Craig Milton
Policy Manager
NSW Minerals Council

Via Email: cmilton@nswmining.com.au

26 October 2023

Upper Hunter Air Quality Monitoring Network Analysis Project – Annual Review for 2021 and 2022

Dear Craig,

1 Introduction

Zephyr Environmental Pty Ltd (Zephyr) has been commissioned by the NSW Minerals Council (NSWMC) Upper Hunter Mining Dialogue (UHMD) to provide an updated air quality analysis, now incorporating the calendar year (CY) 2021 and CY2022, for the Upper Hunter following continued interest in air quality in the region.

The analysis of CY2021 and CY2022 air quality data follows on from the previous work prepared on air quality trends across NSW namely:

- Air Quality Monitoring Data Analysis Project ('the AQ Data Analysis Project', dated 16 November 2020).
- Upper Hunter Air Quality Monitoring Network Analysis Project ('*0012 UHMD UHAQMN Annual Data Review L1 Final Update'*, dated 9 December 2021)

Section 1 of the AQ Data Analysis Project provides background and context to this work, and confirms that the original project was designed to answer two specific air quality questions:

1. Has the air quality in the Upper Hunter Valley changed since monitoring began? and
2. Is the air quality in the Upper Hunter Valley measured at the monitoring stations different from air quality measured at other locations in NSW?

Section 2 of the AQ Data Analysis Project provides an overview of particulate matter size fractions and ambient air quality criteria, including definitions of the terms PM_{10} and $PM_{2.5}$ (particulate matter less than 10 and 2.5 micrometres in aerodynamic diameter, respectively).

Section 3 of the AQ Data Analysis Project provides detail on the 14 air quality monitoring stations that comprise the Upper Hunter Air Quality Monitoring Network (UHAQMN) and their grouping to reflect the following purposes:

- Larger populations (Muswellbrook, Singleton and Aberdeen)
- Smaller communities (Bulga, Camberwell, Jerrys Plains, Maison Dieu, Warkworth, Wybong)
- Diagnostic (Mount Thorley, Muswellbrook NW, Singleton NW)
- Background (Merriwa, Singleton South)

Section 4 and Section 5 of the AQ Data Analysis Project provide a summary of the air quality monitoring data collected to date and their analysis respectively.

The focus of this letter is to provide an update to the AQ Data Analysis Project, now including data from the CY2021 and CY2022.

2 Monitoring Data Update

The NSW Department of Planning and Environment (DPE) makes available ambient air quality monitoring data for NSW via their data download facility. Data has been gathered for the most recent complete calendar years; CY2021 and CY2022.

Table 2.1 and Table 2.2 present a summary of annual and period average PM_{10} and $PM_{2.5}$ monitoring results (respectively) that have been averaged into regions/groups.

Results have been shaded using a green to red colour relative gradient scheme with lowest values shown in green, and highest values shown in red, with the median value shown in yellow. This gradient scheme has been applied to the annual data and 'all years' groups separately.

The data shows that annual average PM_{10} and $PM_{2.5}$ concentrations across all regions in CY2021 and CY2022 continued on a downward trend which began in CY2020.

For the average across all years, the highest concentrations of PM_{10} are measured at the UHAQMN Diagnostic stations, with the next highest observed at the Lower Hunter & Central Coast stations.

The highest concentrations of $PM_{2.5}$ are measured at the UHAQMN Large Population stations, with the next highest observed at the Sydney north-west stations. The lowest concentrations are measured at the Central Tablelands for PM_{10} and Illawarra for $PM_{2.5}$, respectively.

As can be seen, the CY2021 and CY2022 data continues the trend seen in the data set up to CY2020; namely that annual average PM concentrations show a continued improvement across all regions/groups since CY2019 observations.

The CY2021 data indicates that for all station regions / groups, annual average PM_{10} and $PM_{2.5}$ concentrations have reverted to levels below the 'all year' average. Continuing this trend, the CY2022 PM_{10} and $PM_{2.5}$ concentrations have reduced across all regions and groups compared with the CY2021 observations. The annual average PM_{10} and $PM_{2.5}$ concentrations for CY2022 has maintained concentrations below the 'all year' average.

