Ambient Air Quality Monitoring Report
2021-2022
EPBC 2008/45546

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Abbreviations and definitions

Term	Definition	Description and context for this report
µm	Micrometre	One millionth (0.000001) of a metre
CSIRO	The Commonwealth Scientific and Industrial Research Organisation	The Commonwealth Scientific and Industrial Research Organisation is an independent Australian federal government agency responsible for scientific research.
EPBC	Environment Protection and Biodiversity Conservation	Refers to the Australian Government EPBC Act of 1999
Insoluble fraction	Component of deposited dust that is not soluble in water	Deposited dust can comprise of aqueous soluble and insoluble materials depending on mechanisms and sources of dust emissions. The insoluble fraction is typically derived from crustal materials.
MicroVol	MicroVol 1100 low volume sampler	Low volume air sampling instrument for sampling of TSP, manufactured by Ecotech
NH_3	Ammonia	Gaseous air pollutant from natural sources and industrial sources (including YPN TAN Plant)
NO_2	Nitrogen dioxide	Gaseous air pollutant from combustion sources
OEMP	Operational Environmental Management Plan	Management plan prepared by YPN in accordance with Condition 7 of the EPBC Approval (as varied 24 March 2020)
Passive sampling	Ambient air sampling for gaseous substances involving passive samplers	Sampling technique whereby airborne gaseous pollutants are extracted from the air column onto an adsorbent material via a diffusive mechanism
PM_{10}	Particulate matter (10 micrometre)	Dust particles which are present in ambient air with an equivalent aerodynamic diameter of 10 micrometres (µm)
Radiello® passive sampler	Sampler for gaseous substances in ambient air	Sampling devices manufactured by Sigma Aldrich under licence from Fondazione Salvatore Maugeri IRCCS for passively monitoring airborne concentrations of gases
SO_2	Sulfur dioxide	Gaseous air pollutant from oxidation (combustion) of sulfur containing substances
Soluble fraction	Component of deposited dust that is soluble in water	Deposited dust can comprise of aqueous soluble and insoluble materials depending on mechanisms and sources of dust emissions. The soluble fraction is typically derived from marine aerosols
TAN Plant	Technical Ammonium Nitrate Plant	YPN plant on the Burrup for production of ammonium nitrate
TSP	Total suspended particulates	Dust particles which are present in ambient air with equivalent aerodynamic diameter of 50 micrometres (µm)
YPN	Yara Pilbara Nitrates	The operator of the TAN Plant

1. Introduction

Conditions 9 and 9A of EPBC Approval 2008/4546 (as varied 24 March 2020) for the Yara Pilbara Nitrates Pty Ltd (YPN) Technical Ammonium Nitrate (TAN) Plant require monitoring of various air quality parameters. Condition 3 of the EPBC Approval outlines reporting requirements, including an analysis of monitoring data from the monitoring program conducted under condition 9A.

This report is provided in response to Condition 3(a) of the EPBC Approval for the reporting period 1 July 2021 to 30 June 2022.

2. Scope of monitoring program

EPBC Approval 2008/4546 required baseline monitoring to be conducted for a period of not less than 24 months from the commencement of construction of the TAN Plant. YPN issued a report to the Department of the Environment and Energy on 16 June 2017 in compliance with the requirements of Conditions 9(a), (b), (c) and (d) (YPN 2017).

Condition 9A of EPBC Approval 2008/4546 (as varied 24 March 2020) informed the scope of the ongoing monitoring program and is reproduced below (Figure 1).

9A. To protect the values of the Dampier Archipelago (including Burrup Peninsula) National Heritage Place, particularly the rock art sites, the person taking the action must ensure:

a) Ongoing air quality monitoring is undertaken within 30 days after this condition comes into effect (the date the relevant variation to conditions notice is signed) and until expiry of the approval.

b) Air quality monitoring parameters are monitored at the rock art sites: Site 5 (Burrup Road), Site 6 (Water tanks site) and Site 7 (Hearson Cove Road site) as shown in Attachment 2.

c) Monitoring of air quality at rock art sites is undertaken by a suitably qualified person (Air Quality)

The air quality monitoring parameters in the table below must be monitored at the frequencies indicated in the table below:

Element of air quality to be monitored	*Specific air quality parameter to be sampled*	*Minimum frequency of monitoring*
Ambient air concentration of gases	*NH_3 (ammonia)*	*Continuous monitoring for at least 14 consecutive days, every month*
	NO_2 (nitrogen oxide)	
	SO_2 (sulfur oxide)	
Airborne particulate concentration	*Total suspended particulates up to 50 µm (TSP)*	*Every 6 days*
Deposited dust	*Total dust deposition per month (Insoluble Fraction)*	*Quarterly*
	Total dust deposition per month (Soluble Fraction)	

Figure 1: Condition 9A of EPBC Approval 2008/4546 (as varied 24 March 2020)

Condition 3(a)i of the EPBC Approval requires (in part) publication of a report that includes "*...an analysis of monitoring data required under Condition 9A…"*.

On 24 March 2020, approval was granted to relocate monitoring Site 7 (Deep Gorge) to accommodate the development of a boardwalk at the heritage site Ngajarli (formerly known as Deep Gorge) by Murujuga Aboriginal Corporation (MAC).

Consequently, Site 7 was relocated to Hearson Cove on 8 April 2020. This site was referred to as 'Deep Gorge' in the report for 2020-2021; however, the site is now closer to Hearson Cove and is referred to as 'Hearson Cove' herein (including in graphs where data prior to April 2020 is from monitoring at the Deep Gorge site).

Note that earlier studies carried out by CSIRO included monitoring of gaseous nitric acid (HNO_3). The EPBC Approval does not require monitoring of this substance. However, as described in the Operational Environmental Management Plan (OEMP) prepared by YPN for the EPBC Approval, YPN has continued monitoring HNO_3 since the CSIRO studies concluded. This allows for direct comparisons of current deposition rates with the rates determined since 2003.

The initial report for analysis of the monitoring data as required by the EPBC Approval was issued in October 2018 for the period 2017-2018 (Strategen 2018). A report for the period 2018-2019 was issued in October 2019 (Strategen-JBS&G 2019), a report for the period 2019-2020 was issued in October 2020 and a report for the period 2021-2021 was issued in October 2021 (Strategen-JBS&G 2021). This report presents an analysis of monitoring data obtained for the monitoring period 1 July 2021 to 30 June 2022 (referred to herein as 2021-2022).

3. TAN Plant operation 2021-2022

The TAN Plant was in operation for the following dates during the 2021-2022 monitoring period:

- 1 July 2021 to 11 September 2021;
- 15 September 2021 to 3 December 2021;
- 16 December 2021 to 17 March 2022;
- 3 April 2022 to the 25 May 2022; and
- 1 June 2022 to 30 June 2022.

4. Air quality monitoring program

4.1 Gases (NH_3, NO_2, SO_2 and HNO_3)

4.1.1 Results of NH_3, NO_2, SO_2 and HNO_3 monitoring

Monitoring of gases NH_3, NO_2, SO_2 and HNO_3 using Radiello passive sampling was carried out continuously throughout the 2021-2022 monitoring period at the three specified monitoring sites – Site 5 Burrup Road, Site 6 Water Tanks and Site 7 Hearson Cove.

A total of 24 fortnightly measurements were made of NH_3, NO_2, SO_2 and HNO_3 concentrations at each site during the 1 July 2021 to 30 June 2022 reporting period. Sampling commenced on 30 June 2021 when samplers deployed for the previous fortnight were replaced, and sampling concluded on 1 July 2022.

Tabulated results of the monitoring are shown in Appendix A. The concentrations for each parameter at the respective sites are illustrated in Figure 2 for NH_3, Figure 3 for NO_2 and Figure 4 for SO_2. The concentrations of HNO_3 are illustrated in Figure 5.

