collie	PM10	130.9	07/10/2020	PB	EE
Duncraig	PM2.5	31.3	16/05/2020	PB	EE
Duncraig	PM10	61.8	24/05/2020	WD	EE
Duncraig	PM2.5	37.2	21/10/2020	LB	AE
Geraldton	PM10	59.4	09/01/2020	WD	AE
Geraldton	PM10	56.9	30/04/2020	WD	AE
Geraldton	PM10	445.6	24/05/2020	WD	EE
Geraldton	PM2.5	162.3	24/05/2020	WD	EE
Kalgoorlie	PM2.5	27.1	09/01/2020	BF	EE
Kalgoorlie	PM10	77.3	24/05/2020	WD	EE
Kalgoorlie	PM10	75.1	04/06/2020	WD	AE
Kalgoorlie	PM10	50.5	11/06/2020	WD	AE
Kalgoorlie	PM10	54.7	16/06/2020	WD	AE
Kalgoorlie	PM2.5	33.3	27/06/2020	WH	AE
Mandurah	PM2.5	27.0	29/04/2020	PB	EE
Mandurah	PM10	56.5	14/05/2020	PB	EE
Mandurah	PM2.5	43.7	14/05/2020	PB	EE
Mandurah	PM10	52.8	24/05/2020	WD	EE
Mandurah	PM10	56.6	25/05/2020	WD	EE
Mandurah	PM10	52.9	28/05/2020	MA	AE
Mandurah	PM10	51.7	29/05/2020	MA	AE
Mandurah	PM2.5	26.1	09/06/2020	LB	AE
Mandurah	PM10	59.8	14/06/2020	MA	AE
Mandurah	PM10	72.8	23/06/2020	MA	AE
Mandurah	PM10	79.4	24/06/2020	MA	AE
Mandurah	PM10	58.3	28/06/2020	MA	AE
Mandurah	PM10	66.6	29/06/2020	MA	AE
Mandurah	PM10	60.4	30/06/2020	MA	AE
Mandurah	PM10	54.8	13/07/2020	MA	AE
Mandurah	PM10	60.5	14/07/2020	MA	AE
Mandurah	PM10	56.0	16/07/2020	MA	AE
Mandurah	PM10	57.6	28/07/2020	MA	AE
Mandurah	PM10	61.1	10/08/2020	MA	AE
Mandurah	PM10	58.7	01/09/2020	MA	AE
Mandurah	PM10	71.0	02/09/2020	MA	AE
Mandurah	PM10	66.1	03/09/2020	MA	AE
Mandurah	PM10	65.3	04/09/2020	MA	AE
Mandurah	PM10	53.0	05/09/2020	MA	AE
Mandurah	PM10	61.7	06/09/2020	MA	AE
Mandurah	PM10	84.4	07/09/2020	MA	AE
Mandurah	PM10	62.6	08/09/2020	MA	AE
Mandurah	PM10	57.0	10/09/2020	MA	AE

Site	Pollutant	Concentration[1,2]	Date	Cause	Type
Mandurah	PM10	53.7	30/09/2020	MA	AE
Mandurah	PM10	60.6	01/10/2020	MA	AE
Mandurah	PM10	77.8	07/10/2020	PB	EE
Mandurah	PM2.5	53.8	07/10/2020	PB	EE
Mandurah	PM10	50.7	13/10/2020	PB/BF	EE
Mandurah	PM2.5	38.0	13/10/2020	PB/BF	EE
Mandurah	PM10	52.1	16/11/2020	MA	AE
Quinns Rock	PM10	77.7	24/05/2020	WD	EE
Quinns Rock	PM2.5	39.8	21/10/2020	LB	AE
South Lake	PM2.5	26.2	14/05/2020	PB	EE
South Lake	PM2.5	26.7	15/05/2020	PB	EE
South Lake	PM2.5	34.6	07/06/2020	LB	AE
South Lake	PM2.5	25.4	21/10/2020	LB	AE

1. All concentrations are daily averages calculated from midnight to midnight unless otherwise stated.

2. Model 1400AB TEOMs used by the department at Albany, Collie and Geraldton 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. All other sites have a Model 1405DF TEOM which does not require an equivalency factor to be applied.

AE	Assessable event	PB	Prescribed burning activities
BF	Bushfire	LB	Local Burn
EE	Exceptional event	WD	Windborne dust
MA	Marine Aerosols	WH	Wood heater

B. Assessment of compliance with standards and goals

Table B1 2020 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 (North East Metro)	97.9	96.2	96.8	97.5	97.1	0	met
Duncraig (North Metro)	97.6	96.8	97.6	97.6	97.4	0	met
South Lake (South East Metro)	95.5	96.2	97.7	97.1	96.6	0	met
Peel region							
Mandurah	94.1	97.3	97.8	97.1	96.6	0	met
Goldfields region							
Kalgoorlie	97.9	96.4	97.9	97.5	97.4	0	met

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

Table B2 2020 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 average	Number of exceedances	Performance against the standards and goal	
	Q1	Q2	Q3	Q4	Annual	(ppm)	(days)	1-hour	1-year
Perth region									
Caversham (North East Metro)	99.9	98.3	98.6	99.4	99.1	0.004	0	met	met
Duncraig (North Metro)	99.2	98.9	99.3	99.7	99.3	0.005	0	met	met
Quinns Rocks (Outer North Coast)	19.0	69.0	99.9	99.7	72.0	0.004	0	ND	ND
Rockingham (South Coast)	97.1	96.7	97.5	95.0	96.6	0.004	0	met	met
Rolling Green (Outer East Rural)	98.5	98.9	99.5	99.8	99.2	0.002	0	met	met
South Lake (South East Metro)	99.4	97.7	99.2	99.9	99.1	0.006	0	met	met
Swanbourne (Inner West Coast)	99.0	99.2	98.7	100.0	99.2	0.004	0	met	met
Peel region									
Mandurah	96.4	99.5	99.7	98.9	98.6	0.002	0	met	met

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

Table B3 2020 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 (North East Metro)	100.0	98.4	98.8	99.6	99.2	0	0	met	met
Quinns Rocks (Outer North Coast)	15.7	76.9	100	99.8	73.2	0	0	ND	ND
Rockingham (South Coast)	99.8	99.0	100.0	95.8	98.6	0	0	met	met
Rolling Green (Outer East Rural)	99.6	99.0	99.3	100.0	99.5	0	0	met	met
South Lake (South East Metro)	99.5	98.4	99.3	99.9	99.3	0	0	met	met
Swanbourne (Inner West Coast)	99.9	99.2	99.9	99.8	99.7	0	0	met	met
Peel region									
Mandurah	96.6	99.8	100.0	99.1	98.9	0	0	met	met

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

Table B4 2020 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 average	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)	94.5	91.3	94.6	89.3	92.4	0.001	0	0	met	met	met
South Lake (South East Metro)	99.5	98.1	99.9	99.3	99.2	0.002	0	0	met	met	met
Wattleup (South Metro)	94.4	94.1	85.6	93.7	92	0.001	0	0	met	met	met
Goldfields region											
Kalgoorlie	97.6	89.7	97.8	97.5	95.6	0.001	0	0	met	met	met

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

Table B5 2020 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 (North East Metro)	99.6	96.9	96.2	98.6	97.8	3	not met	met
Duncraig (North Metro)	99.2	93.4	99.2	99.4	97.8	1	not met	met
Quinns Rocks (Outer North Coast)	16	67.9	99.7	98.6	70.7	1	ND	ND
South Lake (South East Metro)	99.3	98.1	99.0	99.7	99.0	0	met	met
Peel region								
Mandurah	96.5	99.8	98.8	91.1	96.5	30	not met	not met
Southwest region								
Albany	99.8	94.6	99.5	99.8	98.4	0	met	met
Bunbury	98.9	87.0	99.7	94.8	95.1	1	not met	met
Collie	99.8	95.1	99.0	92.3	96.6	5	not met	met
Mid West region								
Geraldton	96.5	99.5	99.5	98.2	98.5	3	not met	met
Goldfields region								
Kalgoorlie	99.5	99	95.1	99.4	98.2	4	not met	met

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

Table B6 2020 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 (North East Metro)	99.6	96.9	96.2	98.6	97.8	9	not met	met
Duncraig (North Metro)	99.2	96.5	99.2	99.4	98.6	2	not met	met
Quinns Rocks (Outer North Coast)	15.9	67.9	99.7	98.6	70.7	1	ND	ND
South Lake (South East Metro)	99	98.1	99	99.7	99	4	not met	met
Peel region								
Mandurah	96.5	99.8	98.8	90.9	96.5	5	not met	not met
Southwest region								
Bunbury	98.9	87	99.7	94.8	95.2	11	not met	met
Busselton	99.1	45.7	98.6	92.4	84	5	not met	not met
Mid West region								
Geraldton	95.7	91.3	99.5	99.2	96.4	1	not met	not met
Goldfields region								
Kalgoorlie	99.5	99	99.3	99.4	99.3	2	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 2020. 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.

Table C1 2020 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 (North East Metro)	97.1	1.6	15/05/2020	1100	1.4	14/05/2020	1000
Duncraig (North Metro)	97.4	1.2	25/06/2020	0300	1.1	08/06/2020	0300
South Lake (South East Metro)	96.6	1.4	10/06/2020	0200	1.1	15/05/2020	1000
Peel region							
Mandurah	96.6	1.8	07/10/2020	1100	0.9	13/10/2020	1200
Goldfields region							
Kalgoorlie	97.4	2.0	25/06/2020	0400	1.5	16/06/2020	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 2020. 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.

Table C2 2020 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 (North East Metro)	99.1	0.030	14/05/2020	1900	0.029	09/06/2020	1800
Duncraig (North Metro)	99.3	0.031	01/07/2020	0800	0.031	16/06/2020	1900
Quinns Rocks (Outer North Coast)	72.0	0.038	16/06/2020	1900	0.035	09/06/2020	1900
Rockingham (South Coast)	96.6	0.041	23/05/2020	2400	0.029	09/06/2020	2000
Rolling Green (Outer East Rural)	99.2	0.018	22/02/2020	2000	0.017	05/03/2020	0700
South Lake (South East Metro)	99.1	0.036	15/05/2020	1000	0.033	30/10/2020	2200
Swanbourne (Inner West Coast)	99.2	0.032	16/06/2020	2100	0.032	09/06/2020	2100
Peel region							
Mandurah	98.6	0.022	09/06/2020	2000	0.020	21/06/2020	1900

The AAQ NEPM standard for nitrogen dioxide of 0.03 ppm averaged over one year was not exceeded at any site during 2020. Table C2a contains the summary statistics for annual nitrogen dioxide.

Table C2a 2020 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)	99.1	0.004
Duncraig (North Metro)	99.3	0.005
Quinns Rocks (Outer North Coast)	72.0	0.004
Rockingham (South Coast)	96.6	0.004
Rolling Green (Outer East Rural)	99.2	0.002
South Lake (Southeast Metro)	99.1	0.006
Swanbourne (Inner West Coast)	99.2	0.004
Peel region		
Mandurah	98.6	0.002

C.3 Photochemical smog as ozone

The AAQ NEPM standard for ozone of 0.10 ppm averaged over one hour was not exceeded during 2020. 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 WA.

Table C3 2020 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)	(time)	2nd highest (ppm)	2nd highest (date)	(time)
Perth region							
Caversham (North East Metro)	99.2	0.067	09/04/2020	1500	0.062	11/03/2020	1500
Quinns Rocks (Outer North Coast)	73.2	0.065	23/11/2020	1400	0.065	08/12/2020	1400
Rockingham (South Coast)	98.6	0.070	23/12/2020	1500	0.059	10/12/2020	1700
Rolling Green (Outer East Rural)	99.5	0.071	09/04/2020	1800	0.066	28/01/2020	1300
South Lake (South East Metro)	99.3	0.061	25/12/2020	1100	0.059	26/03/2020	1400
Swanbourne (Inner West Coast)	99.7	0.069	30/10/2020	1500	0.069	26/03/2020	1400
Peel region							
Mandurah	98.9	0.076	14/05/2020	1400	0.061	11/04/2020	1400

The AAQ NEPM standard for ozone of 0.08 ppm averaged over four hours was not exceeded during 2020. 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.

Table C4 2020 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 (North East Metro)	99.2	0.058	14/02/2020	1800	0.055	11/03/2020	1600
Quinns Rocks (Outer North Coast)	73.2	0.058	23/12/2020	1800	0.055	23/11/2020	1600
Rockingham (South Coast)	98.6	0.065	23/12/2020	1600	0.055	10/12/2020	1700
Rolling Green (Outer East Rural)	99.5	0.061	05/03/2020	1800	0.060	28/01/2020	1600
South Lake (South East Metro)	99.3	0.054	26/03/2020	1500	0.052	25/12/2020	1300
Swanbourne (Inner West Coast)	99.7	0.062	30/10/2020	1700	0.062	26/03/2020	1600
Peel region							
Mandurah	98.9	0.064	14/05/2020	1500	0.054	11/04/2020	1600

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 2020. 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.

Table C5 2020 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)	92.4	0.037	15/08/2020	1000	0.028	25/07/2020	1100
South Lake (South East Metro)	99.2	0.010	25/10/2020	1800	0.010	13/10/2020	1700
Wattleup (South Metro)	92	0.044	23/11/2020	1600	0.039	07/11/2020	1900
Goldfields region							
Kalgoorlie	95.6	0.075	17/11/2020	2400	0.061	26/07/2020	1200

The AAQ NEPM standard for sulfur dioxide of 0.08 ppm averaged over 24 hours was not exceeded at any site during 2020. 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.

Table C6 2020 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)	92.4	0.008	15/08/2020	2400	0.006	22/06/2020	2400
South Lake (South East Metro)	99.2	0.006	11/04/2020	2400	0.006	04/04/2020	2400
Wattleup (South Metro)	92	0.006	03/12/2020	2400	0.006	12/01/2020	2400
Goldfields region							
Kalgoorlie	95.6	0.011	05/08/2020	2400	0.007	10/07/2020	2400

The AAQ NEPM standard for sulfur dioxide of 0.02 ppm averaged over one year was not exceeded at any site during 2020. Table C7 contains the summary statistics for annual sulfur dioxide.

Table C7 2020 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)	92.4	0.001
South Lake (Southeast Metro)	99.2	0.002
Wattleup (South Metro)	92	0.001
Goldfields region		
Kalgoorlie	95.6	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 during 2020, as detailed in Table A10. The AAQ NEPM goal was not met at Caversham, Geraldton, Kalgoorlie and Mandurah. Table C8 contains the summary statistics for daily peak 24-hour PM_{10}.

Table C8 2020 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)	6th Highest (µg/m^3)	6th Highest (date)
Perth region					
Caversham (North East Metro)	97.8	**71.5**	14/05/2020	38.7	10/06/2020
Duncraig (North Metro)	97.8	**61.8**	24/05/2020	27.1	20/10/2020
Quinns Rocks (Outer North Coast)	70.7	**77.7**	24/05/2020	27.6	21/05/2020
South Lake (South East Metro)	99	45.2	24/05/2020	32.2	31/12/2020
Peel region					
Mandurah	96.5	**84.4**	07/09/2020	**66.6**	29/06/2020
South West region					
Albany	98.4	37.2	10/12/2020	31.9	24/12/2020
Bunbury	95.1	**61.1**	20/10/2020	39.2	22/05/2020
Collie	96.6	**130.9**	07/10/2020	49.4	15/05/2020
Mid West region					
Geraldton	98.5	**445.6**	24/05/2020	45.5	14/01/2020
Goldfields region					
Kalgoorlie	98.2	**77.3**	24/05/2020	45.0	27/06/2020

Bold numerals indicate where a standard has been exceeded.

The AAQ NEPM standard for particles as PM_{10} of 25 µg/m^3 averaged over one year was not met at Mandurah during 2020. Table C9 contains the summary statistics for annual PM_{10}.

Table C9 2020 summary statistics for annual particles as PM_{10}

Regional performance monitoring station	Data availability rates (%)	Annual average (µg/m^3)
		AAQ NEPM standard 25 µg/m^3 (annual average)
Perth region		
Caversham (North East Metro)	97.8	15.1
Duncraig (North Metro)	97.8	13.4
Quinns Rocks (Outer North Coast)	70.7	12.5
South Lake (South East Metro)	99.0	13.9
Peel region		
Mandurah	96.5	26.6
South West region		
Albany	98.4	14.2
Bunbury	95.1	15.5
Collie	96.6	18.1
Mid West region		
Geraldton	98.5	20.9
Goldfields region		
Kalgoorlie	98.2	14.2

Bold numerals indicate where a standard has been exceeded.

C.6 Particles as $PM_{2.5}$

The AAQ NEPM standard for particles as $PM_{2.5}$ of 25 µg/m^3 averaged over 24 hours was exceeded in 2020, as detailed in Table A10. The AAQ NEPM goal was not met at Bunbury, Caversham, Duncraig, Kalgoorlie, Mandurah, Quinns Rocks and South Lake. Table C10 contains the summary statistics for daily peak 24-hour $PM_{2.5}$.

Table C10 2020 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)	6th highest (µg/m^3)	6th highest (date)
Perth region					
Caversham (North East Metro)	97.8	**60.9**	14/05/2020	**28.4**	31/12/2020
Duncraig (North Metro)	98.6	**37.2**	21/10/2020	17.2	20/05/2020
Quinns Rocks (Outer North Coast)	70.7	**39.8**	21/10/2020	17.1	16/05/2020
South Lake (South East Metro)	99	**34.6**	07/06/2020	24.0	20/05/2020
Peel region					
Mandurah	96.5	**53.8**	07/10/2020	23.2	25/05/2020
South West region					
Bunbury	95.2	**55.5**	20/10/2020	**29.6**	10/05/2020
Busselton	84	**37.1**	20/10/2020	22.0	03/06/2020
Mid West region					
Geraldton	96.4	**162.3**	24/05/2020	17.0	14/01/2020
Goldfields region					
Kalgoorlie	99.3	**33.3**	27/06/2020	20.9	24/06/2020

Bold numerals indicate where a standard has been exceeded.

The AAQ NEPM standard for particles as $PM_{2.5}$ of 8 µg/m^3 averaged over one year was not met at the Mandurah and Busselton sites during 2020. Table C11 contains the summary statistics for annual $PM_{2.5}$ in WA.

Table C11 2020 summary statistics for annual particles as $PM_{2.5}$

AAQ NEPM standard
8 µg/m^3 (annual average)

Regional performance monitoring station	Data availability rates (%)	Annual average (µg/m^3)
Perth region		
Caversham (North East Metro)	97.8	7.8
Duncraig (North Metro)	98.6	6.3
Quinns Rocks (Outer North Coast)	70.7	5.4
South Lake (South East Metro)	99	7.2
Peel region		
Mandurah	96.5	**10.0**
South West region		
Bunbury	95.2	7.9
Busselton	84	**8.1**
Mid West region		
Geraldton	96.4	8.0
Goldfields region		
Kalgoorlie	99.3	4.7

Bold numerals indicate where a standard has been exceeded.

D. Data analysis

D.1 Maxima and percentiles by pollutant in 2020

Table D1 2020 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 (North East Metro)	97.1	1.6	0.9	0.7	0.5	0.4	0.2	0.1
Duncraig (North Metro)	97.4	1.2	1.0	0.9	0.7	0.6	0.4	0.3
South Lake (South East Metro)	96.6	1.4	1.1	1.0	0.8	0.6	0.4	0.2
Peel region								
Mandurah	96.6	1.8	0.6	0.5	0.4	0.3	0.2	0.1
Goldfields region								
Kalgoorlie	97.4	2.0	1.3	1.1	0.7	0.4	0.2	0.2

Table D2 2020 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 (North East Metro)	99.1	0.030	0.028	0.025	0.023	0.020	0.015	0.010
Duncraig (North Metro)	99.3	0.031	0.030	0.028	0.026	0.025	0.020	0.013
Quinns Rocks (Outer North Coast)	72.0	0.038	0.033	0.032	0.028	0.026	0.019	0.011
Rockingham (South Coast)	96.6	0.041	0.028	0.027	0.024	0.021	0.016	0.010
Rolling Green (Outer East Rural)	99.2	0.018	0.015	0.014	0.012	0.010	0.007	0.004
South Lake (South East Metro)	99.1	0.036	0.031	0.028	0.025	0.024	0.019	0.014
Swanbourne (Inner West Coast)	99.2	0.032	0.029	0.027	0.023	0.019	0.014	0.009
Peel region								
Mandurah	98.6	0.022	0.019	0.017	0.014	0.011	0.007	0.004

Table D3 2020 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 (North East Metro)	99.2	0.067	0.060	0.056	0.053	0.045	0.034	0.030
Quinns Rocks (Outer North Coast)	73.2	0.065	0.059	0.051	0.044	0.040	0.036	0.033
Rockingham (South Coast)	98.6	0.070	0.056	0.050	0.044	0.040	0.035	0.032
Rolling Green (Outer East Rural)	99.5	0.071	0.065	0.063	0.057	0.046	0.037	0.033
South Lake (South East Metro)	99.3	0.061	0.054	0.048	0.042	0.038	0.032	0.029
Swanbourne (Inner West Coast)	99.7	0.069	0.065	0.059	0.051	0.047	0.041	0.037
Peel region								
Mandurah	98.9	0.076	0.056	0.053	0.046	0.041	0.037	0.033

Table D4 2020 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 (North East Metro)	99.2	0.058	0.053	0.050	0.046	0.040	0.032	0.029
Quinns Rocks (Outer North Coast)	73.2	0.058	0.050	0.046	0.040	0.037	0.035	0.032
Rockingham (South Coast)	98.6	0.065	0.050	0.048	0.042	0.037	0.034	0.031
Rolling Green (Outer East Rural)	99.5	0.061	0.056	0.054	0.048	0.042	0.035	0.032
South Lake (South East Metro)	99.3	0.054	0.049	0.044	0.039	0.035	0.031	0.028
Swanbourne (Inner West Coast)	99.7	0.062	0.055	0.053	0.048	0.043	0.039	0.036
Peel region								
Mandurah	98.9	0.064	0.051	0.047	0.042	0.039	0.036	0.032

Table D5 2020 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)	92.4	0.037	0.024	0.018	0.008	0.006	0.003	0.002
South Lake (South East Metro)	99.2	0.010	0.009	0.009	0.008	0.006	0.005	0.003
Wattleup (South Metro)	92.0	0.044	0.032	0.027	0.022	0.016	0.009	0.003
Goldfields region								
Kalgoorlie	95.6	0.075	0.055	0.046	0.022	0.012	0.005	0.002

Table D6 2020 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)	92.4	0.008	0.004	0.003	0.002	0.002	0.001	0.001
South Lake (South East Metro)	99.2	0.006	0.005	0.005	0.004	0.003	0.003	0.002
Wattleup (South Metro)	92.0	0.006	0.005	0.004	0.003	0.003	0.002	0.001
Goldfields region								
Kalgoorlie	95.6	0.011	0.006	0.004	0.003	0.002	0.001	0.001

Table D7 2020 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 (North East Metro)	97.8	**71.5**	43.1	36.9	28.0	24.3	18.8	12.8
Duncraig (North Metro)	97.8	**61.8**	30.7	24.9	23.3	19.5	15.9	12.4
South Lake (South East Metro)	99	45.2	32.8	31.8	25.3	21.7	16.8	12.6
Peel region								
Mandurah	96.5	**84.4**	**71.9**	**65.3**	**57.3**	48.5	35.5	22.0
South West region								
Albany	98.4	37.2	32.7	29.3	25.9	21.3	16.9	13.4
Bunbury	95.1	**61.1**	41.7	34.9	28.7	24.2	18.0	14.2
Collie	96.6	**130.9**	**57.0**	41.9	35.0	27.4	21.4	16.8
Mid West region								
Geraldton	98.5	**445.6**	47.1	43.5	38.3	33.4	24.3	17.4
Goldfields region								
Kalgoorlie	98.2	**77.3**	49.3	39.1	31.8	24.3	16.7	12.1

Bold numerals indicate where a standard has been exceeded.

Table D8 2020 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 (North East Metro)	97.8	**60.9**	**30.9**	**27.9**	17.6	14.6	9.3	6.1
Duncraig (North Metro)	98.6	**37.2**	18.1	16.3	11.7	9.8	7.4	5.4
Quinns Rocks (Outer North Coast)	70.7	**39.8**	19.7	16.9	11.2	10.4	6.4	4.3
South Lake (South East Metro)	99	**34.6**	24.7	21.8	14.3	11.3	8.3	6.2
Peel region								
Mandurah	96.5	**53.8**	**26.5**	22.0	20.0	17.1	13.6	9.5
South West region								
Bunbury	95.2	**55.5**	**31.4**	**27.5**	22.1	16.4	9.3	5.6
Busselton	84	**37.1**	**27.7**	21.2	16.2	14.2	9.5	6.9
Mid West region								
Geraldton	96.4	**162.3**	17.2	15.8	14.1	12.1	9.2	6.5
Goldfields region								
Kalgoorlie	99.3	**33.3**	22.0	19.9	13.4	8.9	5.1	3.5

Bold numerals indicate where a standard has been exceeded.

D.2 Maxima and percentiles by site 2011-20

Table D9 Daily peak eight-hour carbon monoxide at Caversham (2011–20)
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)
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
2020	97.1	0	1.6	0.9	0.7	0.5	0.4

Table D10 Daily peak eight-hour carbon monoxide at Duncraig (2011–20)
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)
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
2020	97.4	0	1.2	1.0	0.9	0.7	0.6

Table D11 Daily peak eight-hour carbon monoxide at South Lake (2011–20)

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)
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
2020	96.6	0	1.4	1.1	1.0	0.8	0.6

Table D12 Daily peak eight-hour carbon monoxide at Kalgoorlie (2011–20)

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)
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
2020	97.4	0	2.0	1.3	1.1	0.7	0.4

Table D12 Daily peak eight-hour carbon monoxide at Mandurah (2011–20)

Campaign station/region: Mandurah

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)
2011	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-
2020	96.6	0	1.8	0.6	0.5	0.4	0.3

Table D13 Daily peak one-hour nitrogen dioxide at Caversham (2011–20)

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)
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
2020	99.1	0	0.030	0.028	0.025	0.023	0.020

Table D14 Daily peak one-hour nitrogen dioxide at Duncraig (2011–20)

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)
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
2020	99.3	0	0.031	0.030	0.028	0.026	0.025

Table D15 Daily peak one-hour nitrogen dioxide at Quinns Rocks (2011–20)

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)
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	-	-	-	-	-	-	-
2020	72.0	0	0.038	0.033	0.032	0.028	0.026

Table D16 Daily peak one-hour nitrogen dioxide at Rockingham (2011–20)

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)
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
2020	96.6	0	0.041	0.028	0.027	0.024	0.021

Table D17 Daily peak one-hour nitrogen dioxide at Rolling Green (2011–20)

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)
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
2020	99.2	0	0.018	0.015	0.014	0.012	0.010

Table D18 Daily peak one-hour nitrogen dioxide at South Lake (2011–20)

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)
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
2020	99.1	0	0.036	0.031	0.028	0.025	0.024

Table D19 Daily peak one-hour nitrogen dioxide at Swanbourne (2011–20)

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)
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
2020	99.2	0	0.032	0.029	0.027	0.023	0.019

Table D19 Daily peak one-hour nitrogen dioxide at Mandurah (2011–20)

Trend station/region: Mandurah

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)
2011	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-
2020	98.6	0	0.022	0.019	0.017	0.014	0.011

Table D20 Daily peak one-hour ozone at Caversham (2011–20)

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)
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
2020	99.2	0	0.067	0.060	0.056	0.053	0.045

Bold numerals indicate where a relevant standard has been exceeded.

Table D21 Daily peak one-hour ozone at Quinns Rocks (2011–20)

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)
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	-	-	-	-	-	-	-
2020	73.2	0	0.065	0.059	0.051	0.044	0.040

Bold numerals indicate where a relevant standard has been exceeded.

Table D22 Daily peak one-hour ozone at Rockingham (2011–20)

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)
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
2020	98.6	0	0.070	0.056	0.050	0.044	0.040

Table D23 Daily peak one-hour ozone at Rolling Green (2011–20)

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)
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
2020	99.5	0	0.071	0.065	0.063	0.057	0.046

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 (2011–20)

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)
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
2020	99.3	0	0.061	0.054	0.048	0.042	0.038

Table D25 Daily peak one-hour ozone at Swanbourne (2011–20)

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)
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
2020	99.7	0	0.069	0.065	0.059	0.051	0.047

Bold numerals indicate where a relevant standard has been exceeded.

Table D25 Daily peak one-hour ozone at Mandurah (2011–20)

Trend station/region: Mandurah

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)
2011	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-
2020	98.9	0	0.076	0.056	0.053	0.046	0.041

Bold numerals indicate where a relevant standard has been exceeded.

Table D26 Daily peak four-hour ozone at Caversham (2011–20)

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)
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
2020	99.2	0	0.058	0.053	0.050	0.046	0.040

Bold numerals indicate where a relevant standard has been exceeded.

Table D27 Daily peak four-hour ozone at Quinns Rocks (2011–20)

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)
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	-	0	-	-	-	-	-
2019	-	0	-	-	-	-	-
2020	73.2	0	0.058	0.050	0.046	0.040	0.037

Bold numerals indicate where a relevant standard has been exceeded.

Table D28 Daily peak four-hour ozone at Rockingham (2011–20)

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)
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
2020	98.6	0	0.065	0.050	0.048	0.042	0.037

Table D29 Daily peak four-hour ozone at Rolling Green (2011–20)

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)
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
2020	99.5	0	0.061	0.056	0.054	0.048	0.042

Bold numerals indicate where a relevant standard has been exceeded.

Table D30 Daily peak four-hour ozone at South Lake (2011–20)

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)
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
2020	99.3	0	0.054	0.049	0.044	0.039	0.035

Table D31 Daily peak four-hour ozone at Swanbourne (2011–20)

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)
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
2020	99.7	0	0.062	0.055	0.053	0.048	0.043

Bold numerals indicate where a relevant standard has been exceeded.

Table D31 Daily peak four-hour ozone at Mandurah (2011–20)

Trend station/region: Mandurah

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)
2011	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-
2020	98.9	0	0.064	0.051	0.047	0.042	0.039

Bold numerals indicate where a relevant standard has been exceeded.

Table D32 Daily peak one-hour sulfur dioxide at Rockingham (2011–20)

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)
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
2020	92.4	0	0.037	0.024	0.018	0.008	0.006

Table D33 Daily peak one-hour sulfur dioxide at South Lake (2011–20)

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)
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
2020	99.2	0	0.010	0.009	0.009	0.008	0.006

Table D34 Daily peak one-hour sulfur dioxide at Wattleup (2011–20)

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)
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
2020	92.0	0	0.044	0.032	0.027	0.022	0.016

Table D35 Daily peak one-hour sulfur dioxide at Kalgoorlie (2011–20)

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)
2011	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	92.2	0	0.106	0.06	0.038	0.019	0.014
2019	95.7	0	0.082	0.053	0.038	0.020	0.012
2020	95.6	0	0.075	0.055	0.046	0.022	0.012

Table D36 Daily peak 24-hour sulfur dioxide at Rockingham (2011–20)

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)
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
2020	92.4	0	0.008	0.004	0.003	0.002	0.002

Table D37 Daily peak 24-hour sulfur dioxide at South Lake (2011–20)

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)
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
2020	99.2	0	0.006	0.005	0.005	0.004	0.003

Table D38 Daily peak 24-hour sulfur dioxide at Wattleup (2011–20)

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)
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
2020	92.0	0	0.006	0.005	0.004	0.003	0.003

Table D39 Daily peak 24-hour sulfur dioxide at Kalgoorlie (2011–20)

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)
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
2020	95.6	0	0.011	0.006	0.004	0.003	0.002

Table D40 Daily peak 24-hour particles as PM_{10} at Caversham (2011–20)

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)
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
2020	97.8	3	**71.5**	43.1	36.9	28.0	24.3

Bold numerals indicate where a relevant standard has been exceeded.

Table D41 Daily peak 24-hour particles as PM_{10} at Duncraig (2011–20)

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)
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
2020	97.8	1	**61.8**	30.7	24.9	23.3	19.5

Bold numerals indicate where a relevant standard has been exceeded.

Table D42 Daily peak 24-hour particles as PM_{10} at South Lake (2011–2020)

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)
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
2020	99.0	0	45.2	32.8	31.8	25.3	21.7

Bold numerals indicate where a relevant standard has been exceeded.

Table D47 Daily peak 24-hour particles as PM_{10} at Mandurah (2011–20)

Trend station/region: Mandurah

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)
2011	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-
2020	96.5	30	**84.4**	**71.9**	**65.3**	**57.3**	48.5

Bold numerals indicate where a relevant standard has been exceeded.

Table D43 Daily peak 24-hour particles as PM_{10} at Albany (2011–20)

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)
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
2020	98.4	0	37.2	32.7	29.3	25.9	21.3

Bold numerals indicate where a relevant standard has been exceeded.

Table D44 Daily peak 24-hour particles as PM_{10} at Bunbury (2011–20)

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)
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
2020	95.1	1	**61.1**	41.7	34.9	28.7	24.2

Bold numerals indicate where a relevant standard has been exceeded.

Table D45 Daily peak 24-hour particles as PM_{10} at Collie (2011–20)

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)
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
2020	96.6	5	**130.9**	**57.0**	41.9	35.0	27.4

Bold numerals indicate where a relevant standard has been exceeded.