Table 2.1: Annual and period average PM_{10} concentrations by region/group and year (µg/m³)

Region / Group	Year										All years
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
Central tablelands	15.1	14.6	13.4	13.3	14.1	18.8	27.4	17.0	11.4	8.7	15.4
Illawarra	16.9	17.1	16.2	17.4	18.0	20.1	22.5	19.1	15.3	13.2	17.6
Lower Hunter & Central Coast	20.2	18.2	21.7	22.0	22.9	25.2	29.1	22.3	19.2	17.6	21.8
North-west slopes	16.6	15.8	14.1	15.3	15.3	20.1	33.7	16.8	12.7	10.6	17.1
South-west slopes	10.0	18.3	17.3	17.9	18.2	23.6	29.4	21.7	16.0	12.4	18.5
Sydney east	17.9	17.3	16.8	17.2	18.3	20.2	23.6	19.2	15.9	13.5	18.0
Sydney north-west	17.5	16.6	15.1	17.0	17.0	20.3	24.9	18.7	15.7	11.9	17.5
Sydney south-west	16.3	16.0	14.8	15.6	16.1	18.9	23.3	17.2	13.8	11.1	16.3
UHAQMN - BG	17.6	16.8	15.1	15.8	16.8	21.1	29.3	19.0	14.1	12.6	17.8
UHAQMN - DG	23.2	21.1	19.1	20.4	22.2	29.0	34.9	21.7	16.7	14.6	22.3
UHAQMN - LP	21.1	20.1	17.9	18.0	20.0	24.5	31.3	20.3	16.2	14.5	20.4
UHAQMN - SC	21.4	20.1	17.7	18.6	20.7	25.4	33.4	21.2	16.4	14.2	20.9

Note: UHAQMN – upper hunter air quality monitoring network, BG - background, DG – diagnostic, LP – larger populations, SC – smaller communities

Colour Coding by Percentile

0% (min.)	10%	20%	30%	40%	50% (median)	60%	70%	80%	90%	100% (max.)

Note: colour coding is applied to annual data by region (horizontally), whereas 'All years' colour coding is applied vertically, to allow comparison of data between regions.

Table 2.2: Annual and period average $PM_{2.5}$ concentrations by region / group and year ($\mu g/m^3$)

Region / Group	Year										All years
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
Illawarra	7.7	7.0	7.0	7.3	6.9	7.1	11.1	7.2	5.3	4.3	7.1
Lower Hunter & Central Coast	7.5	7.0	7.5	7.8	7.7	8.2	17.3	7.6	6.3	5.5	8.2
South-west slopes	7.9	7.5	7.6	7.4	8.1	8.4	11.3	10.9	6.3	5.3	8.1
Sydney east	8.2	8.4	8.3	8.1	8.4	8.2	16.5	8.0	6.9	5.2	8.6
Sydney north-west	8.3	6.7	8.0	8.3	7.4	8.3	20.5	8.2	6.9	5.1	8.8
Sydney south-west	8.0	7.5	7.4	7.6	7.8	8.7	18.9	7.9	7.0	5.0	8.6
UHAQMN - LP	8.7	8.8	8.2	8.2	8.8	8.8	18.0	8.9	6.8	5.7	9.1
UHAQMN - SC	8.2	7.8	7.2	7.5	7.4	8.4	17.3	7.5	5.7	4.8	8.2

Note: UHAQMN – upper hunter air quality monitoring network, LP – larger populations, SC – smaller communities

Colour Coding by Percentile

0% (min.)	10%	20%	30%	40%	50% (median)	60%	70%	80%	90%	100% (max.)

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3 Analysis Update

Provided below are revisions of some of the key data tables and figures from the AQ Data Analysis Project, updated to include data from CY2021 and CY2022. Additional commentary is provided as it relates to the inclusion of the CY2021 and CY2022 data.

Comparison of UHAQMN and remainder of NSW

Table 3.1 presents a comparison of average PM_{10} concentrations measured across NSW, with the UHAQMN and the remainder of NSW shown separately. Annual data have also been presented as a percentage of the respective 2013-2022 average.

