Assessment of air monitoring results: Cleanup of Glass Recovery Services site

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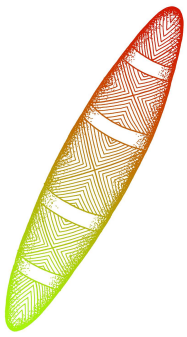

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Acronyms and abbreviations

AGV	Air Quality guideline Values
ATSDR	Agency for Toxic Substances and Disease Registry
AS/NZS	Australia/New Zealand Standard
CO	Carbon Monoxide
GRS	Glass Recycling Services
MRLs	Minimal Risk Levels
NEPM AAQ	National Environment Protection Measure (Ambient Air Quality)
NSW	New South Wales
NE	North East
NW	North West
NO_2	Nitrogen Dioxide
SO_2	Sulfur Dioxide
SE	South East
SW	South West
USEPA	United State Environmental Protection Agency
VOCs	Volatile Organic Compounds

Executive summary

Environment Protection Authority Victoria (EPA) took control of the Glass Recycling Services (GRS) site at Coolaroo from 25 October 2019 to 30 June 2020 due to the mismanagement of waste at the site by GRS. Prior to taking over the site, EPA identified multiple hotspots in glass-waste stockpiles that had caused fires and posed significant risks to the environment and human health. EPA removed stockpiles of smouldering waste materials including glass, paper, plastic and cardboard as well as other materials (putrescible organic wastes, metals, ceramic and porcelain) to make the site safe and protect the local community and environment during 25 October to 30 June 2020.

EPA removed approximately 147,192 tonnes of waste materials from the GRS site. This included removal of waste stockpile hotspots that present a significant fire risk. During the stockpile clean-up activities, smoke was released that contained fine particles ($PM_{2.5}$) as well as noxious and offensive substances such as nitrogen oxide, carbon monoxide, volatile organic compounds (VOCs) that led to reports of an unpleasant odour around the site.

EPA assessed the impacts associated with the removal of waste stockpiles from the GRS site to sensitive land uses. In the context of this document, "sensitive land use" is defined as a land use where it is plausible for humans to be exposed to toxic substances over durations greater than 24 hours, such as commercial and residential premises and education centres.

EPA conducted continuous air monitoring of $PM_{2.5}$ during the stockpile clean-up activities and collected a series of VOCs samples from October to December 2019 in several locations within a 5 km radius west and south of the GRS site.

Generally, the daily average of $PM_{2.5}$ results were below the 24-hour ambient air quality standard for $PM_{2.5}$ at all locations for the duration of the cleanup activities (between November 2019 to June 2020). However, poor air quality was observed on several days in the period December 2019 to February 2020 at the boundary of the GRS site and at Dallas Brooks Primary School due to smoke from bushfires burning in Eastern Victoria and NSW.

The levels of VOCs detected near the GRS site were up to four times lower than health-based guideline values used to assess the impacts to human health. Some of the VOCs detected are very odorous even at concentrations below those likely to cause adverse health impacts. Significant odour impacts were reported by nearby communities between November and December 2019. This was the same time that the peak of the waste stockpile hotspots removals occurred from the GRS site to a licensed landfill. These unpleasant odours can cause nuisance and discomfort in the surrounding communities.

The air monitoring results were used by EPA to inform the community of potential health risks during the clean-up of the GRS site. The air monitoring results demonstrated that there were negligible health impacts for nearby communities and the results were made available on EPA's website.

Stockpile cleanup activities were completed by June 2020, and air monitoring for this site was discontinued at the same time.

1. Introduction

EPA took control of the Glass Recycling Services (GRS) site at 82-88 Maffra Street, Coolaroo, Victoria 3048 (referred to as the GRS site in this report) from 25 October 2019 to 30 June 2020. This regulatory action occurred due to the mismanagement of waste on site by GRS. Prior to taking over the GRS site, EPA identified multiple hotspots in glass-waste stockpiles that had caused fires and posed significant risks to the environment and human health. Hotspots are stockpiles with elevated temperatures that present a significant fire risk. EPA commenced its cleanup of the GRS site in late October 2019 through to June 2020. In total, approximately 147,192 tonnes of waste materials were removed including glass, paper, plastic and cardboard as well as other materials (putrescible organic wastes, metals, ceramic and porcelain) as shown in Figure 1.