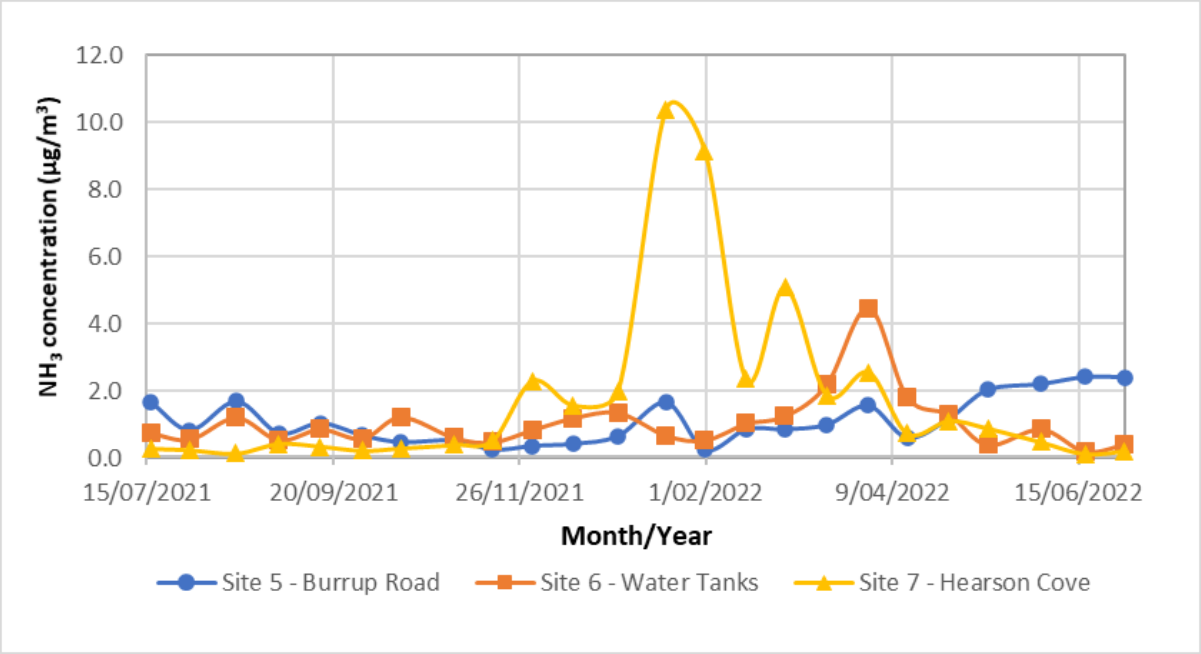

Figure 2: Measured NH_3 concentrations for 1 July 2021 to 30 June 2022

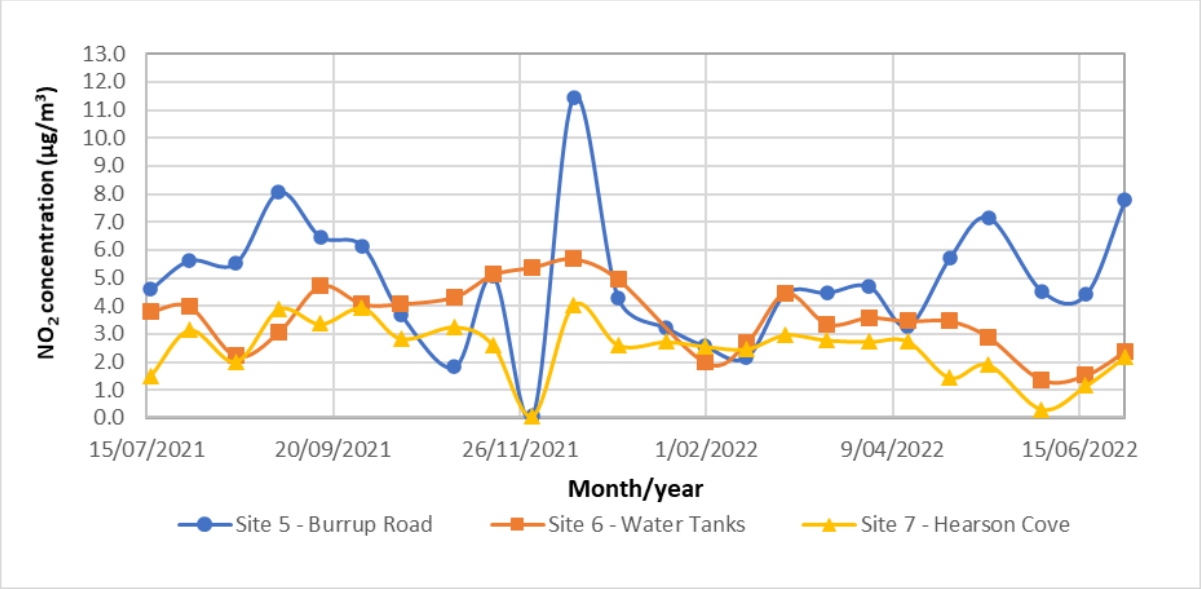

Figure 3: Measured NO_2 concentrations for 1 July 2021 to 30 June 2022

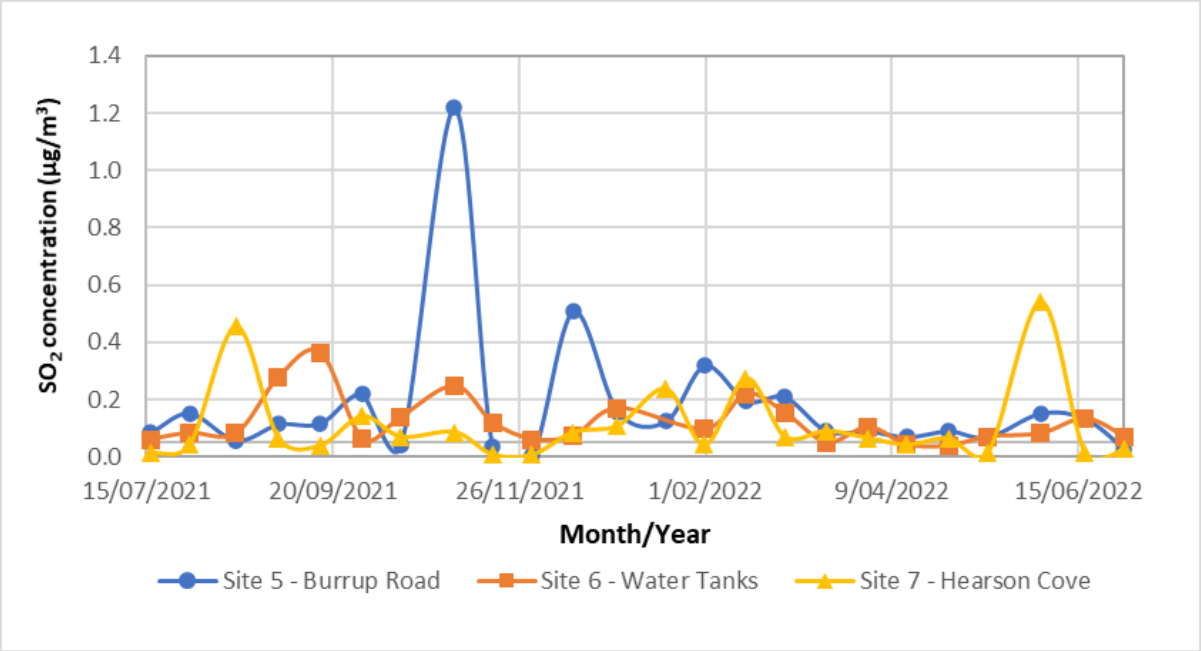

Figure 4: Measured SO_2 concentrations for 1 July 2021 to 30 June 2022

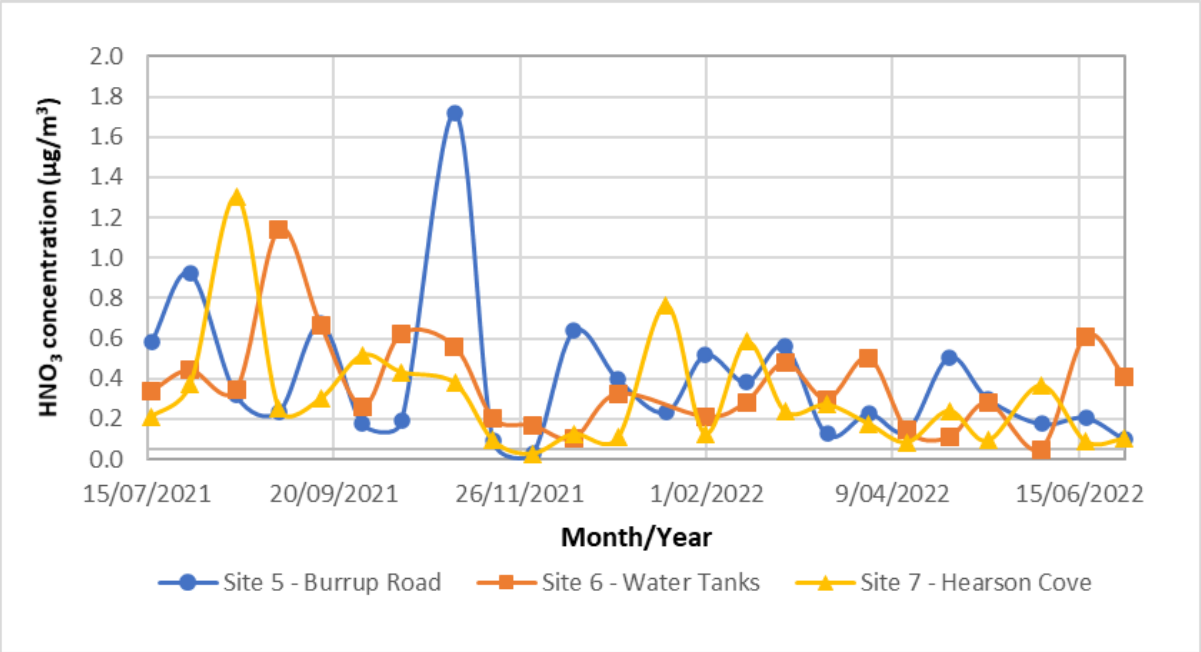

Figure 5: Measured HNO_3 concentrations for 1 July 2021 to 30 June 2022

4.1.2 Analysis of NH_3, NO_2 and SO_2 data

Analysis of measured concentrations involved a comparison of descriptive statistics for the 2021-2022 monitoring period with those from monitoring conducted in the baseline study (YPN 2017). These statistics are shown in Table 1 for concentrations of NH_3, Table 2 for NO_2, Table 3 for SO_2 and Table 4 for HNO_3. Concentrations are calculated for the actual duration of exposure of the samplers, which were nominally 15 days but may vary a day on either side of that duration for logistical reasons.

Table 1: Descriptive statistics for NH_3 concentrations (2021-2022 and baseline)

Ammonia concentration µg/m³						
Statistic	Site 5 - Burrup Rd		Site 6 - Water Tanks		Site 7 - Hearson Cove	
	2021-2022	Baseline	2021-2022	Baseline	2021-2022	Baseline
Minimum	0.24	0	0.20	0	0.12	0
Average	1.10	0.44	1.06	0.93	1.82	0.75
Maximum	2.42	1.2	4.47	3.97	10.37	4.35
Standard deviation	0.69	0.34	0.87	0.76	2.71	0.82

Table 2: Descriptive statistics for NO_2 monitoring (2021-2022 and baseline)

Nitrogen Dioxide concentration µg/m³						
Statistic	Site 5 - Burrup Rd		Site 6 - Water Tanks		Site 7 - Hearson Cove	
	2021-2022	Baseline	2021-2022	Baseline	2021-2022	Baseline
Minimum	0.08	0.38	1.36	0.31	0.08	0.4
Average	4.88	3.6	3.59	2.56	2.47	2.31
Maximum	11.45	6.53	5.69	5.27	4.05	4.12
Standard deviation	2.34	1.46	1.20	1.04	1.02	0.69

Table 3: Descriptive statistics for SO_2 monitoring (2021-2022 and baseline)

Sulfur Dioxide concentration µg/m³						
Statistic	Site 5 - Burrup Rd		Site 6 - Water Tanks		Site 7 - Hearson Cove	
	2021-2022	Baseline	2021-2022	Baseline	2021-2022	Baseline
Minimum	0.01	0.07	0.04	0	0.01	0.13
Average	0.18	1.38	0.12	0.95	0.11	0.82
Maximum	1.22	3.09	0.36	3.5	0.54	2.01
Standard deviation	0.25	0.83	0.08	0.84	0.14	0.53

Table 4: Descriptive statistics for HNO_3 monitoring (2021-2022 and baseline)

Nitric acid concentration µg/m³						
Statistic	Site 5 - Burrup Rd		Site 6 - Water Tanks		Site 7 - Hearson Cove	
	2021-2022	Baseline	2021-2022	Baseline	2021-2022	Baseline
Minimum	0.03	0.00	0.05	0.00	0.03	0.00
Average	0.39	0.58	0.37	0.54	0.30	0.48
Maximum	1.72	1.55	1.14	1.81	1.30	1.42
Standard deviation	0.36	0.45	0.24	0.48	0.28	0.37

The concentrations from 2021-2022 have been compared with the baseline (for each location) via statistical analysis (t-test) to determine if differences in the average concentrations are statistically significant. The results are summarised in Table 5 and key findings from these data are summarised in Table 6.