This relationship has also been shown for $PM_{2.5}$ which has a lesser association with mechanically generated particulate emissions such as those from mining. Figure 3.1 provides a graphical representation of these data.

As noted within the AQ Data Analysis Project and reinforced with the inclusion of CY2021 and CY2022 data, the consistency of temporal trends in the UHAQMN and ‘Remainder of NSW’ monitoring subsets show that the changes in PM_{10} concentrations within the Upper Hunter are generally consistent with changes experienced across the rest of NSW.

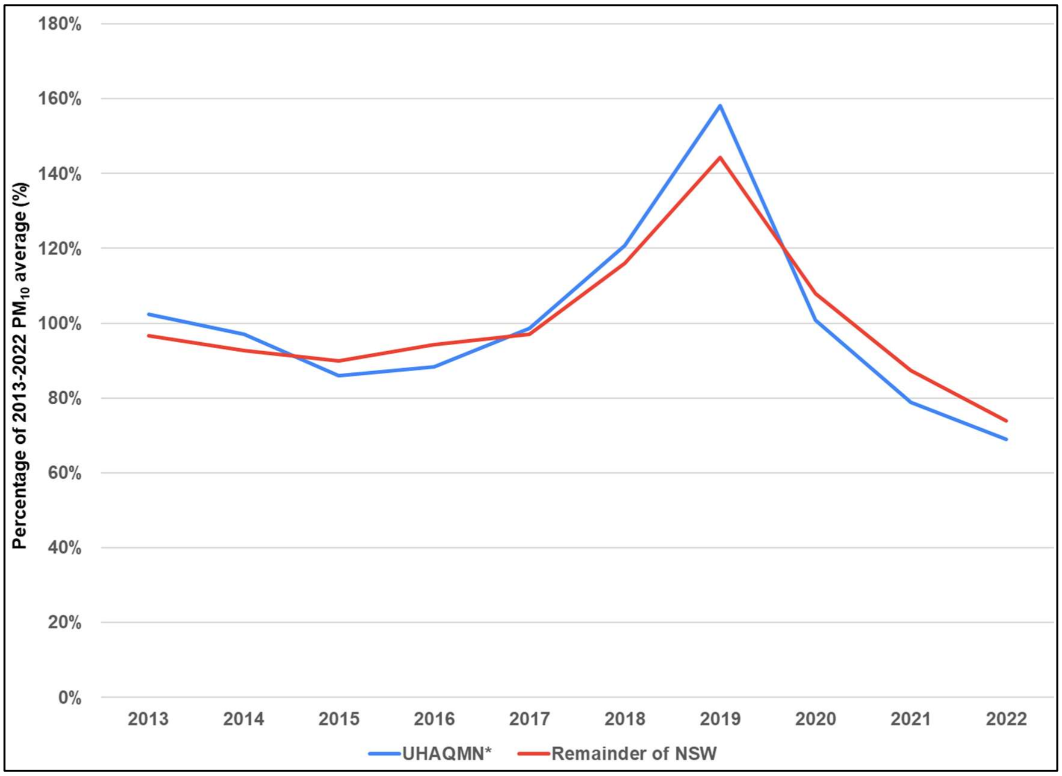
This in turn indicates that the changes in annual average PM_{10} concentrations are associated with regional particulate sources and that the contribution of mining operations on the UHAQMN to these trends is not discernible.