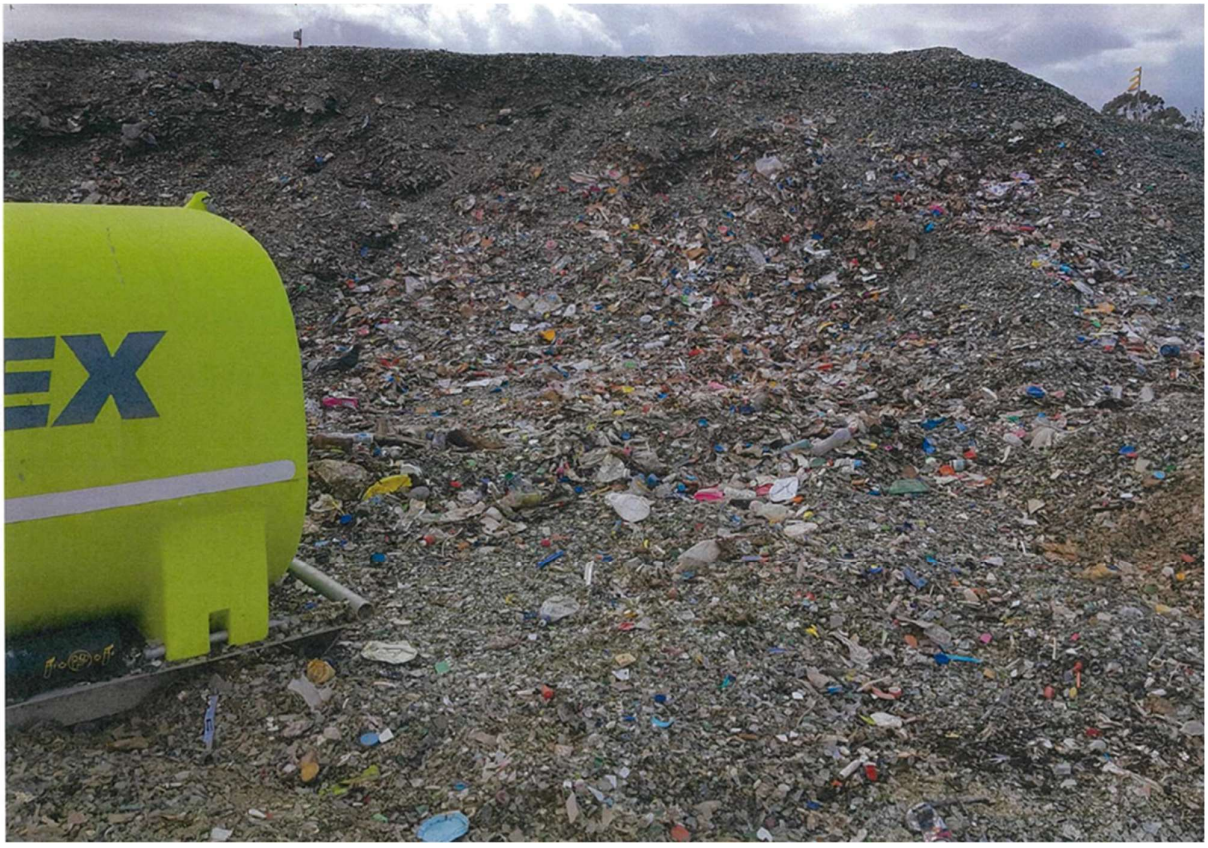


Figure 1 Mixture of glass and other waste materials at the GRS site.

Hotspots with internal temperatures of 400-600 °C in stockpiles up to 10 m high of waste materials were identified in the GRS site. These stockpiles were split up into smaller stockpiles to allow the waste material to cool down before being sent to landfill. This process allowed water and oxygen to get into the stockpiles, generating lots of steam with a strong odour.

During the removal of waste stockpiles, smoke containing toxic substances was released to the atmosphere. The substances included fine particles ($PM_{2.5}$), Volatile Organic Compounds (VOCs), and gases such carbon monoxide (CO), sulfur dioxide (SO_2) and nitrogen dioxide (NO_2).

The community were concerned with odour and smoke emitted from the GRS site during clean-up activities. The nearest communities to the GRS site are commercial and industrial businesses

immediately adjacent to the GRS site. There are also sensitive land uses such as residential areas approximately 900 m south and 500 m west of the GRS site. Coolaroo South Primary School and Dallas Brooks Community Primary School are respectively 1 km south west and 1.4 km south of the GRS site. In the context of this document, "sensitive land use" is defined as a land use where it is plausible for humans to be exposed to toxic substances over durations greater than 24 hours, such as in residential premises and education centres.

EPA engaged an independent occupational hygienist to conduct occupational air monitoring of CO, SO_2 and NO_2 at the GRS site as part of the site occupational health, safety and environmental monitoring plan. Occupational air monitoring was used to manage and evaluate the effectiveness of control measures to minimise on and offsite impacts on air quality and determine if further controls were required during the waste stockpile cleanup activities. The independent occupational hygienist air monitoring results is not provided in this report. However, the occupational air monitoring conducted at the southern boundary of the GRS site closest to the community were used by EPA to assess potential offsite emissions and their impact on the community. It is noted that the results of CO, SO_2 and NO_2 concentration levels provided by the occupational hygienist were below the respective air quality standards for assessing risk to population.

EPA conducted ambient air monitoring of $PM_{2.5}$ and VOCs common pollutants of concern associated with the removal of waste stockpiles on site and in nearby residential premises and education centres. EPA also received pollution reports of strong odour associated with the GRS site from nearby communities. EPA air monitoring results and pollution reports were used to assess potential risks to the community and are presented in this document.

2. Methods

2.1. Sampling Procedure

EPA conducted air monitoring of $PM_{2.5}$ and VOCs in several locations on site and in nearby residential premises and education centres (**Figure 2**

Particles smaller than 2.5 micrometres in diameter (PM2.5)
Volatile organic compounds (VOCs)

Figure 2).

The air sampling and monitoring was in accordance with the Australia/New Zealand Standard™ Methods for sampling and analysis of ambient air (AS 3580.1.1).

The purpose of the air monitoring was to determine whether levels of air pollutants exceeded health-based guidelines of unacceptable risk, identify the areas affected by the release of air pollutants during removal of waste stockpiles and to help EPA manage the GRS site appropriately and minimise risk.

2.2. Selection of monitoring locations

Sampling locations were selected based on field observations, hotspot locations and pollution reports received from the community within a 2 km radius of the GRS site.

The sites chosen (**Figure 2** and **Table 1**) include primary schools and residential areas. These were considered representative of sensitive groups and communities near the GRS site. Table 1 provides a summary of the air monitoring site details and sampling duration.

VOCs monitoring was conducted from October to December 2019 in several locations within a 5 km radius west and south of the GRS site. Most of the waste stockpiles with hotspots were removed during this period. The removal of stockpiles with hotspots is the worse potential scenario for the release of VOCs from the clean-up activities.

2.2.1.Fine particulate matter ($PM_{2.5}$)

Optical monitors were used to measure $PM_{2.5}$ near the GRS site. $PM_{2.5}$ data was collected at three sites near the GRS site (Site 1 – 3) as shown in **Figure 2** and **Table 1**. Site 1 and 2 were set up on the GRS site boundary to enable early assessment and management of community health impacts. Site 3 was at a local primary school.

Site 4 is EPA Alphington air monitoring station, an ambient air pollution background site that routinely measures $PM_{2.5}$ in ambient air with a beta attenuation monitor (AS 3580.9.12). The distance from the GRS site to Site 4 is approximately 15 km. Site 4 was chosen as a reference because the air quality in the area would not be impacted by the emissions from the GRS site clean-up activities.