Table 5: T-test results for comparison of 2021-2022 and baseline NH_3, NO_2, SO_2 and HNO_3 concentration data

Parameter	Monitoring period	Statistic	Site 5 - Burrup Rd	Site 6 - Water Tanks	Site 7 - Hearson Cove
NH_3	2021-2022	Average	1.10	1.06	1.82
	baseline	Average	0.44	0.93	0.75
		P value	$1.18x10^{-04}$	0.54	0.07
NO_2	2021-2022	Average	4.88	3.59	2.47
	baseline	Average	3.60	2.56	2.31
		P value	0.02	0.001	0.49
SO_2	2021-2022	Average	0.18	0.12	0.11
	baseline	Average	1.41	0.95	0.82
		P value	$2.77x10^{-10}$	$5.62x10^{-09}$	$1.20x10^{-10}$
HNO_3	2021-2022	Average	0.39	0.37	0.30
	baseline	Average	0.58	0.54	0.48
		P value	0.08	0.07	0.04

Table 6: Analysis of NH_3, NO_2, SO_2 and HNO_3 concentration data

Parameter	Site	Finding
NH_3	Burrup Rd	The (higher) average NH_3 concentration from 2021-2022 monitoring compared with baseline monitoring at this site is statistically significant.
	Water Tanks	The (higher) average NH_3 concentration from 2021-2022 monitoring compared with baseline monitoring is not statistically significant
	Hearson Cove	The (higher) average NH_3 concentration from 2021-2022 monitoring compared with baseline monitoring is not statistically significant
NO_2	Burrup Road	Differences in the NO_2 concentrations from 2021-2022 compared with baseline monitoring are statistically significant at the Burrup Road and Water Tanks sites.
	Water Tanks	
	Hearson Cove	
SO_2	Burrup Road	The (lower) average SO_2 concentrations from 2021-2022 monitoring compared with baseline monitoring are statistically significant at all three monitoring sites.
	Water Tanks	
	Hearson Cove	
HNO_3	Burrup Road	The (lower) average HNO_3 concentrations from 2021-2022 monitoring compared with baseline monitoring are not statistically significant.
	Water Tanks	
	Hearson Cove	The (lower) average HNO_3 concentrations from 2021-2022 monitoring compared with baseline monitoring are statistically significant.

The average concentrations of NH_3 detected at Water Tanks and Hearson Cove during 2021-2022 were determined to be statistically insignificant from the baseline dataset. The higher average NH_3 levels measured at Burrup Road, however, were determined to be statistically significant. The average was contributed to by elevated concentrations from four sampling periods in mid-May 2022 onwards and were above the levels measured at the other two monitoring sites.

A TAN Plant shut down occurred on 25 May 2022 followed by a start-up on the 1 June 2022, which means that TAN Plant operation is not the likely source of the prolonged increase in ammonia levels. This suggests other sources of ammonia may have contributed to the ambient concentration at Burrup Road.

The differences in average concentrations of NO_2 at the Water Tanks and Burrup Road sites recorded during 2021-2022 and baseline were statistically significant.

Continuing from previous years, statistically significant decreases in the SO_2 concentrations recorded during the 2021-2022 monitoring period compared with the baseline study were determined for all three monitoring sites (Table 5). The reasons for the apparent decrease in average SO_2 concentrations since the baseline data were recorded are not known but may reflect a reduced frequency of flaring at the gas plants on the Burrup Peninsula or the use of lower sulfur fuels in ships that visit the Port of Dampier.

The reason for a statistically significant decrease in the HNO_3 concentrations recorded at Hearson Cove during the 2021-2022 monitoring period relative to the baseline study is unknown but is consistent with results from the previous reporting period (Table 5).

4.1.3 Dry deposition rates - gases

Annual (total) dry deposition rates were calculated from the gas sampling at the three monitoring sites for the duration of the baseline and ongoing monitoring program. Total annual deposition rates were calculated from the combined rates for NH_3, NO_2, SO_2 and HNO_3. The results for total annual dry deposition are illustrated in Figure 6.

Monitoring periods are from the start of July to the end of June in the following year, except for the 2013-2014 monitoring period, which is reported for September 2013 to August 2014; thus, overlapping with the 2014-2015 period to represent an entire 12-month period.

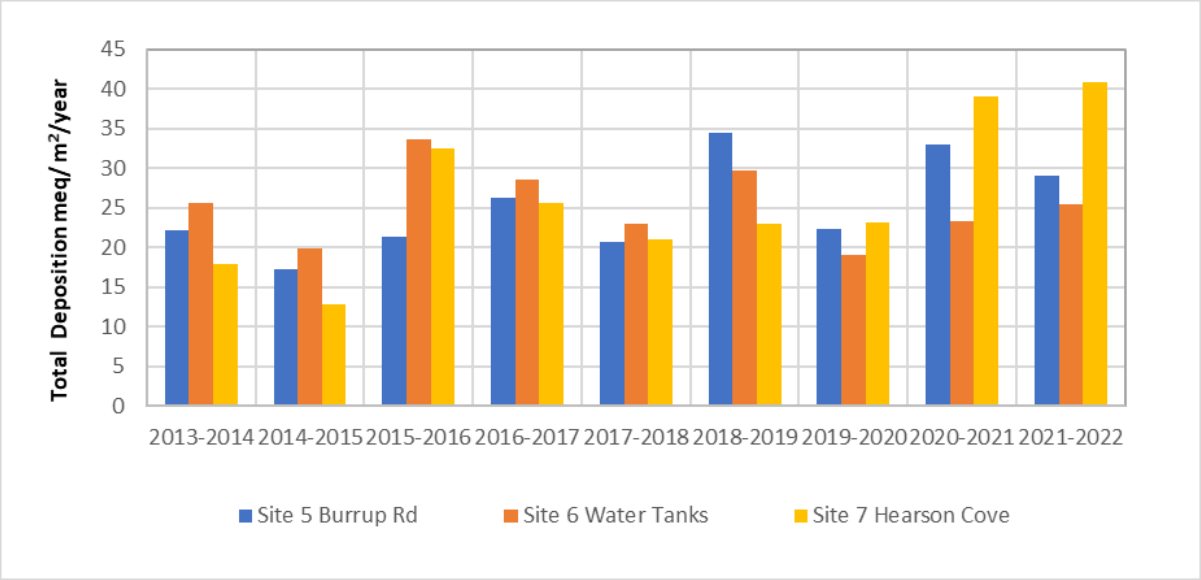

Figure 6: Annual deposition rates from measured gases (2013-2022)

The results are summarised in Table 7. Investigation levels were derived from the average of rolling monthly annual deposition rates from the baseline period plus three standard deviations (as described in the OEMP).

Table 7: Annual dry deposition rates

Year	Annual deposition rates meq/m²/year		
	Site 5 Burrup Rd	Site 6 Water Tanks	Site 7 Hearson Cove
2013-2014	22.1	25.6	17.9
2014-2015	17.3	19.8	12.9
2015-2016	21.3	33.6	32.4
2016-2017	26.3	28.5	25.6
2017-2018	20.7	23.0	21.0
2018-2019	34.5	29.7	23.0
2019-2020	22.4	19.0	23.2
2020-2021	32.9	23.3	39.1
2021-2022	29.1	25.4	40.9
investigation level	25.5	42.2	51.8

Annual rates for 1 July to 30 June, except for 2013-2014 which is for 1 September 2013 to 31 August 2014

During 2021-2022, dry deposition rates of gas species have remained within the levels observed in previous years at the Burrup Road and Water Tanks sites. At Site 7, which was relocated to Hearson Cove in April 2020, the results have been elevated compared to data collected in previous years (June 2013 – June 2020) at Deep Gorge. This may be a direct result of of the change in location, with the Hearson Cove site being in a more exposed location than the previous Deep Gorge site.

The Burrup Road site was determined as remaining above the investigation level in 2021-2022, while Water Tanks and Hearson Cove continued to remain below the respective investigation level. The composition of the total deposition at each site is illustrated in Figure 7 to Figure 9.