Table D46 Daily peak 24-hour particles as PM_{10} at Geraldton (2011–20)

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)
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
2020	98.5	3	**445.6**	47.1	43.5	38.3	33.4

Bold numerals indicate where a relevant standard has been exceeded.

Table D47 Daily peak 24-hour particles as PM_{10} at Kalgoorlie (2011–20)

Trend station/region: Kalgoorlie

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)
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
2020	98.2	4	**77.3**	49.3	39.1	31.8	24.3

Bold numerals indicate where a relevant standard has been exceeded.

Table D48 Daily peak 24-hour particles as $PM_{2.5}$ at Caversham (2011–20)

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)
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
2020	97.8	9	**60.9**	**30.9**	**27.9**	17.6	14.6

Bold numerals indicate where a relevant standard has been exceeded.

Table D49 Daily peak 24-hour particles as $PM_{2.5}$ at Duncraig (2011–20)

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)
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
2020	98.6	2	**37.2**	18.1	16.3	11.7	9.8

Bold numerals indicate where a relevant standard has been exceeded.

Table D50 Daily peak 24-hour particles as $PM_{2.5}$ at Quinns Rocks (2011–20)

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)
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	-	0	-	-	-	-	-
2019	-	0	-	-	-	-	-
2020	70.7	1	**39.8**	19.7	16.9	11.2	10.4

Bold numerals indicate where a relevant standard has been exceeded.

Table D52 Daily peak 24-hour particles as $PM_{2.5}$ at Mandurah (2011–20)

Trend station/region: Mandurah

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)
2011	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-
2020	96.5	5	**53.8**	**26.5**	22.0	20.0	17.1

Bold numerals indicate where a relevant standard has been exceeded.

Table D51 Daily peak 24-hour particles as $PM_{2.5}$ at South Lake (2011–20)

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)
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
2020	99.0	4	**34.6**	24.7	21.8	14.3	11.3
2011	99.2	1	**48.2**	16.2	15.3	13.1	11.5

Bold numerals indicate where a relevant standard has been exceeded.

Table D52 Daily peak 24-hour particles as $PM_{2.5}$ at Bunbury (2011–20)

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)
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
2020	95.2	11	**55.5**	**31.4**	**27.5**	22.1	16.4

Bold numerals indicate where a relevant standard has been exceeded.

Table D53 Daily peak 24-hour particles as $PM_{2.5}$ at Busselton (2011–20)

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)
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
2020	84.0	5	**37.1**	**27.7**	21.2	16.2	14.2

Bold numerals indicate where a relevant standard has been exceeded.

Table D54 Daily peak 24-hour particles as $PM_{2.5}$ at Kalgoorlie (2011–20)

Trend station/region: Kalgoorlie

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)
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
2020	99.3	2	**33.3**	22.0	19.9	13.4	8.9

Bold numerals indicate where a relevant standard has been exceeded.

Table D54 Daily peak 24-hour particles as $PM_{2.5}$ at Geraldton (2011–20)

Trend station/region: Geraldton

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)
2011	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	-	-	-	-	-	-	-
2019	99.4	0	18.4	16.5	14.6	13.3	11.8
2020	96.4	1	**162.3**	17.2	15.8	14.1	12.1

Bold numerals indicate where a relevant standard has been exceeded.

D.3 Maxima by pollutant 2011–20

Table D55 Peak eight-hour carbon monoxide concentrations (ppm) for 2011–20

AAQ NEPM standard
9.0 ppm (eight-hour average)

Regional performance monitoring station	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Perth region										
Caversham (North East Metro)	1.5	0.9	0.9	0.7	1.2	0.9	2.9	1.1	1.0	1.6
Duncraig (North Metro)	1.9	2.4	2.1	1.9	1.7	1.4	1.4	1.5	1.2	1.2
South Lake (South East Metro)	1.7	2.2	1.7	1.8	1.9	2.3	1.9	1.9	1.4	1.4
Peel region										
Mandurah	-	-	-	-	-	-	-	-	-	1.8
Goldfields region										
Kalgoorlie	-	-	-	-	-	-	-	1.9	2.1	2.0

Table D56 Peak one-hour nitrogen dioxide concentrations (ppm) for 2011–20

AAQ NEPM standard
0.12 ppm (one-hour average)

Regional performance monitoring station	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Perth region										
Caversham (North East Metro)	0.035	0.037	0.043	0.033	0.041	0.036	0.042	0.034	0.039	0.030
Duncraig (North Metro)	0.035	0.047	0.040	0.048	0.036	0.033	0.032	0.036	0.037	0.031
Quinns Rocks (Outer North Coast)	0.031	0.041	0.032	0.031	0.030	0.029	0.019	-	-	0.038
Rockingham (South Coast)	0.034	0.053	0.035	0.034	0.062	0.029	0.074	0.029	0.107	0.041
Rolling Green (Outer East Rural)	0.023	0.029	0.030	0.021	0.023	0.023	0.018	0.023	0.023	0.018
South Lake (South East Metro)	0.041	0.046	0.043	0.034	0.043	0.038	0.045	0.047	0.036	0.036
Swanbourne (Inner West Coast)	0.032	0.045	0.037	0.036	0.036	0.030	0.033	0.039	0.037	0.032
Peel region										
Mandurah	-	-	-	-	-	-	-	-	-	0.022

Table D57 Peak one-hour ozone concentrations (ppm) for 2011–20

AAQ NEPM standard
0.10 ppm (one-hour average)

Regional performance monitoring station	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Perth region										
Caversham (North East Metro)	0.077	0.098	**0.101**	0.091	**0.103**	0.096	0.099	0.067	0.082	0.067
Quinns Rocks (Outer North Coast)	0.083	**0.130**	0.087	0.073	0.083	0.089	0.066	-	-	0.065
Rockingham (South Coast)	0.065	0.095	0.084	0.076	0.069	0.087	0.069	0.061	0.079	0.070
Rolling Green (Outer East Rural)	0.073	**0.103**	0.099	0.080	**0.105**	0.075	0.069	0.075	0.100	0.071
South Lake (South East Metro)	0.076	0.085	0.087	0.065	0.067	0.091	0.074	0.061	0.083	0.061
Swanbourne (Inner West Coast)	0.085	**0.128**	0.083	0.066	0.074	**0.103**	0.079	0.075	0.070	0.069
Peel region										
Mandurah	-	-	-	-	-	-	-	-	-	0.076

Bold numerals indicate where a relevant standard has been exceeded.

Table D58 Peak four-hour ozone concentrations (ppm) for 2011–20

AAQ NEPM standard
0.08 ppm (one-hour average)

Regional performance monitoring station	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Perth region										
Caversham (North East Metro)	0.063	**0.086**	0.075	0.073	**0.084**	**0.085**	0.077	0.056	0.065	0.058
Quinns Rocks (Outer North Coast)	0.075	**0.108**	0.079	0.062	0.071	0.079	0.062	-	-	0.058
Rockingham (South Coast)	0.061	0.079	0.075	0.067	0.064	0.079	0.062	0.057	0.067	0.065
Rolling Green (Outer East Rural)	0.061	**0.081**	**0.083**	0.070	**0.093**	0.066	0.064	0.067	**0.087**	0.061
South Lake (South East Metro)	0.064	0.080	0.074	0.058	0.060	0.080	0.067	0.053	0.076	0.054
Swanbourne (Inner West Coast)	0.073	**0.108**	0.068	0.057	0.067	**0.081**	0.070	0.063	0.066	0.062
Peel region										
Mandurah	-	-	-	-	-	-	-	-	-	0.064

Bold numerals indicate where a relevant standard has been exceeded.

Table D59 Peak one-hour sulfur dioxide concentrations (ppm) for 2011–20

AAQ NEPM standard
0.20 ppm (one-hour average)

Regional performance monitoring station	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Perth region										
Rockingham (South Coast)	0.040	0.040	0.037	0.036	0.051	0.064	0.030	0.031	0.034	0.037
South Lake (South East Metro)	0.044	0.039	0.044	0.051	0.037	0.034	0.037	0.022	0.019	0.010
Wattleup (South Metro)	0.067	0.043	0.090	0.061	0.067	0.072	0.068	0.038	0.057	0.044
Goldfields region										
Kalgoorlie	-	-	-	-	-	-	-	0.106	0.082	0.075

Table D60 Peak 24-hour sulfur dioxide concentrations (ppm) for 2011–20

AAQ NEPM standard
0.08 ppm (24-hour average)

Regional performance monitoring station	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Perth region										
Rockingham (South Coast)	0.008	0.006	0.007	0.007	0.013	0.014	0.009	0.007	0.009	0.008
South Lake (South East Metro)	0.006	0.006	0.014	0.010	0.007	0.010	0.009	0.005	0.006	0.006
Wattleup (South Metro)	0.008	0.008	0.010	0.008	0.009	0.011	0.007	0.007	0.008	0.006
Goldfields region										
Kalgoorlie	-	-	-	-	-	-	-	0.008	0.012	0.011

Table D60a Annual averaged sulfur dioxide concentrations (ppm) for 2011–20

AAQ NEPM standard
0.02 ppm (annual average)

Regional performance monitoring station	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
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	0.002	0.003	0.003	0.002	0.002	0.002
Wattleup (South Metro)	0.001	0.001	0.002	0.002	0.002	0.001	0.001	0.002	0.002	0.001
Goldfields region										
Kalgoorlie	-	-	-	-	-	-	-	0.001	0.001	0.001

Table D61 Peak 24-hour particles as PM_{10} concentrations ($\mu g/m^3$) for 2011–20

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

Regional performance monitoring station	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Perth Region										
Caversham (North East Metro)	**76.1**	**68.7**	**62.4**	**52.6**	46.8	38.1	**79.2**	**77.9**	**107.7**	**71.5**
Duncraig (North Metro)	**65.9**	**89.5**	37.6	**53.0**	**82.7**	40.0	**51.4**	**61.3**	**68.1**	**61.8**
South Lake (South East Metro)	-	-	-	-	-	-	-	-	-	**77.7**
	66.2	**81.5**	38.8	44.5	**53.3**	47.0	49.6	**57.1**	**98.8**	45.2
Peel region										
Mandurah	-	-	-	-	-	-	-	-	-	**84.4**
South West region										
Bunbury										
Collie	**68.4**	**53.5**	46.8	44.5	**62.9**	**74.6**	45.5	**51.9**	**131.0**	**61.1**
Albany	**61.5**	**91.7**	**61.6**	**73.3**	**111.9**	**89.9**	**81.5**	**84.6**	**83.5**	**130.9**
	37.3	37.0	**110.8**	43.5	**76.7**	**94.9**	**61.8**	**89.6**	**128.5**	37.2
Mid West region										
Geraldton	**63.0**	**61.5**	**63.1**	**55.7**	**68.1**	**66.0**	**73.5**	**70.0**	**88.4**	**445.6**
Goldfields region										
Kalgoorlie								**60.5**	**67.6**	**77.3**

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's report.

Table D62 Peak 24-hour particles as $PM_{2.5}$ concentrations ($\mu g/m^3$) for 2011–20

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

Regional performance monitoring station	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Perth region										
Caversham (North East Metro)	**41.5**	**45.9**	22.6	**39.3**	**30.0**	24.1	**65.9**	**36.7**	**25.4**	**60.9**
Duncraig (North Metro)	**52.1**	**77.3**	18.7	**47.6**	**35.8**	**27.0**	**40.5**	**48.6**	25.0	**37.2**
Quinns Rocks (Outer North Coast)	**43.2**	**74.5**	19.3	**39.5**	**37.9**	**28.8**	12.2	-	-	**39.8**
South Lake (South East Metro)	**48.2**	**71.6**	17.1	**29.8**	**34.5**	**30.4**	**46.6**	**43.3**	**28.9**	**34.6**
Peel region										
Mandurah	-	-	-	-	-	-	-	-	-	**53.8**
South West region										
Bunbury	**45.5**	**43.0**	**38.3**	**34.6**	**52.1**	**61.5**	**33.9**	**38.4**	**118.2**	**55.5**
Busselton	**85.2**	**78.0**	17.9	**25.1**	**37.8**	**61.1**	**28.8**	**56.5**	**78.5**	**37.1**
Mid West region										
Geraldton	-	-	-	-	-	-	-	-	18.4	**162.3**
Goldfields region										
Kalgoorlie	-	-	-	-	-	-	-	**36.2**	**40.8**	**33.3**

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's report.

Table D63 Annual averaged particles as PM_{10} concentrations ($\mu g/m^3$) for 2011–20

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

Regional performance monitoring station	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Perth region										
Caversham (North East Metro)	16.2	16.8	15.4	17.4	16.7	15.0	16.1	16.3	18.7	15.1
Duncraig (North Metro)	15.3	16.2	15.5	15.5	16.5	14.4	15.7	15.1	14.8	13.4
South Lake (South East Metro)	16.3	16.9	16.6	17.4	17.9	15.8	16.7	16.3	17.7	13.9
Peel Region										
Mandurah	-	-	-	-	-	-	-	-	-	**26.6**
South West region										
Bunbury	17.0	17.5	16.8	16.1	17.5	16.5	16.5	16.1	16.6	15.5
Collie	19.6	20.0	20.1	19.2	22.4	19.3	21.7	19.3	22.0	18.1
Albany	14.5	15.0	15.4	16.0	15.9	17.5	16.6	14.6	15.3	14.2
Mid West region										
Geraldton	19.6	21.3	20.9	22.3	20.2	18.8	21.3	20.1	22.2	20.9
Goldfields region										
Kalgoorlie	-	-	-	-	-	-	-	12.8	15.2	14.2

Table D64: Annual averaged particles as $PM_{2.5}$ concentrations ($\mu g/m^3$) for 2011–20

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

Regional performance monitoring station	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Perth region										
Caversham (North East Metro)	7.0	7.8	7.9	**8.1**	**8.5**	7.7	**8.5**	8.0	**8.3**	7.8
Duncraig (North Metro)	7.8	**8.2**	7.6	7.6	**8.4**	7.5	**8.2**	7.7	7.4	6.3
Quinns Rocks (Outer North Coast)	7.2	7.9	7.8	8.0	**8.3**	7.5	7.8	-	-	5.4
South Lake (Outer North Coast)	7.8	**8.9**	8.0	**8.1**	**8.8**	8.0	**8.7**	**8.4**	**8.2**	7.2
Peel region										
Mandurah	-	-	-	-	-	-	-	-	-	**10.0**
South West region										
Bunbury	8.0	**8.6**	7.8	7.8	**9.3**	**8.4**	**8.7**	**8.4**	**8.5**	7.9
Busselton	**8.5**	**8.6**	7.7	7.2	**8.6**	**8.1**	**8.2**	7.9	**8.1**	**8.1**
Mid West region										
Geraldton	-	-	-	-	-	-	-	-	7.9	8.0
Goldfields region										
Kalgoorlie	-	-	-	-	-	-	-	5.1	5.6	4.7

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 concentrations for all pollutants monitored by the department. 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

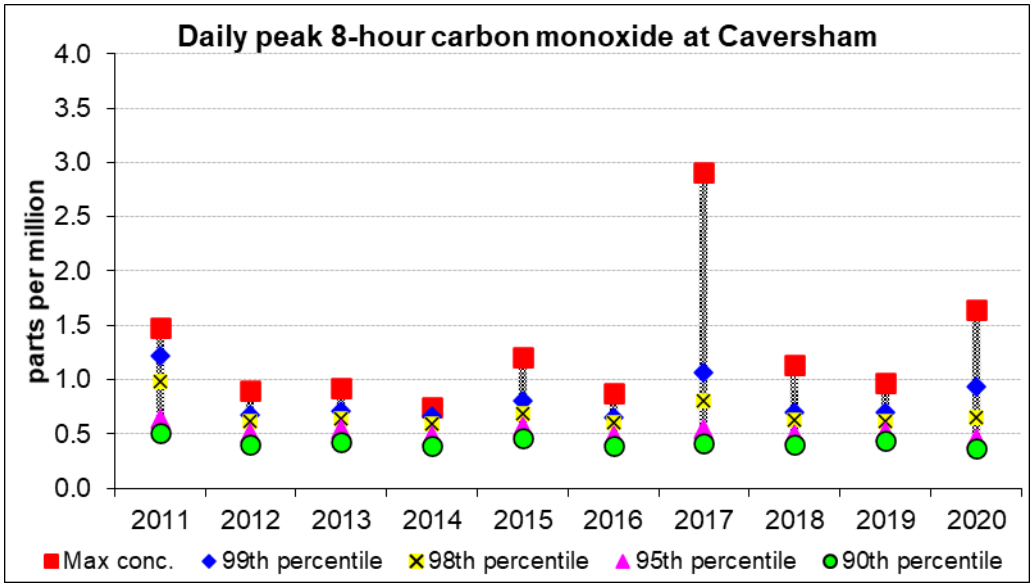


Figure E1-1 Eight-hour carbon monoxide at Caversham.

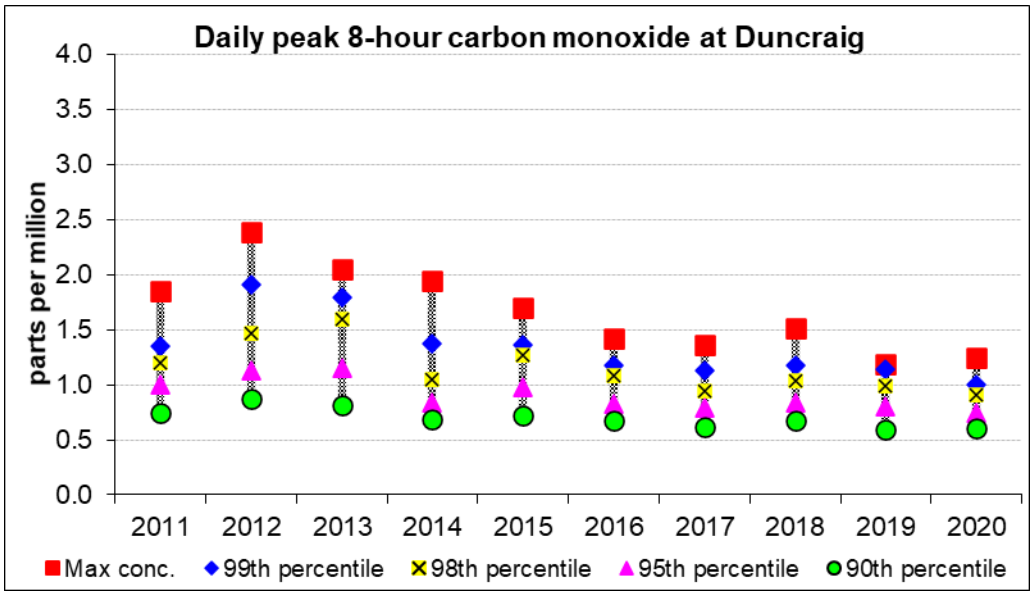


Figure E1-2 Eight-hour carbon monoxide at Duncraig.

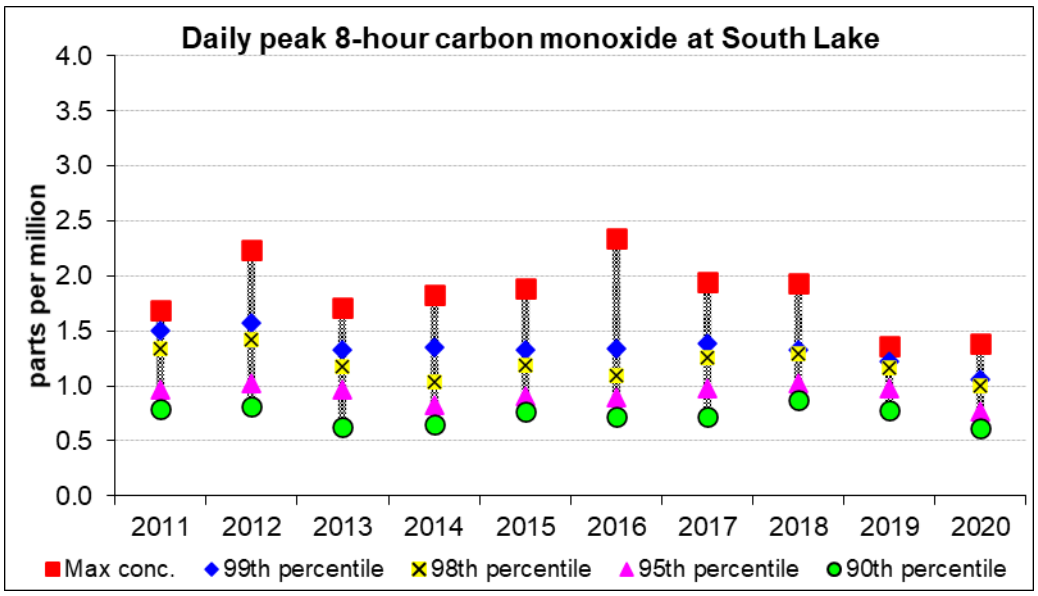


Figure E1-3 Eight-hour carbon monoxide at South Lake.

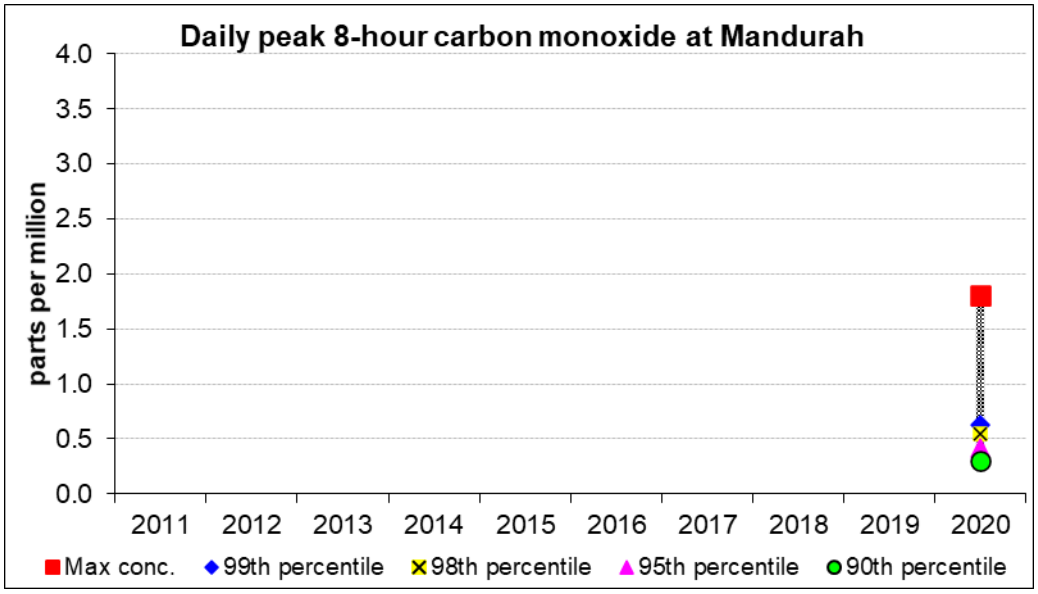


Figure E1-3 Eight-hour carbon monoxide at Mandurah.

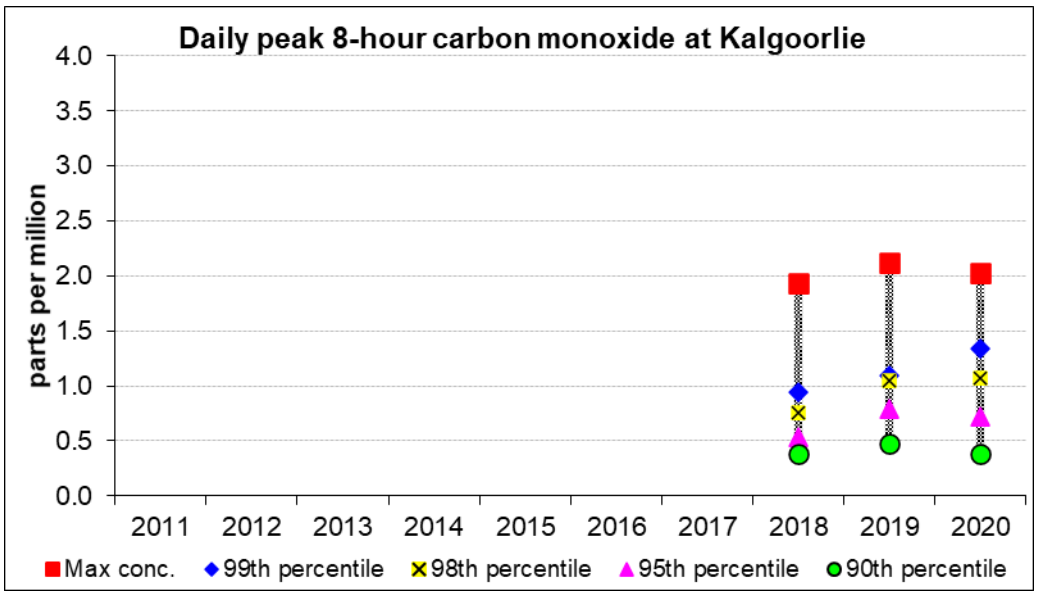


Figure E1-4 Eight-hour carbon monoxide at Kalgoorlie.

E.2 Nitrogen dioxide

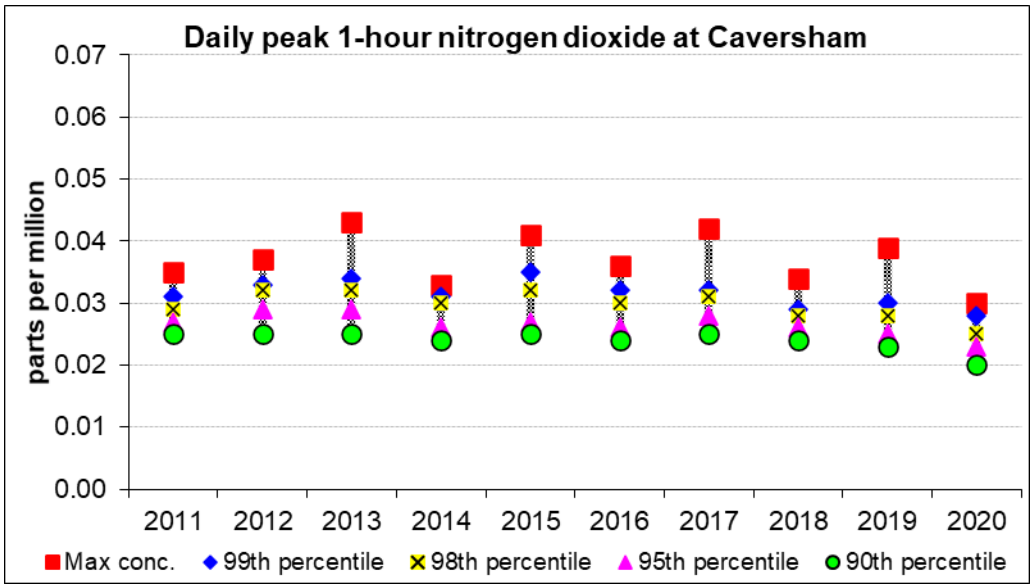


Figure E2-1 One-hour nitrogen dioxide at Caversham.

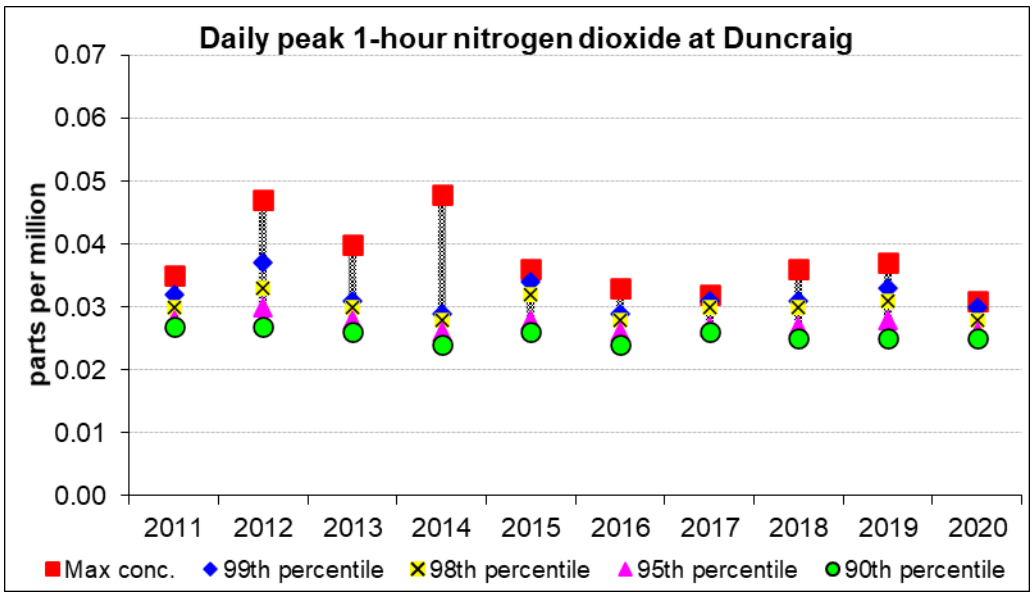


Figure E2-2 One-hour nitrogen dioxide at Duncraig.

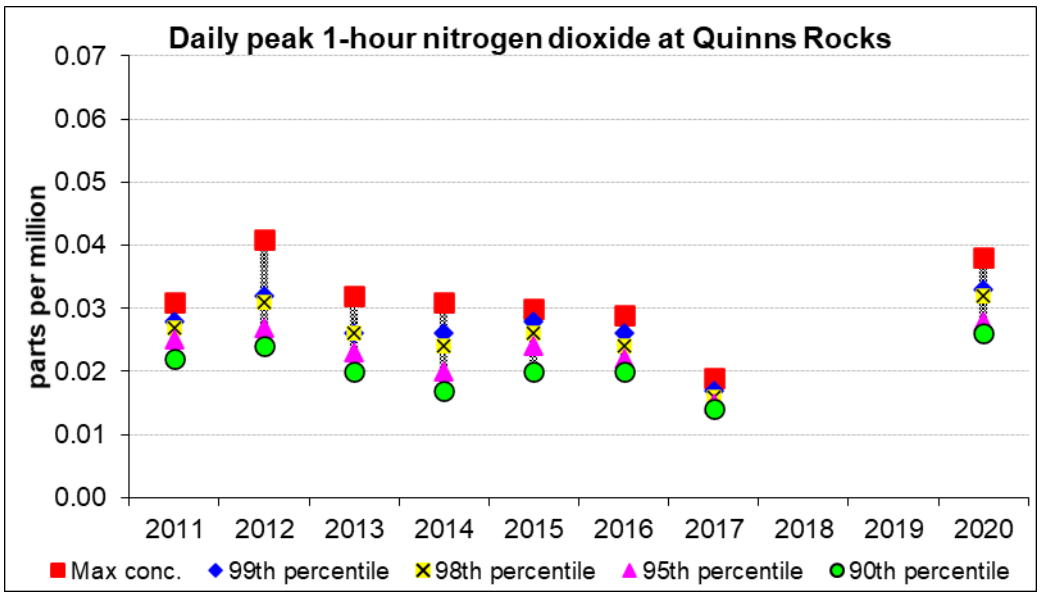


Figure E2-3 One-hour nitrogen dioxide at Quinns Rocks (2017 to 2019 not included).

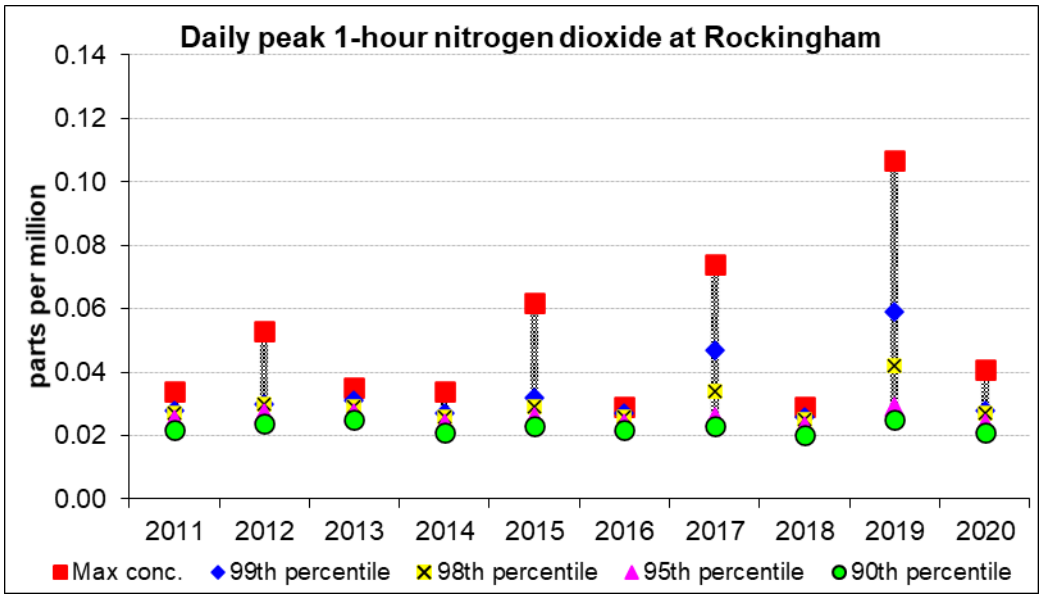


Figure E2-4 One-hour nitrogen dioxide at Rockingham.