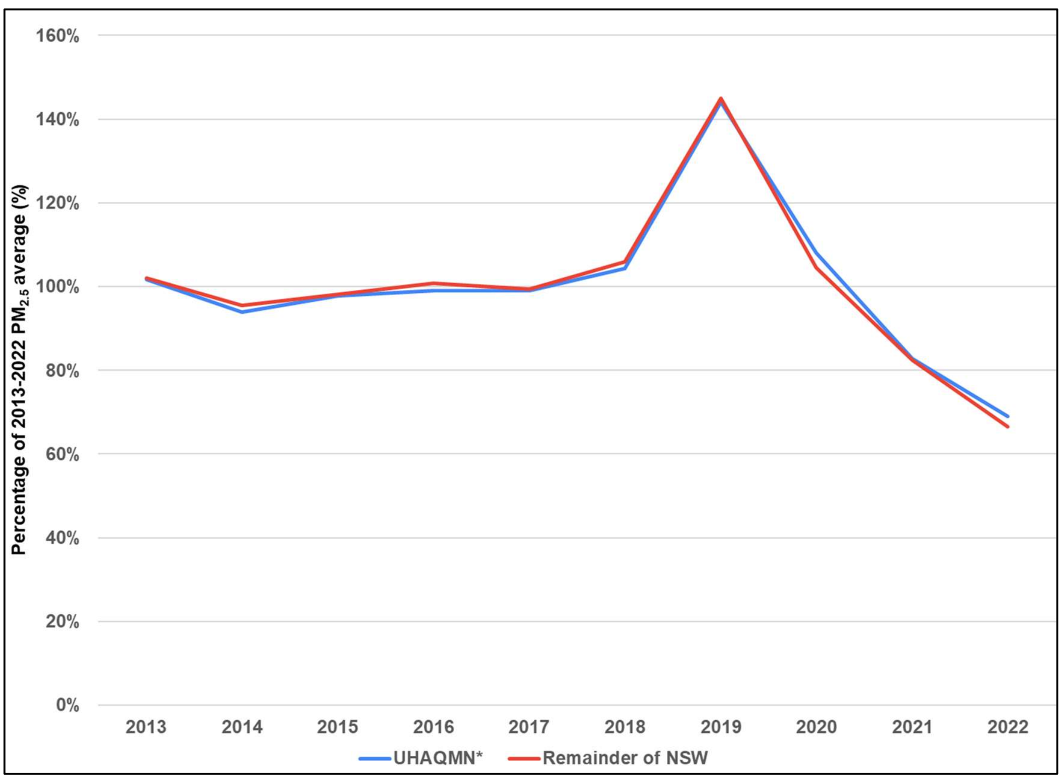
Notably, the CY2021 and CY2022 PM_{10} data for the UHAQMN is below the ‘all years’ average, reversing the anomalously high values experienced in CY2019 associated with the ‘Black Summer’ bushfire event. A similar pattern is also observed in $PM_{2.5}$, indicating that changes in $PM_{2.5}$ (less likely to be attributed to mining operations) are generally consistent with those observed elsewhere in NSW. As with the PM_{10} data set, the values for CY2021 and CY2022 emphasise that the annual average for CY2019 was anomalously high.

Table 3.1: Comparison of PM_{10} and $PM_{2.5}$ variability – UHAQMN vs remainder of NSW regions

Monitoring subset	Parameter	Year										All Years
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
PM_{10}												
UHAQMN*	Concentration (µg/m³)	21.2	20.1	17.8	18.3	20.4	25.0	32.7	20.9	16.3	14.3	20.7
	% of average (all years)	102%	97%	86%	88%	99%	121%	158%	101%	79%	69%	-
Remainder of NSW	Concentration (µg/m³)	17.4	16.7	16.2	17.0	17.5	20.9	26.0	19.4	15.7	13.3	18.0
	% of average (all years)	97%	93%	90%	94%	97%	116%	144%	108%	87%	74%	-
$PM_{2.5}$												
UHAQMN*	Concentration (µg/m³)	7.9	7.3	7.6	7.7	7.7	8.1	11.2	8.4	6.4	5.4	7.8
	% of average (all years)	102%	94%	98%	99%	99%	104%	144%	108%	83%	69%	-
Remainder of NSW	Concentration (µg/m³)	7.9	7.4	7.6	7.8	7.7	8.2	11.2	8.1	6.4	5.1	7.7
	% of average (all years)	102%	96%	98%	101%	99%	106%	145%	104%	82%	66%	-

Note: UHAQMN – upper hunter air quality monitoring network, * - Larger Populations and Smaller Communities station groups.





Note: UHAQMN data relates to Larger Populations and Smaller Communities station groups.