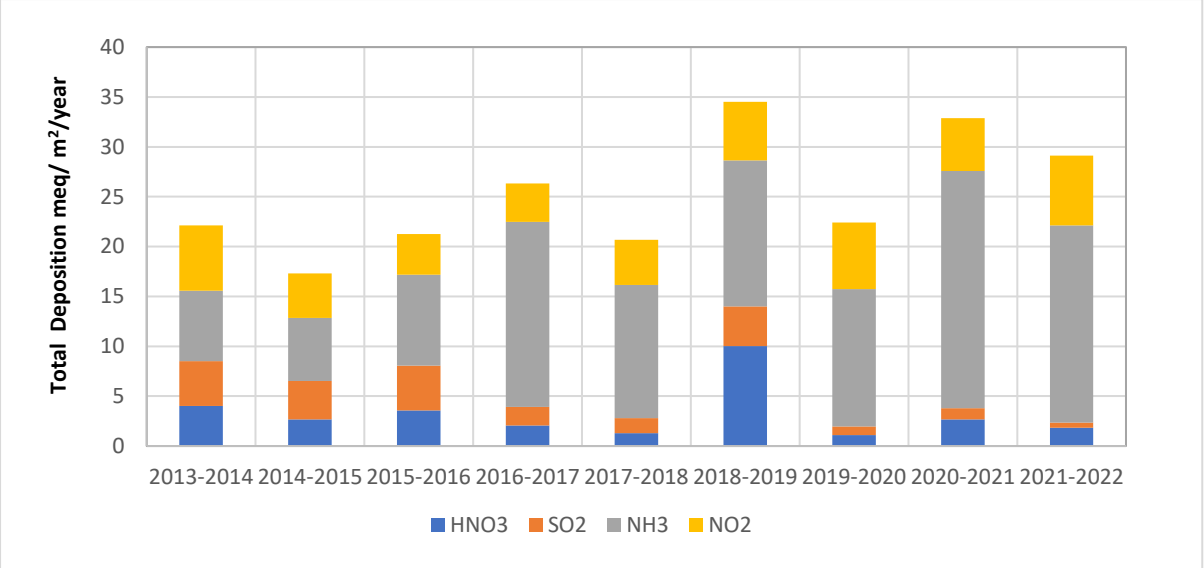

Figure 7: Burrup Road dry deposition composition

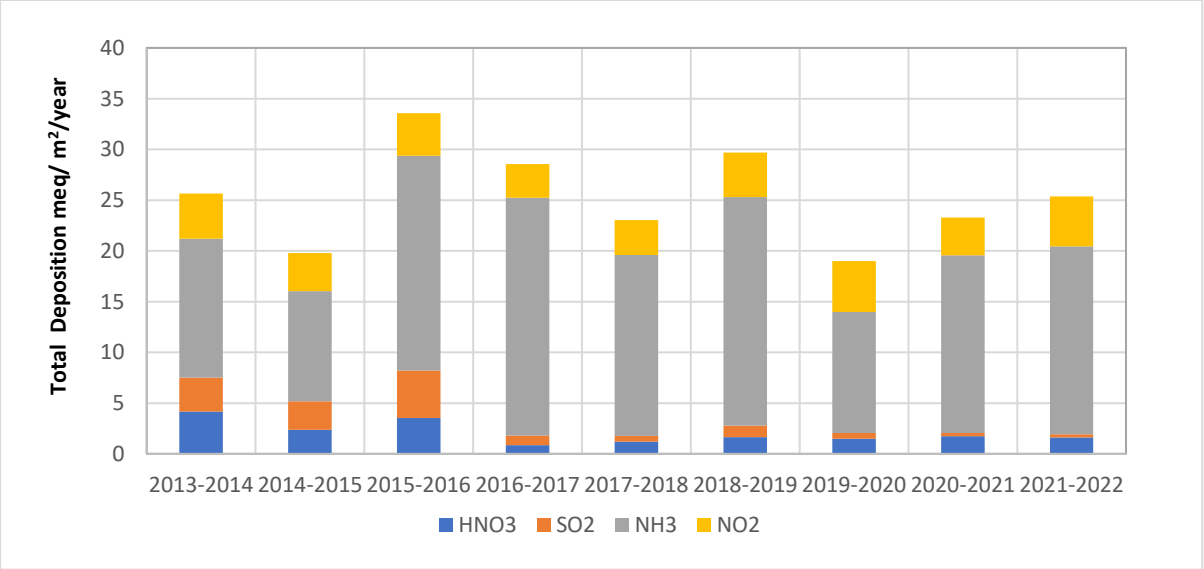

Figure 8: Water Tanks dry deposition rates

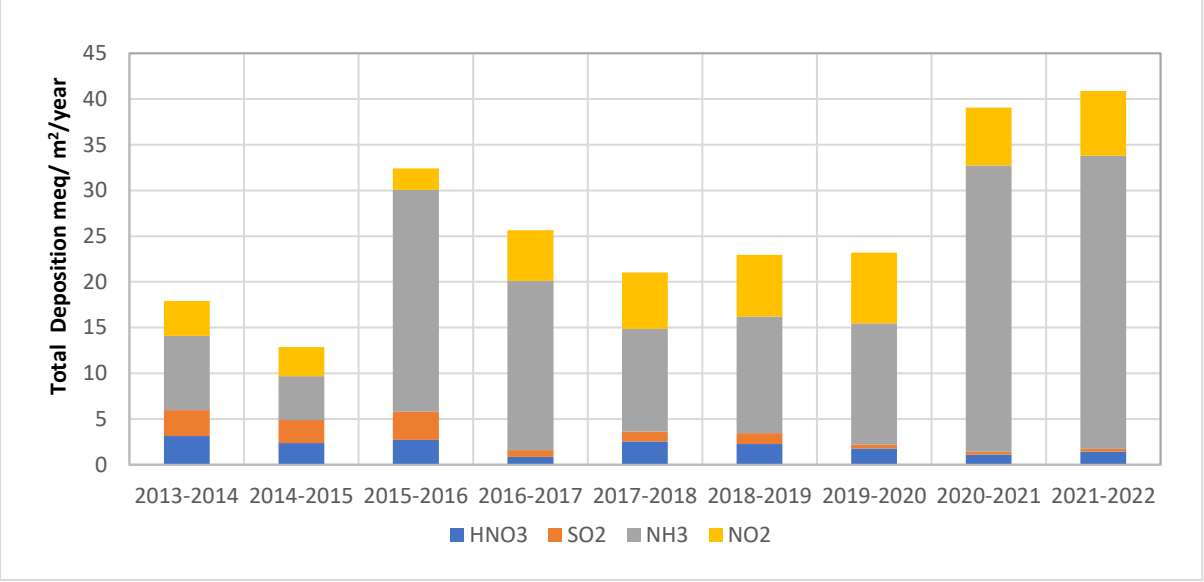

Figure 9: Hearson Cove dry deposition rates

The OEMP advises that increases in deposition rates above the control limits (now referred to as investigation levels) will trigger an investigation into the reasons for the increase. Findings from that investigation are discussed in Section 5.

4.2 Total suspended particulates

4.2.1 Results of TSP monitoring 2021-2022

Monitoring for total suspended particulate (TSP) using MicroVol samplers was conducted at the three monitoring sites. Monitoring was conducted for 24 hours every six days from the period 3 July 2021 to 28 June 2022.

Valid data was collected at all sites throughout the monitoring period. The exception was the Hearson Cove sample for 24 November 21, as gravimetric analysis determined the filter weighed less than the start weight after exposure. No explanation for this anomaly was identified, and the sample was considered a spoiled sample and was discarded from the data set.

Similar trends in the concentrations from the three monitoring sites are observable across the year (Figure 10). This suggests the monitoring data reflects TSP trends in the Burrup airshed rather than direct impacts from individual local sources.

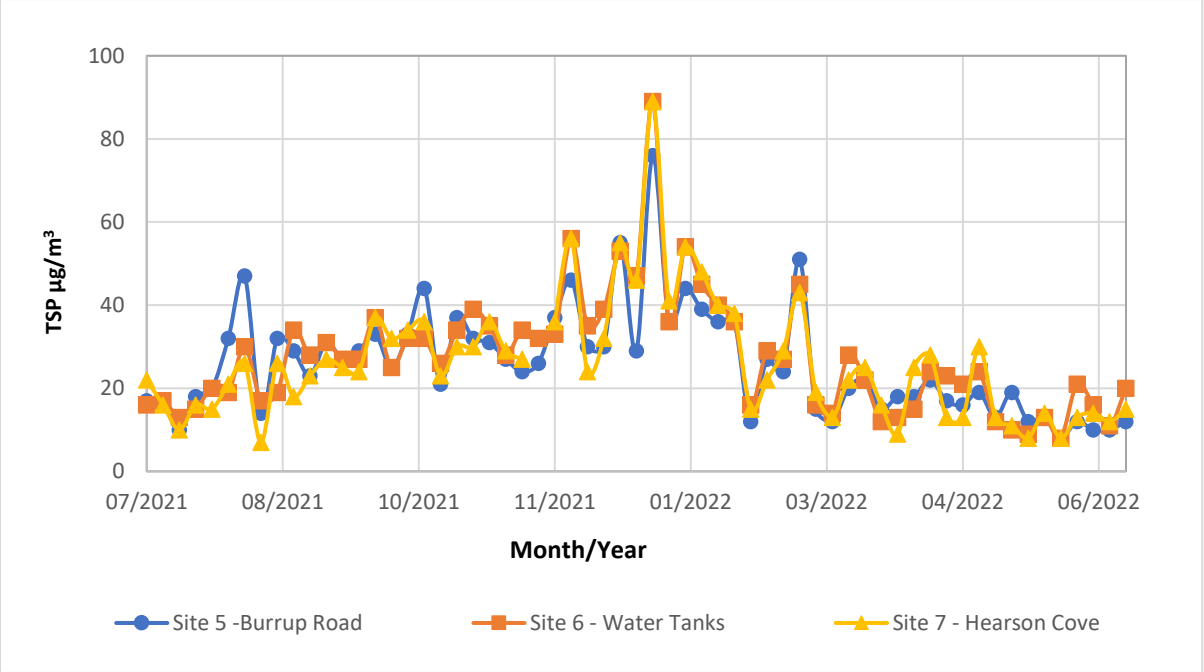

Figure 10: Measured TSP concentrations for 2021-2022

The baseline dataset was derived from direct TSP measurements as well as from estimates calculated from measured PM_{10} concentrations as described in the baseline report (YPN 2017). Furthermore, the measured baseline dataset for Water Tanks was impacted by local activities associated with the construction of the TAN Plant, resulting in an over-representation of background levels at that site. The ongoing measured average concentration data are consequently compared to both the measured and calculated datasets for baseline (Figure 11).

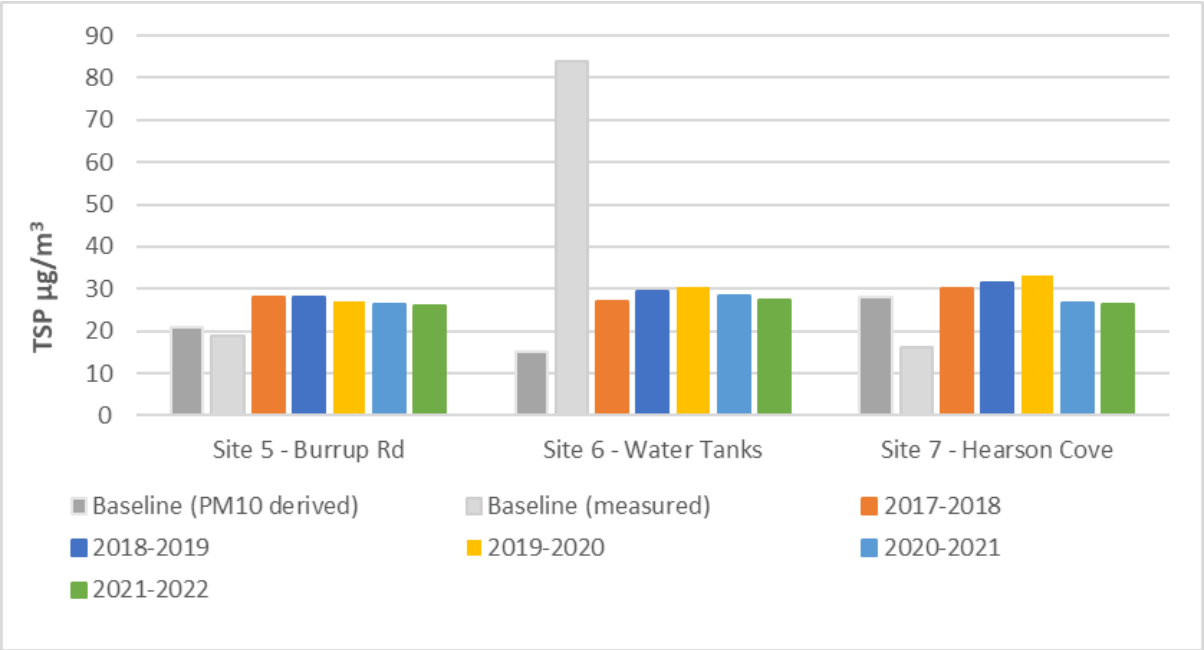

Figure 11: Comparison of average TSP concentrations for 2021 to 2022 with previous years' and baseline data

Descriptive statistics for 2021-2022 TSP monitoring at all three sites are shown in Table 8 alongside the monitoring data for 2020-2021, 2019-2020, 2018-2019 and 2017-2018.