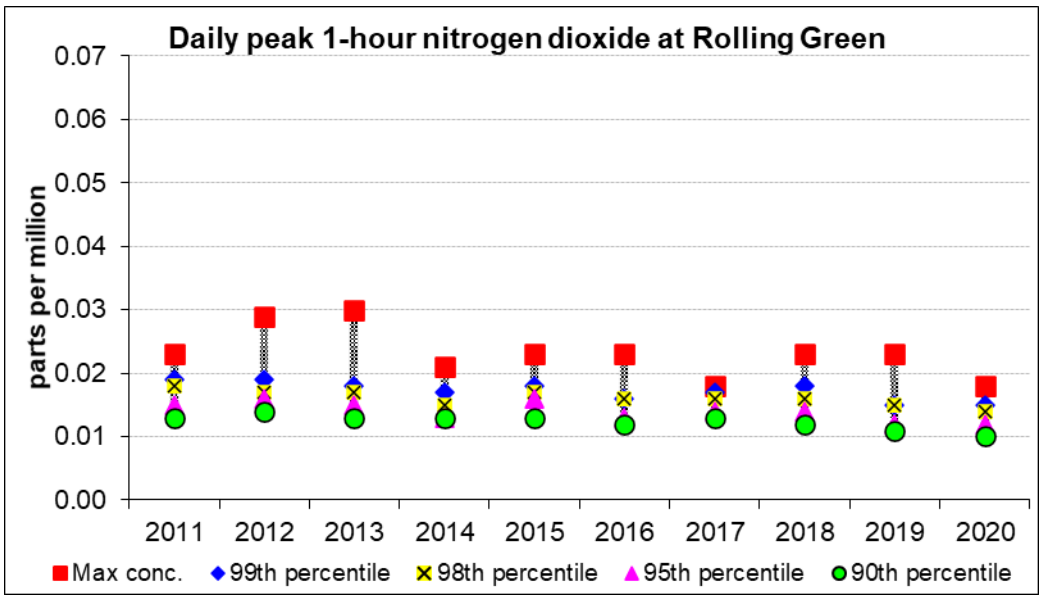


Figure E2-5 One-hour nitrogen dioxide at Rolling Green.

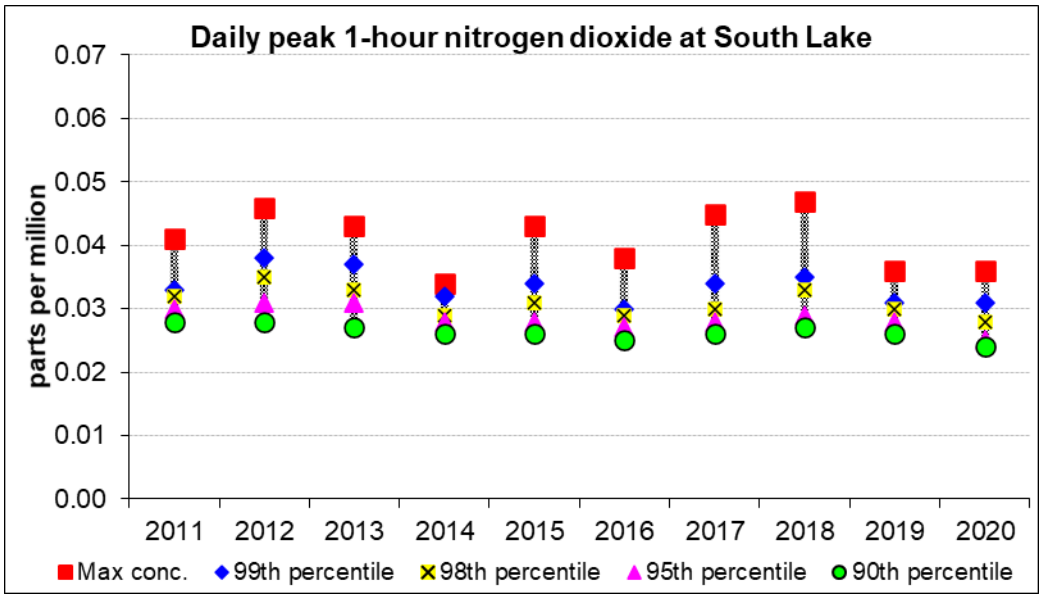


Figure E2-6 One-hour nitrogen dioxide at South Lake.

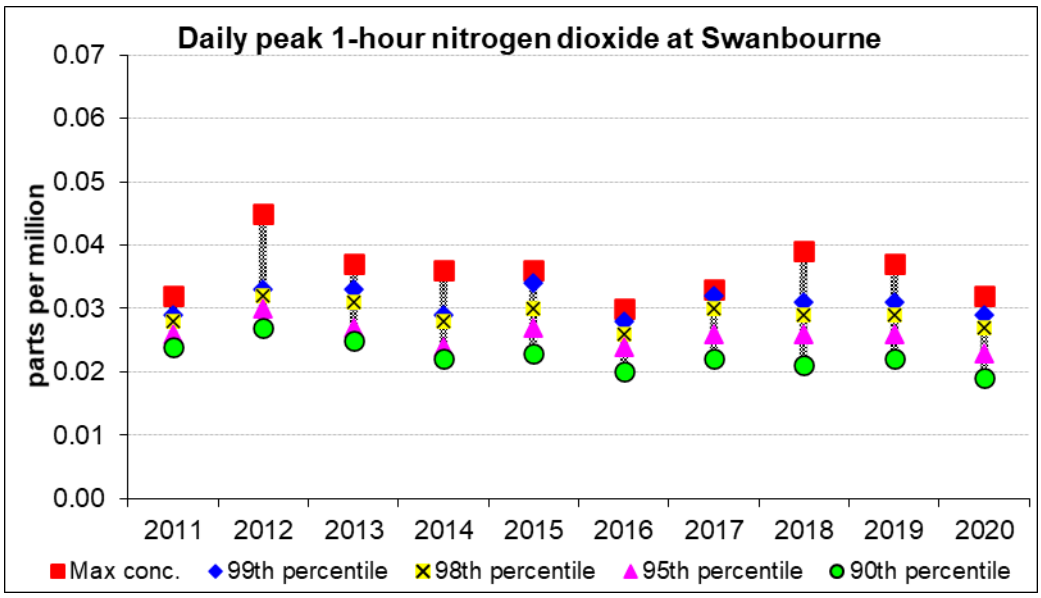


Figure E2-7 One-hour nitrogen dioxide at Swanbourne.

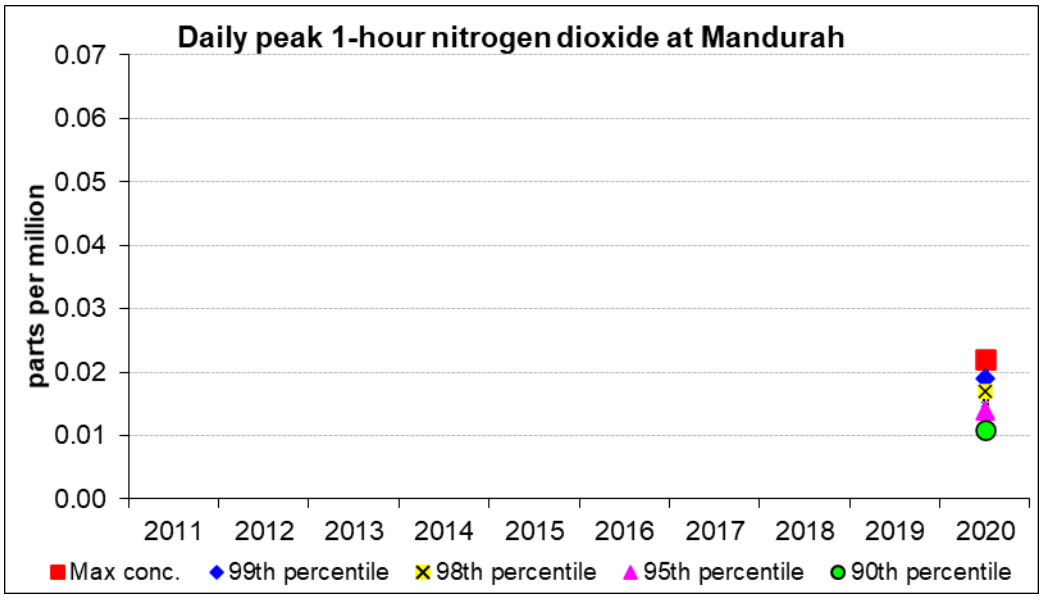


Figure E2-7 One-hour nitrogen dioxide at Mandurah.

E.3 Ozone

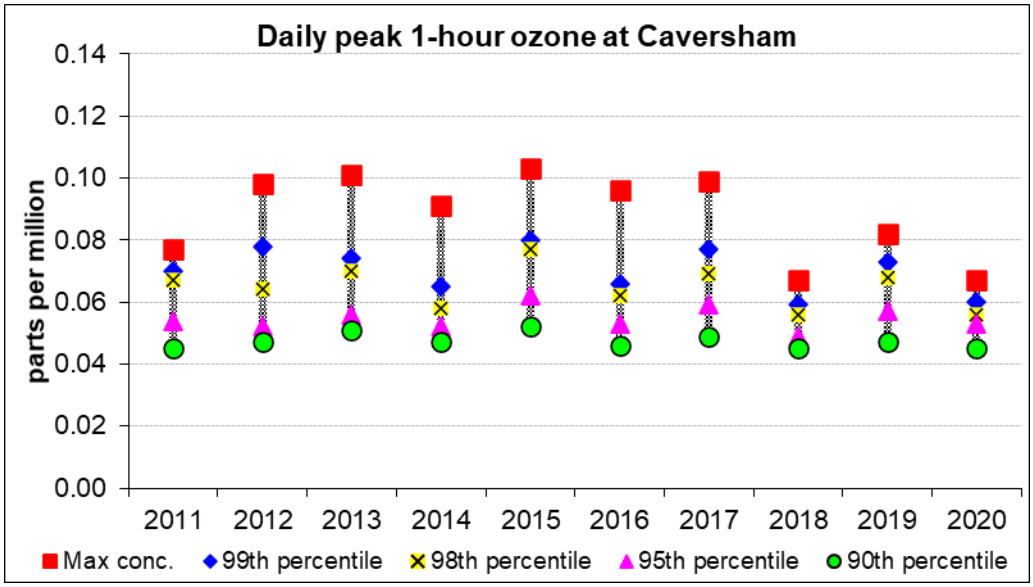


Figure E3-1 One-hour ozone at Caversham.

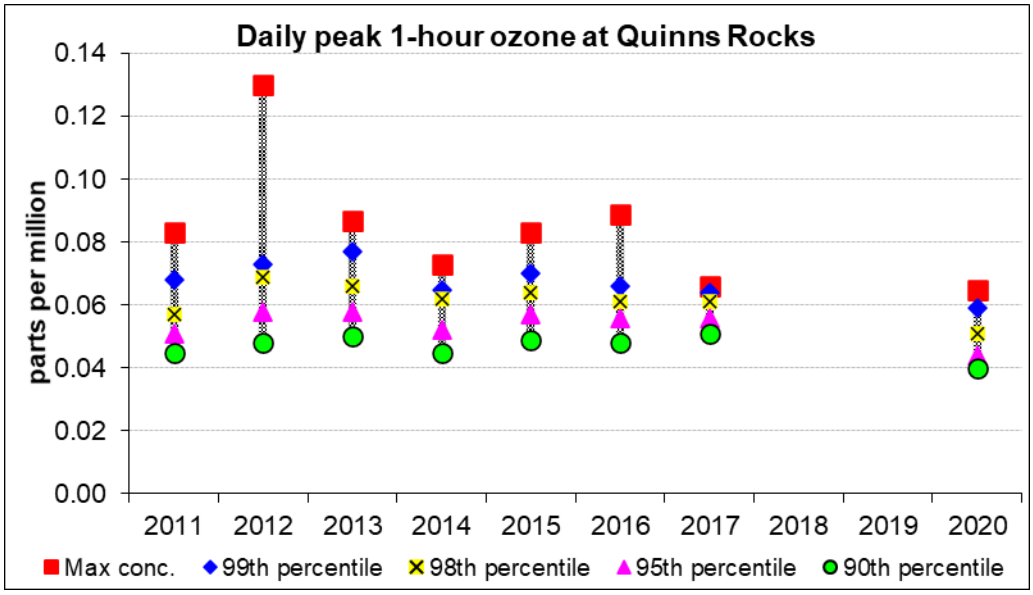


Figure E3-2 One-hour ozone at Quinns Rocks (2017 to 2019 not included).

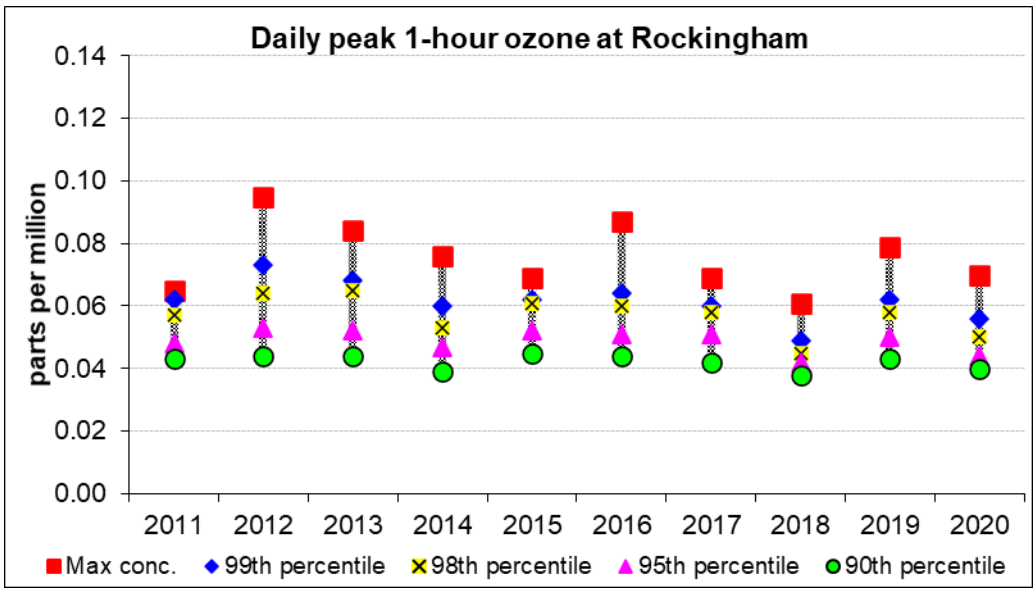


Figure E3-3 One-hour ozone at Rockingham.

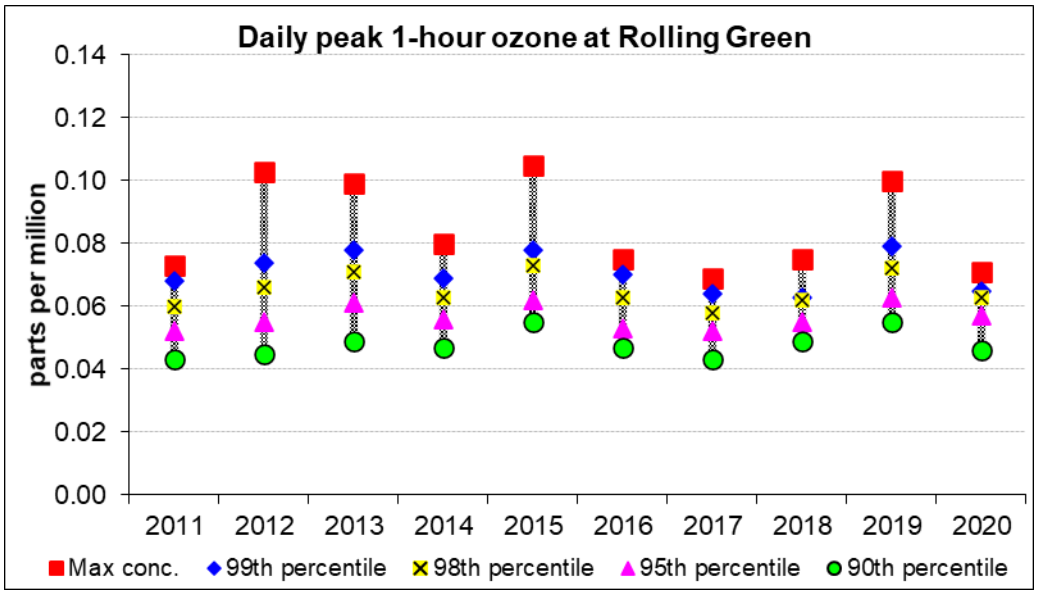


Figure E3-4 One-hour ozone at Rolling Green.

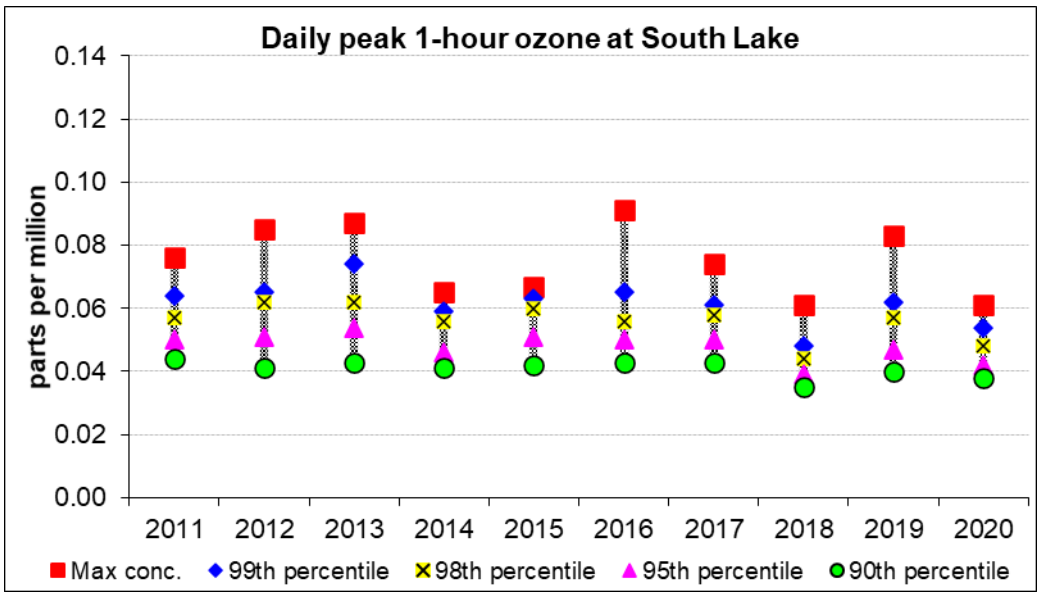


Figure E3-5 One-hour ozone at South Lake.

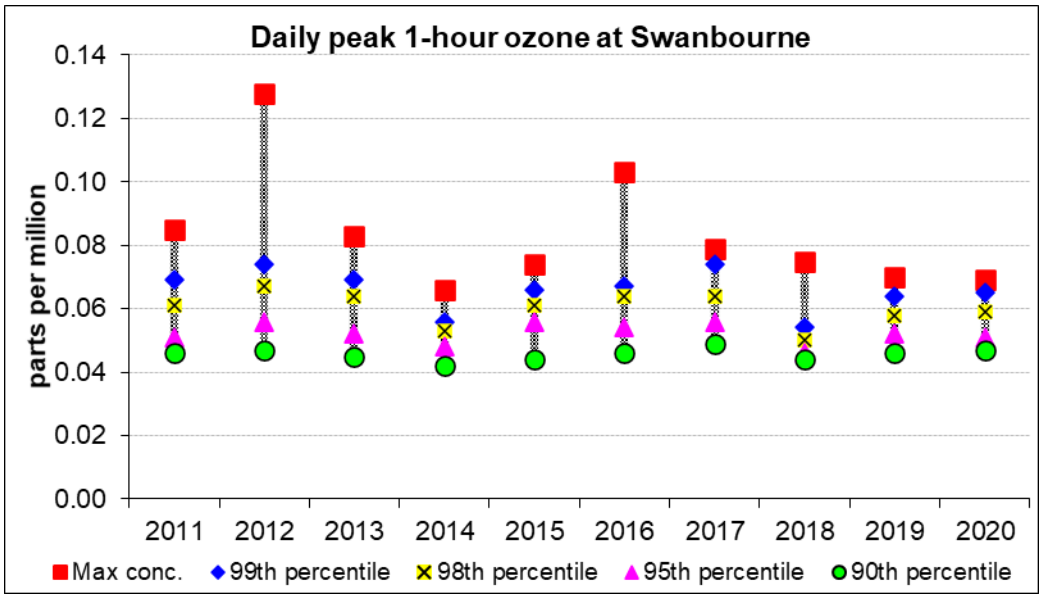


Figure E3-6 One-hour ozone at Swanbourne.

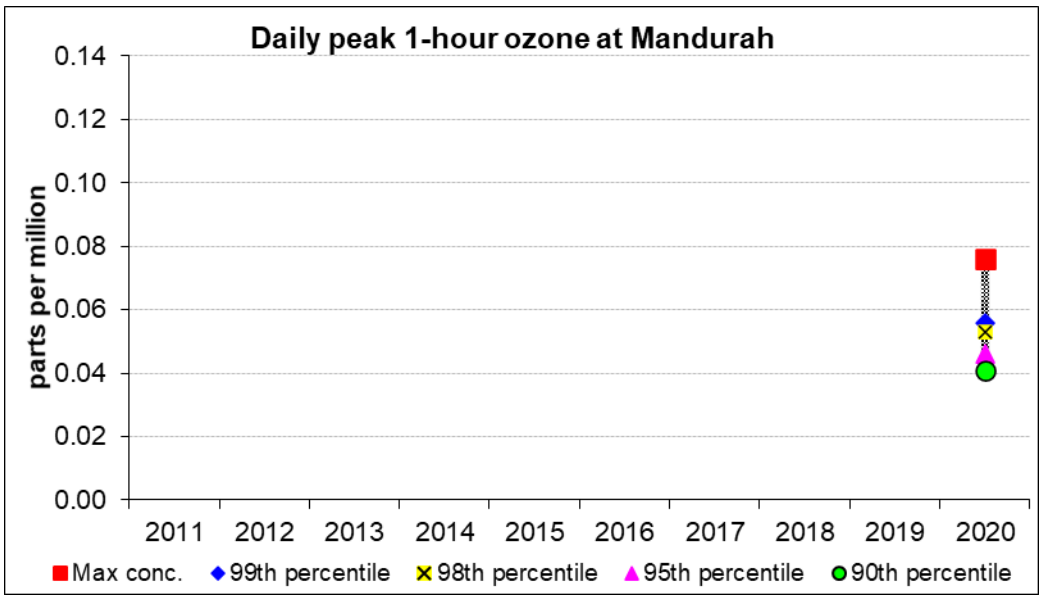


Figure E3-6 One-hour ozone at Mandurah.

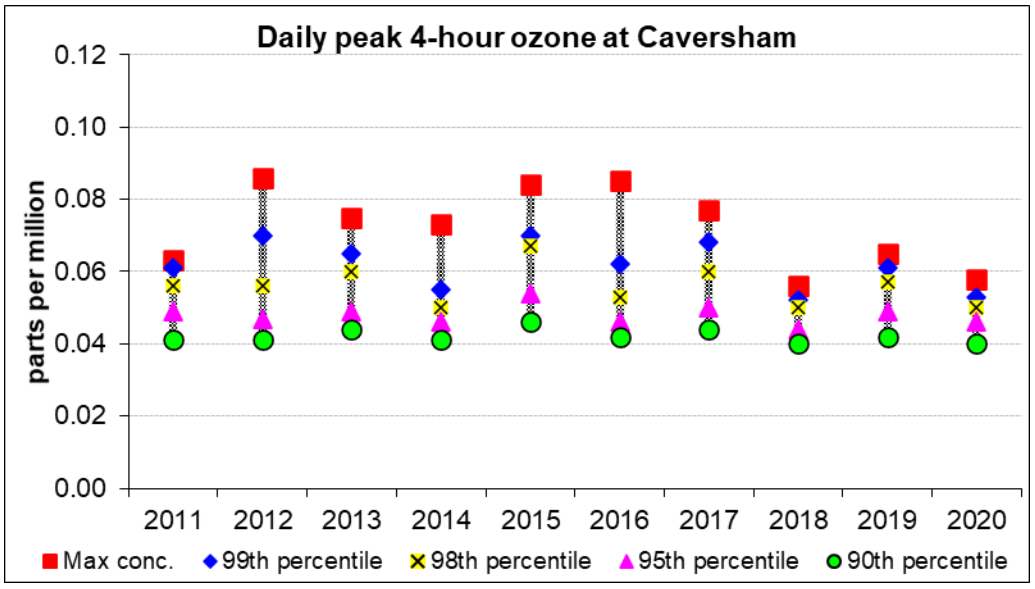


Figure E3-7 Four-hour ozone at Caversham.

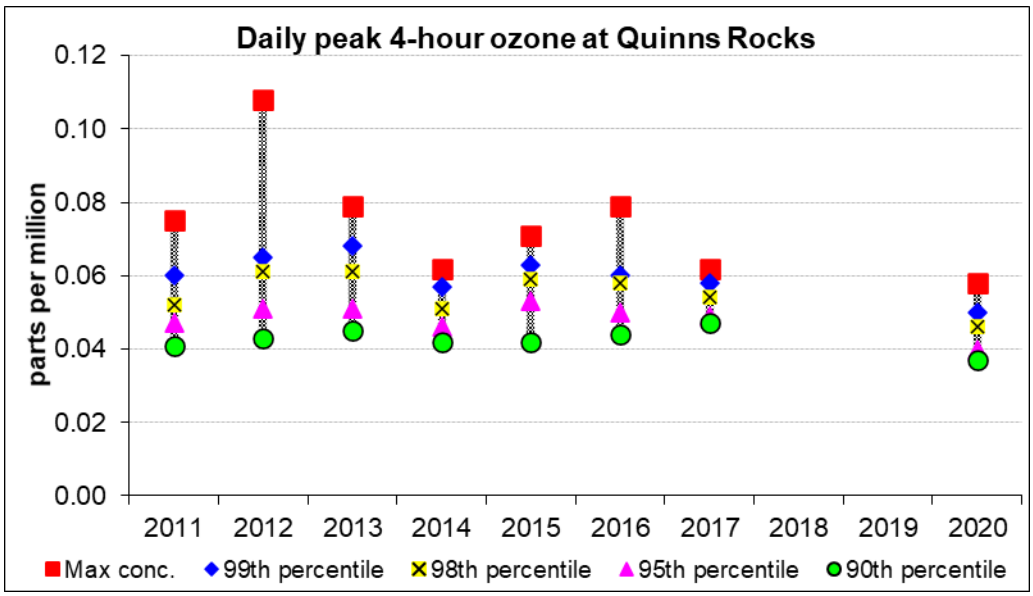


Figure E3-8 Four-hour ozone at Quinns Rocks (2017 to 2019 not included).

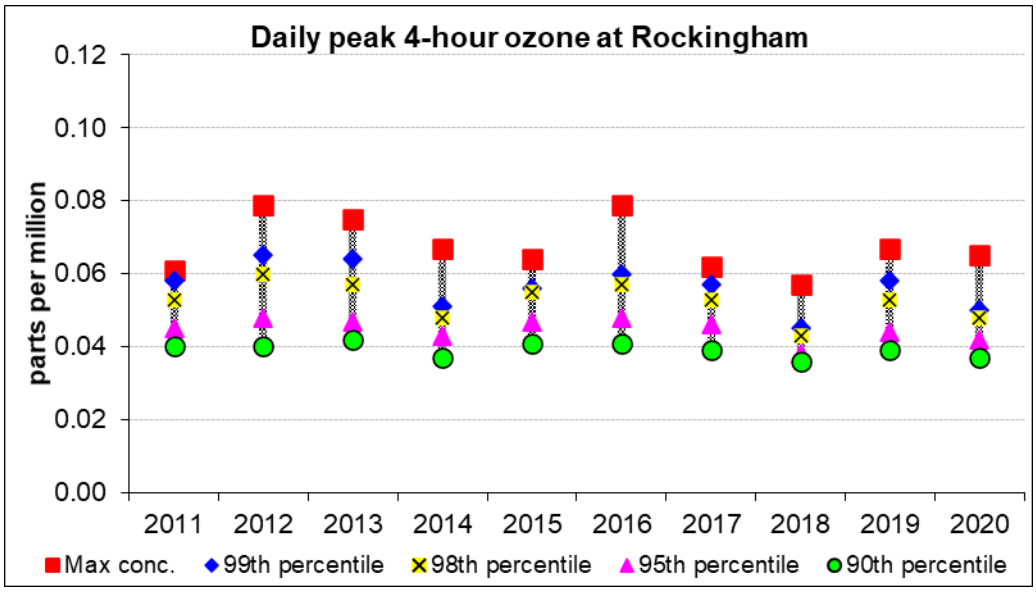


Figure E3-9 Four-hour ozone at Rockingham.

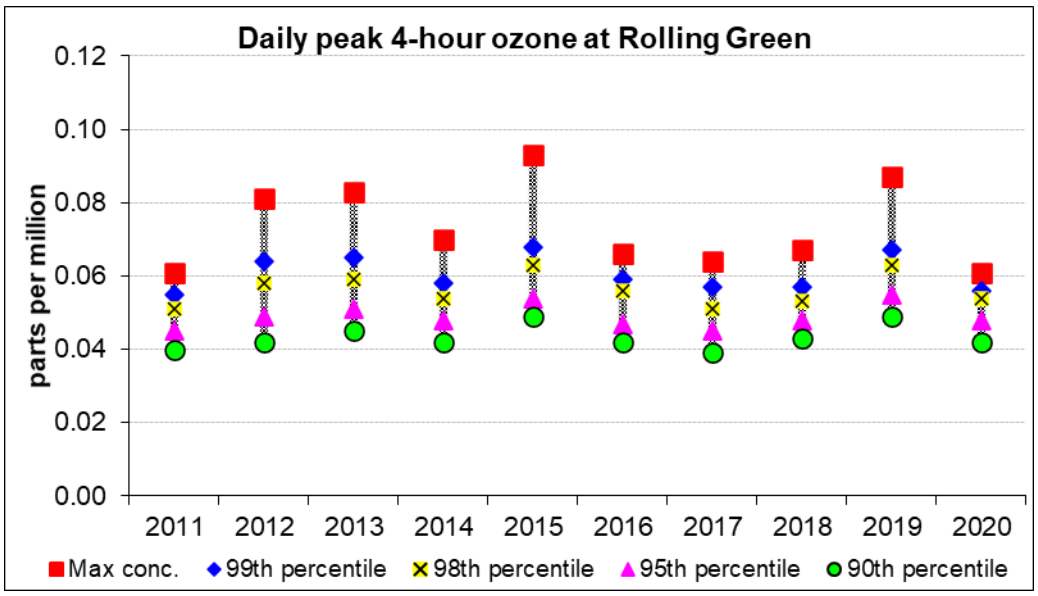


Figure E3-10 Four-hour ozone at Rolling Green.

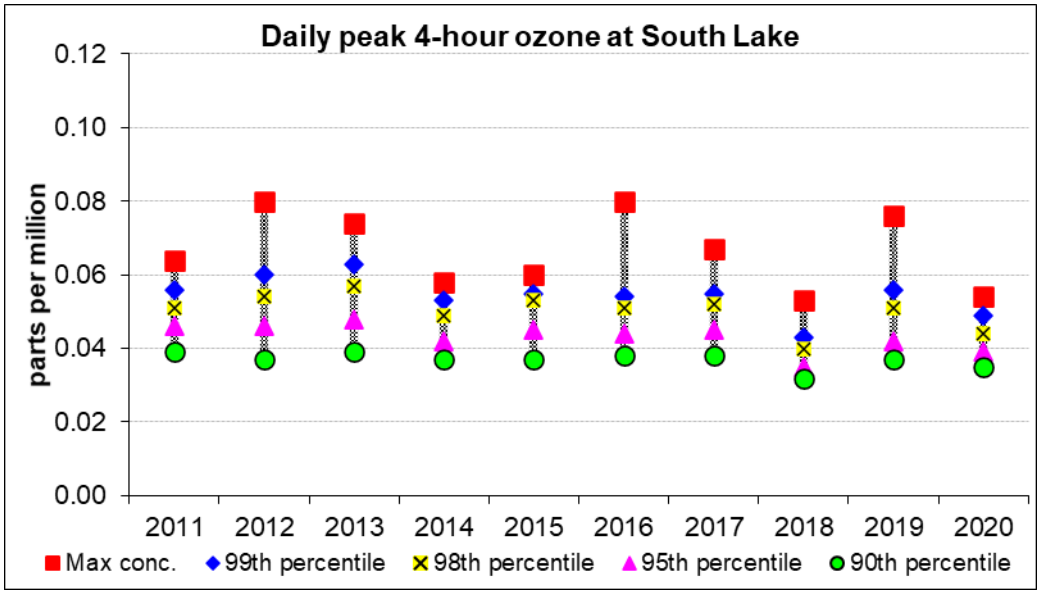


Figure E3-11 Four-hour ozone at South Lake.