Figure 3.1: Comparison of PM_{10} (top) and $PM_{2.5}$ (bottom) variability – UHAQMN vs remainder of NSW regions

Comparison across sub-divisions of the UHAQMN

For each station group, Table 3.2 shows the annual PM_{10} variance against the CY2013 – CY2022 average PM_{10} concentration for that station group. This is instructive in showing changes in the difference between station groups across the study period, into CY2022. The same data is shown graphically in Figure 3.2.

Table 3.2: Annual variance against CY2013 – CY2022 station group average (µg/m³)

Station Group	Year									
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Larger Population	1	0	-2	-2	0	5	11	0	-4	-6
Smaller Communities	0	-1	-3	-2	0	4	12	0	-5	-7
Diagnostic	1	-1	-3	-2	0	5	13	0	-5	-7
Background	0	-1	-3	-2	-1	3	11	1	-4	-5

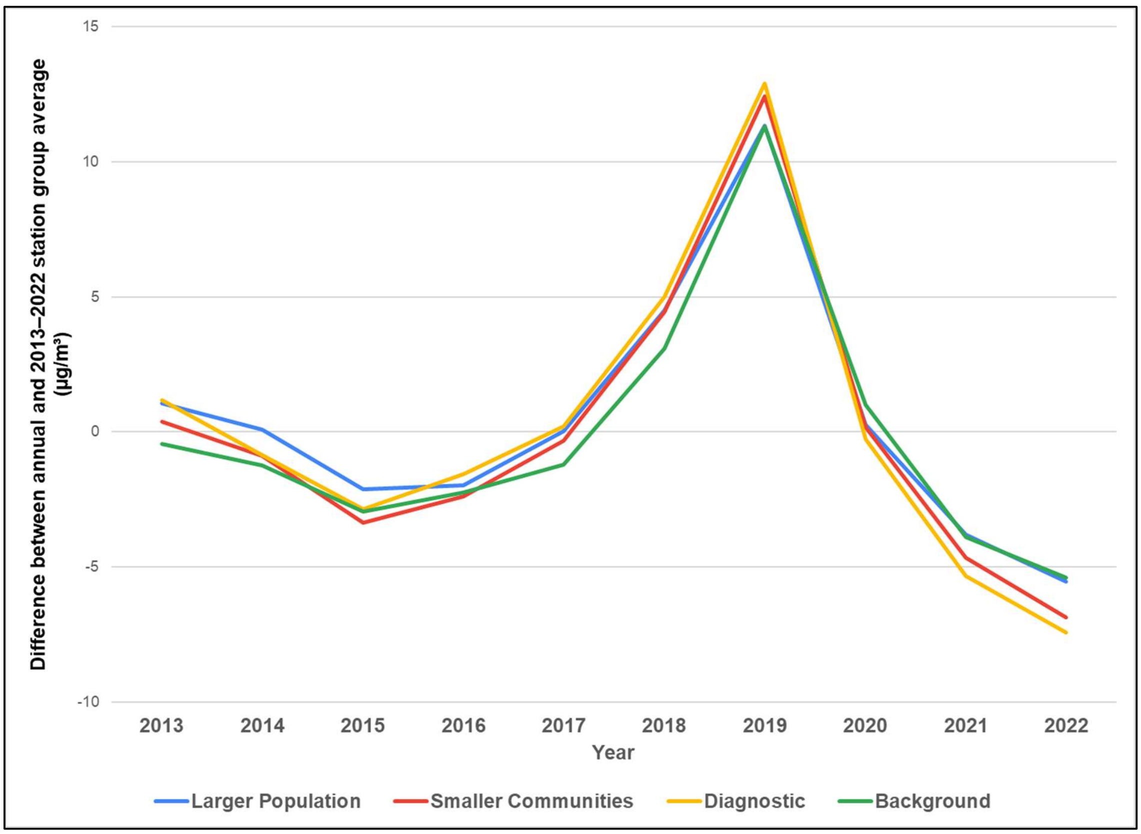


Figure 3.2: Comparison of trends between each UHAQMN station group

Figure 3.2 shows that the differences between PM_{10} concentrations at Background stations and Diagnostic stations are near identical across CY2013-CY2022 (up to 2 µg/m³ variability), while the range in annual average PM_{10} concentrations across this period is 22 µg/m³. This reinforces that changes in Upper Hunter PM_{10} concentrations are associated with regional conditions and are indicative of a minimal change in the contribution from local emission sources inclusive of mining.