Table 8: Descriptive statistics for TSP monitoring 2018 to 2022 – Burrup Road

TSP concentration µg/m³					
	Site 5 - Burrup Rd				
Statistic	2021-2022	2020-2021	2019-2020	2018-2019	2017-2018
Minimum	8	5	8	2	6
Average	26	27	27	28	28
Maximum	76	78	77	66	76
Standard deviation	13	14	15	14	13

Table 9: Descriptive statistics for TSP monitoring 2018 to 2022 – Water Tanks

TSP concentration µg/m³					
	Site 6 - Water Tanks				
Statistic	2021-2022	2020-2021	2019-2020	2018-2019	2017-2018
Minimum	8	5	9	8	6
Average	28	28	31	29	27
Maximum	89	79	141	63	76
Standard deviation	14	15	22	13	12

Table 10: Descriptive statistics for TSP monitoring 2018 to 2022 – Hearson Cove

TSP concentration µg/m³					
	Site 7 - Hearson Cove				
Statistic	2021-2022	2020-2021	2019-2020	2018-2019	2017-2018
Minimum	7	7	8	8	11
Average	26	27	33	32	30
Maximum	89	67	148	67	79
Standard deviation	15	14	23	15	15

A comparison of the mean TSP concentrations measured during baseline and the subsequent five years of the monitoring program shows the average TSP concentration for 2021-2022 was similar to the results from the four previous years (Figure 11 and Table 8).

The levels monitored at Water Tanks in the five years after the baseline study have persisted lower than the baseline measured data and are comparable to the levels recorded at other sites. This continues to support the hypothesis that the baseline measurements at the Water Tanks site were affected by construction activities.

The 2021-2022 data were compared to the measured datasets from 2017-2018, 2018-2019, 2019-2020 and 2020-2021 to determine if there was any significant change in the recorded ambient TSP levels. The 2021-2022 dataset was determined not to be statistically significantly different from previous reporting years at any of the three monitoring sites.

4.3 Dust deposition

4.3.1 Results from monitoring deposited dust for 2021-2022

Results of dust deposition monitoring at the three sites are shown in Table 9. Values with a less than (<) prefix indicate deposition rates measured were below the method detection limits, with the value indicating the limit. The detection limit was high for the May 2022 sample due to the volume of rainwater in the dust deposition bottles.

Table 9: Results of dust deposition monitoring 2021-2022

Date Deployed	Date Collected	Site 5 - Burrup Road		Site 6 - Water Tanks		Site 7 – Hearson Cove	
		Soluble solids	Insoluble solids	Soluble solids	Insoluble solids	Soluble solids	Insoluble solids
		g/m²/month	g/m²/month	g/m²/month	g/m²/month	g/m²/month	g/m²/month
30/06/2021	30/07/2021	<0.7	<0.8	1.0	1.0	<0.7	0.9
30/07/2021	31/08/2021	<0.7	1.5	1.3	<0.8	<0.7	<0.8
31/08/2021	30/09/2021	<0.7	1.0	<0.7	<0.8	<0.7	<0.8
30/09/2021	2/11/2021	<0.7	0.9	1.1	1.3	<0.7	<0.8
2/11/2021	30/11/2021	<0.7	<0.8	1.7	1.4	0.9	1.9
30/11/2021	31/12/2021	1.4	1.8	<0.7	1.6	0.7	1.6
31/12/2021	31/01/2022	0.9	1.5	<0.7	1.8	0.9	1.7
31/01/2022	1/03/2022	1.9	1.3	1.4	1.3	1.7	1.3
1/03/2022	31/03/2022	<0.7	1.5	0.8	1.7	<0.7	1.7
31/03/2022	29/04/2022	1.1	0.9	1.6	0.8	0.9	1.4
29/04/2022	1/06/2022	<3	<0.8	6.3	0.8	6	1.1
1/06/2022	1/07/2022	1.1	1.1	1	<0.8	1.3	<0.8

4.3.2 Analysis of dust deposition data

A comparison of the dust deposition data from 2021-2022 with the baseline data (insoluble fraction only) is shown in Table 10.

Table 10: Descriptive statistics for dust deposition monitoring 2021-2022 and baseline study

Statistic(1)	Burrup Rd (g/m²/month)			Water Tanks (g/m²/month)			Hearson Cove (g/m²/month)		
	2021-2022		Baseline	2021-2022		Baseline	2021-2022		Baseline
	Soluble	Insoluble	Insoluble	Soluble	Insoluble	Insoluble	Soluble	Insoluble	Insoluble
Minimum	0.4	0.4	0.4	0.4	0.4	0.9	0.4	0.4	0.4
Average	0.8	1.1	1.4	1.1	1.2	1.5	0.8	1.1	1.4
95th percentile	1.68	1.64	3.77	1.75	3.64	1.83	1.68	1.64	3.77
Maximum	1.9	1.8	6.3	1.8	6.0	1.9	1.9	1.8	6.3

(1) Half method detection limit deposition rates for non-detect results were used for calculations of statistics.

Average deposition rates for the insoluble fraction are slightly lower than the baseline across all three monitoring sites. The differences between the baseline and 2021-2022 datasets were not statistically significant at any of the three monitoring sites (determined by t-test P values >0.05). The average measured insoluble fraction is within the range seen in other years (Figure 12).

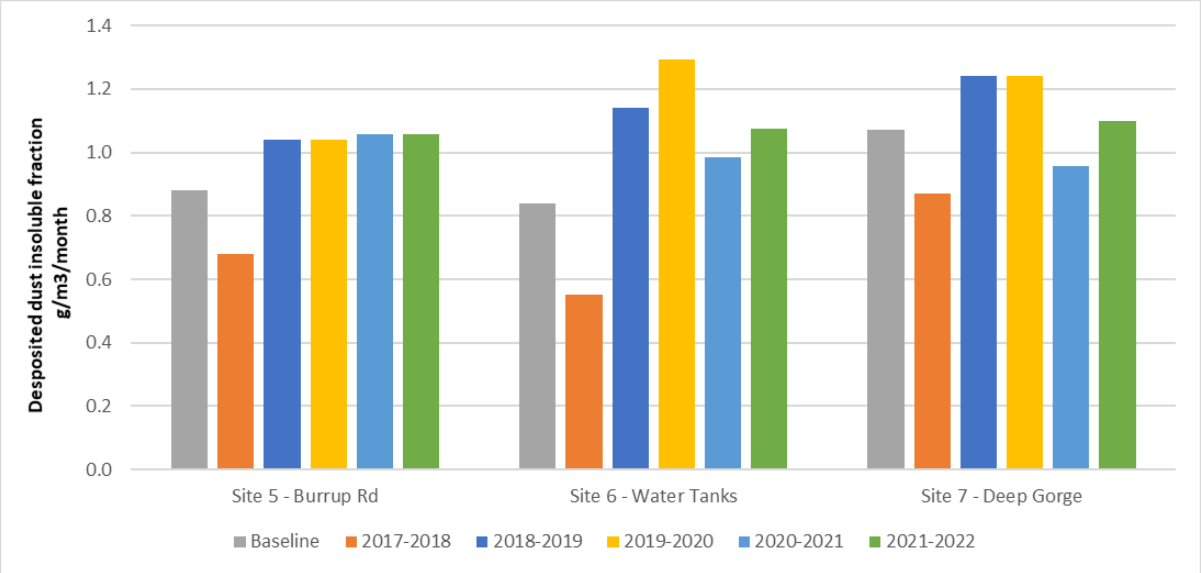

Figure 12: Deposited dust average insoluble fraction 2021-2022

Similar trends in the insoluble deposition rates were observed at the three sites across most of the monitoring period (Figure 13). Note that these comparisons reflect the use of non-detect deposition rates of half the detection limits for the 2021-2022 data. The actual deposition rates below detection limits may be lower or higher than the half detection rates.