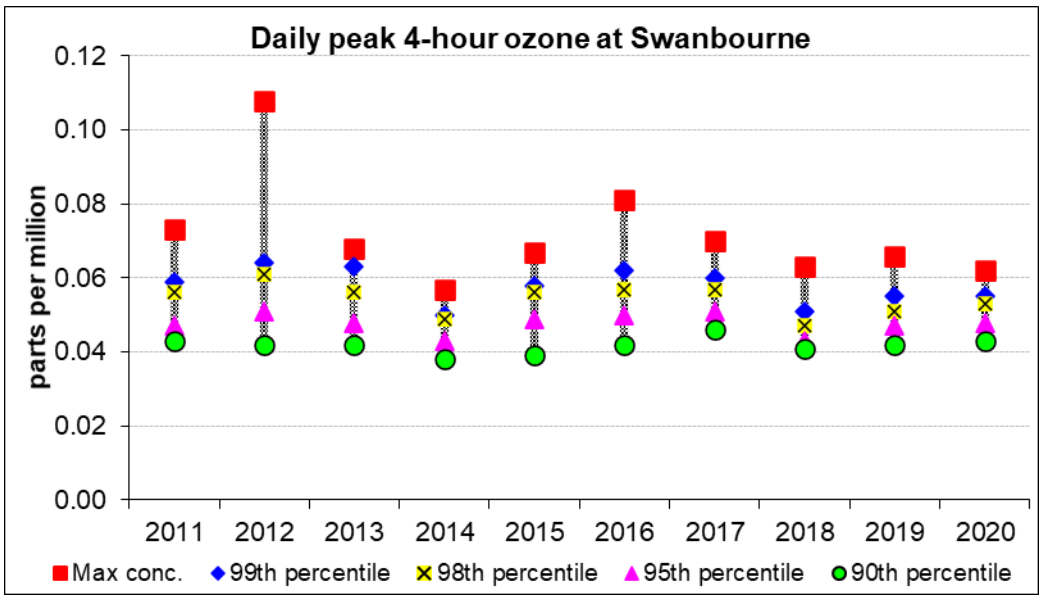


Figure E3-12 Four-hour ozone at Swanbourne.

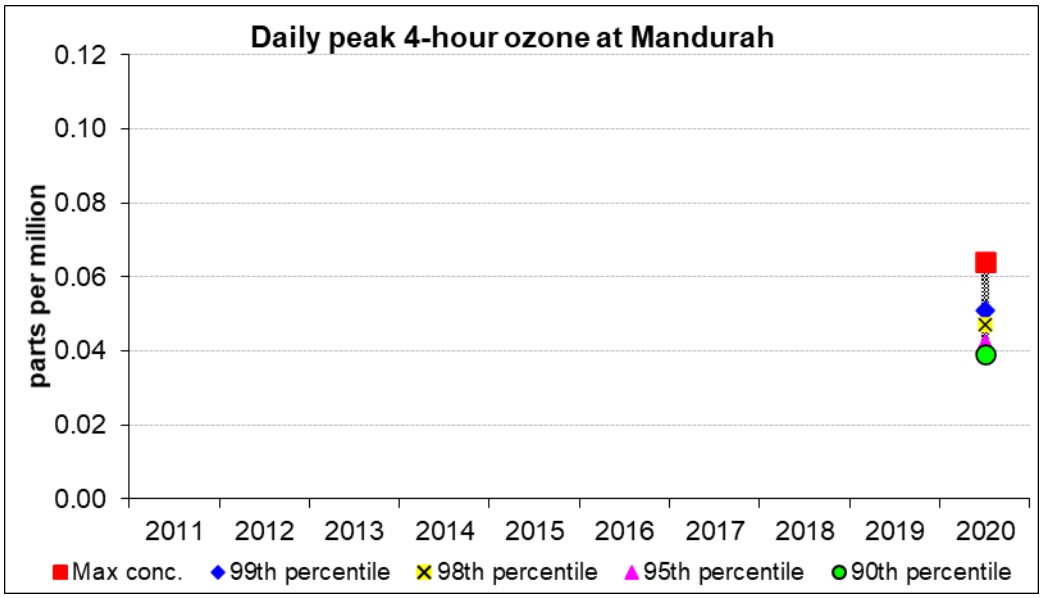


Figure E3-12 Four-hour ozone at Mandurah.

E.4 Sulfur dioxide

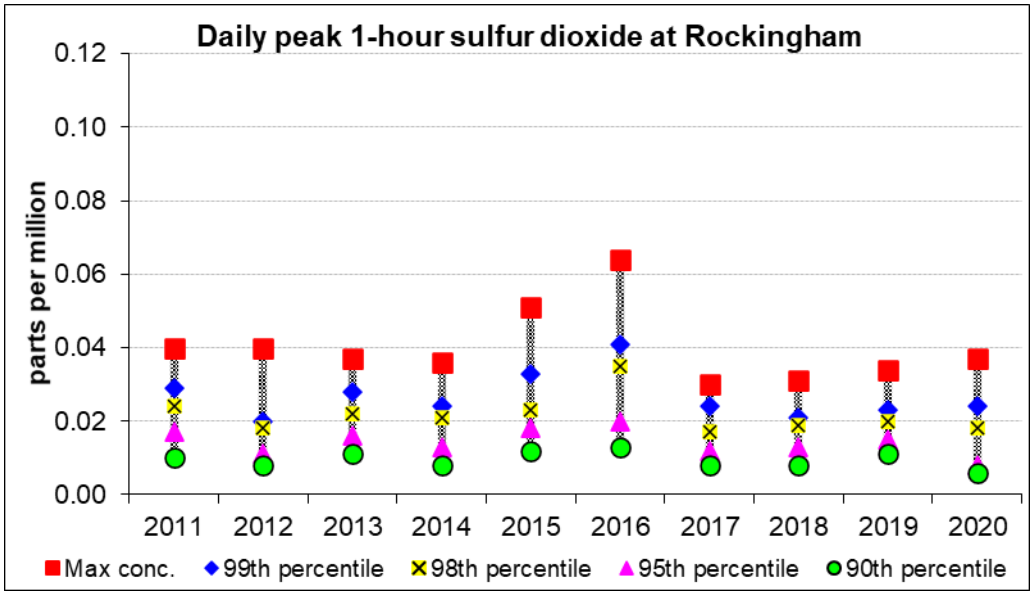


Figure E4-1 One-hour sulfur dioxide at Rockingham.

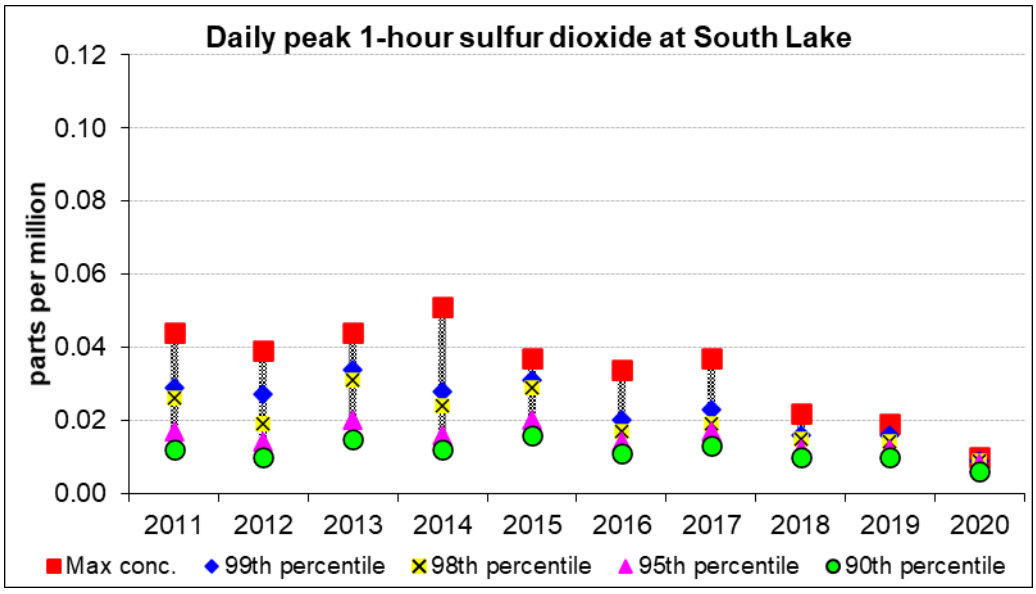


Figure E4-2 One-hour sulfur dioxide at South Lake.

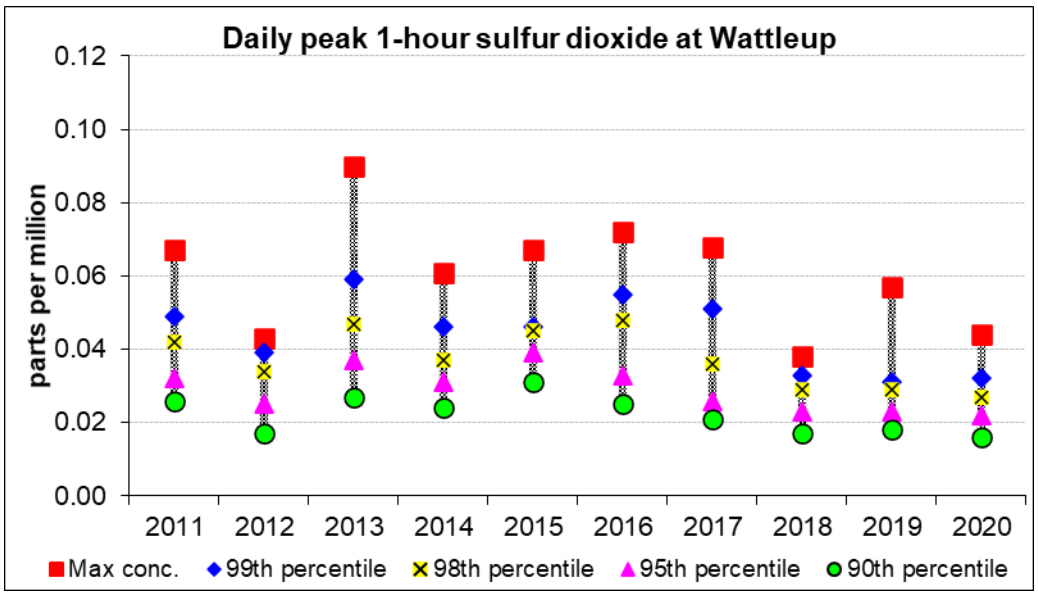


Figure E4-3 One-hour sulfur dioxide at Wattleup.

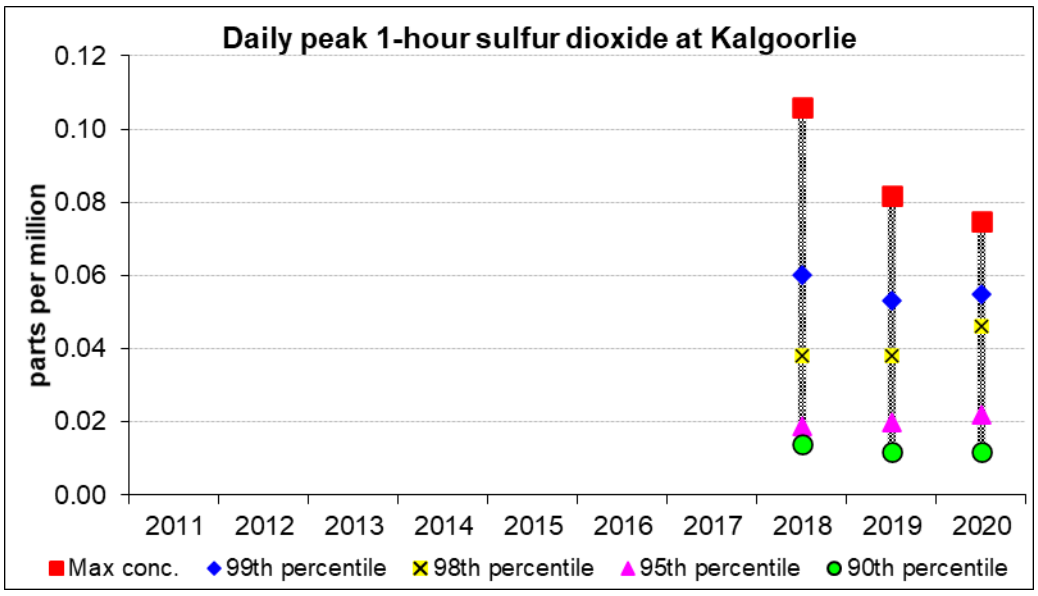


Figure E4-4 One-hour sulfur dioxide at Kalgoorlie.

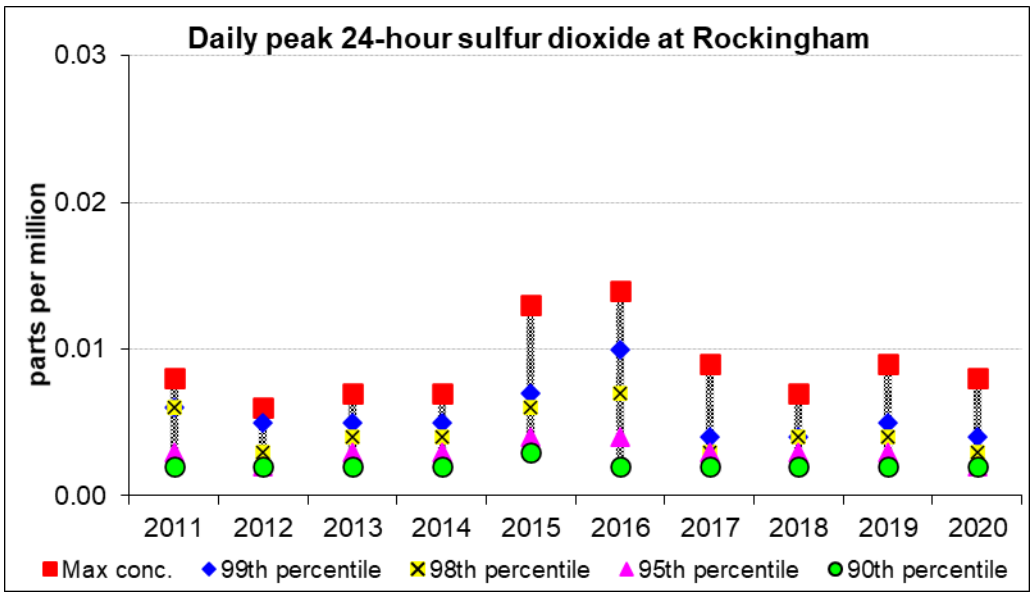


Figure E4-5 24-hour sulfur dioxide at Rockingham.

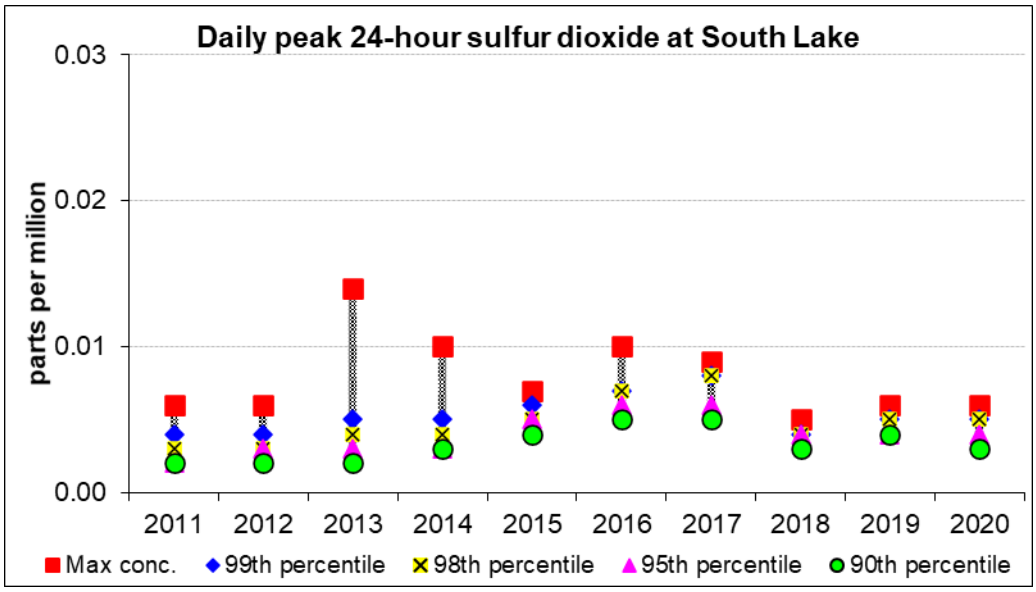


Figure E4-6 24-hour sulfur dioxide at South Lake.

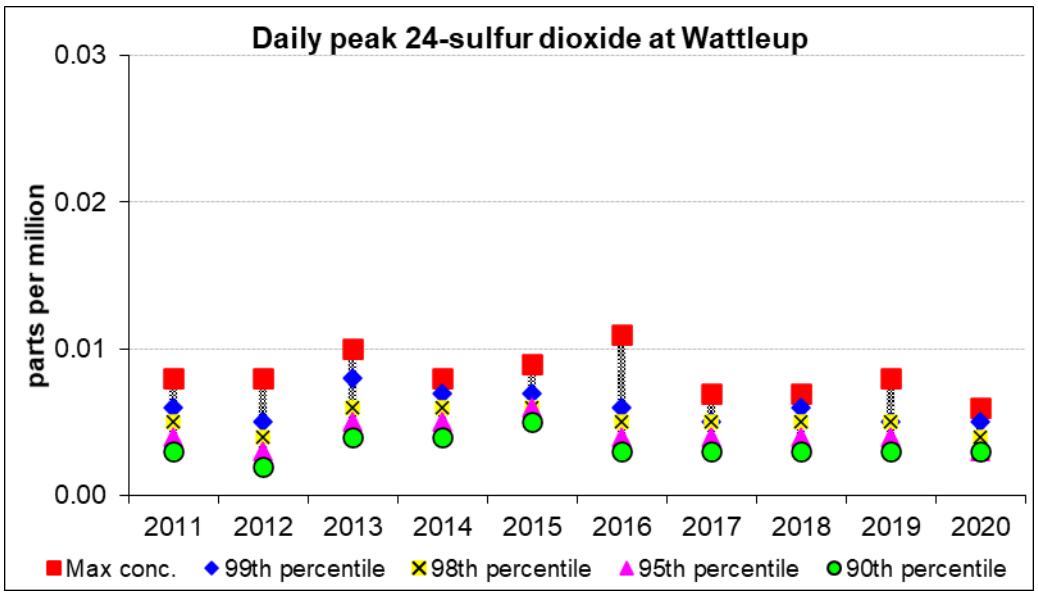


Figure E4-7 24-hour sulfur dioxide at Wattleup.

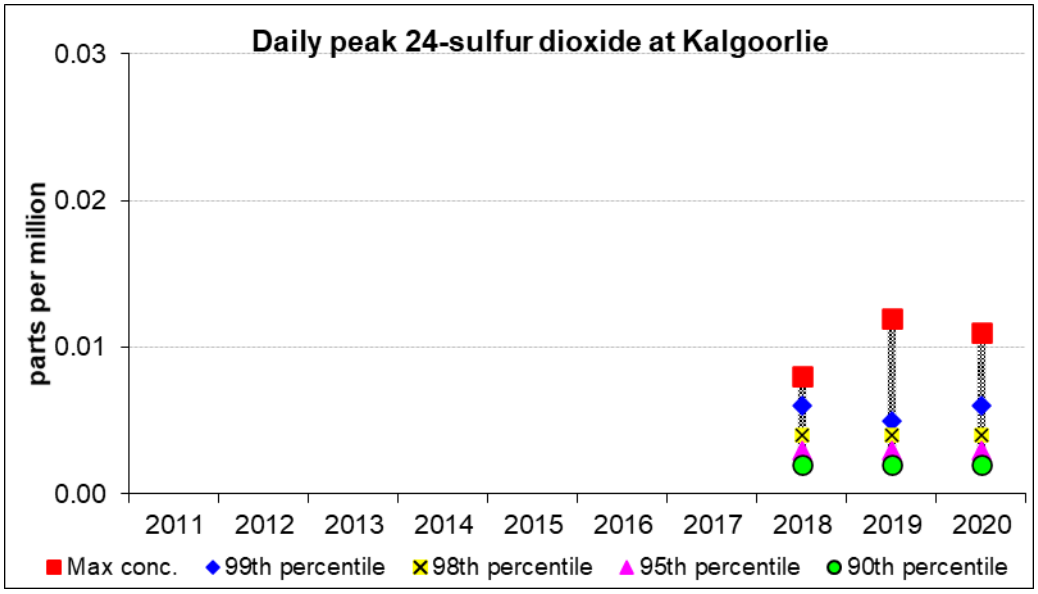


Figure E4-8 24-hour sulfur dioxide at Kalgoorlie.

E.5 Particles as PM_{10}

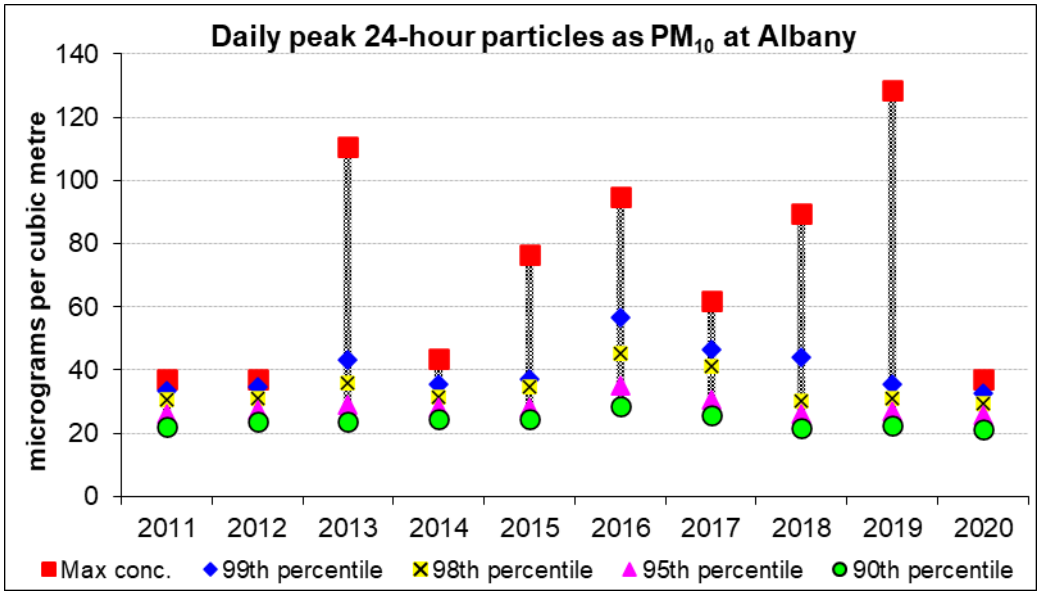


Figure E5-1 24-hour PM_{10} at Albany.

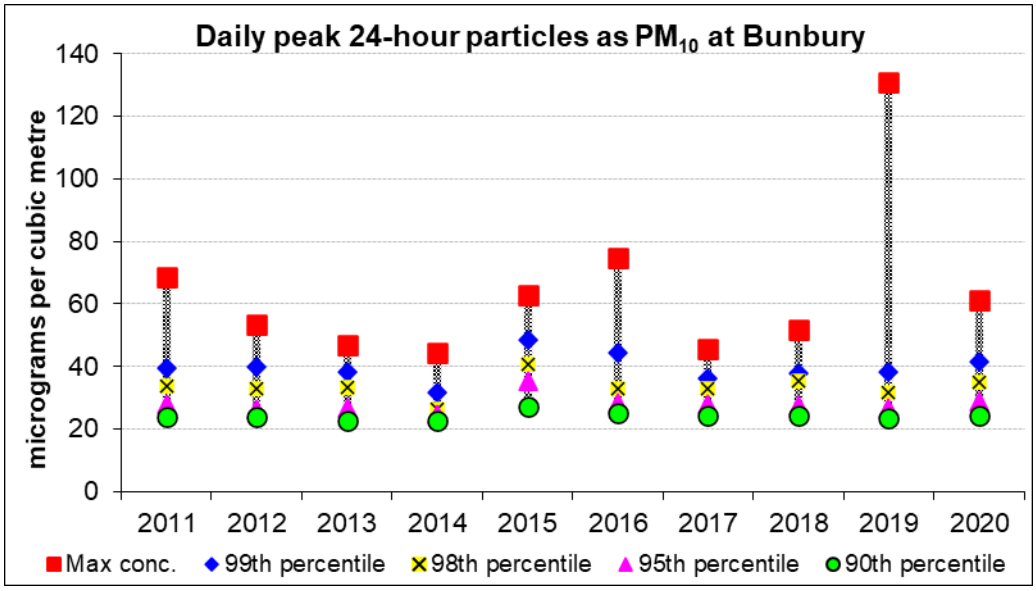


Figure E5-2 24-hour PM_{10} at Bunbury.

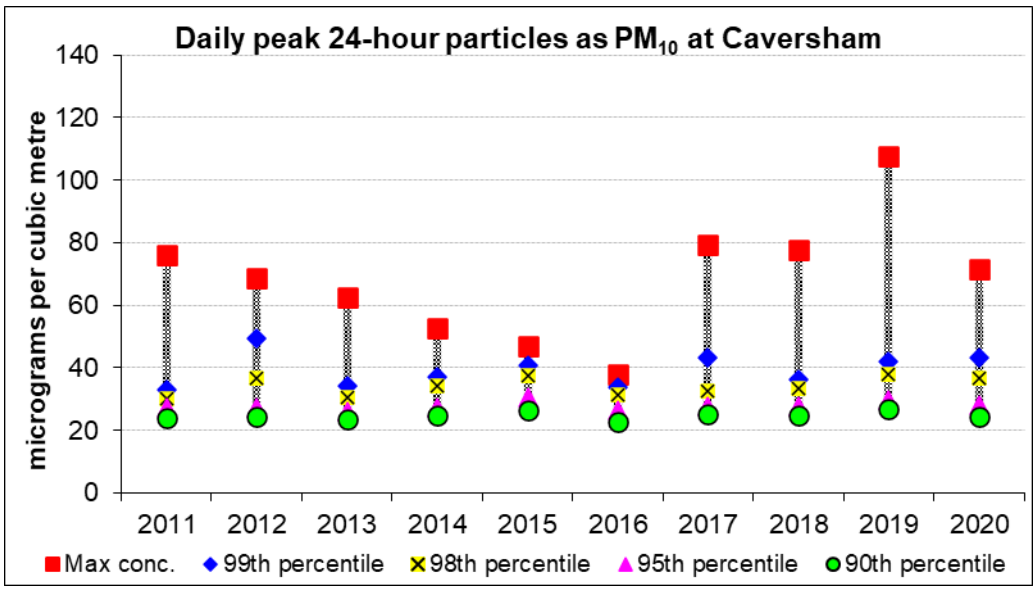


Figure E5-3 24-hour PM_{10} at Caversham.

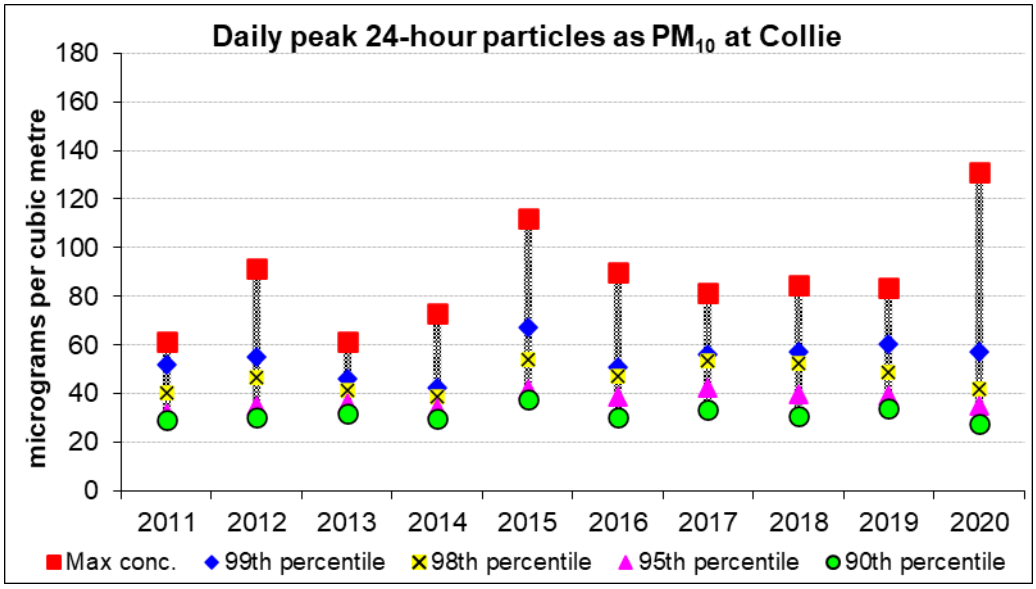


Figure E5-4 24-hour PM_{10} at Collie.

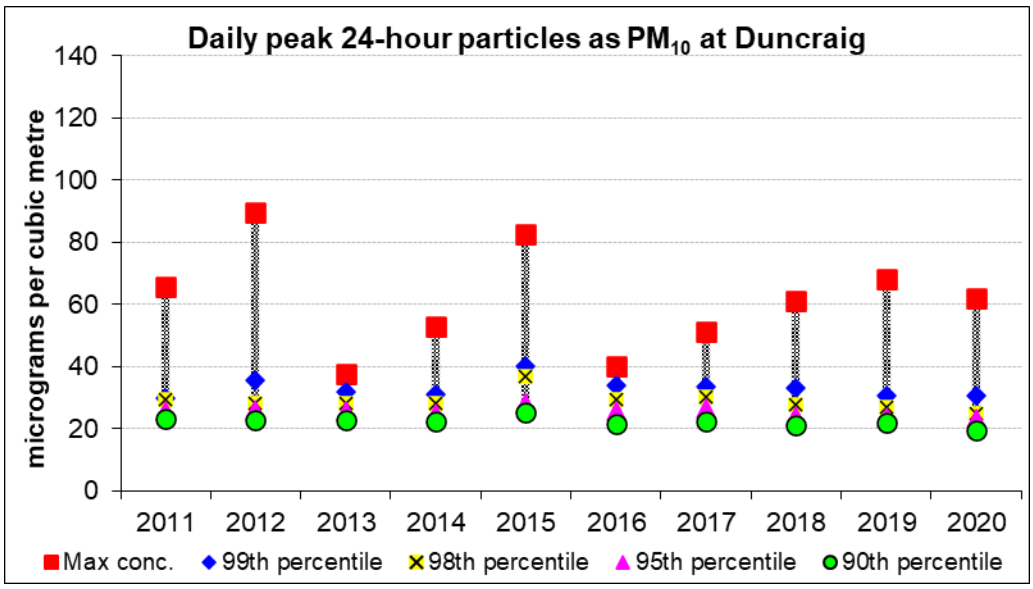


Figure E5-5 24-hour PM_{10} at Duncraig.

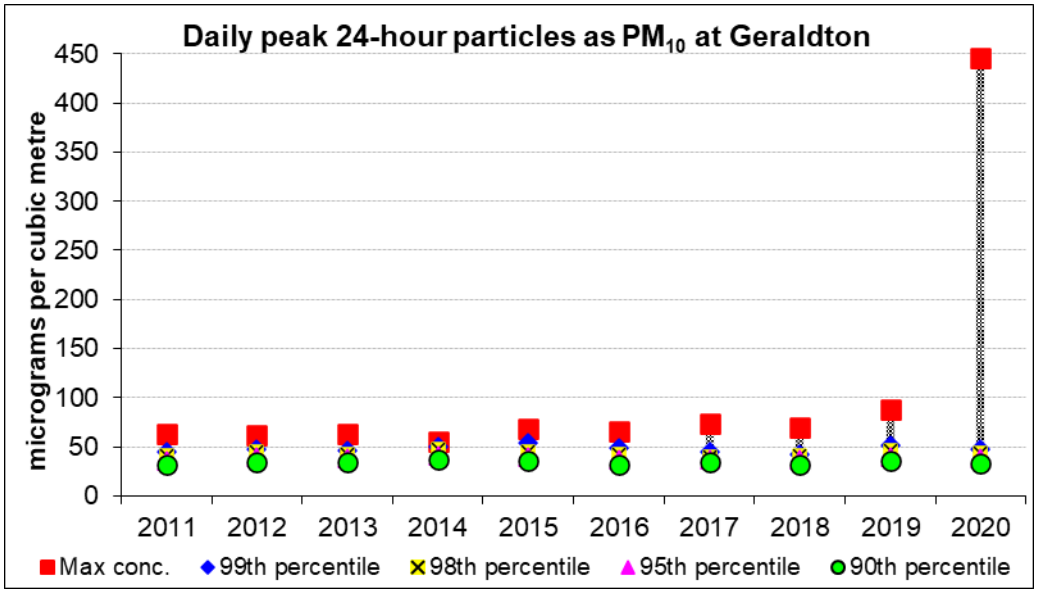


Figure E5-6 24-hour PM_{10} at Geraldton.