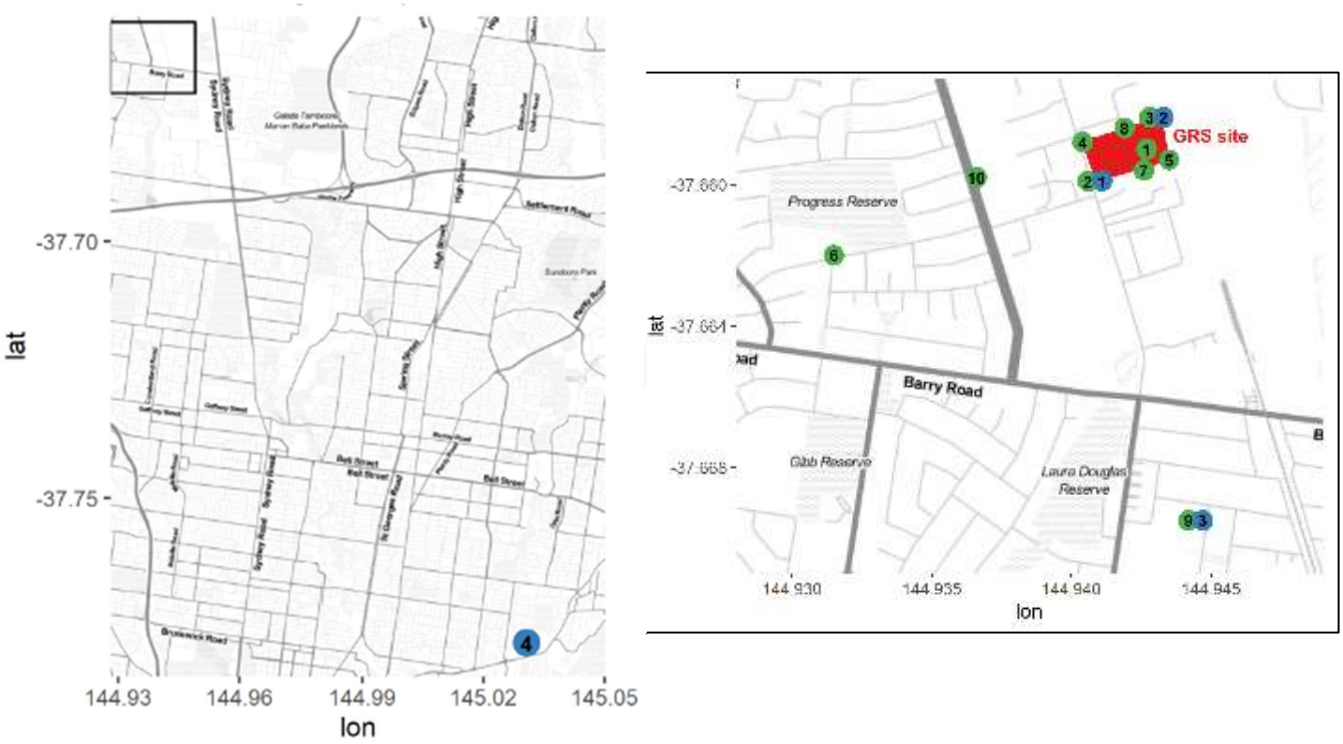
2.2.2. Volatile organic compounds (VOCs)

VOCs were collected using canisters and passive gas sampling tubes (radiello) at ten locations at the GRS site and in nearby communities (Figure 2

Particles smaller than 2.5 micrometres in diameter (PM2.5)
Volatile organic compounds (VOCs)

Figure 2 and Table 1). VOC samples collected were analysed in a NATA accredited laboratory using the United States Environmental Protection Agency (USEPA) Method TO-15A for canisters and USEPA Method TO-17 for the radiello passive gas sampling tubes.

The first round of monitoring was conducted in a waste stockpile hotspot area at the GRS site (30 October 2019). Subsequent air monitoring was conducted in areas near the GRS site (**Figure 2** and **Table 1**).



Description of sites:

- Particles smaller than 2.5 micrometres in diameter ($PM_{2.5}$)
- Volatile organic compounds (VOCs)

Figure 2 Map showing air monitoring and sampling locations.
Image produced using R package "ggplot2" (Wickham 2016; R Core Team 2020).

Table 1 Air monitoring site details for particles smaller than 2.5 micrometers in diameter ($PM_{2.5}$) and volatile organic compounds (VOCs).

Site No.	Location	Latitude	Longitude	Method
Particles smaller than 2.5 micrometers (µm) in diameter ($PM_{2.5}$)				
1	GRS site SW boundary	-37.6601	144.9411	Optical monitor
2	GRS site NE boundary	-37.6581	144.9433	Optical monitor
3	Dallas Brooks Community Primary School	-37.6695	144.9433	Optical monitor
4	Alphington air monitoring station	-37.7784	145.0306	AS 3580.9.12

Site No.	Location	Latitude	Longitude	Method
Volatile organic compounds (VOCs)				
1	GRS site hotspot	-37.6590	144.9427	USEPA TO-15A
2	GRS site SW boundary	-37.6600	144.9411	USEPA TO-17
3	GRS site NE boundary	-37.6581	144.9432	USEPA TO-17, USEPA TO-15A
4	GRS site NW boundary	-37.6588	144.9404	USEPA TO-17
5	GRS site SE boundary	-37.6593	144.9435	USEPA TO-17
6	Coolaroo South Primary School	-37.6620	144.9315	USEPA TO-17
7	GRS site S boundary	-37.6596	144.9426	USEPA TO-17
8	GRS site N boundary	-37.6584	144.9419	USEPA TO-17
9	Dallas Brooks Community Primary School	-37.6695	144.9444	USEPA TO-17
10	Coolaroo	-37.6598	144.9366	USEPA TO-17

Table notes: GPS co-ordinates provided are approximate locations.
SW – South West; SE – South East, NE- North East, NW – North West, N – North, S – South

3. Air quality guidelines for interpreting air sampling results

The National Environment Protection Measure (Ambient Air Quality) (NEPM AAQ 2016) outlines national reporting standards for the management of ambient air quality in Victoria. Air quality guidelines are set to be protective of population health from common air pollutants including $PM_{2.5}$. Air quality guidelines used for assessing $PM_{2.5}$ air monitoring results are provided in Table 2.

Table 2 Air quality guidelines for $PM_{2.5}$

Air pollutants	Duration	Guideline values (µg/m^3)
$PM_{2.5}$	24-hours	25

The selection of air quality guidelines for assessing potential health risks associated with exposure to VOCs was carried out in accordance with Section 5.12: Guidance on selecting sources of toxicological data and environmental health criteria (enHealth 2012). The air quality guidelines for VOCs are adopted from the United States Agency for Toxic Substances and Disease Registry Minimal Risk Levels (ATSDR MRLs) for acute inhalation (1-14 days) (ATSDR MRLs 2020). Air quality guidelines such as ATSDR MRLs are levels of atmospheric pollutants in the ambient air, below which ambient air quality is protective of human health.