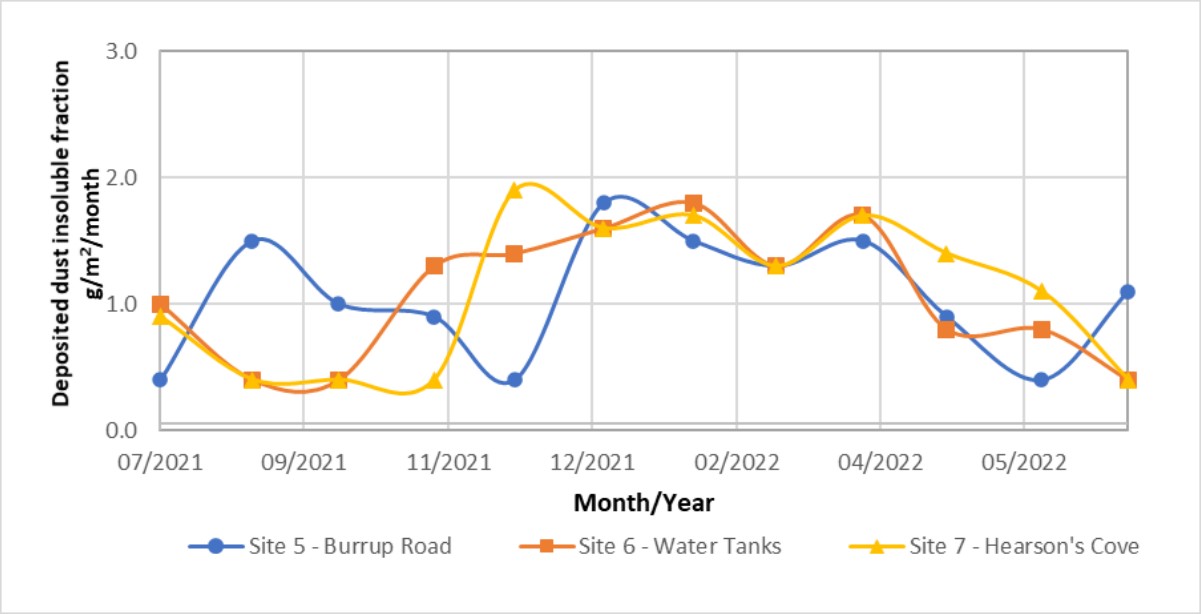

Figure 13: Deposited dust insoluble fraction 2021-2022

The soluble fraction was not determined in samples collected for the baseline study as the EPBC Approval at the time (dated 14 September 2011) only required measurements of TSP and "dust". The latter requirement was interpreted to mean the insoluble fraction of deposited dust. The amended approval of 12 September 2017 required both insoluble and soluble fractions of deposited dust to be monitored. In the absence of baseline data, the data for the 2021-2022 soluble fraction is compared to the data collected for the 2017-2018, 2018-2019, 2019-2020, and 2020-2021 monitoring periods.

The average soluble fraction measured from the deposited dust collected in 2021-2022 is comparable to previous years at Burrup Road and Hearson Cove (Figure 14).

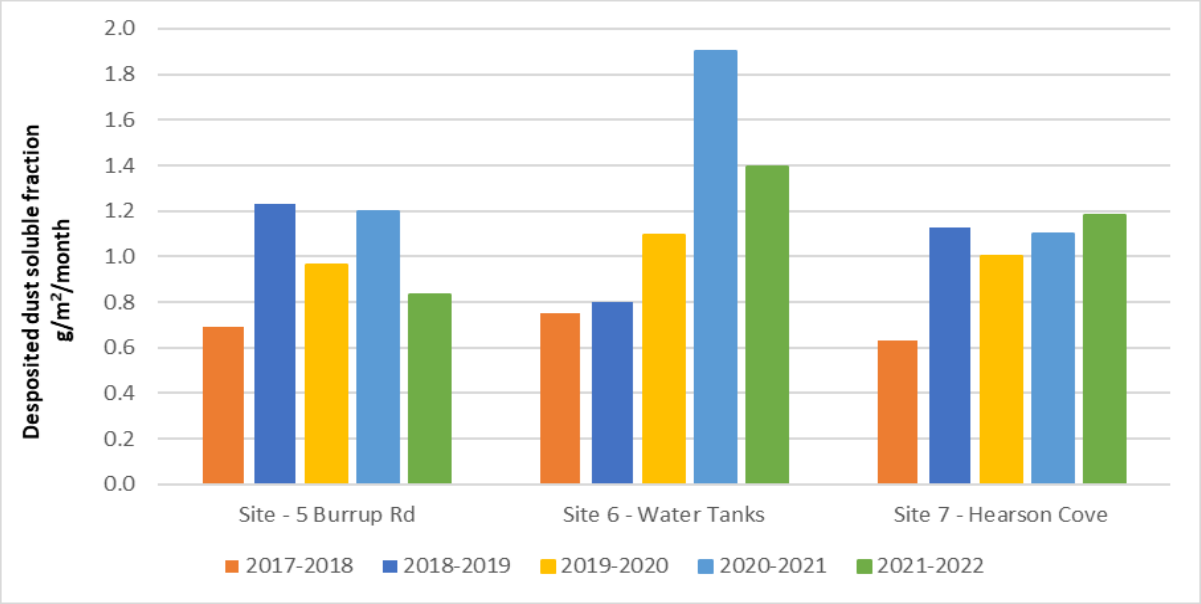

Figure 14: Deposited dust average soluble fraction 2021-2022

Some variability in the monthly data for the soluble fraction of deposited dust across the three monitoring sites is evident (Figure 15). The May 2022 results from Water Tanks and Hearson Cove monitoring sites were elevated compared to other monitoring periods and the Burrup Road site, including the May 2022 monitoring period.

There was high rainfall during May 2022, and, thus, it is possible that prevailing stormy conditions may have led to elevated atmospheric salt from sea spray. The elevated concentrations at the two monitoring stations to the east may reflect shielding of the Burrup Road site from salt blown from a westerly direction, or that Water Tanks and Hearson Cove are in closest proximity to the coast (to the east).

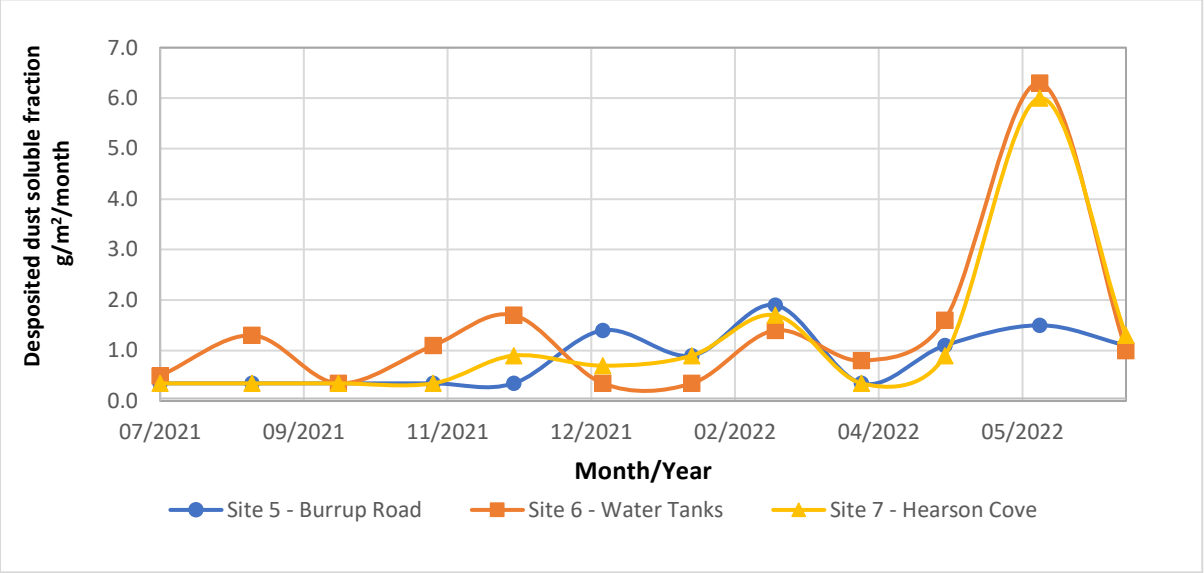

Figure 15: Deposited dust soluble fraction 2021-2022

Most of the soluble dust deposited on the Burrup is expected to be from marine sources, i.e., sea salt, which suggests similar soluble deposition rates should be observed at the three monitoring sites. The more variable nature of soluble deposition rates from September 2021 to January 2022, similar to what has been seen in previous reporting periods, may reflect the wind being predominantly from the west.

During westerly winds, the landform that air coming from the ocean must pass over could influence the amount of entrained sea salt, and thus deposition varies at the three sites, which have varying degrees of shielding to the west. During the months that the three sites recorded similar deposition, the winds were predominantly from the east. During an easterly wind, sea salt could be carried relatively unimpeded from the ocean to the three monitoring sites.

A confounding factor for soluble deposition at the three sites is the potential for aerosol emissions from the sea-water cooling tower at the adjacent Ammonia Plant and the (smaller) sea-water cooling tower on the northwest corner of the TAN Plant. Aerosol emissions (known as “drift”) may occur from the top of the towers if the mist eliminator efficiency declines in the cooling towers or if strong crosswinds occur that mobilise droplets from the sides of the cooling towers. The water in the aerosols is likely to evaporate, leaving behind particulate matter (salt) that will deposit in the immediate surroundings of the towers depending on the particle size. If salt particles persist in the air column, then they can report to the soluble deposition fraction at the monitoring sites for relevant wind directions.

Note that sea salt deposition is accounted for in the calculation of total deposition rates to facilitate the identification of other sources of particulate matter that can deposit on surfaces in the vicinity of the Ammonia Plant and TAN Plant.

Overall, the levels of dust deposited at the monitoring sites are largely consistent with those observed from the baseline study and previous monitoring since 2017.

5. Dry deposition rate investigation and actions

5.1 Investigation

As described in Section 4.1.3, the monitoring conducted for 2021-2022 showed that dry deposition rates at Burrup Road (29.1 meq/m^2/y) exceeded the investigation level (25.5 meq/m^2/y) established from the baseline study. This outcome has triggered an investigation as per the OEMP.

Key factors examined include trends and contributions of individual gases to the total deposition rates and TAN Plant availability and operation.

Trends in deposition rates since 2014 (as monthly rolling annual total rates) are illustrated in Figure 16. The 2021-2022 monitoring period is indicated in the graph. Ammonia was the dominant contributor to dry deposition at Burrup Road (Figure 16). Ammonia annual deposition fell from the peak recorded at the end of the 2020-2021 reporting period to levels within the annual deposition rates previously recorded. Monthly deposition rates were comparable to peak deposition rates, typically occuring during May-June, from previous years at Burrup Road (Figure 17).