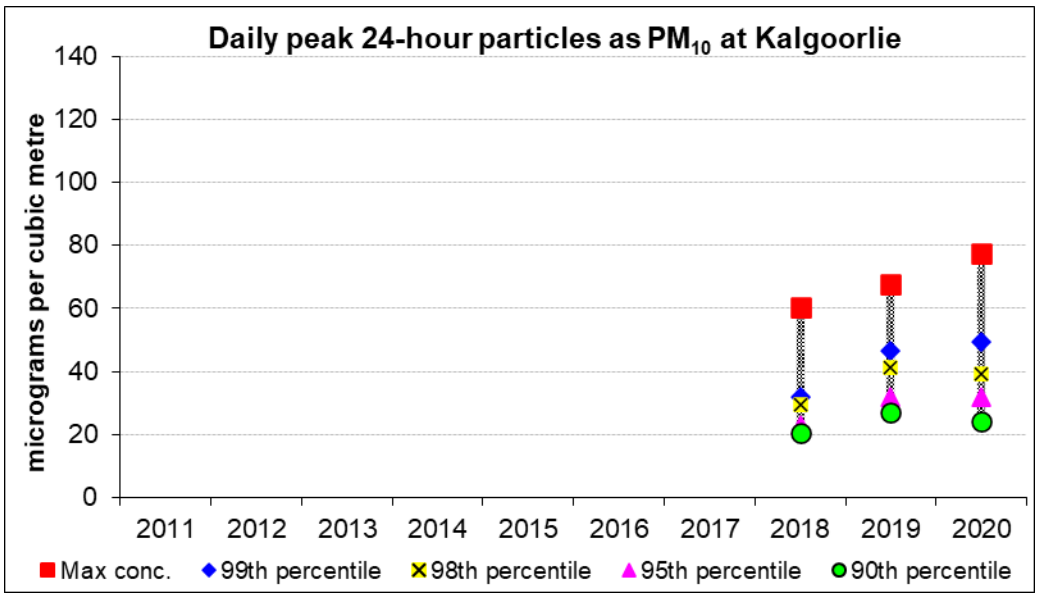


Figure E5-7 24-hour PM_{10} at Kalgoorlie.

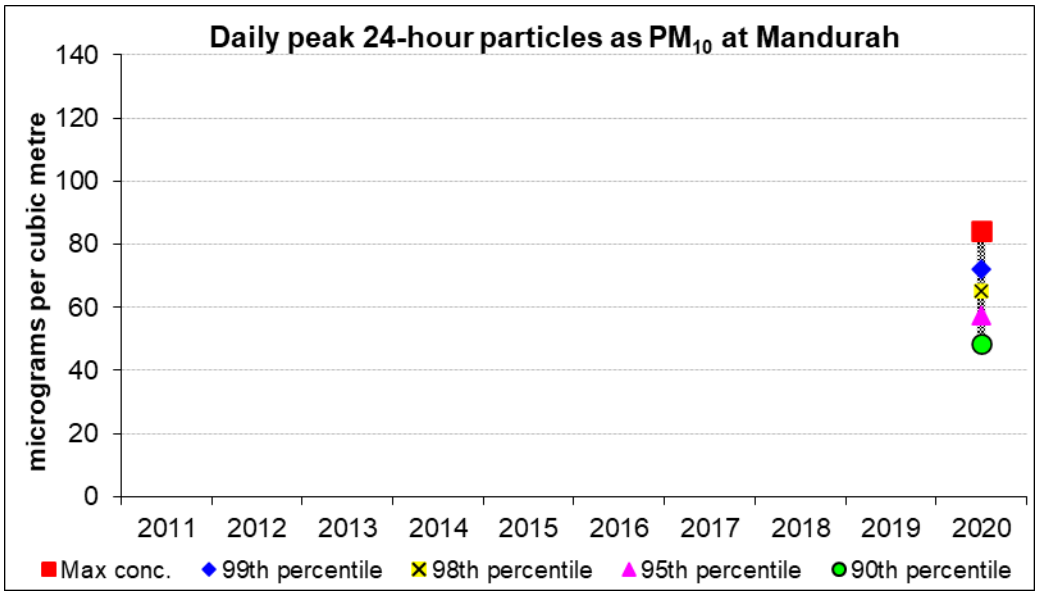


Figure E5-7 24-hour PM_{10} at Mandurah.

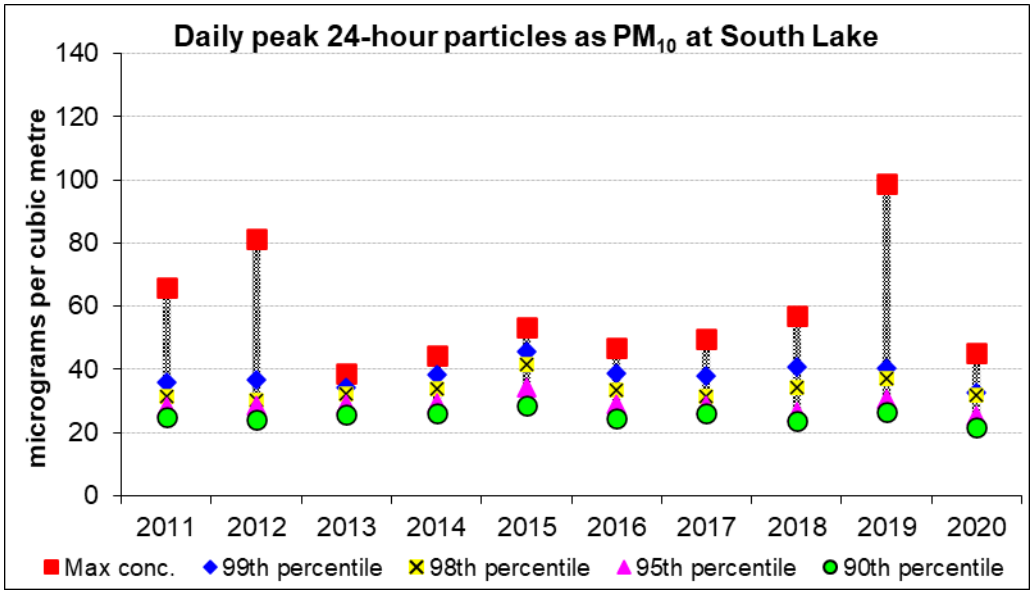


Figure E5-8 24-hour PM_{10} at South Lake.

E.6 Particles as $PM_{2.5}$

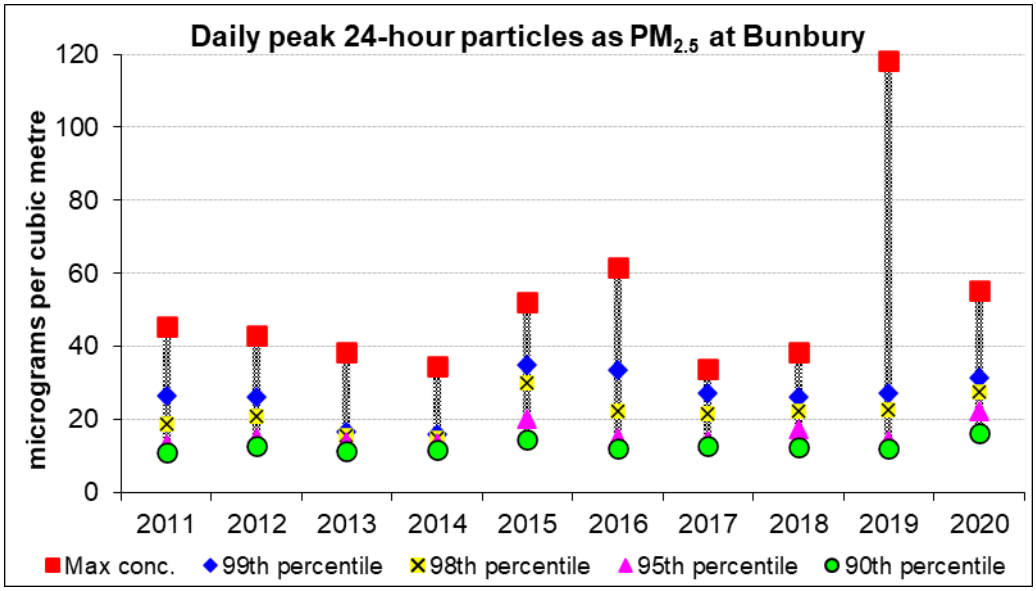


Figure E6-1 24-hour $PM_{2.5}$ at Bunbury.

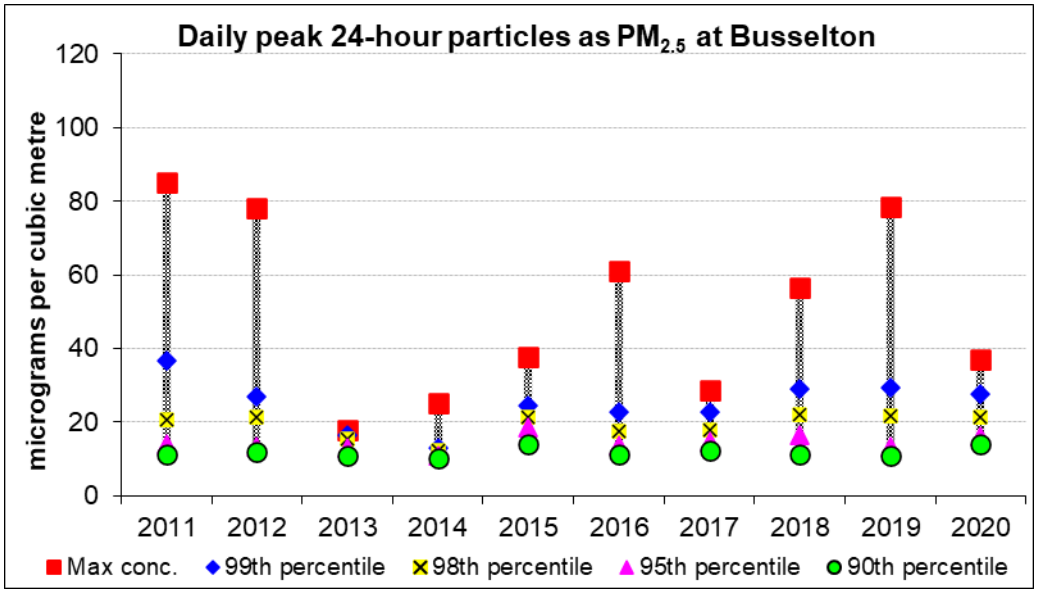


Figure E6-2 24-hour $PM_{2.5}$ at Busselton.

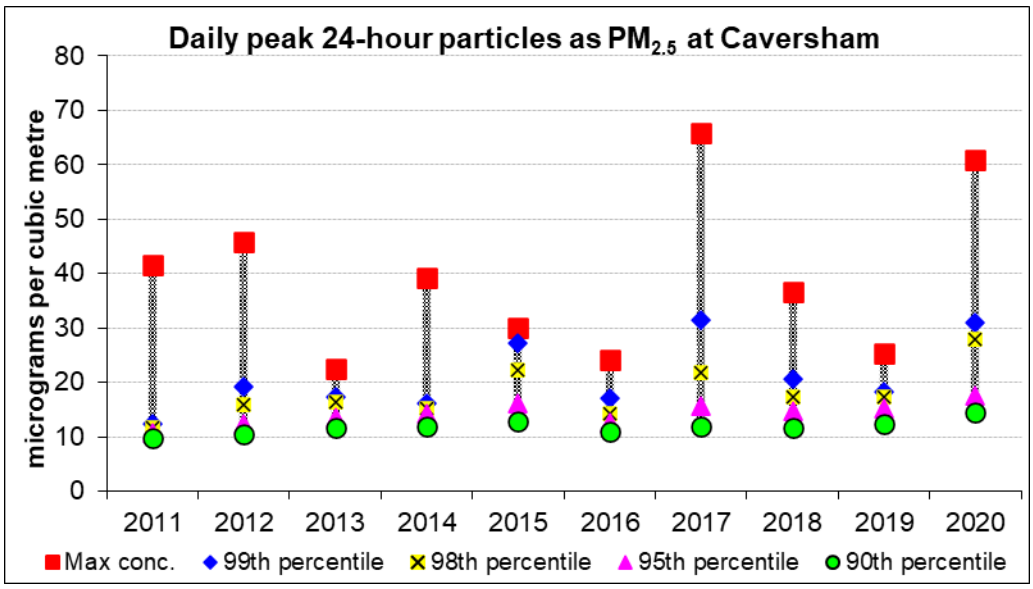


Figure E6-3 24-hour $PM_{2.5}$ at Caversham.

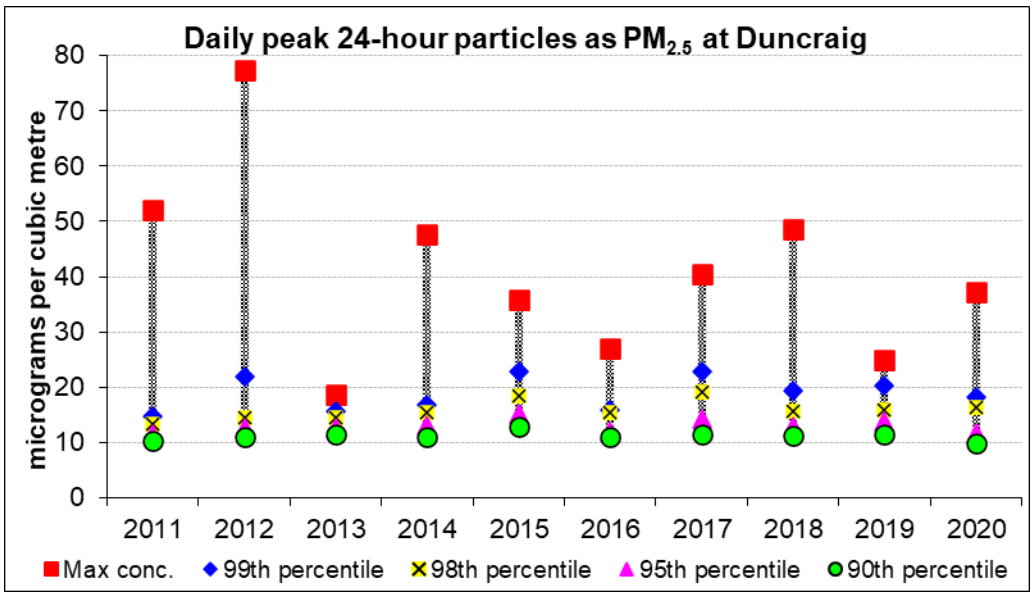


Figure E6-4 24-hour $PM_{2.5}$ at Duncraig.

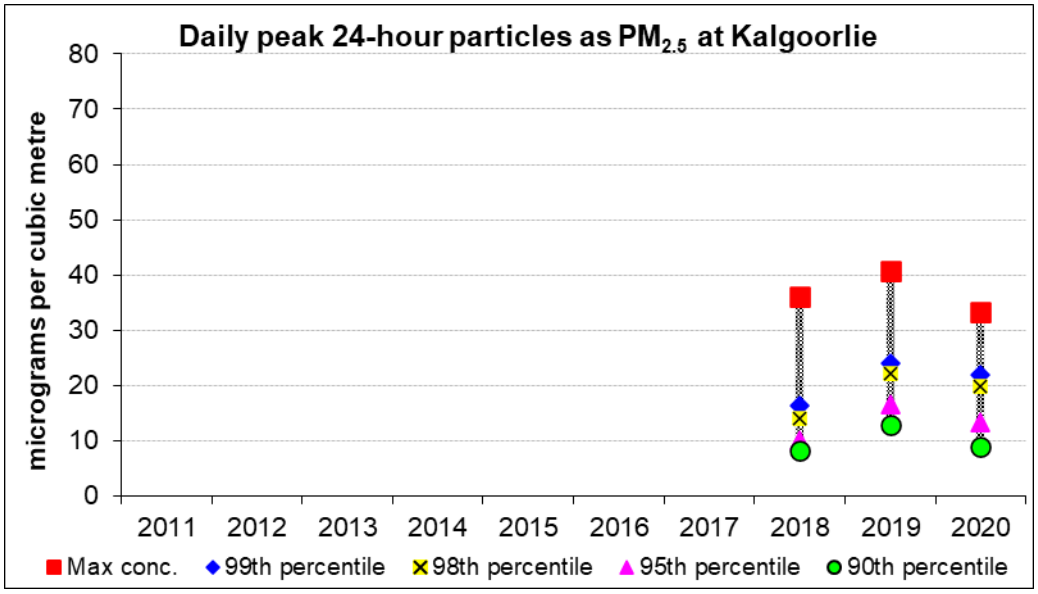


Figure E6-5 24-hour $PM_{2.5}$ at Kalgoorlie.

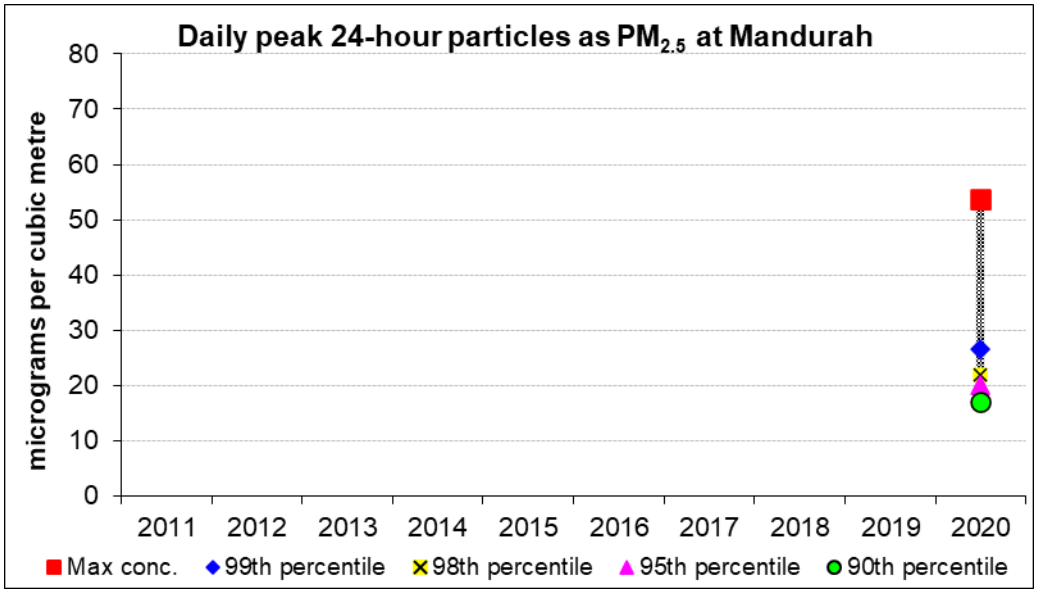


Figure E6-5 24-hour $PM_{2.5}$ at Mandurah.

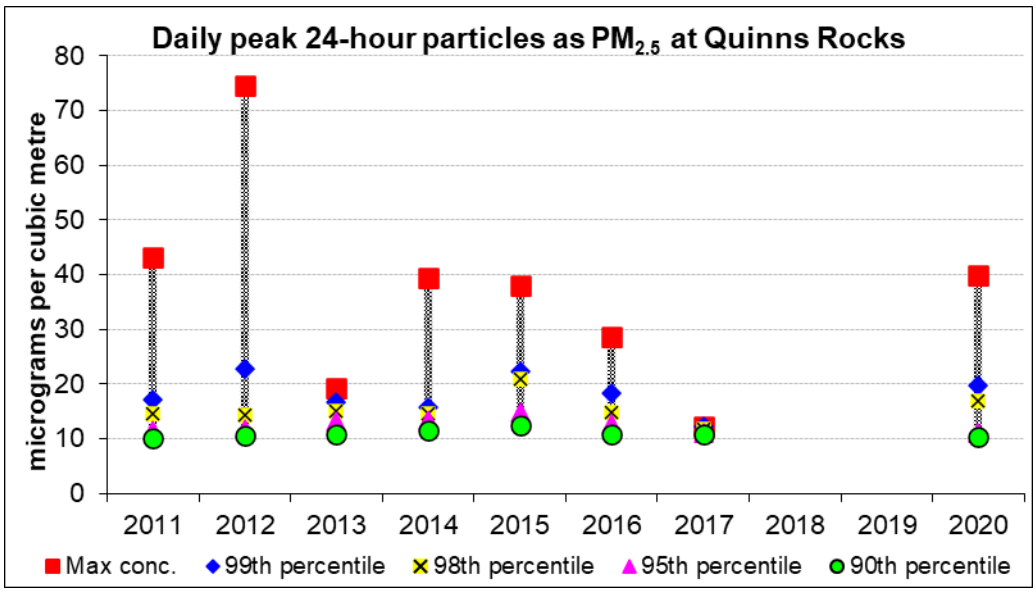


Figure E6-6 24-hour $PM_{2.5}$ at Quinns Rocks (2017 to 2019 not included).

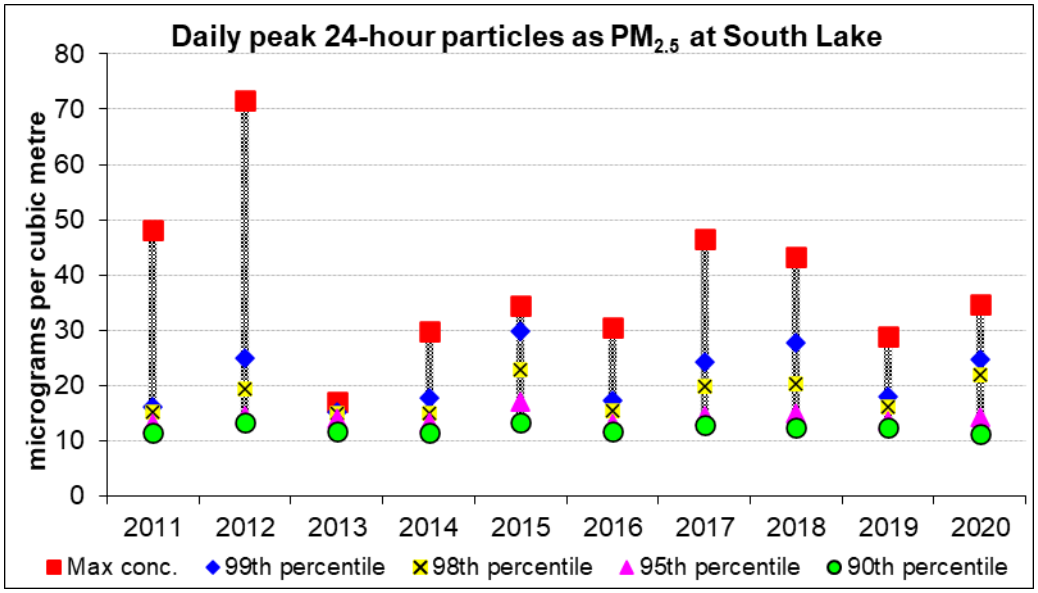


Figure E6-7 24-hour $PM_{2.5}$ at South Lake.

F. Exceedance analysis

This section contains information specific to each parameter exceeding the relevant AAQ NEPM standard during 2020. 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 to arrive at a specific location at a certain time. A back trajectory uses the wind speed and direction information recorded at monitoring sites to track a simple path backwards to a possible origin site. Assumptions made in the calculation of these back trajectories, such as no air dispersion throughout the path, create large uncertainties in the indicated path. Despite this, the back trajectories calculated are considered to provide a reasonable approximation for the possible path taken by an air parcel.

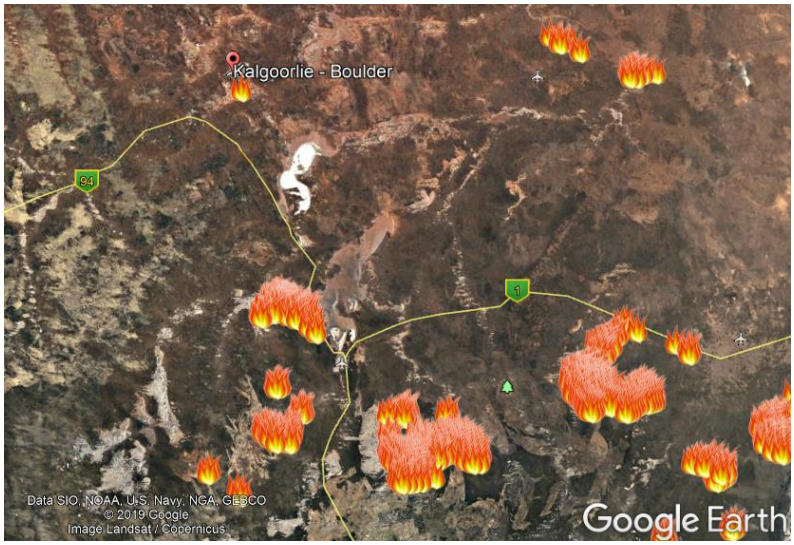
Satellite images are obtained from earthdata.nasa.gov/labs/worldview, where available and when cloud cover does not obscure the plume.

Abbreviations are occasionally used to represent the department's AQMS sites. These are:

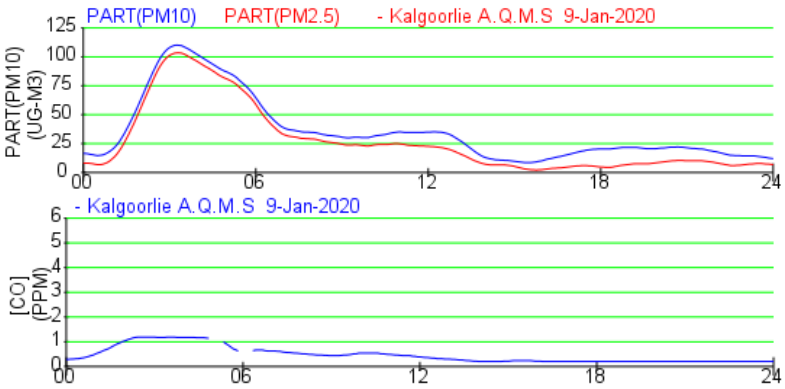
Metropolitan sites	
Ca	Caversham
Du	Duncraig
QR	Quinns Rocks
Ro	Rockingham
RG	Rolling Green
SL	South Lake
Sw	Swanbourne
Wt	Wattleup

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

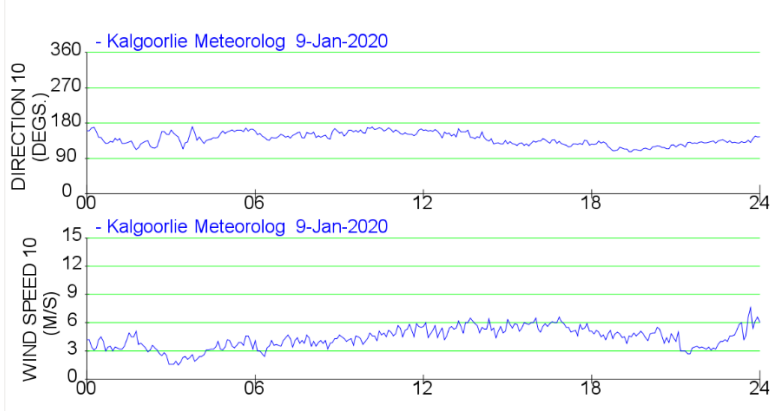
09 January 2020



Active fires around Kalgoorlie. From: firms.modaps.eosdis.nasa.gov/data/active_fire/modis-c6.1/kml/MODIS_C6_1_Australia_NewZealand_24h.kml (accessed on 09/01/2020).



60 minute averaged PM (upper) and CO (lower) for Kalgoorlie.



5-minute averaged wind direction and wind speed for Kalgoorlie.

Pollutant

$PM_{2.5}$

Monitoring site

Kalgoorlie

NEPM standard

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	PM_{10}	$PM_{2.5}$
CA	33.2	17.9
QR	NA	NA
DU	15.8	6.0
SL	22.1	7.3
MA	16.2	5.8
BN	12.3	3.4
CO	20.8	NA
GE	**59.4**	17.7
AL	23.2	NA
KA	35.6	**27.1**

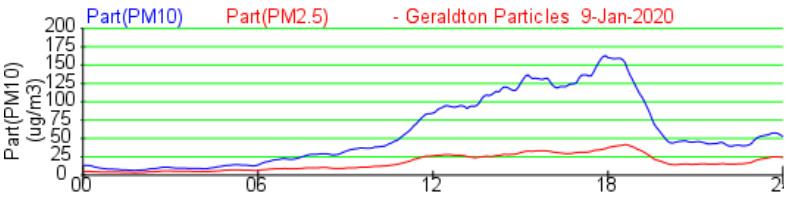
Description of event

Several bushfires caused smoke in the region which impacted the Kalgoorlie site.

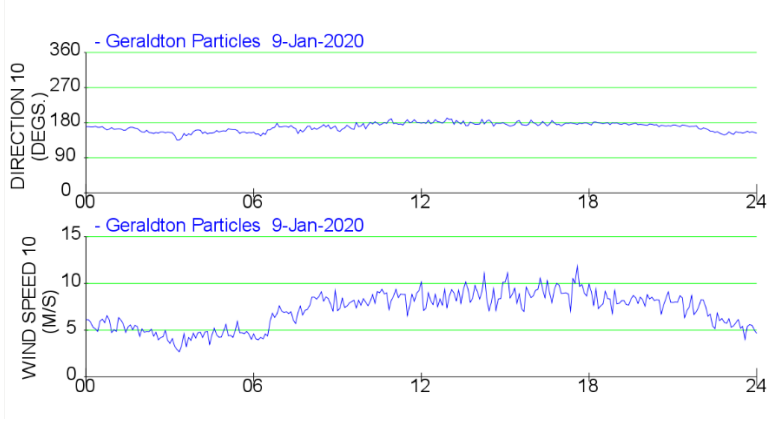
Exceptional event

09 January 2020

Google Earth satellite image showing no bushfires were active in the region.



60-minute averaged PM10 and PM2.5 particle concentration for Geraldton.



5-minute averaged wind direction and wind speed for Geraldton.

Pollutant

PM_{10}

Monitoring site

Geraldton

NEPM standard

PM_{10} – 50µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	PM_{10}	$PM_{2.5}$
CA	33.2	17.9
QR	NA	NA
DU	15.8	6.0
SL	22.1	7.3
MA	16.2	5.8
BN	12.3	3.4
CO	20.8	NA
GE	**59.4**	17.7
AL	23.2	NA
KA	35.6	**27.1**

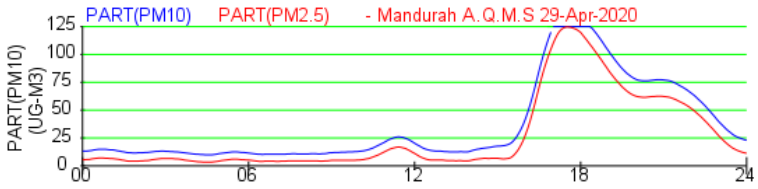
Description of event

No prescribed burns or bushfires were active on the day. The elevated PM_{10} levels was most likely due to local crustal matter originating from the south of the site.

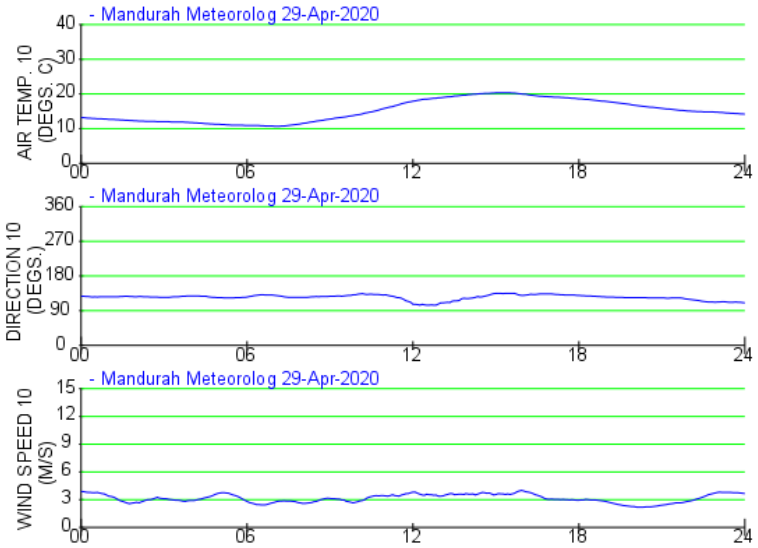
Assessable event

29 April 2020

Terra/MODIS satellite image showing prescribed burns.



60-minute moving average PM10 and PM2.5 particle concentration



60-minute moving average meteorological data.

Pollutant

$PM_{2.5}$

Monitoring site

Mandurah

NEPM standard

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	PM_{10}	$PM_{2.5}$
CA	23.1	11.3
QR	NA	NA
DU	16.9	7.3
SL	21.7	11.8
MA	37.3	**27.0**
BN	17.0	7.7
CO	38.7	NA
GE	30.7	6.3
AL	16.1	NA
KA	13.9	3.3

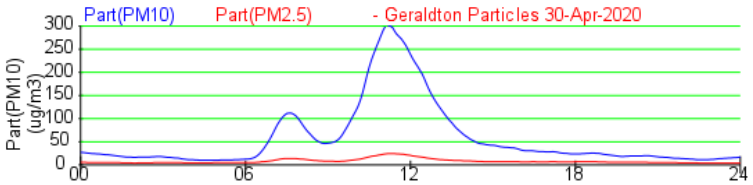
Description of event

Prescribed burns were undertaken in the south-west of the state.