4. Interpretation of air quality results

4.1. Fine particles ($PM_{2.5}$) results

To evaluate air quality impacts on communities likely to be affected by smoke from the GRS site, 24-hour rolling average of $PM_{2.5}$ air monitoring results (Figure 3) from the three air monitoring sites were assessed against the air quality guideline value for $PM_{2.5}$ of 25 µg/m^3.

The $PM_{2.5}$ daily average concentrations at sites 1 to 3 (Figure 3) were similar to background monitoring results at site 4 (Figure 3) and were below the 24-hour air quality standard for $PM_{2.5}$ for the duration of the clean-up activities with the exceptions of periods of poor air quality during 20 December 2019, 3-4, 6, and 13-16 January 2020 and 7 February 2020 at all sites. These exceptions were due to smoke from bushfires burning in Eastern Victoria and New South Wales (NSW).

Smoke from bushfires burning in Eastern Victoria and NSW resulted in poor to hazardous air quality for several days across Victoria between December 2019 to February 2020. Smoke from bushfires can affect areas not immediately impacted by fire due to weather patterns (i.e. temperature, wind speed and wind direction). On each day impacted by bushfires, satellite data (see Appendix) and field observations (for example, observed haze and smell of bushfire smoke) confirmed bushfire smoke affected $PM_{2.5}$ measurements near the GRS site and across the state.

Figure A1 – Figure A4 show plumes of bushfire smoke with elevated $PM_{2.5}$ concentrations occurring often overnight and lingering over several days. It was unlikely that the cleanup activities on the GRS site would result in measured elevated concentrations of $PM_{2.5}$ for prolong periods during most of the impacted days (20 December 2019, 3-4, 6, and 13-16 January 2020 and 7 February 2020). Over the Christmas and New Year period (starting on Sunday 20 December 2019 through to early January 2020), earthworks contractors were working at a reduced workload and paused the excavation of hot combustible waste at the GRS site. Instead, they focused on removal of cold waste materials from other areas of the GRS site and established new cooling areas that would assist in expedited cooling and transfer of hot combustible waste when cleanup activities recommenced in 2020. This change in activity resulted in less cleanup activities that could generate smoke at the GRS site over the Christmas and New Year period.

The reduced cleanup activity at the GRS site over the late December 2019 – early January 2020 period provides further confidence that elevated levels of $PM_{2.5}$ concentrations for sites 1 to 3 in December 2019 and January 2020 were from bushfires.

Site 4 (background) $PM_{2.5}$ monitoring data showed that the general air quality across Melbourne was affected by smoke from Eastern Victorian and NSW bushfires for the days assessed. On days not impacted by bushfire smoke the air quality was below the 24-hour air quality guideline value for $PM_{2.5}$ (site 4 in Figure 3), with the exception of a few days in May and June 2020 that may be attributed to residential wood heaters near site 4. Residential wood heaters are commonly used in the area during cooler days and are a major source of $PM_{2.5}$.

The $PM_{2.5}$ air monitoring results presented in this report were used to inform public health risks for nearby communities and were made available on **EPA Airwatch** during the clean-up activities.