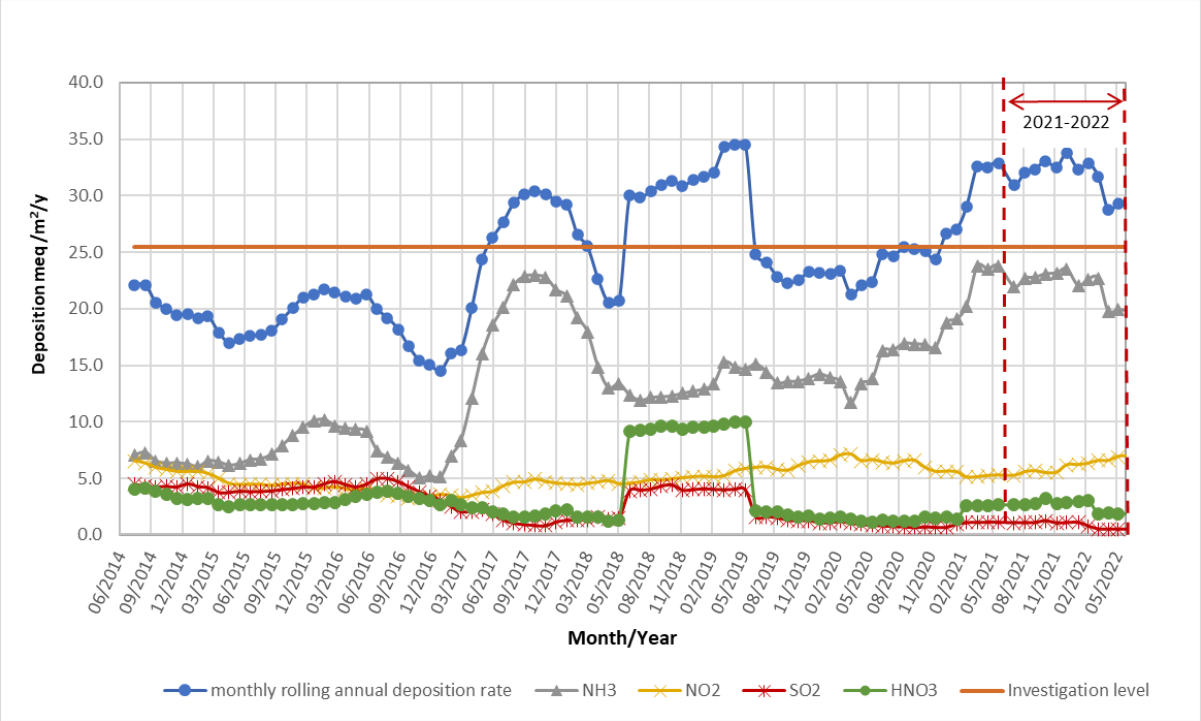

Figure 16: Monthly rolling annual total and individual gas dry deposition rates – Burrup Road

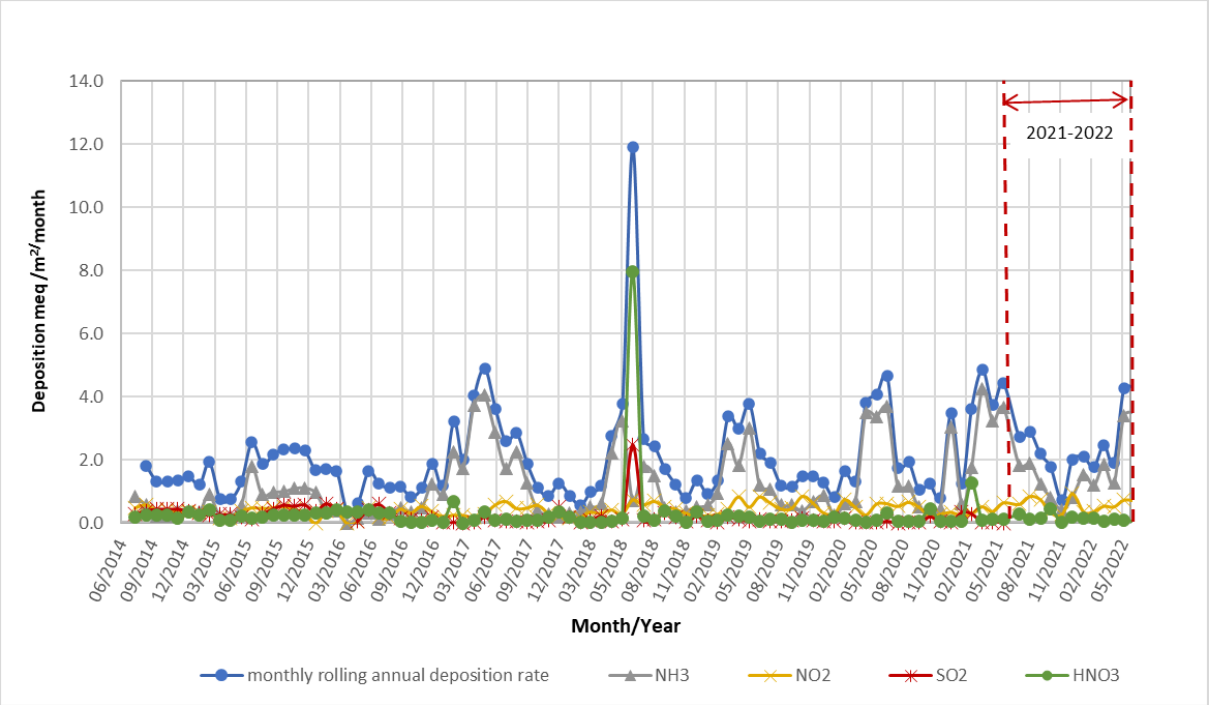

Figure 17: Monthly total and individual gas dry deposition rates – Burrup Road

Deposition at the Water Tanks site was within levels previously measured (Figure 18). Hearson Cove exhibited an increasing trend in the rolling annual deposition rate during the middle of the monitoring period (November 2021 through January 2022). A peak in NH_3 deposition during January 2022 (maximun of 14.78 meq m^{-2}) was the dominant contributor to the cumulative annual deposition, exceeding the previous peak annual deposition in January 2021 (7.87 meq m^{-2}). Deposition rates fell following the peak to within previous ranges from February 2022 onwards (Figure 20).

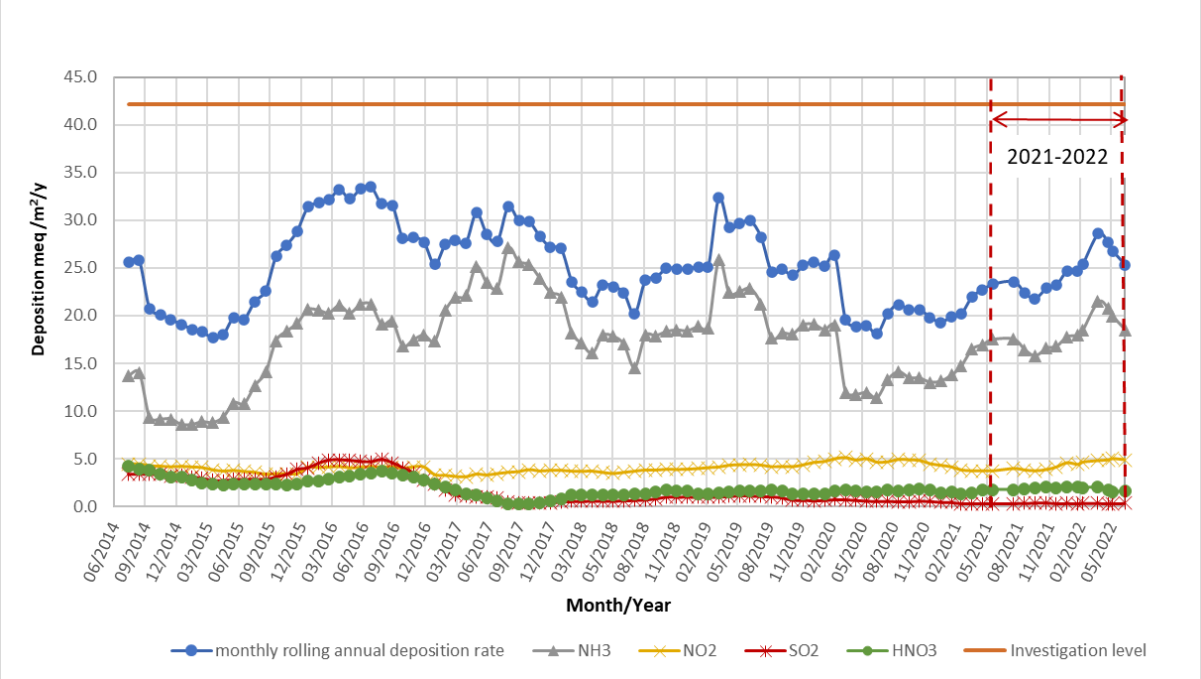

Figure 18: Monthly rolling annual total and individual gas dry deposition rates – Water Tanks

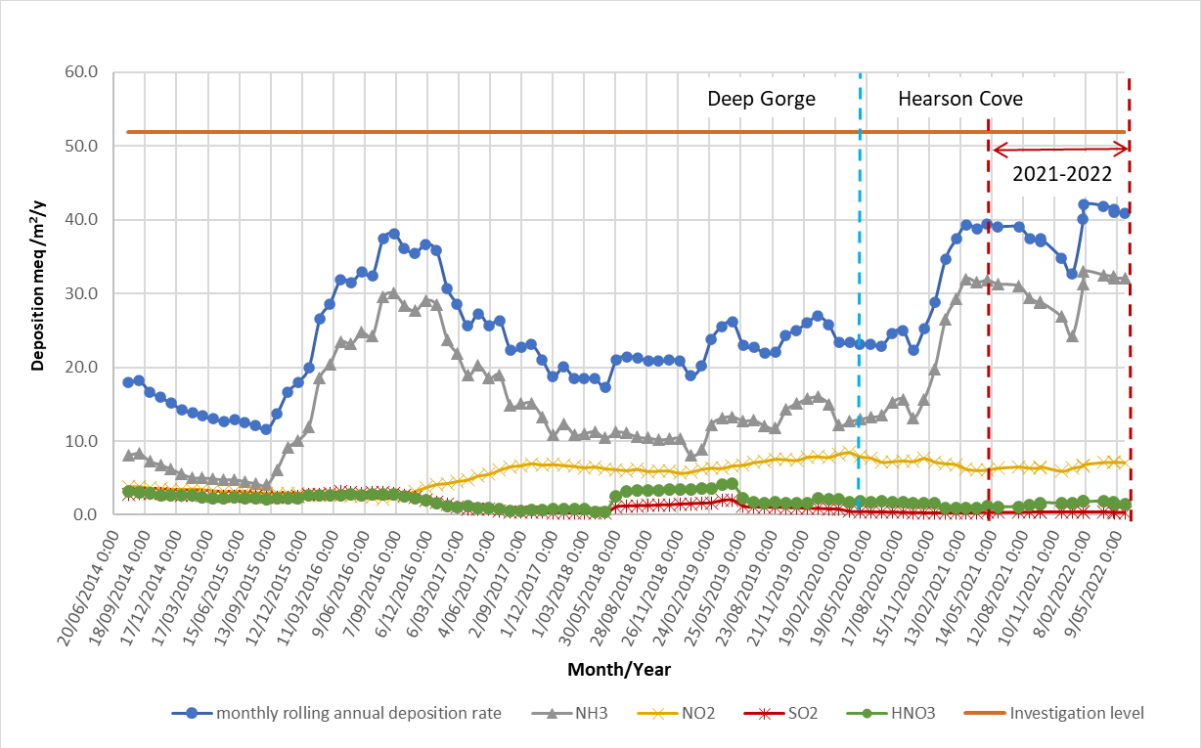

Figure 19: Monthly rolling annual total and individual gas dry deposition rates – Hearson Cove