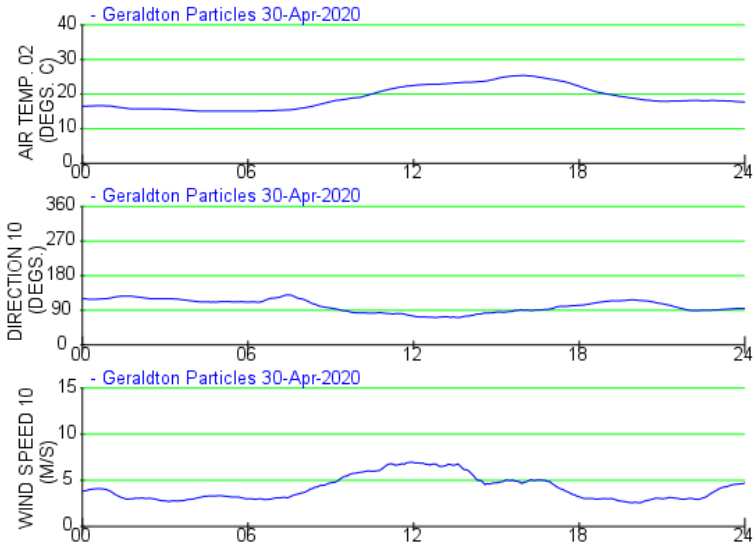
Exceptional event

30 April 2020

Terra/MODIS satellite image showing prescribed burns.



60-minute moving average PM10 and PM2.5 particle concentration.



60-minute moving average meteorological data.

Pollutant

PM_{10}

Monitoring site

Geraldton

NEPM standard

PM_{10} – 50µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	PM_{10}	$PM_{2.5}$
CA	17.8	4.7
QR	15.7	3.5
DU	15.1	3.8
SL	14.0	4.3
MA	15.2	5.4
BN	19.0	7.7
CO	31.1	NA
GE	**56.9**	7.9
AL	15.9	NA
KA	13.2	2.6

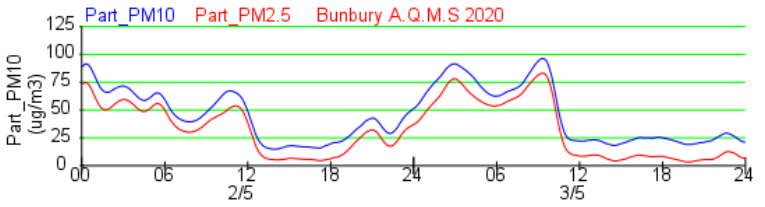
Description of event

Although there were fires in the vicinity, the wind speed and direction combined with the low $PM_{2.5}$:PM_{10} ratio indicates a windborne dust event.

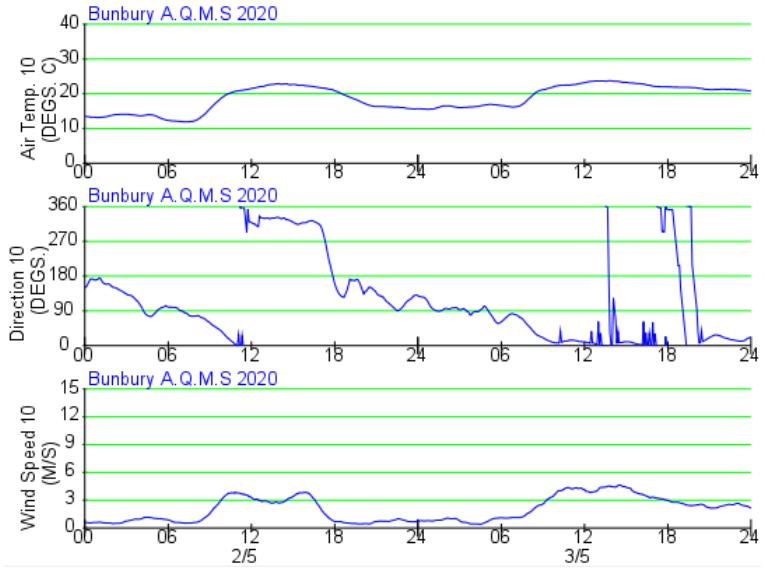
Assessable event

2 and 3 May 2020

Terra/MODIS satellite image showing prescribed burns.



60-minute moving average PM10 and PM2.5 particle concentration



60-minute moving average meteorological data.

Pollutant

$PM_{2.5}$

Monitoring site

Bunbury & Collie

NEPM standard

PM_{10} – 50µg/m^3

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

2 May 2020	PM_{10}	$PM_{2.5}$
CA	18.6	10.1
QR	17.9	7.3
DU	16.9	9.6
SL	18.5	11.1
MA	38.1	10.2
BN	43.0	**31.3**
CO	**62.8**	NA
GE	23.4	7.6
AL	16.5	NA
KA	11.2	3.4

3 May 2020	PM_{10}	$PM_{2.5}$
CA	17.7	7.8
QR	15.7	6.2
DU	12.4	5.0
SL	14.1	6.6
MA	40.6	10.3
BN	45.6	**31.4**
CO	**52.6**	NA
GE	24.9	10.6
AL	26.2	NA
KA	9.9	2.3

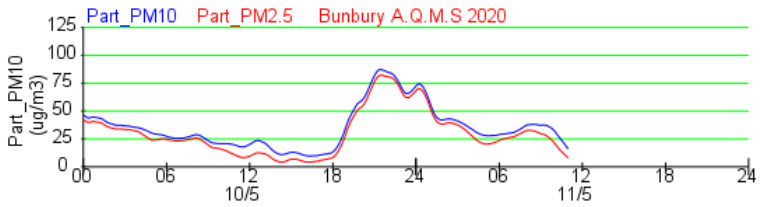
Description of event

Several prescribed burns were undertaken in the south-west and likely caused smoke to impact Bunbury.

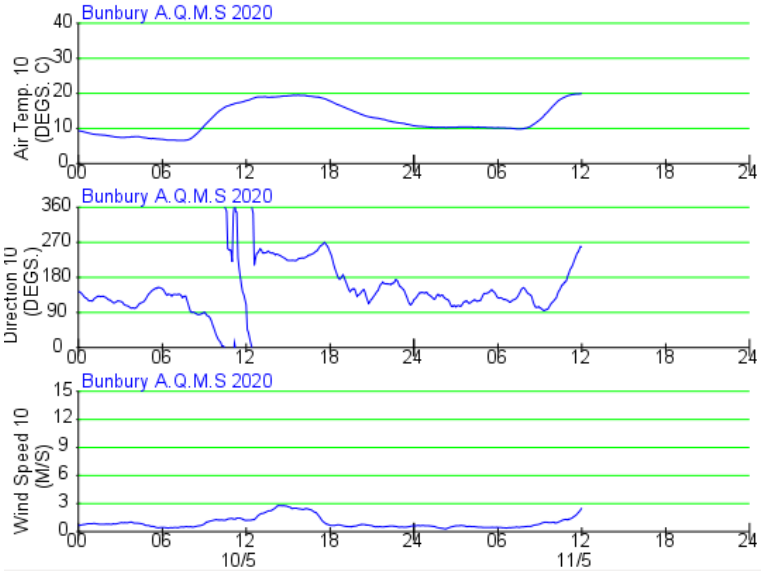
Exceptional event

10 May 2020

Terra/MODIS satellite image showing prescribed burns.



60-minute moving average PM10 and PM2.5 particle concentration.



60-minute moving average meteorological data.

Pollutant

$PM_{2.5}$

Monitoring site

Bunbury

NEPM standard

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

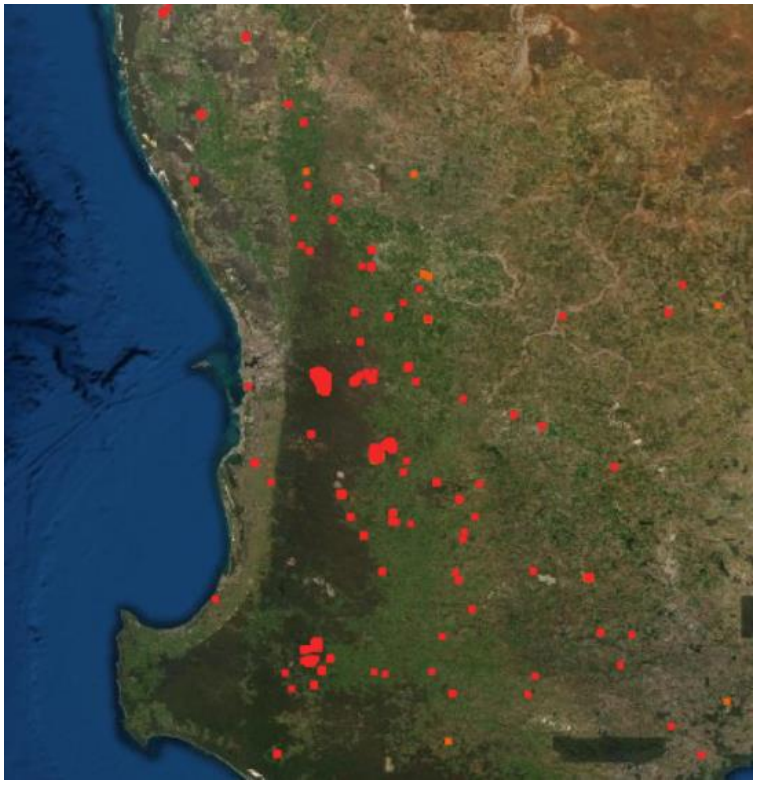
SITE	PM_{10}	$PM_{2.5}$
CA	15.9	10.6
QR	12.8	7.4
DU	15.1	11.0
SL	15.4	10.8
MA	21.0	13.6
BN	34.8	**29.6**
CO	14.9	NA
GE	14.1	5.8
AL	19.6	NA
KA	18.6	5.0

Description of event

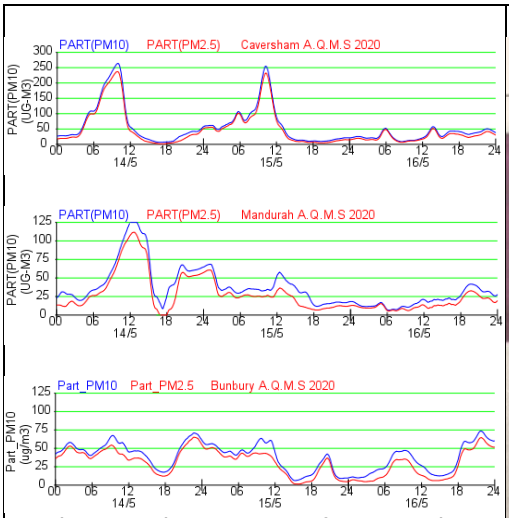
Very low wind speed overnight and no prescribed burns on the day. Likely wood heater smoke.

Assessable event

14, 15 and 16 May 2020



Satellite image showing prescribed burns and bush fires on 15.05.2020. From: firms.modaps.eosdis.nasa.gov/map/#t:adv;d:2020-05-15;@118.6,-32.5,7z



60-minute moving averages of PM10 and PM2.5 at selected sites and an article from the West Australian Newspaper dated 16/05/2020.

The West Australian
Saturday, May 16, 2020

ORANGE IS THE NEW MORNING

Perth woke to the smell of smoke yesterday with the grey haze filtering the sun and turning the sky orange.

For the second straight morning prescribed burns caused a thick haze to hang over the city. It led to a smoke alert being issued for the metropolitan area – stretching from the Perth Hills down to Mandurah.

Residents were told to shut doors and windows and turn off air-conditioners if the smoke became particularly bad in their area. People with asthma and pre-existing respiratory or cardiovascular illnesses were also advised to take precautions.

The Parks and Wildlife Service said the smoke was the result of several prescribed and private burns being carried out around Perth and the South West.

It was expected to clear by today as a result of south-westerly winds but could return next week when more burning is planned.

Pollutant

PM_{10} & $PM_{2.5}$

Monitoring site

Caversham, Mandurah, Collie, Bunbury

NEPM standard

PM_{10} – 50µg/m^3

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	14 May	15 May	16 May
PM10			
CA	**71.5**	**63.1**	31.1
DU	21.3	17.9	36.1
QR	33.8	16.9	22.5
SL	32.1	27.5	25.6
MA	**56.5**	32.3	20.3
BN	47.5	34.1	34.1
CO	**61.8**	49.4	21.9
GE	22.3	22.0	30.1
AL	21.7	21.3	25.9
PM2.5			
CA	**60.9**	**55.1**	**25.1**
DU	14.7	12.5	**31.3**
QR	23.8	10.4	17.1
SL	**26.2**	**26.7**	19.9
MA	**43.7**	22.4	14.6
BN	**40.3**	**26.9**	24.8

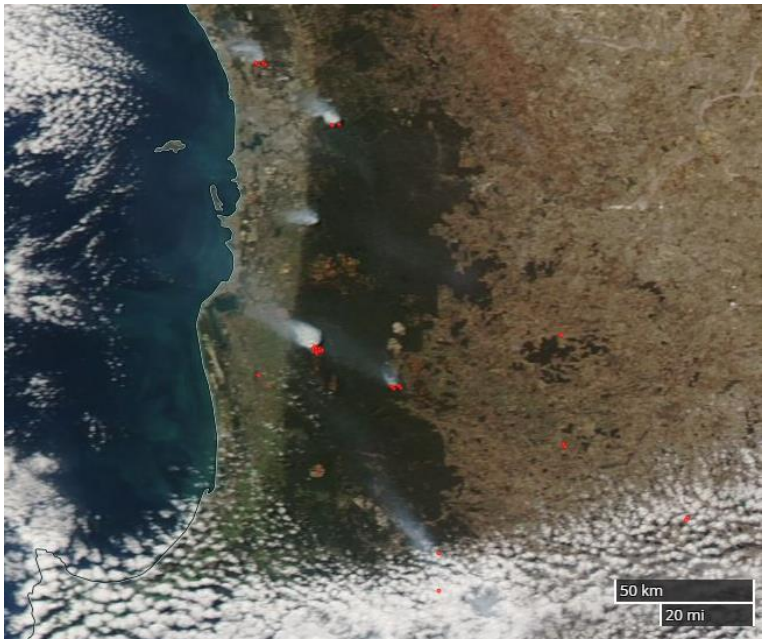
*NEPM exceedances in **bold***

Description of event

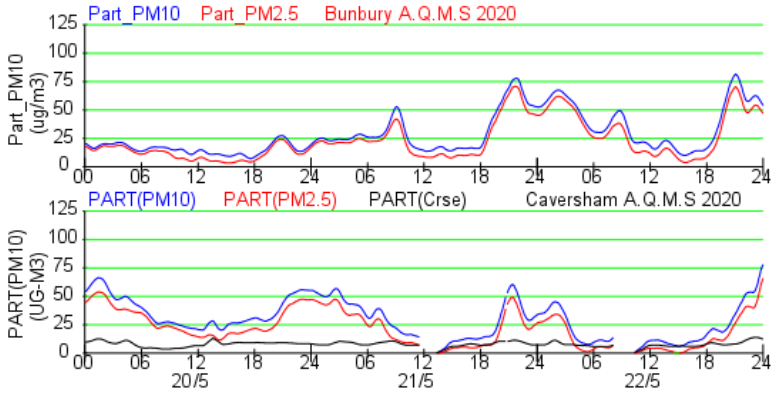
Several prescribed burns were undertaken in the south-west of the state causing smoke pollution at a number of population centres.

Exceptional event

20, 21 and 22 May 2020



Satellite image showing prescribed burns and bush fires on 20.05.2020. From: worldview.earthdata.nasa.gov/



60-minute moving averages of PM10 and PM2.5 at selected sites

Pollutant

$PM_{2.5}$

Monitoring site

Caversham, Bunbury, Busselton

NEPM standard

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	20 May	21 May	22 May
PM10			
CA	37.1	30.1	23.0
QR	24.6	27.6	14.2
DU	23.3	19.1	19.3
SL	32.0	19.2	23.4
MA	25.9	29.4	24.2
BN	15.6	32.0	39.2
BS	NA	NA	32.7
CO	30.9	42.0	48.6
GE	23.1	20.6	18.0
AL	11.1	12.8	12.6
PM2.5			
CA	**29.0**	22.0	15.3
DU	17.1	19.0	7.30
QR	17.2	13.0	13.8
SL	24.0	13.6	17.1
MA	21.0	21.0	12.2
BN	11.7	**26.3**	**31.8**
BS	NA	NA	**27.8**

*NEPM exceedances in **bold***

Description of event

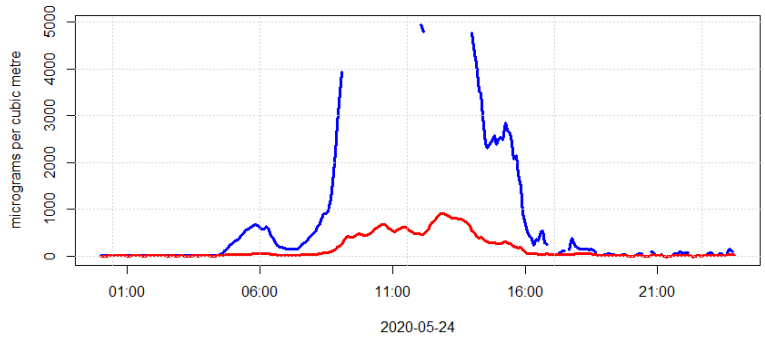
Several prescribed burns were undertaken in the south-west of the state causing smoke pollution at a number of population centres.

Exceptional event

23, 24 and 25 May 2020

Several prescribed burns were underway in the south-west on 24/05/2020.

Geraldton was hit by a dust storm on 24/05/2020 stirred up by the strong winds. From: ABC News, Cecile O'Connor, www.abc.net.au/news/2020-05-25/massive-storm-hits-perth-as-ex-tropical-cyclone-mangga-strikes/12281886



5-minute moving averages of PM10 and PM2.5 at Geraldton. (The missing data pertains to an automatic nulling of the data due to excess noise. Preliminary investigations indicate that these data are in fact valid and may be able to be included. This will increase the 24 hour average.)

Pollutant

PM_{10} & $PM_{2.5}$

Monitoring site

Quinns Rocks, Duncraig, Mandurah, Geraldton, Kalgoorlie

NEPM standard

PM_{10} – 50µg/m^3

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	23 May	24 May	25 May
PM10			
CA	24.4	NA	18.8
QR	11.2	**77.7**	25.3
DU	14.7	**61.8**	25.0
SL	22.3	45.2	23.2
MA	23.7	**52.7**	**56.6**
BN	27.6	34.4	25.7
BS	27.7	38.6	NA
CO	**75.4**	NA	NA
GE	27.1	**445.6**	42.9
AL	10.0	12.6	15.5
KA	10.1	**77.3**	NA
PM2.5			
CA	12.2	NA	7.3
DU	2.2	20.5	7.1
QR	6.9	18.7	8.0
SL	14.4	12.7	8.6
GE	3.8	**162.2**	13.2
MA	8.2	20.2	23.2
BN	18.8	12.0	8.7
BS	20.1	14.2	NA

*NEPM exceedances in **bold***

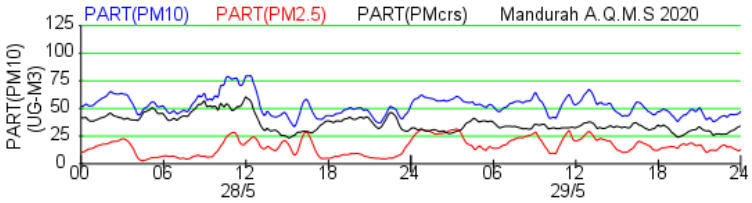
Description of event

On 24 and 25 May very high winds due to ex-Tropical Cyclone Mangga interacting with a cold front caused high winds which created dust lift-off at various centres in WA. The 23 May exceedance was caused by prescribed burns in the south-west.

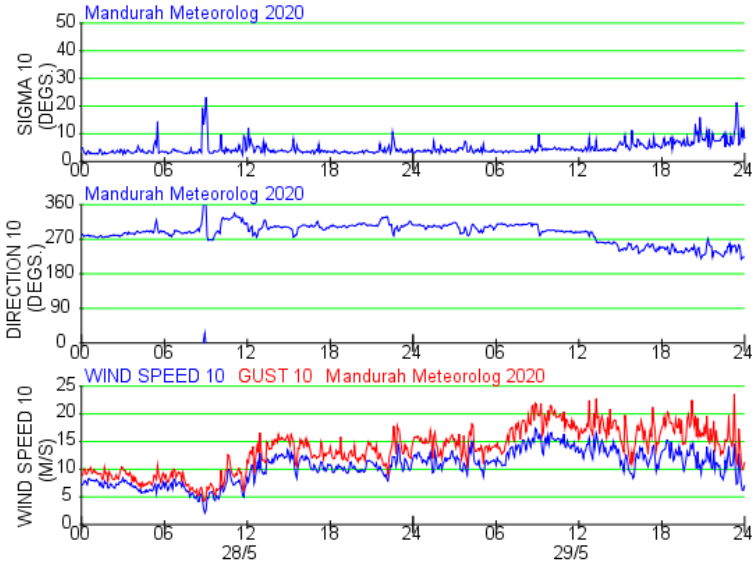
Exceptional event

28 and 29 May 2020

Frequency plot from November 2019 to June 2020 shows the high proportion of PM_{10} originating from the west (ocean) side of the site especially during high wind conditions indicating likely marine aerosols or sand.



Hourly averaged PM10 (blue), $PM_{2.5}$ (red) & PM_{crs} (black).



5-minute averaged meteorological data.

Pollutant

PM_{10}

Monitoring site

Mandurah

NEPM standard

PM_{10} – 50µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

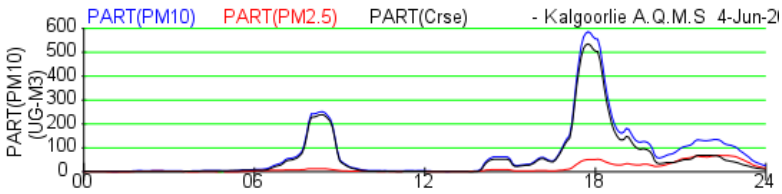
SITE	28 May	29 May
PM10		
CA	NA	9.2
QR	6.3	10.7
DU	7.6	11.3
SL	8.3	11.5
MA	**52.9**	**51.7**
BN	16.9	18.9
BS	16.1	13.7
CO	9.6	12.5
GE	10.2	13.7
AL	8.3	7.9
aPM2.5		
CA	NA	4.3
DU	1.0	2.0
QR	3.0	3.3
SL	4.2	4.0
MA	12.1	19.3
BN	4.7	5.8
BS	5.8	4.2

Description of event

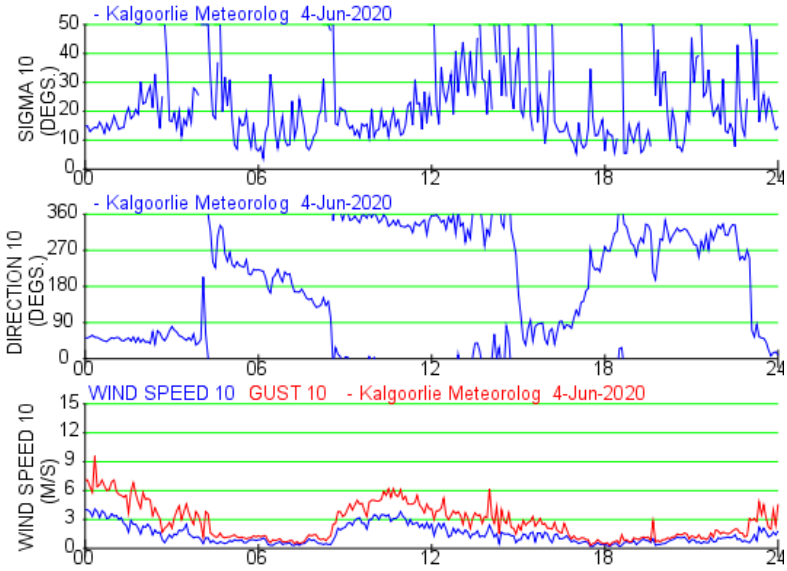
Mandurah is located about 100 metres from the ocean at the end of an open car park. Westerly winds gusting up to 20 m/s likely caused marine aerosols and possibly beach sand to impact the instrument.

Assessable event

4 June 2020



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



5-minute averaged meteorological data

Pollutant

PM_{10}

Monitoring site

Kalgoorlie

NEPM standard

PM_{10} – 50µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	PM_{10}	$PM_{2.5}$
CA	18.0	13.0
QR	13.8	7.7
DU	15.3	11.0
SL	22.8	16.5
AR	NA	NA
MA	19.9	16.4
BN	28.7	23.5
BS	38.6	**35.0**
CO	35.4	NA
GE	15.7	NA
AL	18.0	13.0
KA	13.8	7.7

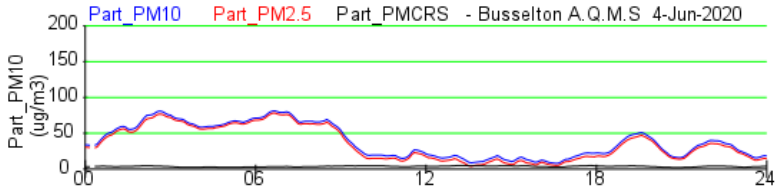
Description of event

Local dust event during low wind speed. Majority of particles were in the course fraction so likely not a smoke event.

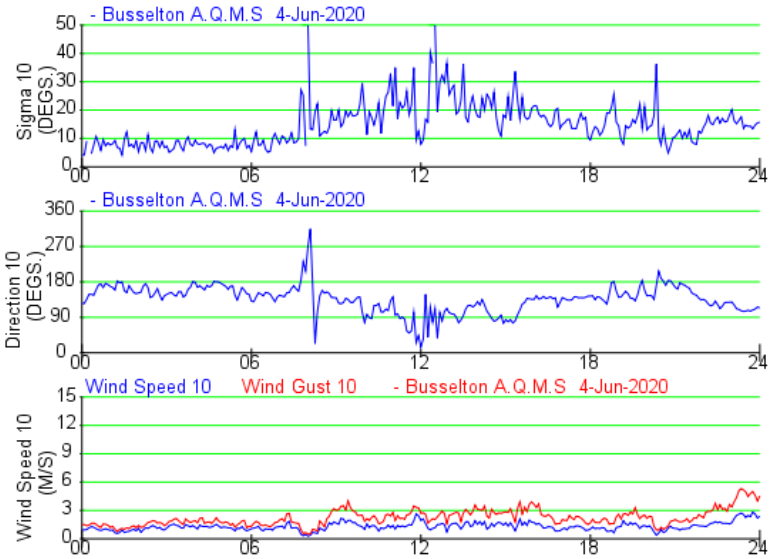
Assessable events

4 June 2020

Aqua/Modis satellite from worldview.earthdata.nasa.gov/.



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black)



5-minute averaged meteorological data.

Pollutant

$PM_{2.5}$

Monitoring site

Busselton

NEPM standard

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

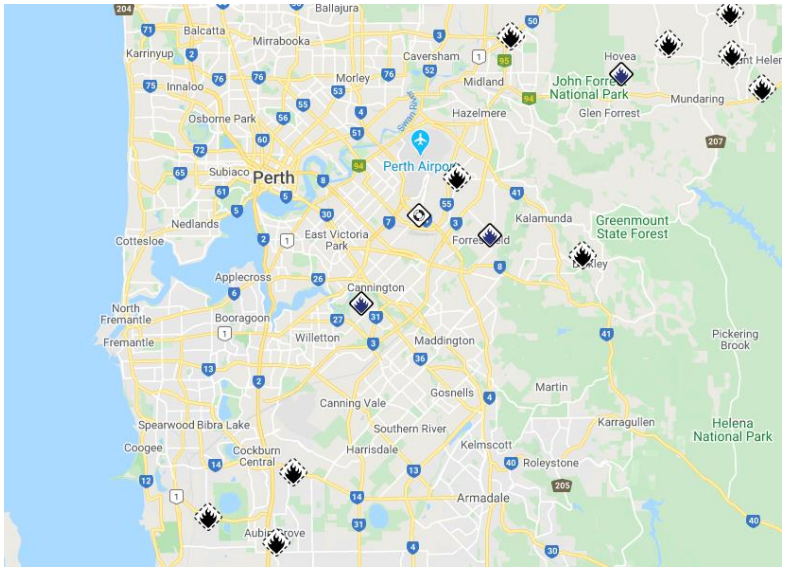
SITE	PM_{10}	$PM_{2.5}$
CA	18.0	13.0
QR	13.8	7.7
DU	15.3	11.0
SL	22.8	16.5
AR	NA	NA
MA	19.9	16.4
BN	28.7	23.5
BS	38.6	**35.0**
CO	35.4	NA
GE	15.7	NA
AL	19.0	NA
KA	**75.1**	15.0

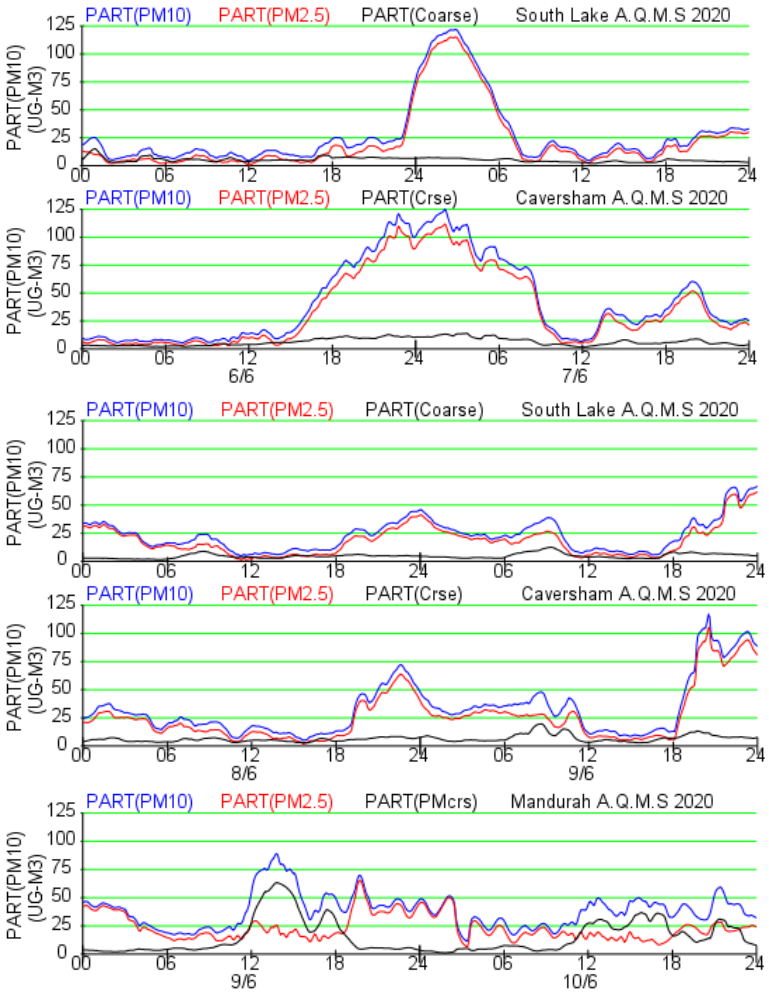
Description of event

High ratio of $PM_{2.5}$ to PM_{10} indicates a smoke event. Several prescribed burns were underway in the south-west with smoke impacting Busselton.

Exceptional event

6, 7, 9 and 10 June 2020





Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).

Pollutant

$PM_{2.5}$

Monitoring site

Caversham, South Lake and Mandurah

NEPM standard

PM_{10} – 50µg/m^3

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

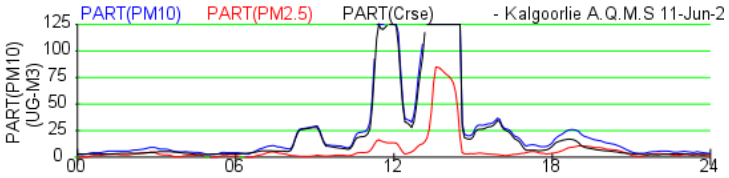
	6 June	7 June	9 June	10 June
PM_{10}				
CA	34.0	**52.0**	40.7	38.7
QR	12.7	17.3	15.5	11.8
DU	12.3	23.5	19.5	16.6
SL	15.2	39.1	26.2	31.1
MA	36.5	27.8	41.5	35.4
BN	21.9	25.5	25.3	24.8
BS	13.3	18.1	20.0	24.3
CO	23.8	40.6	39.4	39.5
GE	16.2	10.2	11.2	11.5
AL	15.5	15.4	24.7	29.5
KA	9.6	4.0	48.0	30.1
$PM_{2.5}$				
CA	**28.2**	**45.1**	**33.1**	**28.2**
DU	5.3	12.3	10.7	6.3
QR	7.7	19.0	15.2	11.6
SL	9.1	**34.6**	20.9	24.3
MA	14.8	22.0	**26.1**	20.7
BN	12.5	20.4	18.1	15.7
BS	6.9	13.3	15.2	18.2
KA	1.8	1.5	11.2	8.6

Description of event

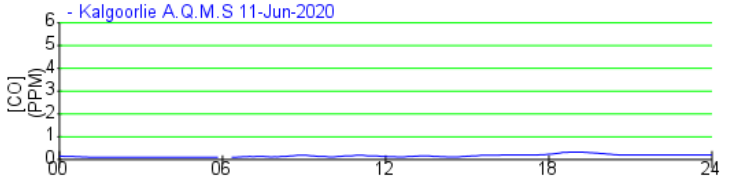
Several private and local council burn-offs were underway around the metropolitan region.