As before, inclusion of data for CY2021 and CY2022 reinforces that the annual average for CY2019 was anomalously high across all station groups.

Comparison of UHAQMN annual average PM_{10} and NSW/ACT rainfall

In Appendix A1.4 of the AQ Data Analysis Project, the conclusion is that there is a statistically significant relationship between NSW mean annual rainfall and annual average PM_{10}. This relationship is thus explored further through the inclusion of additional data for CY2021 and CY2022.

Table 3.3 presents NSW/ACT annual rainfall and UHAQMN annual average PM_{10} over the period CY2013-CY2022. These data are shown in Figure 3.3.

Table 3.3: NSW/ACT annual rainfall and UHAQMN annual average PM_{10}

Parameter	Year									
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
UHAQMN PM_{10} (µg/m³)	21	20	18	18	20	25	33	21	16	14
NSW Rainfall (mm)	464	467	541	661	453	333	250	639	721	864

Figure 3.3 clearly shows that there is a negative correlation between rainfall and particulate matter concentrations across the UHAQMN. Given the consistency between PM_{10} trends across NSW and the UHAQMN (refer Figure 3.1), this relationship also holds for NSW PM_{10} concentrations more broadly.

Inclusion of annual average PM_{10} concentration and rainfall data for CY2021 and CY2022 further supports the negative correlation between rainfall and particulate matter concentration. In contrast with CY2019, CY2020-CY2022 shows a significant increase in annual rainfall which was experienced during La Niňa conditions, and a corresponding decrease in annual PM_{10} concentrations.