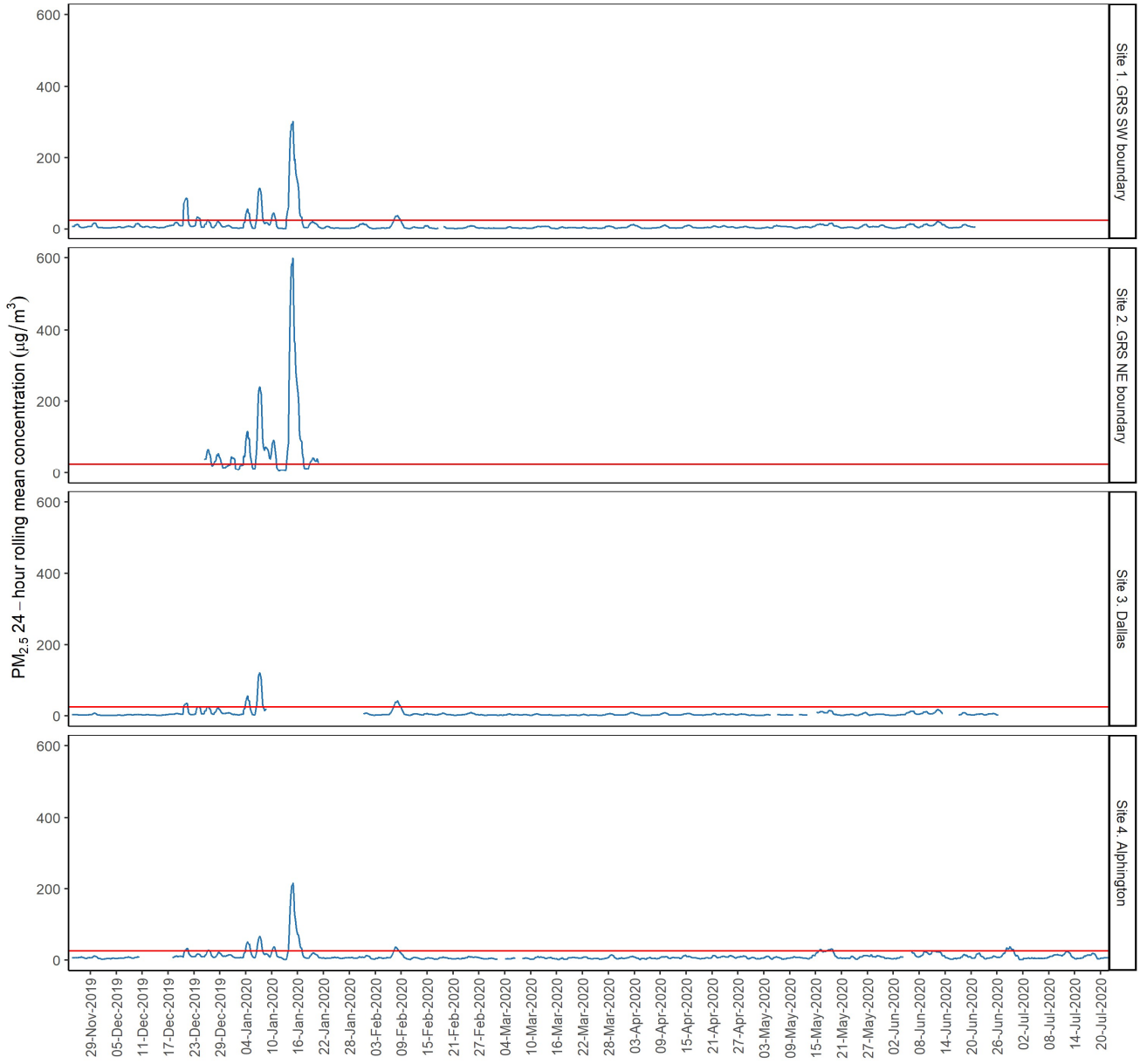


Figure 3 Timeseries of 24-hour rolling average $PM_{2.5}$ concentrations from 24 November 2019 to 26 June 2020. The red line is the NEPM AAQ (2016) $PM_{2.5}$ standard value of 25 µg/m^3. Notes: A technical issue with the instrument at site 2 – GRS site NE boundary resulted in no valid data being collected after 20 January 2020. A technical issue with the instrument at site 3 – Dallas Brooks Community Primary resulted in no valid data being collected from 8 to 30 January 2020.

4.2. Volatile organic compounds (VOCs) results

4.2.1. GRS site hotspot monitoring

The first VOC sample was collected using a canister (30 – 31 October 2019) positioned on top of a smouldering stockpile hotspot within the GRS site. The stockpile was approximately 10 m high and the temperature within the stockpile on the day of the monitoring was between 400 – 600°C. The air quality monitoring results close to the stockpile hotspot showed very high concentration levels of benzene (460 μg/m^3) (Table 3) compared to the air quality guideline for community exposure for benzene (29 μg/m^3). The hotspot sample highlighted the risk that VOCs were likely to be released from the waste stockpile. Consequently, further VOC monitoring was conducted on the GRS site boundary and in the nearby community to assess any potential risk.

Table 3 Summary of VOC measurements conducted at GRS site hotspot, 30 October 2019 using a cannister.

Site information		**Sampling period**			**Compound – concentration measured (μg/m^3)**				
No.	Location	Start date	End date	Duration	Benzene	Ethylbenzene	Styrene	Toluene	Xylenes
1	GRS site waste stockpile hotspot	30/10/2019	31/10/2019	24-hour	460	900	1600	590	44

4.2.2. GRS site boundary and community monitoring

The VOC passive gas samples located on the GRS site boundary and community monitoring sites from 30 October to 6 November 2019 showed much lower concentrations of all VOCs (as shown in Table 4) than the concentrations measured at the hotspot (Table 3). The hotspot sample was collected at the source of emissions and the rest were further away, at least approximately 100 m from the stockpile, on the GRS site boundary. Concentrations of air pollutants are expected to be higher at the source of emissions and be lower further away from the source as they disperse.

All detected concentrations of VOCs at the GRS site boundary and community monitoring sites were compared to air quality guidelines (ATSDR MRL – section 3). All air concentrations of individual VOC compounds at the GRS site boundary and community sites were below health guideline values (Table 4). In all cases, monitored concentrations were up to four times lower than their respective ATSDR MRLs for acute exposure, indicating that health risks to the community from VOCs were within acceptable limits by a very wide margin of safety.

The VOCs sampling results were used by EPA to inform the community of potential risks during the clean-up activities at the GRS site.

Table 4 Summary of VOC measurements conducted during 30 October to 16 December 2019 using passive gas samplers (radiello).

Site information		**Sampling period**			**Compound – concentration measured (µg/m³)**				
No.	Location	Start date	End date	Duration	Benzene	Ethylbenzene	Styrene	Toluene	Xylenes
GRS sites									
2	GRS SW boundary	30/10/2019	06/11/2019	168-hour (7-days)	2.5	2.8	8.6	3.3	1.0
3	GRS NE boundary	30/10/2019	06/11/2019	168-hour (7-days)	3	4.3	6.4	4.2	5.6
4	GRS NW boundary	30/10/2019	06/11/2019	168-hour (7-days)	1.3	2.1	7.8	3	1.6
5	GRS SE boundary	30/10/2019	06/11/2019	168-hour (7-days)	15	12	27	11	7.3
3	GRS NE boundary	12/11/2019	13/11/2019	24-hour	ND	ND	ND	ND	ND
7	GRS S boundary	09/12/2019	16/12/2019	168-hour (7-days)	8	5.8	9.5	4.6	2
8	GRS N boundary	09/12/2019	16/12/2019	168-hour (7-days)	7.7	5.9	10	4.6	1.7
Community monitoring sites									
6	Coolaroo South Primary School	30/10/2019	06/11/2019	168-hour (7-days)	0.54	0.7	1.3	1.3	0.9
9	Dallas Brooks Community Primary School	12/11/2019	19/11/2019	168-hour (7-days)	0.39	0.4	0.8	0.9	0.5
6	Coolaroo South Primary School	12/11/2019	19/11/2019	168-hour (7-days)	0.25	0.1	0.3	0.8	0.5
10	Coolaroo	12/11/2019	19/11/2019	168-hour (7-days)	0.25	0.2	0.3	1.1	0.7
6	Coolaroo South Primary School	09/12/2019	16/12/2019	168-hour (7-days)	0.41	0.3	0.3	1	0.6
10	Coolaroo	09/12/2019	16/12/2019	168-hour (7-days)	0.4	0.4	1	1.2	1.1
			ATSDR MRL (µg/m³)		**29**	**21,711**	**21,298**	**7,537**	**8,685**

Table notes: ND = Not Detected, GPS co-ordinates provided are approximate location.

4.3. Pollution Reports

EPA assessed pollution reports relating to odour from the community within a 2 km radius of the GRS site. The number of pollution reports increased significantly between November 2019 to January 2020 by five to seven times compared to the reports received in October 2019, when the clean-up activities began (see Figure 4). Reports were highest in November 2019 and reduced over the eight months of waste stockpile clean-up activities. The peak of the waste stockpile hotspots removal to landfill occurred in November and December 2019, causing more steam and odour than during removal of the cooler stockpiles that occurred later in the project. Pollution reports received during December 2019 and February 2020 were also likely to include pollution reports attributable to bushfire smoke.

Unpleasant odours can cause nuisance and discomfort within the surrounding communities. Some of the chemicals released during the periods of clean-up activities were very odorous even at concentrations below those likely to cause adverse health impacts.