Assessable event

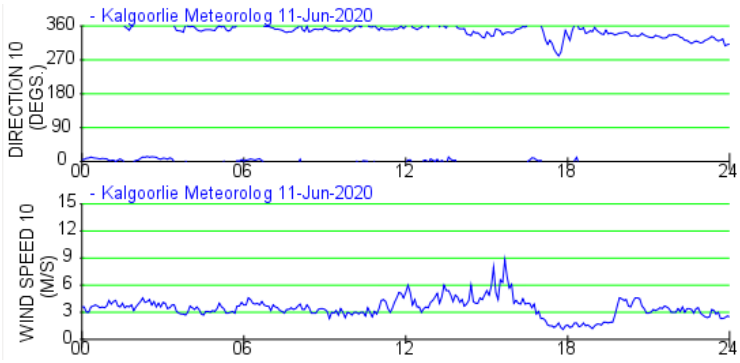
11 June 2020



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



Hourly averaged CO.



5-minute averaged meteorology.

Pollutant

PM_{10}

Monitoring site

Kalgoorlie

NEPM standard

PM_{10} – 50µg/m^3

Averaging Period

24 hours

Concentration (µg/m^3)

SITE	PM_{10}	$PM_{2.5}$
CA	9.8	5.5
QR	5.9	1.2
DU	NA	NA
SL	NA	NA
MA	39.7	14.8
BN	11.9	5.0
BS	12.3	5.8
CO	10.1	NA
GE	15.5	NA
AL	16.0	NA
KA	**50.5**	6.9

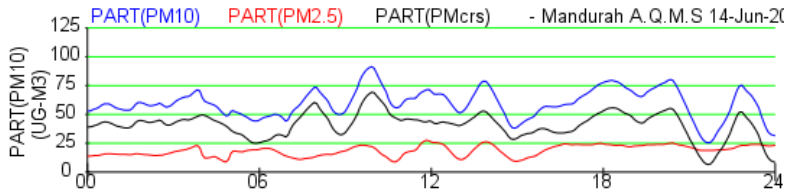
Description of event

Northerly winds combined with a transient local event possibly caused by crustal emissions from surrounding vacant land.

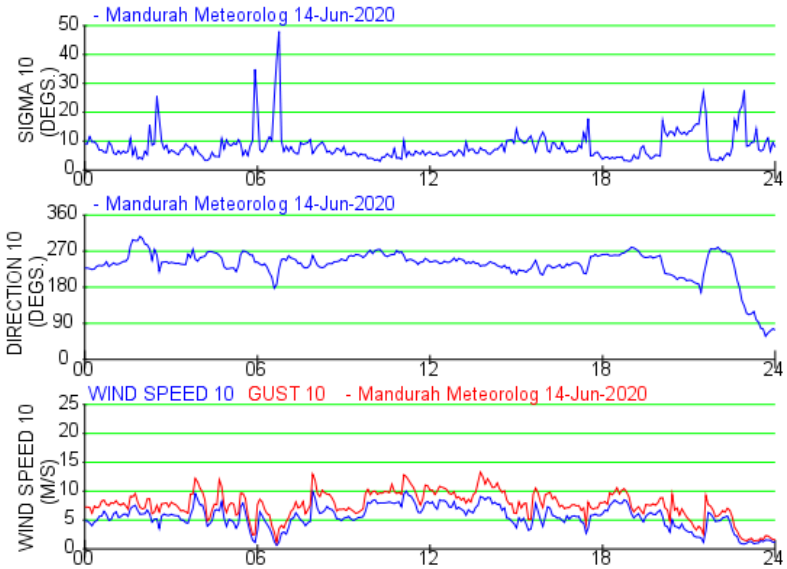
Assessable event

14 June 2020

Frequency plot from November 2019 to June 2020 showing the high proportion of PM10 originating from the west (ocean) side of the site especially during high wind conditions indicating likely marine aerosols or sand.



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



5-minute averaged meteorology.

Pollutant

PM_{10}

Monitoring site

Mandurah

NEPM standard

PM_{10} – 50µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

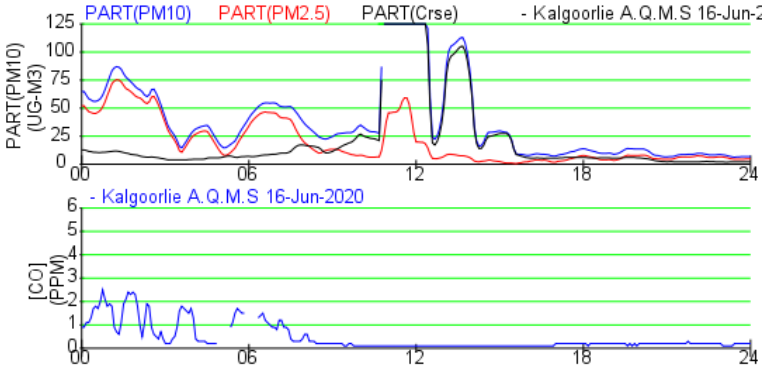
SITE	PM_{10}	$PM_{2.5}$
CA	13.1	8.0
QR	11.2	3.2
DU	10.9	3.8
SL	6.0	5.4
MA	**59.8**	18.8
BN	16.7	6.7
BS	16.7	8.0
CO	20.0	NA
GE	9.5	5.6
AL	NA	NA
KA	8.6	4.4

Description of event

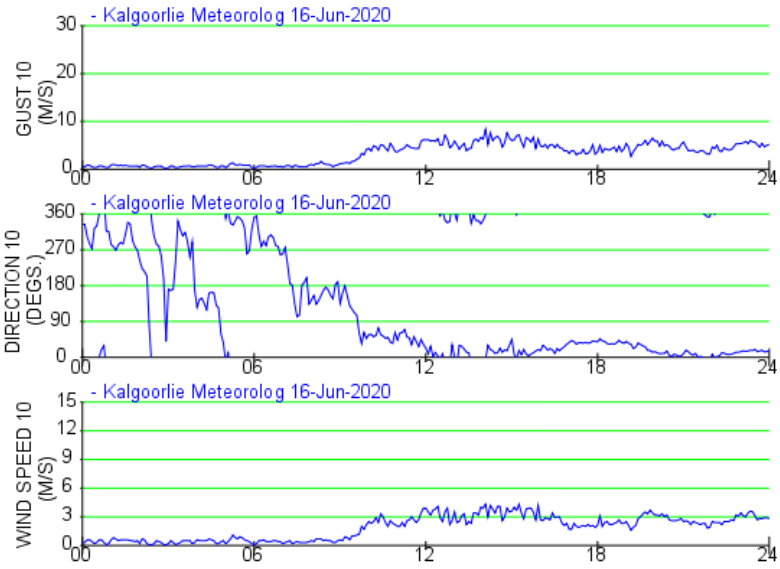
Mandurah is located about 100 metres from the beach at the end of an open car park. Westerly winds gusting up to 10 m/s likely caused marine aerosols and possibly beach sand to impact the instrument.

Assessable event

16 June 2020



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



5-minute averaged meteorology.

Pollutant

PM_{10}

Monitoring site

Kalgoorlie

NEPM standard

PM_{10} – 50µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

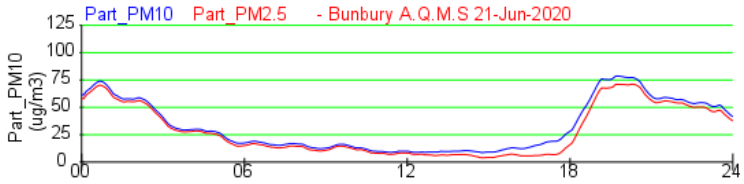
SITE	PM_{10}	$PM_{2.5}$
CA	19.8	14.5
QR	12.0	7.8
DU	12.4	8.1
SL	15.2	14.5
MA	34.3	15.7
BN	11.8	6.6
BS	10.3	4.9
CO	21.9	NA
GE	10.1	5.4
AL	NA	NA
KA	**54.7**	19.2

Description of event

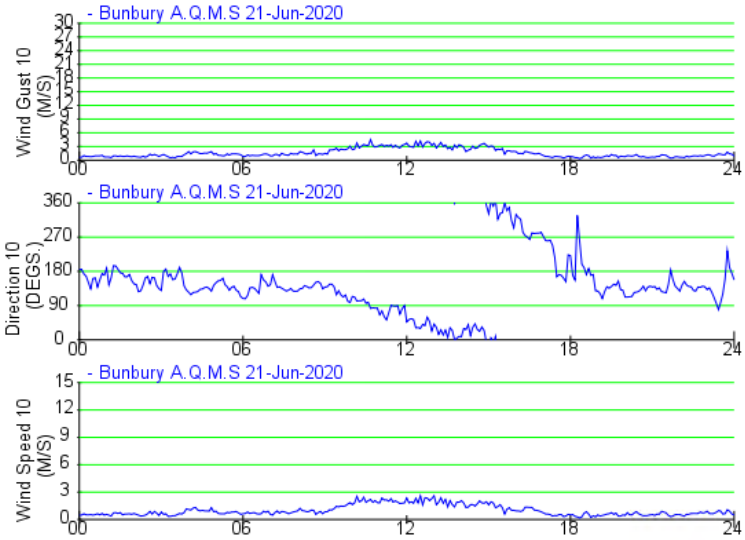
Overnight and morning smoke combined with some local coarse dust lift-off in the afternoon caused this exceedance. Winds were not excessive enough to cause passive dust lift-off. (note similarity to 11 June event).

Assessable event

21 June 2020



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



5-minute averaged meteorology.

Pollutant

$PM_{2.5}$

Monitoring site

Bunbury

NEPM standard

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	PM_{10}	$PM_{2.5}$
CA	7.8	5.8
QR	6.0	2.9
DU	9.0	5.3
SL	12.5	11.8
MA	24.1	11.6
BN	32.4	**28.4**
BS	23.5	21.3
CO	24.6	NA
GE	9.5	4.8
AL	7.8	NA
KA	9.2	2.4

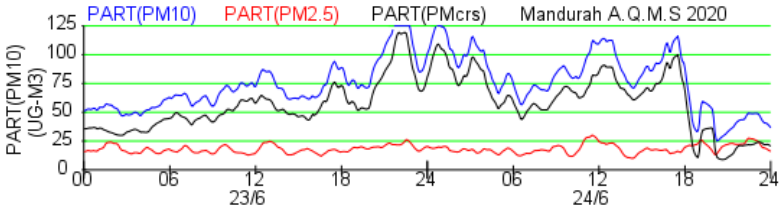
Description of event

Overnight wood heater smoke likely caused this exceedance.

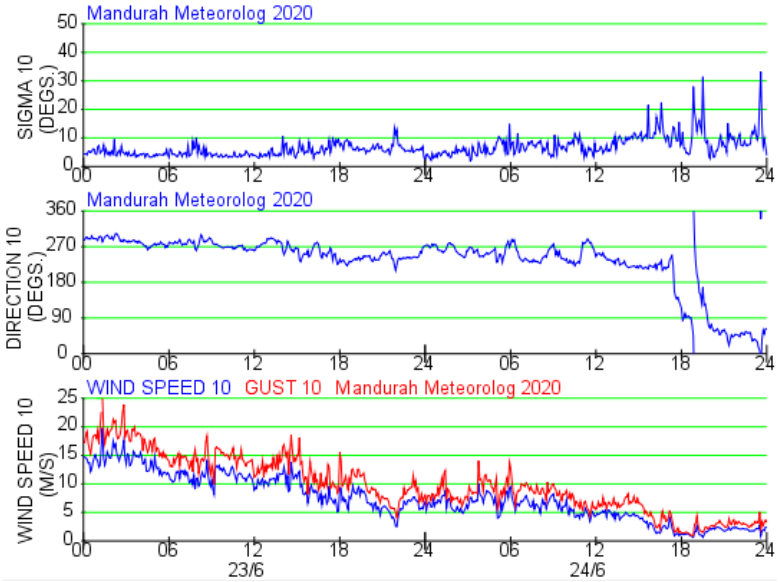
Assessable event

23 and 24 June 2020

Frequency plot from November 2019 to June 2020 showing the high proportion of PM10 originating from the west (ocean) side of the site especially during high wind conditions indicating likely marine aerosols or sand



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



5-minute averaged meteorology.

Pollutant

PM_{10}

Monitoring site

Mandurah

NEPM standard

PM_{210} – 50µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	23 June	24 June
PM_{10}		
CA	17.1	13.6
QR	22.1	16.3
DU	20.1	19.6
SL	7.86	11.2
MA	**72.8**	**79.4**
BN	22.2	16.1
BS	20.6	5.8
CO	19.8	20.2
GE	23.7	10.4
AL	14.1	16.7
KA	16.0	36.6

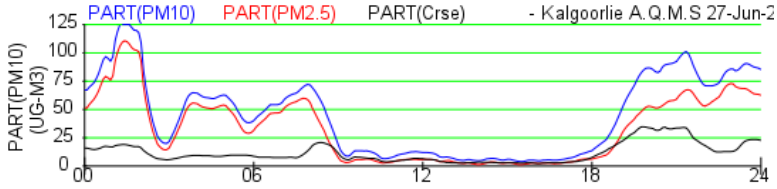
Description of event

Mandurah is located about 100 metres from the ocean at the end of an open car park. Westerly winds gusting up to 10 m/s likely caused marine aerosols and possibly beach sand to impact the instrument.

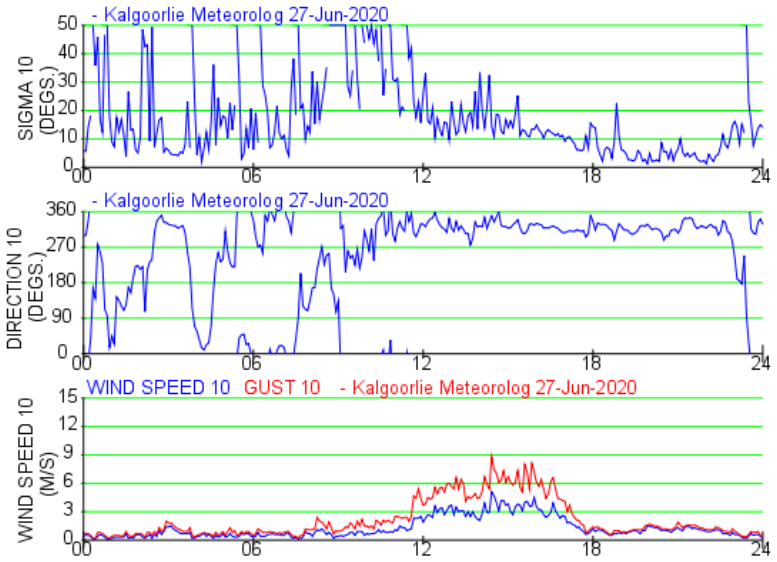
$PM_{2.5}$ concentrations at Mandurah were below 19µg/m^3 for each of the two days.

Assessable event

27 June 2020



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



5-minute averaged meteorology.

Pollutant

$PM_{2.5}$

Monitoring site

Kalgoorlie

NEPM standard

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

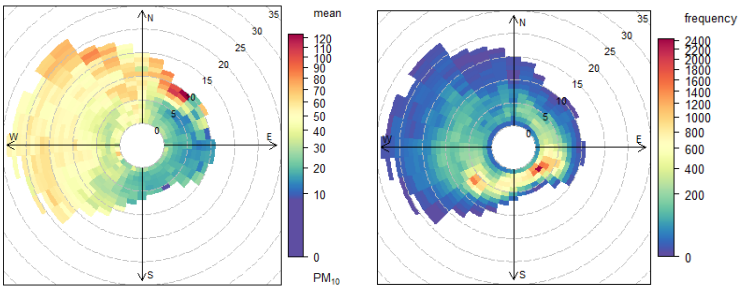
SITE	PM10	PM2.5
CA	4.6	3.2
QR	3.7	1.1
DU	5.9	4.0
SL	4.5	4.1
AR	NA	NA
MA	45.4	9.9
BN	NA	NA
BS	15.4	3.5
CO	6.6	NA
GE	8.3	4.5
AL	6.7	NA
KA	45.0	**33.3**

Description of event

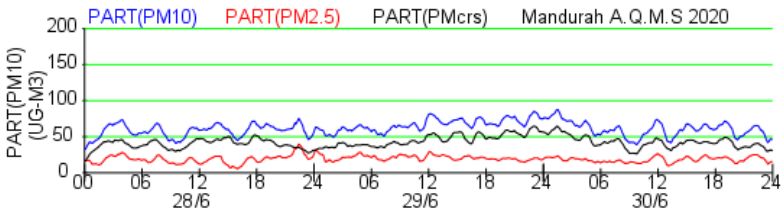
High $PM_{2.5}$ to PM_{10} ratio indicates some proportion of smoke. Likely some wood heater smoke is possibly the cause.

Assessable event

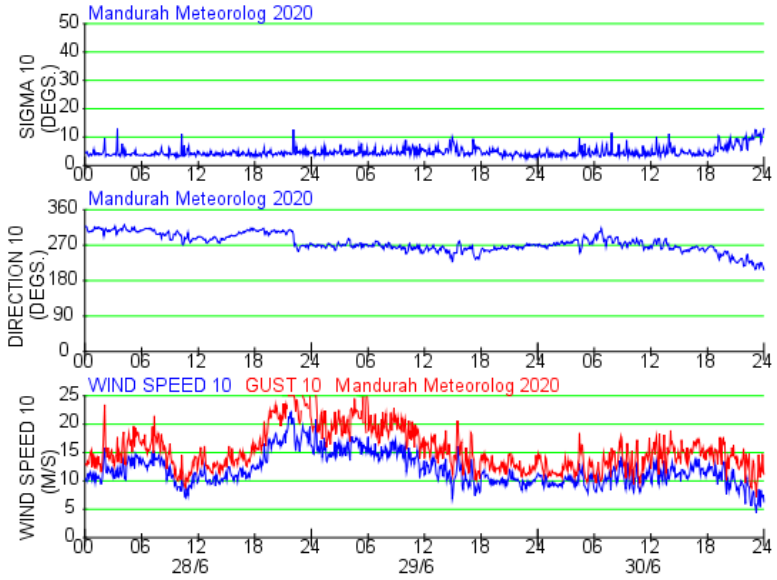
28, 29 and 30 June 2020



Frequency plots from November 2019 to July 2020 showing the high proportion of PM10 originating from the west (ocean) side of the site especially during low frequency high wind conditions indicating likely marine aerosols or sand.



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



5-minute averaged meteorology.

Pollutant

PM_{10}

Monitoring site

Mandurah

NEPM standard

PM_{10} – 50µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	28 June	29 June	30 June
PM_{10}			
CA	7.6	NA	NA
QR	15.5	20.5	14.5
DU	12.5	18.7	13.5
SL	7.9	9.1	6.4
AR	NA	NA	NA
MA	**58.3**	**66.6**	**60.4**
BN	NA	NA	NA
BS	28.0	19.1	14.2
CO	15.0	14.7	12.4
GE	17.2	25.6	11.3
AL	12.8	10.4	14.4
KA	10.1	12.1	7.2

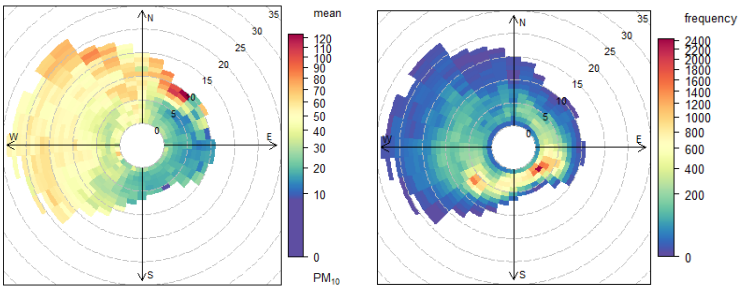
Description of event

Mandurah is located about 100 metres from the ocean at the end of an open car park. Westerly winds gusting between 10 and 25 m/s likely caused marine aerosols and possibly beach sand to impact the instrument.

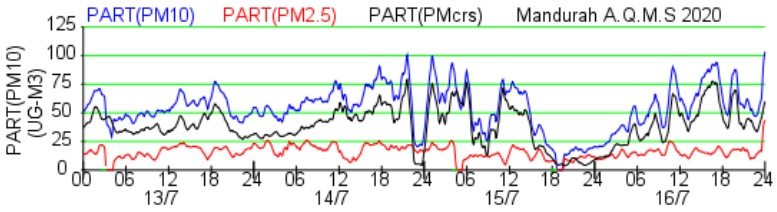
$PM_{2.5}$ concentrations at Mandurah were between 15 and 19µg/m^3 for each of the three days.

Assessable event

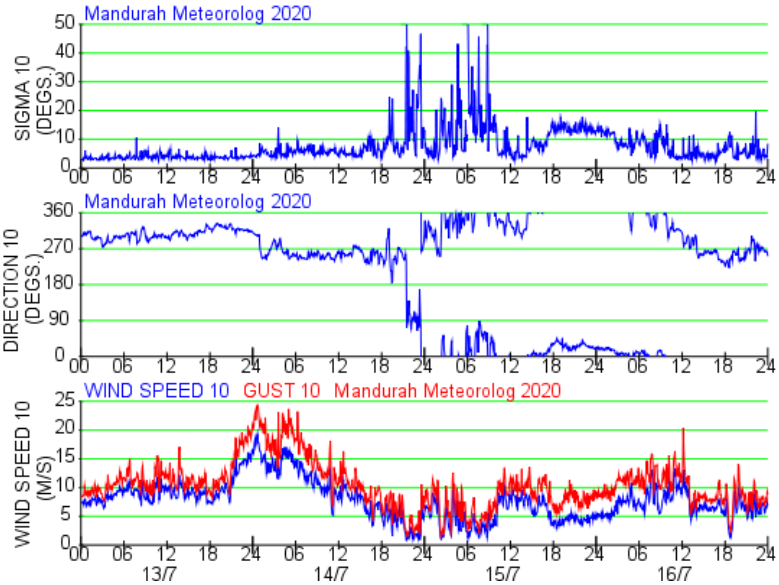
13, 14 & 16 July 2020



Frequency plots from November 2019 to July 2020 showing the high proportion of PM10 originating from the west (ocean) side of the site especially during low frequency high wind conditions indicating likely marine aerosols or sand.



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



5-minute averaged meteorology.

Pollutant

PM_{10}

Monitoring site

Mandurah

NEPM standard

PM_{10} – 50µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	13 July	14 July	16 July
PM_{10}			
CA	8.5	8.8	7.7
QR	8.7	15.2	7.7
DU	9.9	12.3	7.7
SL	6.1	6.5	4.7
AR	10.2	8.9	7.0
MA	**54.2**	**60.4**	**56.0**
BN	15.4	14.1	12.3
BS	12.3	16.1	12.3
CO	6.5	11.3	7.3
GE	19.0	17.5	9.9
AL	8.8	6.7	6.5
KA	20.1	14.3	8.8

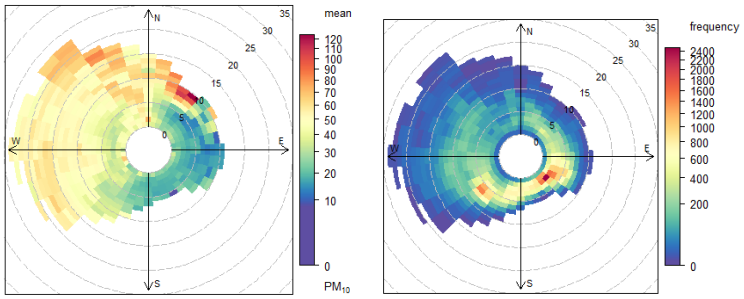
Description of event

Mandurah is located about 100 metres from the ocean at the end of an open car park. Westerly winds gusting between 10 and 25 m/s likely caused marine aerosols and possibly beach sand to impact the instrument.

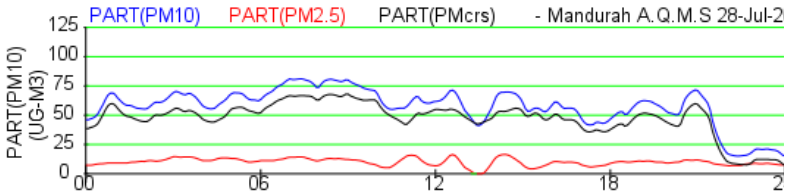
$PM_{2.5}$ concentrations at Mandurah were between 15 and 19µg/m^3 for each of the three days.

Assessable event

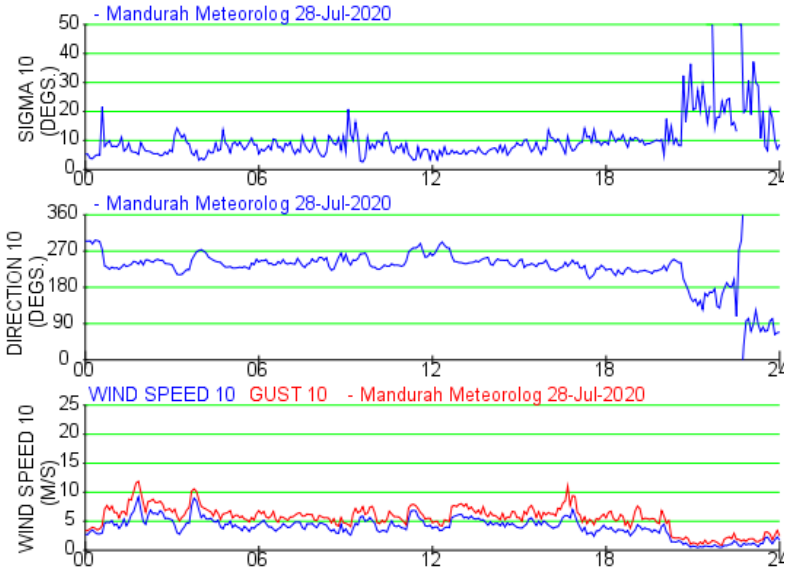
28 July 2020



Frequency plots from November 2019 to July 2020 showing the high proportion of PM10 originating from the west (ocean) side of the site especially during low frequency high wind conditions indicating likely marine aerosols or sand.



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black)



5-minute averaged meteorology.

Pollutant

PM_{10}

Monitoring site

Mandurah

NEPM standard

PM_{10} – 50µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	28 July	
	PM_{10}	$PM_{2.5}$
CA	8.8	4.8
QR	9.7	1.3
DU	10.5	3.7
SL	8.4	5.8
AR	9.5	4.7
MA	**57.6**	10.0
BN	19.0	9.8
BS	20.5	15.0
CO	16.3	NA
GE	12.0	5.7
AL	9.9	NA
KA	19.4	8.9

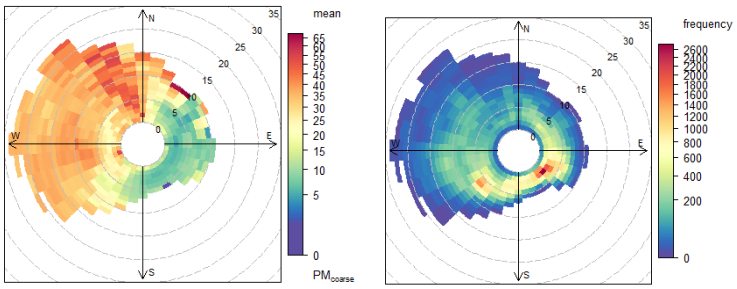
Description of event

Mandurah is located about 100 metres from the ocean at the end of an open car park. Westerly winds were between 4 and 10 m/s likely caused marine aerosols to impact the instrument.

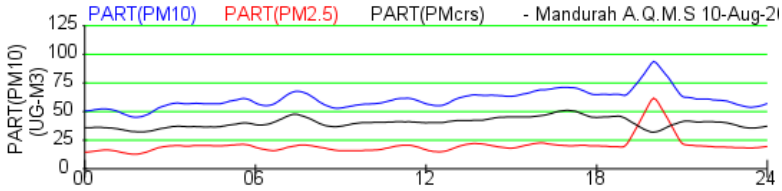
$PM_{2.5}$ concentration at Mandurah was 10µg/m^3 for the day.

Assessable event

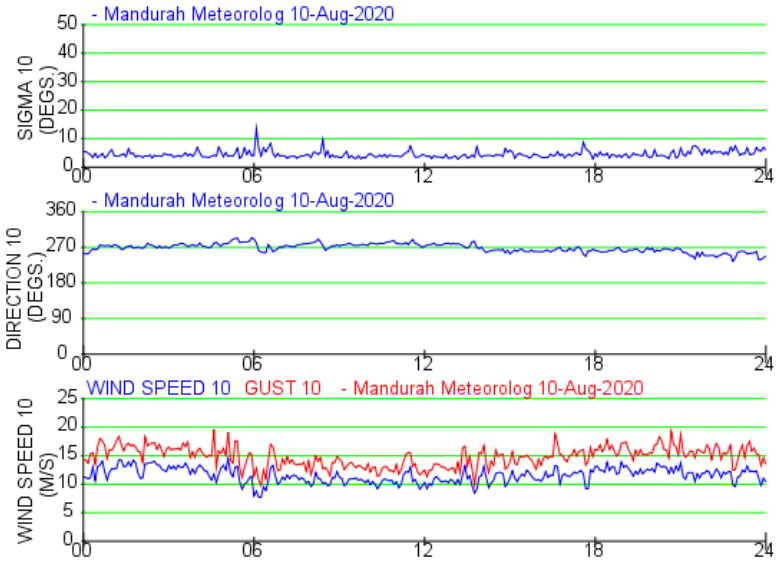
10 August 2020



Frequency plots from November 2019 to September 2020 showing the high proportion of PM10 originating from the west (ocean) side of the site especially during low frequency high wind conditions indicating likely marine aerosols or sand.



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



5-minute averaged meteorology.

Pollutant

PM_{210}

Monitoring site

Mandurah

NEPM standard

PM_{10} – 50µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	10 August	
	PM_{10}	$PM_{2.5}$
CA	7.9	1.1
QR	15.8	2.7
DU	15.5	5.1
SL	13.0	3.7
AR	8.0	1.7
MA	**61.1**	20.7
BN	18.5	5.6
BS	14.7	3.8
CO	10.9	NA
GE	21.9	8.3
AL	8.8	NA
KA	4.0	1.6

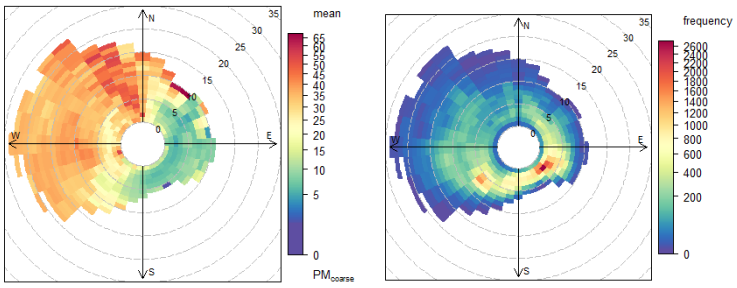
Description of event

Mandurah is located approximately 100 metres from the ocean at the end of an open car park. Westerly winds were between 10 and 20 m/s likely caused marine aerosols to impact the instrument.

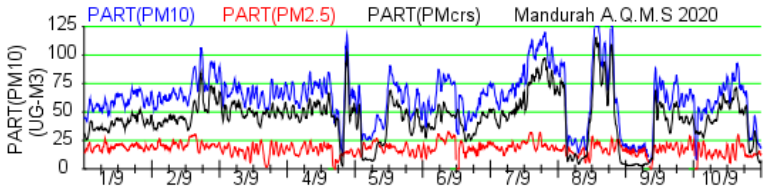
$PM_{2.5}$ concentration at Mandurah was 21µg/m^3 for the day.

Assessable event

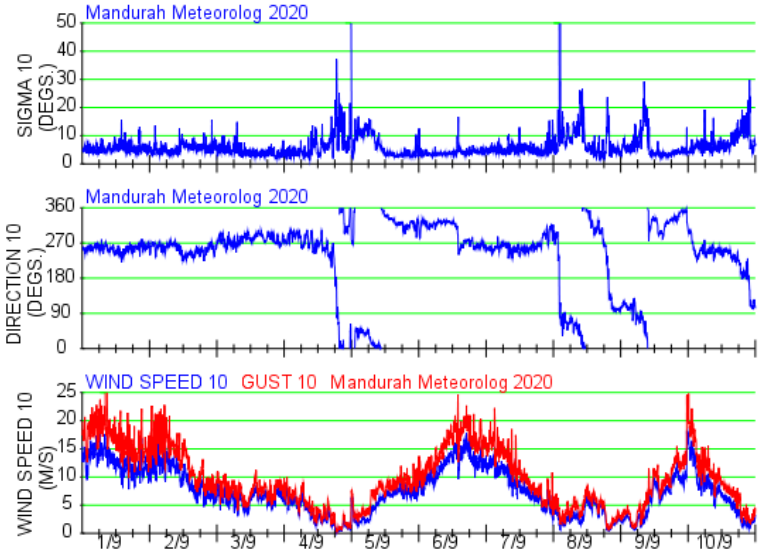
1 to 8 and 10 September 2020



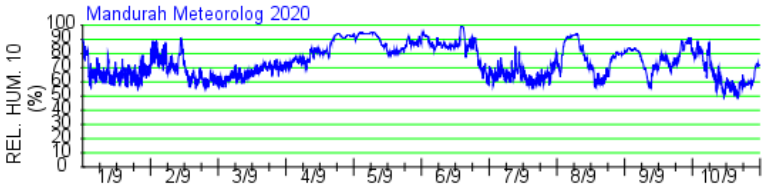
Frequency plots from November 2019 to September 2020 showing the high proportion of PM10 originating from the west (ocean) side of the site especially during low frequency high wind conditions indicating likely marine aerosols.