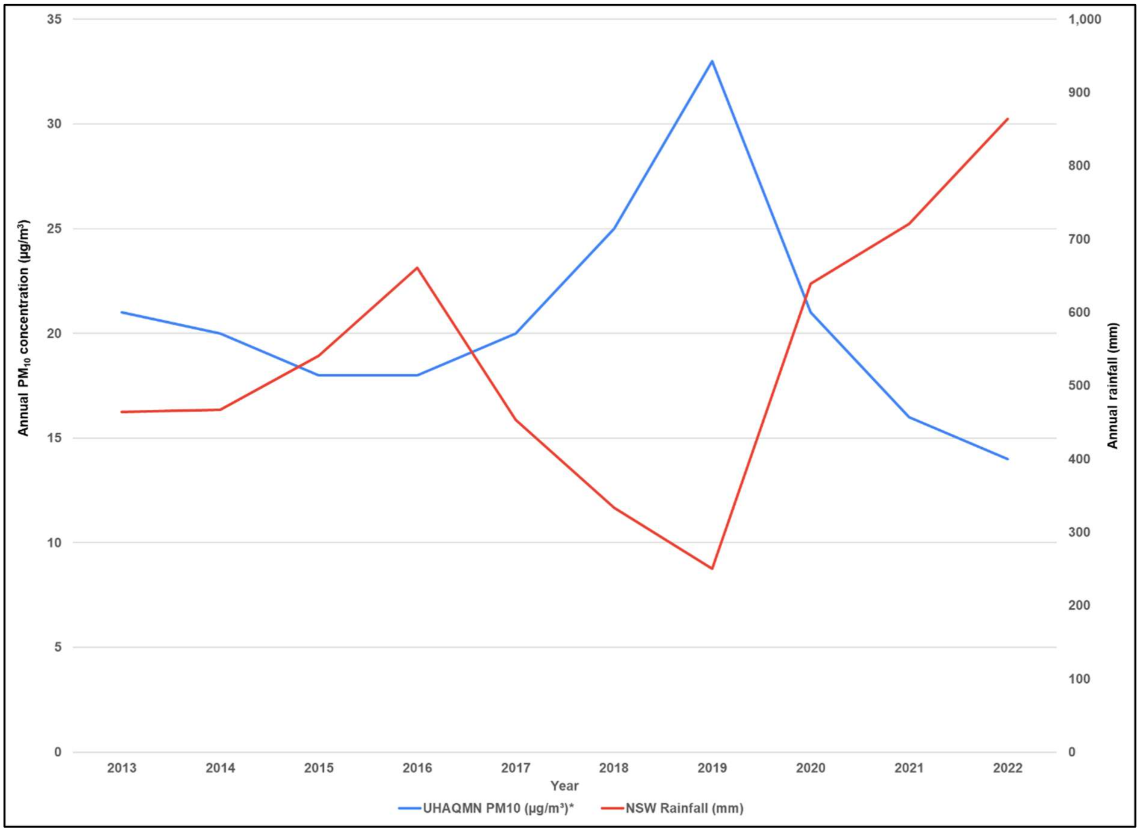


Figure 3.3: NSW/ACT annual rainfall and UHAQMN annual average PM_{10}

Comparison of UHAQMN annual average PM_{10} and Hunter Valley Coal Production

Appendix A1.1 of the AQ Data Analysis Project demonstrated that, over the period 2013-2019, the relationship between annual coal production and annual average PM_{10} is not statistically significant. Similarly, Appendix A1.2 of the AQ Data Analysis Project showed that the relationship between annual National Pollutant Inventory (NPI) reported PM_{10} emissions and annual average PM_{10} concentrations is not statistically significant. This update now presents a comparison of Hunter Valley coal production data and PM_{10} concentrations measured by the UHAQMN including data for CY2021 and CY2022. Table 3.4 presents the Hunter Valley raw coal production between CY2013 and CY2022.

Table 3.4: Hunter Valley raw coal production (2013-2022)

Year	Hunter Valley Raw Coal Production (Mt)	Percentage of 2013 Raw Coal Production (%)
2013	158	100%
2014	160	102%
2015	146	92%
2016	145	92%
2017	146	92%
2018	151	96%
2019	155	99%
2020	146	92%
2021	142	90%
2022	126	80%

As shown in Table 3.4, the annual Hunter Valley raw coal production rates have been generally consistent over the period CY2013-CY2021, ranging between 90% and 102% of the 2013 value. Annual coal production rates for CY2022 are lower than other years at 80% of CY2013 values. CY2013 has been nominated as a reference year to show the relative scale of coal production since the beginning of the monitoring study period. Production levels have been decreasing year on year since 2019.

Figure 3.4 presents the comparison of Hunter Valley coal production data and UHAQMN annual average PM_{10} concentrations.