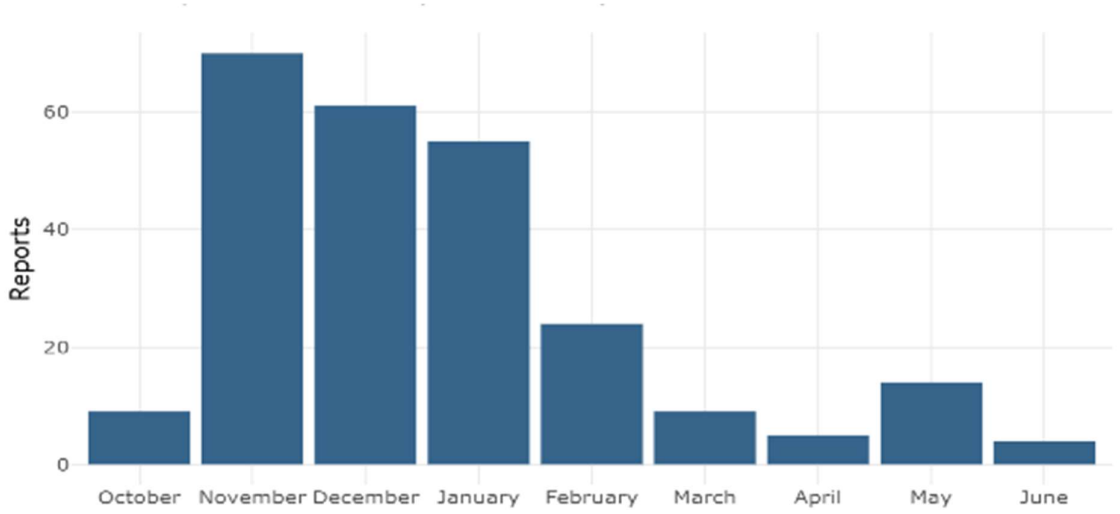


Figure 4 Number of pollution reports received by EPA per month from October 2019 to June 2020. Image produced using R package "ggplot2" (Wickham 2016; R Core Team 2020)

5. Conclusion

EPA carried out air monitoring at several locations in communities near the GRS site to assess if levels of $PM_{2.5}$, and VOCs associated with emissions from the GRS site exceeded the respective health-based standards or guideline values. The monitoring results were also used to assess if further actions were required to minimise emissions from GRS site.

Generally, the daily $PM_{2.5}$ results were below the ambient air quality standard for all locations during cleanup activities at the GRS site. However, poor air quality was observed on several days during December 2019 to February 2020 at the boundary of the GRS site and at Dallas Brooks Primary School due to smoke from bushfires burning in Eastern Victoria and NSW. All air concentrations of VOCs measured and detected at GRS site boundary and in the community were up to four times lower than the relevant health-based guideline values.

The air monitoring results were used by EPA to inform the community of potential health risks during the cleanup of the GRS site. The air monitoring results demonstrated that there were negligible health impacts for nearby communities and the results were made available on EPA's website.

Some of the chemicals released during the periods of cleanup activities were very odorous even at concentrations below those likely to give rise to adverse health impacts. Significant odour impacts were reported by nearby communities between November and December 2019. This was the same time that the peak of the waste stockpile hotspots removal occurred from the GRS site to a licensed landfill.

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7. Appendix

$PM_{2.5}$ measurements collected at incident sites near the GRS site that were displayed on EPA AirWatch during the project are presented here in Figure A1 to Figure A4 as supplementary data to Section 4.1.

Periods of poor air quality on 20 December 2019 (Figure A1) were caused by a bushfire plume passing the area. Satellite image of smoke movement from NSW to Coolaroo on 20 December 2019 (approximate location of GRS site shown by green dot on satellite image in Figure A1, location of active fires shown by orange-coloured areas (thermal anomalies) on satellite image).

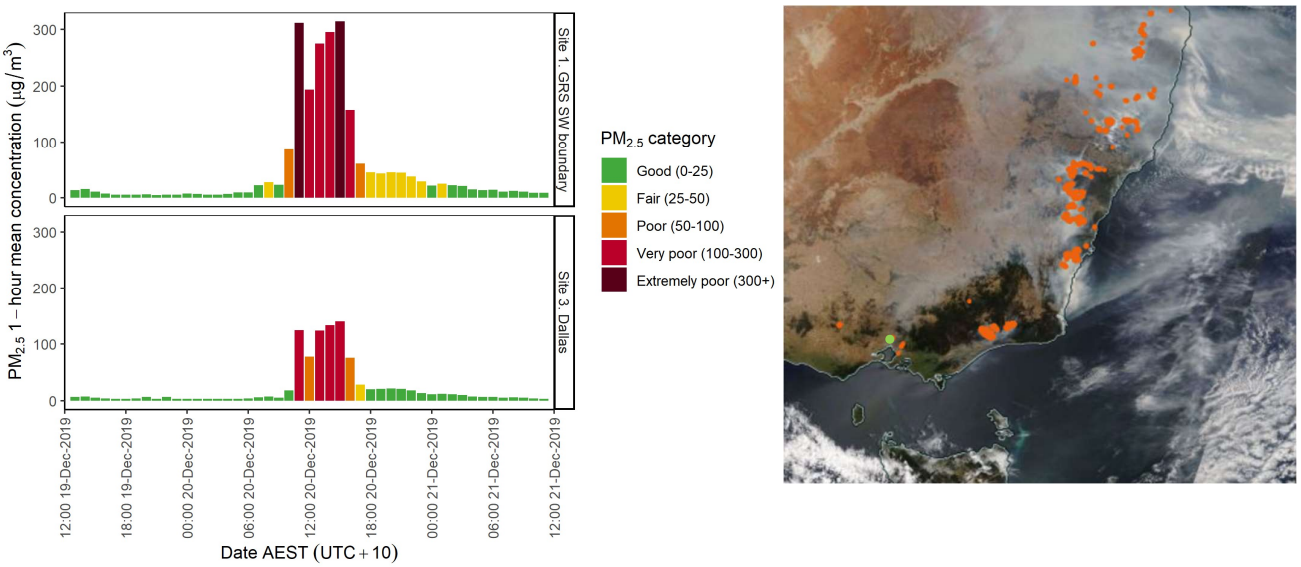

Figure A1 Timeseries of 1-hour average $PM_{2.5}$ concentrations using EPA air quality categories shown on AirWatch, 20 December 2019. Bar graph produced using R package "ggplot2" (Wickham 2016; R Core Team 2020). Satellite image source: https://worldview.earthdata.nasa.gov/?v=116.69290581493246,-49.9598364410258,169.3142434639516,-24.27952739043677&t=2019-12-20-T00%3A07%3A44Z&l=MODIS_Combined_Thermal_Anomalies_All,Reference_Labels(hidden),Reference_Features(hidden),Coastlines,VIIRS_NOAA20_CorrectedReflectance_TrueColor(hidden),VIIRS_SNPP_CorrectedReflectance_TrueColor(hidden),MODIS_Aqua_CorrectedReflectance_TrueColor(hidden),MODIS_Terra_CorrectedReflectance_TrueColor).