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black)



5-minute averaged meteorology



5-minute averaged relative humidity measured at Mandurah.

Pollutant

PM_{10}

Monitoring site

Mandurah

NEPM standard

PM_{10} – 50µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

Date	PM_{10}	$PM_{2.5}$
1 Sept	**58.7**	19.2
2 Sept	**71.0**	21.4
3 Sept	**66.1**	15.9
4 Sept	**65.3**	15.5
5 Sept	**53.0**	17.7
6 Sept	**61.7**	19.1
7 Sept	**84.4**	20.5
8 Sept	**62.6**	17.0
10 Sept	**57.0**	13.5

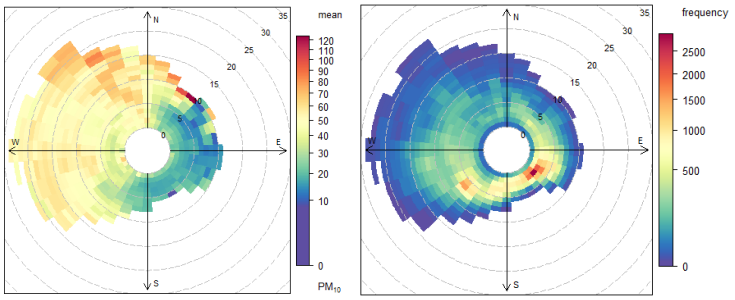
Description of event

Mandurah is located about 100 metres from the ocean at the end of an open car park. Westerly winds were up to 25 m/s. The exceedances were likely caused by marine aerosols impacting the instrument.

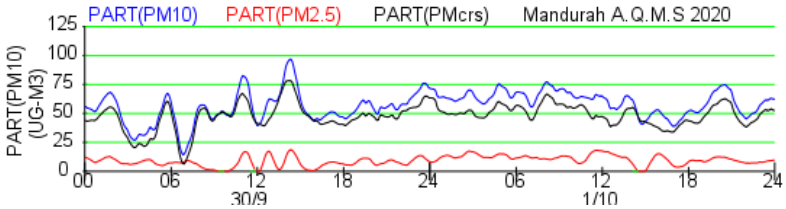
The NEPM standard for Mandurah $PM_{2.5}$ was not exceeded.

Assessable event

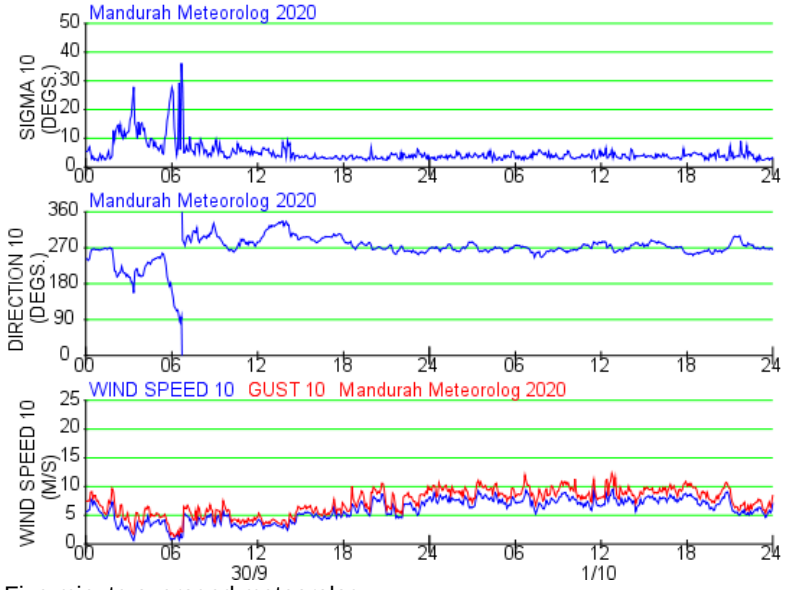
30 September and 1 October 2020



Frequency plots from November 2019 to September 2020 showing the high proportion of PM10 originating from the west (ocean) side of the site especially during low frequency high wind conditions indicating likely marine aerosols or sand.



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



Five minute averaged meteorology.

Pollutant

PM_{10}

Monitoring site

Mandurah

NEPM standard

PM_{10} – 50µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	30 Sep	1 Oct
CA	6.9	12.3
QR	9.1	14.1
DU	8.1	14.9
SL	7.7	14.6
AR	5.5	2.2
MA	**53.7**	**60.6**
BN	9.6	18.2
BS	6.7	19.3
CO	6.4	14.5
GE	14.4	21.6
AL	9.6	16.1
KA	17.6	24.1

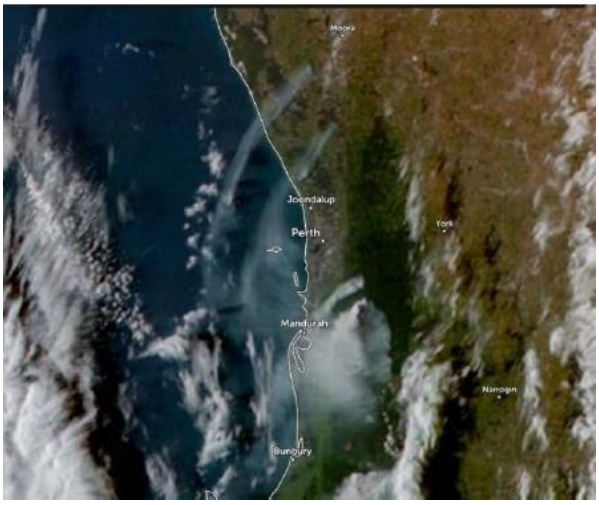
Description of event

Mandurah is located about 100 metres from the ocean at the end of an open car park. Westerly winds gusting between 5 and 10 m/s likely caused marine aerosols and possibly beach sand to impact the instrument.

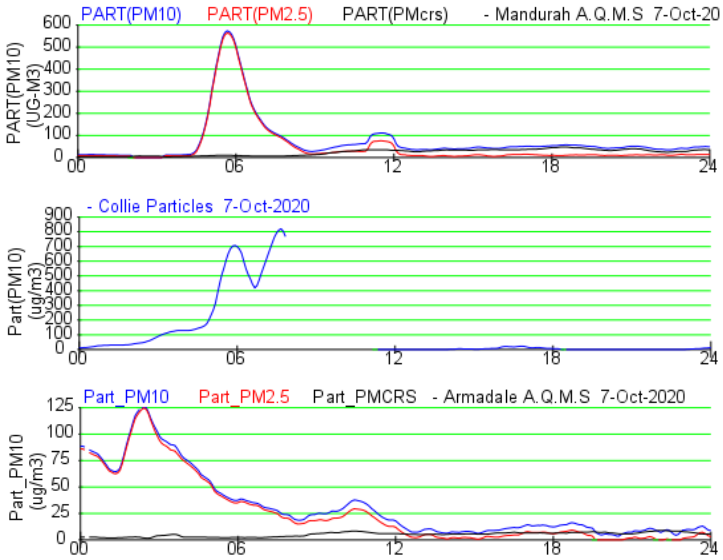
$PM_{2.5}$ concentrations at Mandurah were below 20 µg/m^3 for each of the two days.

Assessable event

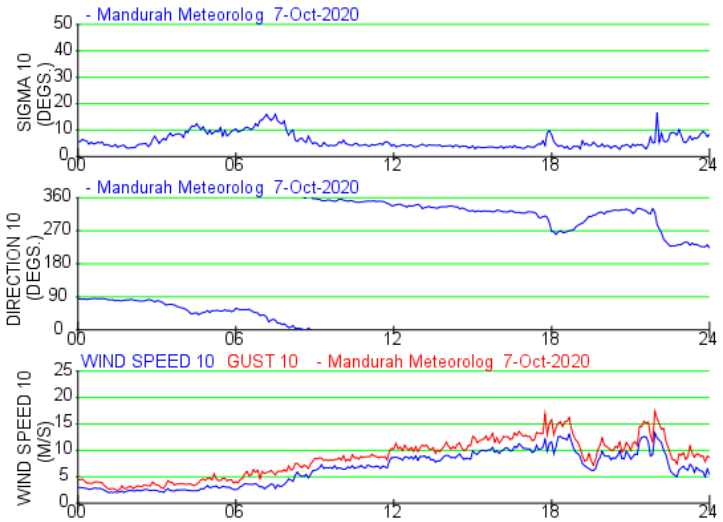
7 October 2020



Satellite image on 6 October 4:50pm (zoom.earth).



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



5-minute averaged meteorology.

Pollutant

PM_{10} & $PM_{2.5}$

Monitoring site

Mandurah, Collie & Armadale

NEPM standard

PM_{10} – 50µg/m^3

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	7 October	
	PM_{10}	$PM_{2.5}$
CA	20.0	12.6
QR	20.7	12.7
DU	23.8	16.5
SL	29.5	23.1
AR	31.3	**26.2**
MA	**77.8**	**53.7**
BN	17.9	7.6
BS	15.7	6.1
CO	**130.8**	NA
GE	13.9	5.3
AL	11.9	NA
KA	8.2	2.1

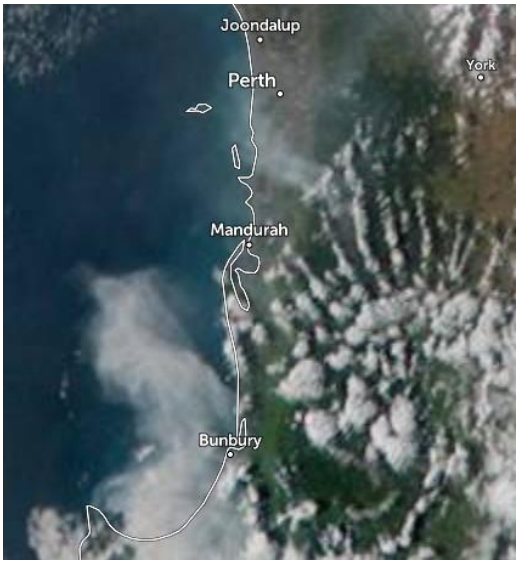
Description of event

Elevated particle levels throughout the early morning with a secondary peak occurring around midday caused by smoke from nearby prescribed burns, local burns and bushfires.

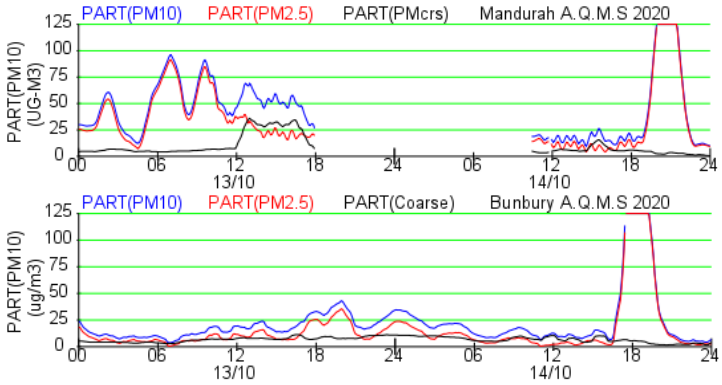
The gap in Collie data was caused by an overwhelmed filter causing the instrument to go into status mode. The filter was exchanged late morning.

Exceptional event

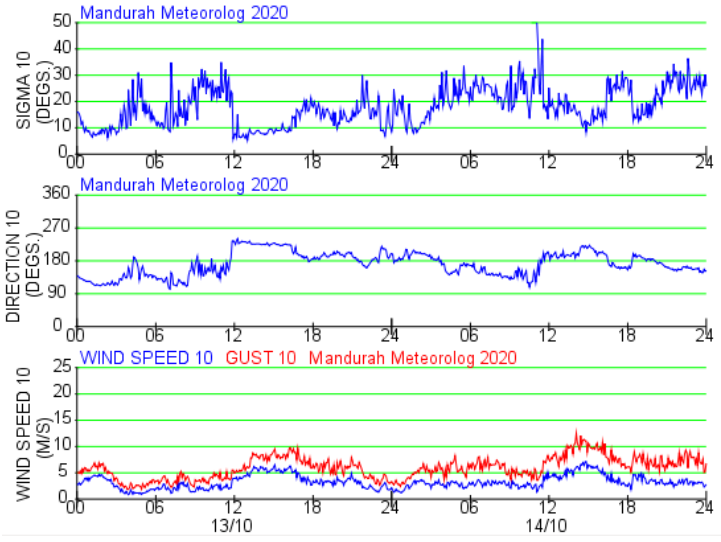
13 and 14 October 2020



Smoke from fires in the south west. From: zoom.earth/#view=-32.8145,116.0744,8z/date=2020-10-14,16:20,+8



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



5-minute averaged meteorology.

Pollutant

PM_{10} & $PM_{2.5}$

Monitoring site

Mandurah and Bunbury

NEPM standard

PM_{10} – 50µg/m^3

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

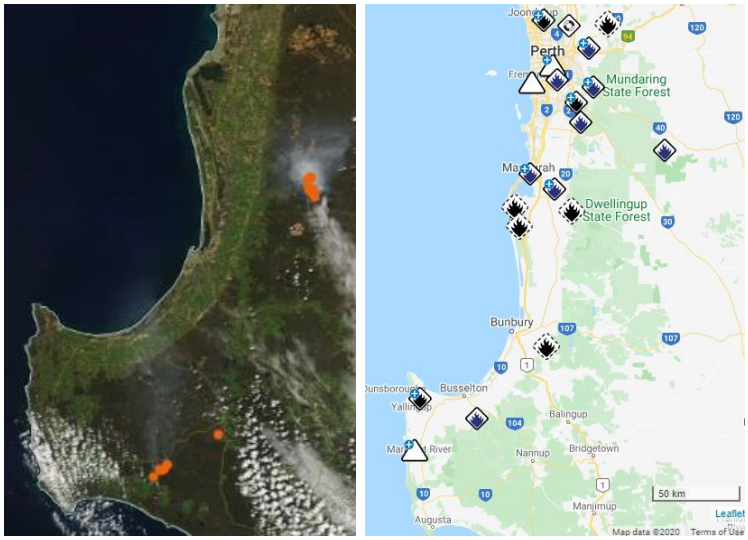
SITE	13 October		14 October	
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
CA	15.9	7.9	24.4	16.0
QR	19.3	10.3	21.4	11.6
DU	20.9	11.7	22.6	13.0
SL	19.7	11.3	20.9	11.9
AR	13.6	6.7	20.7	15.5
MA	**50.7**	**38.0**	NA	NA
BN	18.0	11.9	32.2	**25.7**
BS	10.4	5.1	9.8	3.4
CO	20.3	NA	12.7	NA
GE	34.4	17.2	22.4	9.7
AL	19.1	NA	15.2	NA
KA	19.0	5.5	16.1	5.8

Description of event

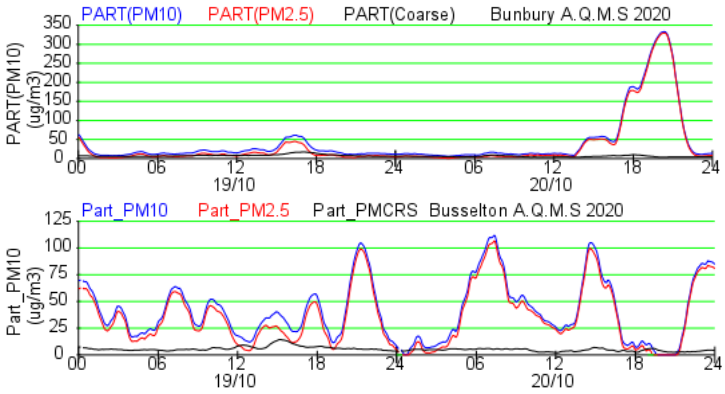
Several controlled burns and/or bushfires active in the south-west caused smoke to impact Bunbury and Mandurah.

Exceptional event

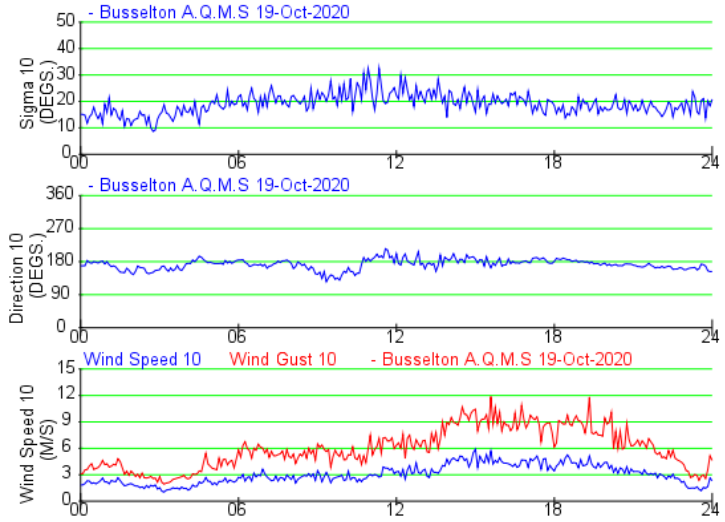
19 and 20 October 2020



Several fires were prescribed burns and bushfires were burning in the south-west.



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



5-minute averaged meteorology.

Pollutant

$PM_{2.5}$

Monitoring site

Bunbury and Busselton

NEPM Standard

PM_{10} – 50µg/m^3

$PM_{2.5}$ – 25µg/m^3

Averaging Period

24 hours

Concentration (µg/m^3)

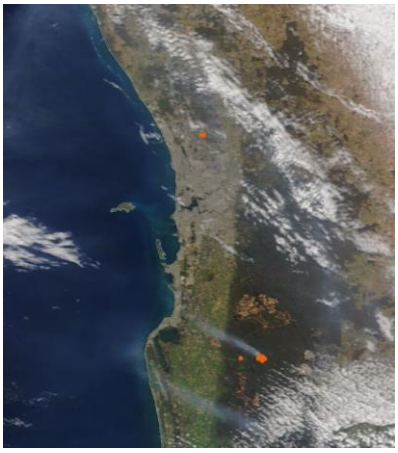
SITE	19 October		20 October	
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
CA	17.2	7.4	22.7	10.8
QR	16.6	6.3	26.1	15.2
DU	19.5	9.6	27.0	16.7
SL	21.0	10.7	26.4	15.4
AR	16.1	7.9	21.7	13.2
MA	NA	NA	NA	NA
BN	20.3	11.9	**61.1**	**55.5**
BS	39.1	**32.9**	41.5	**37.1**
CO	33.1	NA	21.6	NA
GE	32.1	14.0	25.8	11.2
AL	21.5	NA	9.3	NA
KA	13.3	3.4	9.7	3.7

Description of event

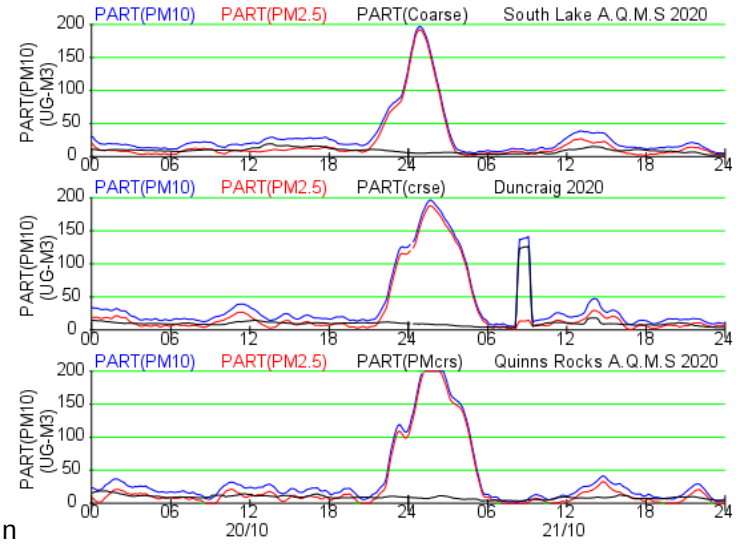
Several controlled burns active in the south-west caused smoke to impact Busselton.

Exceptional event

21 October 2020

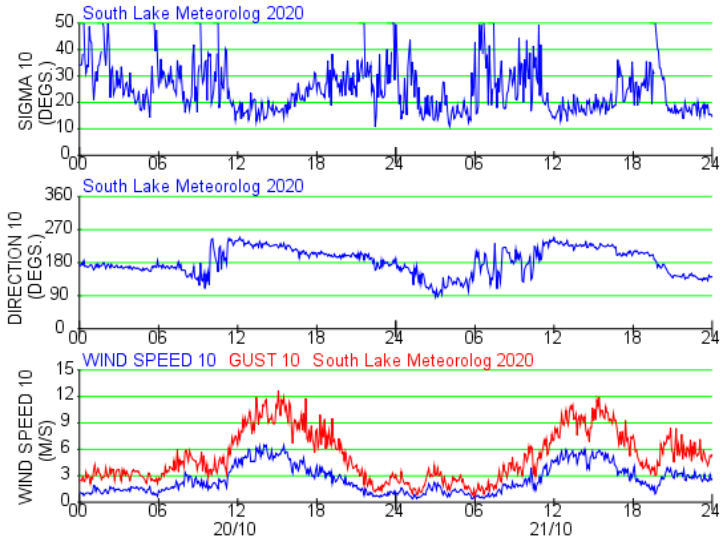


Several fires were prescribed burns were burning in the south-west. From: worldview.earthdata.nasa.gov/.



n

Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



5-minute averaged meteorology.

Pollutant

$PM_{2.5}$

Monitoring site

Quinns Rocks, Duncraig and South Lake

NEPM standard

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

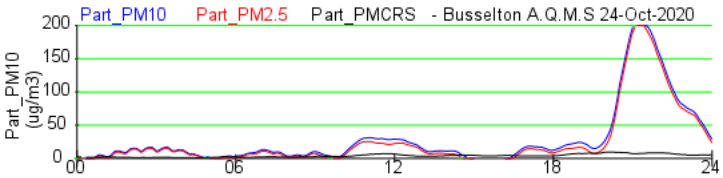
SITE	PM_{10}	$PM_{2.5}$
CA	23.7	16.8
QR	47.0	**39.8**
DU	49.9	**37.2**
SL	32.2	**25.4**
AR	12.7	7.9
MA	NA	NA
BN	8.5	3.8
BS	17.9	14.1
CO	21.0	NA
GE	22.8	10.5
AL	10.5	NA
KA	12.5	5.0

Description of event

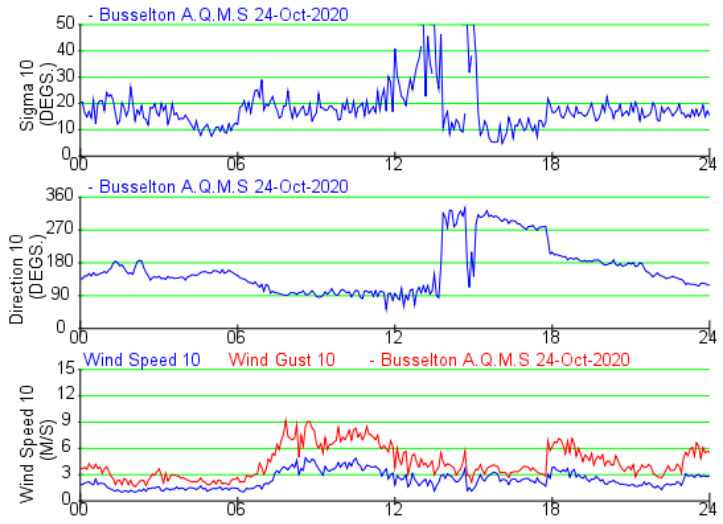
While several prescribed burns were undertaken in the south-west of the state, the short duration overnight indicates possible local night burn and/or wood heater smoke.

Assessable event

24 October 2020



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



5-minute averaged meteorology.

Pollutant

$PM_{2.5}$

Monitoring site

Busselton

NEPM standard

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	PM_{10}	$PM_{2.5}$
CA	9.3	2.8
QR	11.4	4.6
DU	9.6	4.0
SL	10.3	4.2
AR	8.1	3.5
MA	8.5	0.5
BN	24.1	19.2
BS	30.3	**26.3**
CO	18.8	NA
GE	23.8	9.0
AL	9.4	NA
KA	7.3	2.3

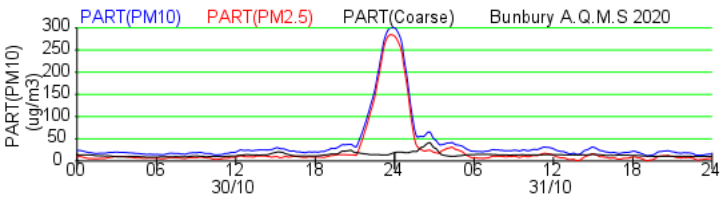
Description of event

Prescribed burns were active in the day near Augusta, south of Busselton.

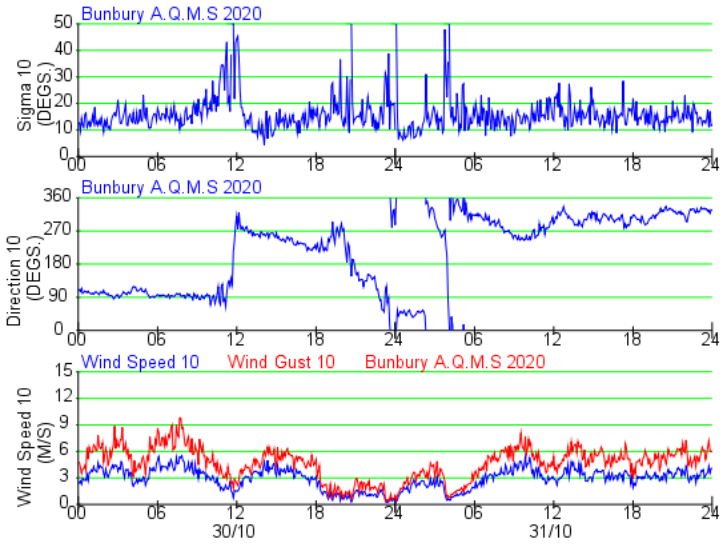
Exceptional event

30 October 2020

Smoke from fires active in the south west. From: worldview.earthdata.nasa.gov/.



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



5- minute averaged meteorology.

Pollutant

$PM_{2.5}$

Monitoring site

Bunbury

NEPM standard

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

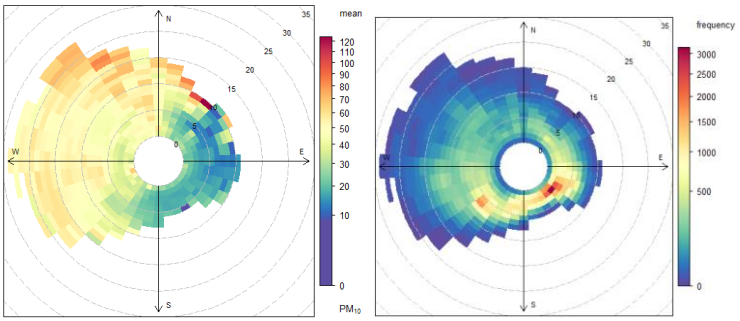
SITE	PM_{10}	$PM_{2.5}$
CA	16.1	6.0
QR	17.8	4.8
DU	19.4	7.8
SL	19.1	7.6
AR	15.5	6.2
MA	30.1	3.1
BN	40.3	**27.5**
BS	20.2	10.9
CO	33.3	NA
GE	38.1	14.7
AL	25.9	NA
KA	18.6	5.2

Description of event

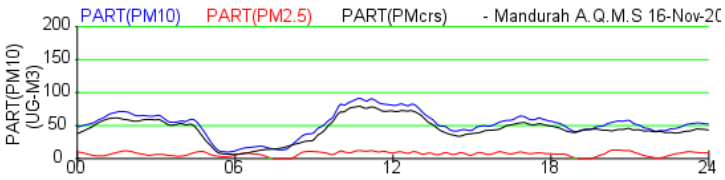
While several prescribed burns were undertaken in the south-west of the state, the short duration overnight indicates possible local night burn and/or wood heater smoke.

Assessable event

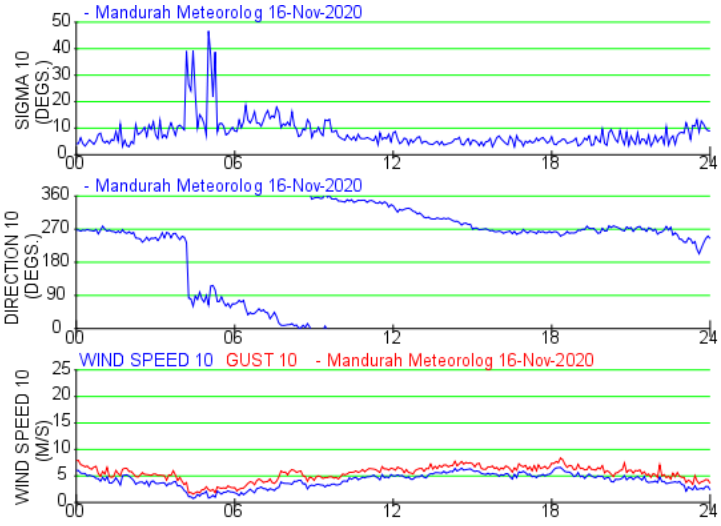
16 November 2020



Frequency plots from November 2019 to November 2020 showing the high proportion of PM10 originating from the west (ocean) side of the site especially during low frequency high wind conditions indicating likely marine aerosols.



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black)



5-minute averaged meteorology

Pollutant

PM_{10}

Monitoring site

Mandurah

NEPM standard

PM_{10} – 50µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	PM_{10}	$PM_{2.5}$
CA	12.3	7.1
QR	8.6	1.8
DU	10.5	4.1
SL	11.6	5.2
AR	12.6	6.6
MA	**52.1**	7.1
BN	11.0	4.0
BS	7.5	1.8
CO	10.1	NA
GE	15.3	6.4
AL	15.0	NA
KA	11.9	2.3

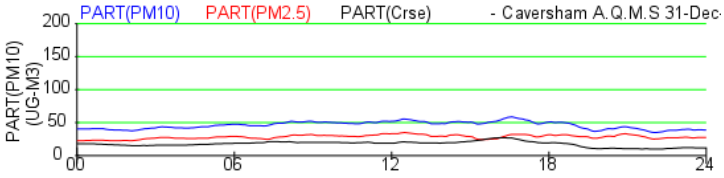
Description of event

Mandurah is located about 100 metres from the ocean at the end of an open car park. Westerly winds were predominant over the day. The exceedance was likely caused by marine aerosols impacting the instrument.

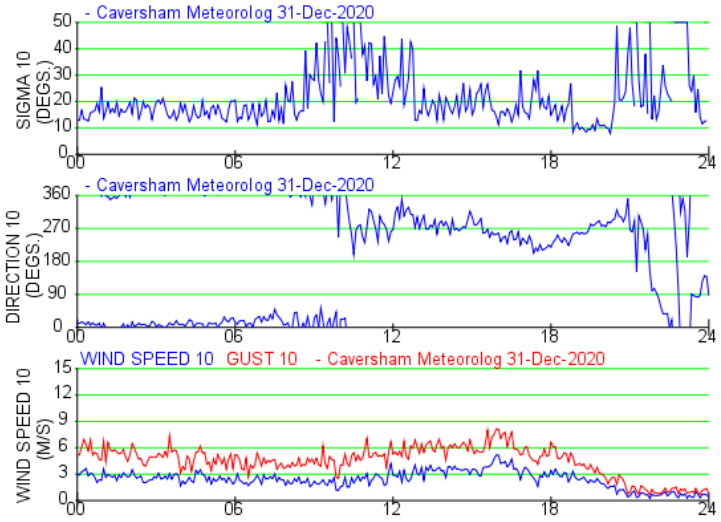
The NEPM standard for Mandurah $PM_{2.5}$ was not exceeded.

Assessable event

31 December 2020



Hourly averaged PM10 (blue), PM2.5 (red) & PMcrse (black).



5-minute averaged meteorology.

Pollutant

$PM_{2.5}$

Monitoring site

Caversham

NEPM standard

$PM_{2.5}$ – 25µg/m^3

Averaging period

24 hours

Concentration (µg/m^3)

SITE	PM_{10}	$PM_{2.5}$
CA	46.0	**28.4**
QR	33.0	12.7
DU	32.9	13.6
SL	32.2	13.8
AR	31.1	12.5
MA	38.1	10.5
BN	16.2	5.4
BS	NA	NA
CO	NA	NA
GE	30.7	14.6
AL	23.2	NA
KA	11.3	2.7

Description of event

General low-level smoke in the region. Possible residual smoke from a bushfire event.

Exceptional event