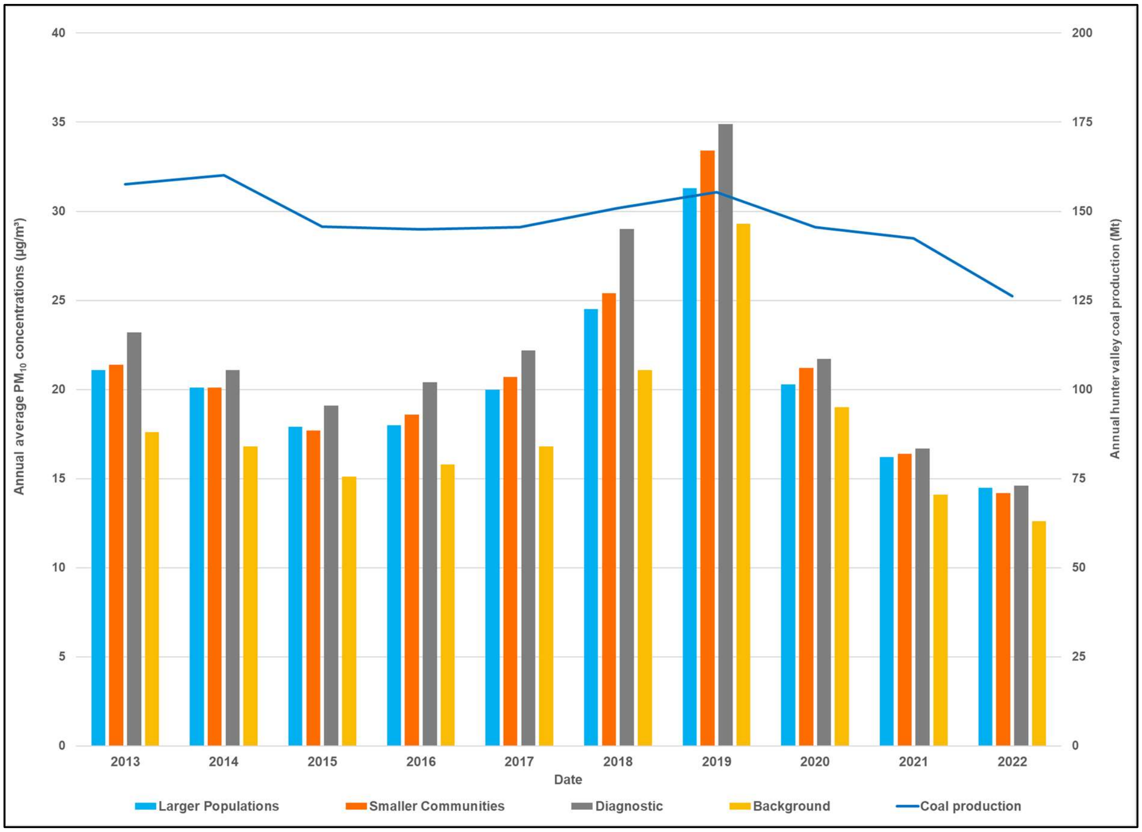


Figure 3.4: Comparison of Hunter Valley coal production data and UHAQMN annual average PM_{10} concentrations

As shown in these data, there is no visually apparent correlation between raw coal production and ambient PM_{10} concentrations measured by the UHAQMN between 2013 and 2019. Figure 3.4 shows inconsistency in the scale of variability in each metric across 2013 – 2019, with minor proportional variability in coal production relative to significant proportional variability in annual average PM_{10}.

From 2019 to 2022, both coal production and annual average PM_{10} concentrations have reduced year on year. However, the reductions in annual average PM_{10} concentrations are anticipated to be related to the lower ambient temperatures and significant amounts of rainfall during these years, rather than the reduced coal production. It is recommended that this apparent trend be reevaluated in future years.

4 Closure

As noted within the previous reports and reinforced with the inclusion of CY2021 and CY2022 data, the temporal trends in the UHAQMN and 'Remainder of NSW' monitoring subsets show that the changes in PM_{10} concentrations within the Upper Hunter are generally consistent with changes experienced across the rest of NSW.

With the inclusion of CY2021 and CY2022 data, it continues to be seen that there is a negative correlation between rainfall and particulate matter concentrations across the UHAQMN. Given the consistency between PM_{10} trends across NSW and the UHAQMN, this relationship also holds for NSW PM_{10} concentrations more broadly.

The differences between PM_{10} concentrations at Background stations and Diagnostic stations are near identical across CY2013-CY2022 (up to 2 µg/m³ variability), while the range in annual average PM_{10} concentrations across this period is 22 µg/m³. This reinforces that changes in Upper Hunter PM_{10} concentrations are associated with regional conditions and are indicative of a minimal change in the contribution from local emission sources inclusive of mining.

There is no visually apparent correlation between raw coal production and ambient PM_{10} concentrations measured by the UHAQMN between CY2013 and CY2019. The supporting figure shows inconsistency in the scale of variability in each metric across this period, with minor proportional variability in coal production relative to significant proportional variability in annual average PM_{10}.

From 2019 to 2022, both coal production and annual average PM_{10} concentrations have reduced year on year. However, the reductions in annual average PM_{10} concentrations are anticipated to be related to the lower ambient temperatures and significant amounts of rainfall during these years, rather than the reduced coal production. It is recommended that this apparent trend be reevaluated in future years.

We trust that the above provides an appropriate level of detail to meet your requirements. Do not hesitate to contact the undersigned if you have any queries on the above.

Yours sincerely

Damon Roddis
Principal - Air Quality and Carbon
Zephyr Environmental
damon.roddis@zephyrenviro.com

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