Periods of poor air quality on 3, 4 and 6 January 2020 (Figure A2) were caused by bushfire plumes passing the area. Satellite image of smoke movement from Eastern Victoria to Coolaroo on 3 January 2020 (approximate location of GRS site shown by green dot on satellite image in Figure A2, location of active fires shown by orange-coloured areas (thermal anomalies) on satellite image).

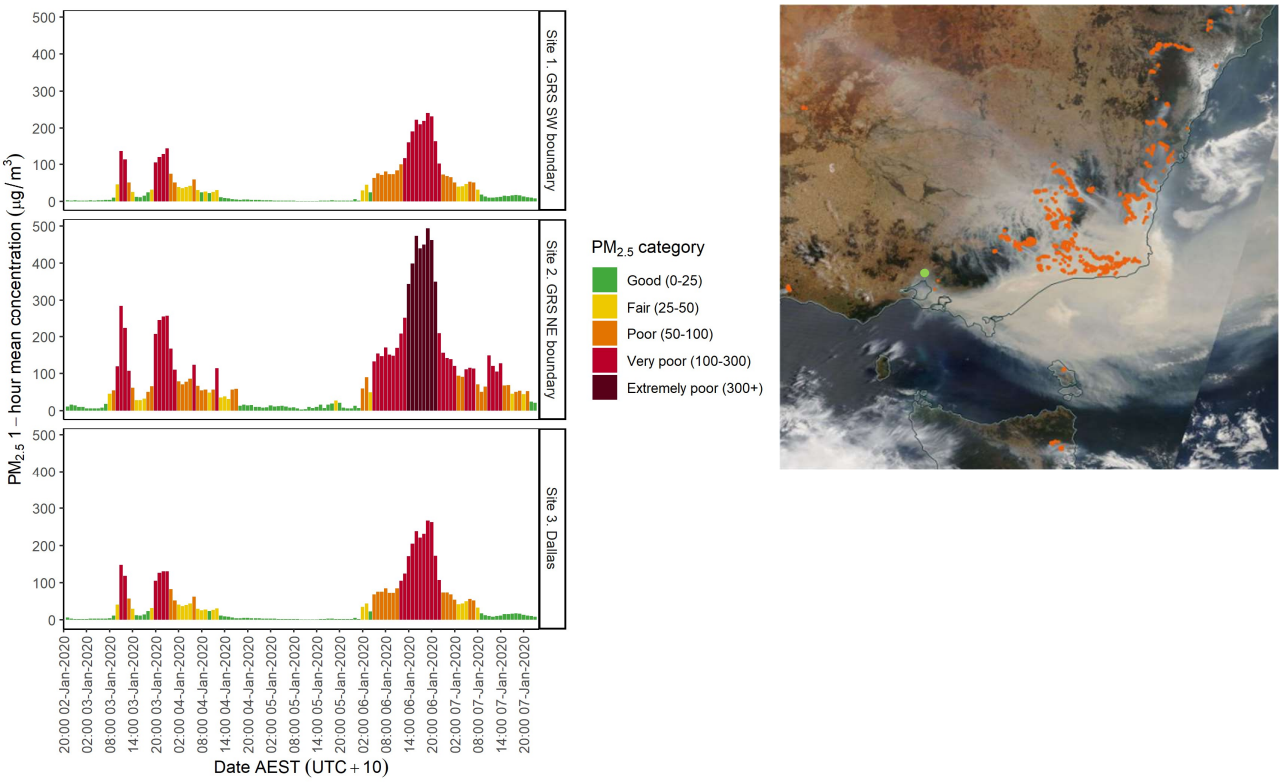

Figure A2 Timeseries of 1-hour average $PM_{2.5}$ concentrations using EPA air quality categories shown on AirWatch, 3, 4 and 6 January 2020. Bar graph produced using R package "ggplot2" (Wickham 2016; R Core Team 2020). Satellite image source: https://worldview.earthdata.nasa.gov/?v=127.03602340104914,-48.03362540748206,165.59441777833837,-29.216325651482066&t=2020-01-03-T18%3A00%3A00Z&l=MODIS_Combined_Thermal_Anomalies_All,Reference_Labels(hidden),Reference_Features(hidden),Coastlines,VIIRS_NOAA20_CorrectedReflectance_TrueColor(hidden),VIIRS_SNPP_CorrectedReflectance_TrueColor(hidden),MODIS_Aqua_CorrectedReflectance_TrueColor(hidden),MODIS_Terra_CorrectedReflectance_TrueColor).

Periods of poor air quality on 13-16 January 2020 (Figure A3) were caused by a bushfire plume passing the area. Note: A technical issue with the instrument at Dallas Brooks Community Primary School resulted in no valid data being collected from 8 to 30 January 2020. Satellite image of smoke movement from Eastern Victoria to Coolaroo on 14 January 2020 (approximate location of GRS site shown by green dot on satellite image in Figure A3, location of active fires shown by orange-coloured areas (thermal anomalies) on satellite image). Smoke covers Victoria, Tasmania and parts of NSW in the satellite image in Figure A3.

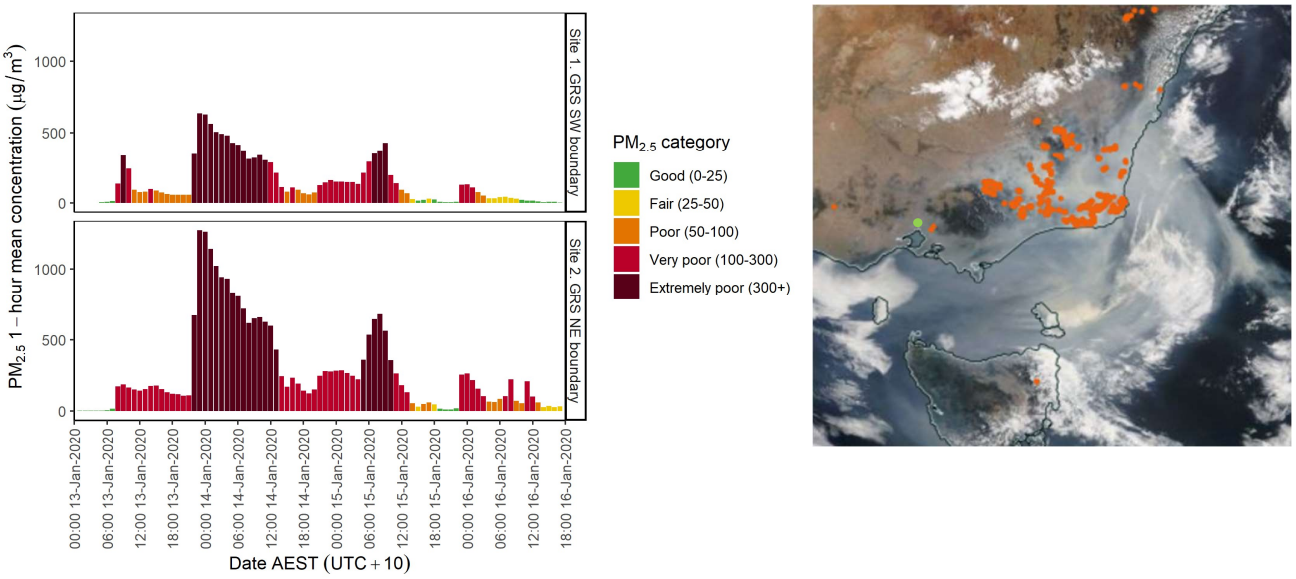

Figure A3 Timeseries of 1-hour average $PM_{2.5}$ concentrations using EPA air quality categories shown on AirWatch,13-16 January 2020. Bar graph produced using R package "ggplot2" (Wickham 2016; R Core Team 2020).Satellite image source: https://worldview.earthdata.nasa.gov/?v=116.69290581493246,-49.9598364410258,169.3142434639516,-24.27952739043677&t=2020-01-14-T00%3A07%3A44Z&l=MODIS_Combined_Thermal_Anomalies_All,Reference_Labels(hidden),Reference_Features(hidden),Coastlines,VIIRS_NOAA20_CorrectedReflectance_TrueColor(hidden),VIIRS_SNPP_CorrectedReflectance_TrueColor(hidden),MODIS_Aqua_CorrectedReflectance_TrueColor(hidden),MODIS_Terra_CorrectedReflectance_TrueColor).

Periods of poor air quality on 7 February 2020 (Figure A4) were caused by a bushfire plume passing the area. Satellite image of smoke movement from Eastern Victoria to Coolaroo on 7 February 2020 (approximate location of GRS site shown by green dot on satellite image in Figure A4, location of active fires shown by orange-coloured areas (thermal anomalies) on satellite image). Smoke and cloud cover Victoria in the satellite image in Figure A4.

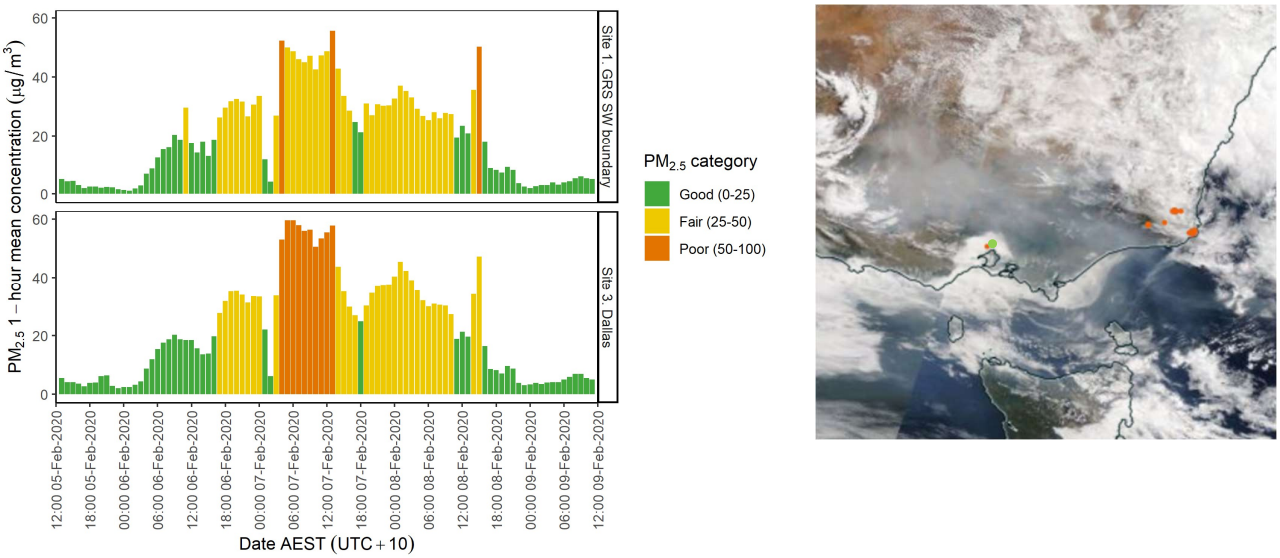

Figure A4 Timeseries of 1-hour average $PM_{2.5}$ concentrations using EPA air quality categories shown on AirWatch, 7 February 2020. Bar graph produced using R package "ggplot2" (Wickham 2016; R Core Team 2020). Satellite image source: https://worldview.earthdata.nasa.gov/?v=116.69290581493246,-49.9598364410258,169.3142434639516,-24.27952739043677&t=2020-02-07-T01%3A52%3A45Z&l=MODIS_Combined_Thermal_Anomalies_All,Reference_Labels(hidden),Reference_Features(hidden),Coastlines,VIIRS_NOAA20_CorrectedReflectance_TrueColor(hidden),VIIRS_SNPP_CorrectedReflectance_TrueColor(hidden),MODIS_Aqua_CorrectedReflectance_TrueColor(hidden),MODIS_Terra_CorrectedReflectance_TrueColor

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