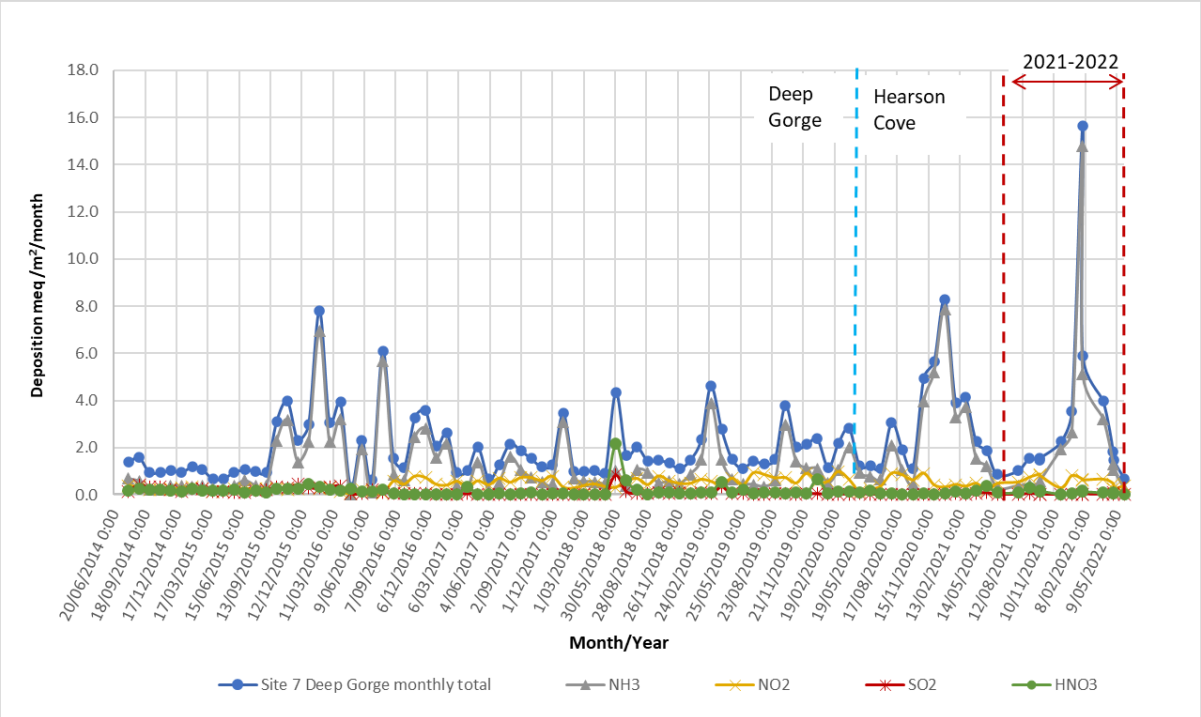

Figure 20: Monthly total and individual gas dry deposition rates – Hearson Cove

Key findings from the investigation into the elevated deposition rates exceeding the investigation level at Burrup Road are summarised in Table 11.

Table 11: Findings from investigation into elevated deposition rates

Factor	Investigation	Finding	Comment
Contributions from individual gases	Examine individual contributions to identify gases reasonable for increase in deposition rate compared to baseline.	Burrup Road: elevated NH_3 deposition across the year (i.e., not driven by a single elevated point) when compared to previous years (see Figure 16).	Increase in NH_3 may be due to sources other than TAN Plant emissions. Elevated ambient concentrations did not directly correlate with elevated NH_3 stack emission data. Further investigation, by Yara Pilbara, into all ammonia sources is on-going.
TAN Plant operations	TAN Plant availability and any operating conditions that could have led to elevated emissions from the nitric acid plant stack or other sources associated with the TAN Plant.	The TAN Plant was operating under steady state for most of the monitoring period. There were no adverse plant conditions that led to elevated emissions being recorded by stack continuous emissions monitors (CEMS).	Review of emissions data did not identify a probable cause related to TAN Plant operations for elevated ammonia concentrations.

6. Concluding remarks

Monitoring data are reported for all parameters specified in EPBC Approval 2008/4546 (as varied 24 March 2020).

Analysis of data for gases shows the following:

- The average NH_3 concentration at Burrup Road was found to be statistically significantly different (higher) to the baseline;
- The average NH_3 concentrations at Water Tanks and Hearson Cove were higher than baseline but the difference was not statistically significant;
- The average NO_2 concentrations at Burrup Road and Water tanks were higher than baseline and statistically significant. Hearson Cove was also higher than baseline but not found to be statistically significant; and
- The average SO_2 concentrations at all three monitoring sites were lower than the baseline concentrations, with differences in the averages being statistically significant.

The TAN Plant was operating at steady state for most of the reported period. Plant start-ups, when potentially higher NH_3 emissions may occur, did not correlate with elevated ambient concentrations.

Overall, there is no evidence to show that operation of the TAN Plant has resulted in significant increases in NO_2 levels over the monitoring period.

Analysis of annual dry deposition rates of gas species shows the following:

- Dry deposition rates increased at Burrup Road and Hearson Cove in 2021-2022 compared to the previous year;
- The Burrup Road dry deposition rate was above the investigation level derived from baseline measurements; and
- NH_3 is the dominant contributor to dry deposition at all monitoring sites.

The exceedance of the investigation level triggered an investigation as per the requirements of the OEMP. That investigation did not support a hypothesis that the emissions from the TAN Plant operations were responsible for exceedances of the investigation level.

Analysis of the TSP data shows the following:

- Concentrations of TSP measured in 2021-2022 continue to be consistent across the three monitoring sites suggesting reflection of air shed background concentrations as seen in previous reporting periods; and
- Average TSP concentrations at all three monitoring sites were similar to the results from the monitoring conducted since 2017.

Overall, there is no evidence to show that the operation of the TAN Plant has resulted in a significant increase in ambient TSP concentrations in 2021-2022.

Analysis of dust deposition data shows the following:

- Similar average insoluble deposition rates were observed at all three sites;
- Average insoluble deposition at all sites was not statistically significantly different to those concentrations measured in the baseline study for all sites;
- The soluble fraction of the deposited dust from 2021-2022 was consistent with previous years; and
- The soluble fraction of the deposited dust at Water Tanks and Hearson Cove during May 2022 was higher than Burrup Road; the source of this elevated result is likely marine aerosols.

Overall, there is no evidence to suggest that the operation of the TAN Plant has resulted in materially significant increases in insoluble dust deposition rates.

7. References

Strategen (2018). *Yara Pilbara Nitrates, EPBC Approval 2008/4546.* Ambient air quality report 2017-2018. Document 650-200-rep-sec-0004, issued October 2018.

Strategen (2019). *Yara Pilbara Nitrates, EPBC Approval 2008/4546.* Ambient air quality report 2018-2019. Document 650-200-rep-sec-0006, issued October 2019.

Strategen (2020). *Yara Pilbara Nitrates, EPBC Approval 2008/4546.* Ambient air quality report 2019-2020. 650-200-rep-sec-0007, issued October 2020.

Strategen JBS&G (2021). *Yara Pilbara Nitrates, EPBC Approval 2008/4546.* Ambient air quality report 2020-2021. 650-200-rep-sec-0007, issued October 2021.

YPN (2017). *Yara Pilbara Nitrates, EPBC Approval 2008/4546. Baseline Air Quality Monitoring Report*. Document 250-200-rep-ypf-0002, issued 16 June 2017, updated 24 March 2020.

Limitations

Scope of services

This report ("the report") has been prepared by Strategen-JBS&G in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Strategen-JBS&G. In some circumstances, a range of factors such as time, budget, access and/or site disturbance constraints may have limited the scope of services. This report is strictly limited to the matters stated in it and is not to be read as extending, by implication, to any other matter in connection with the matters addressed in it.

Reliance on data

In preparing the report, Strategen-JBS&G has relied upon data and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise expressly stated in the report, Strategen-JBS&G has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Strategen-JBS&G has also not attempted to determine whether any material matter has been omitted from the data. Strategen-JBS&G will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented, or otherwise not fully disclosed to Strategen-JBS&G. The making of any assumption does not imply that Strategen-JBS&G has made any enquiry to verify the correctness of that assumption.

The report is based information received at the time of preparation of this report. Strategen-JBS&G disclaims responsibility for any changes that may have occurred after this time. This report and any legal issues arising from it are governed by and construed in accordance with the law of Western Australia as at the date of this report.

Environmental conclusions

Within the limitations imposed by the scope of services, the preparation of this report has been undertaken and performed in a professional manner, in accordance with generally accepted environmental consulting practices. No other warranty, whether express or implied, is made.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

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Appendix A Results from monitoring of gases for 2021-2022

Site	Date on	Date off	NH_3 µg/m³	NO_2 µg/m³	SO_2 µg/m³	HNO_3 µg/m³
Site 5 - Burrup Road	30/06/2021	16/07/2021	1.66	4.60	0.09	0.58
Site 5 - Burrup Road	16/07/2021	30/07/2021	0.83	5.62	0.15	0.92
Site 5 - Burrup Road	30/07/2021	16/08/2021	1.69	5.53	0.06	0.32
Site 5 - Burrup Road	16/08/2021	31/08/2021	0.74	8.06	0.11	0.24
Site 5 - Burrup Road	31/08/2021	15/09/2021	1.04	6.47	0.12	0.67
Site 5 - Burrup Road	15/09/2021	30/09/2021	0.68	6.15	0.22	0.17
Site 5 - Burrup Road	30/09/2021	14/10/2021	0.48	3.70	0.04	0.19
Site 5 - Burrup Road	14/10/2021	2/11/2021	0.53	1.82	1.22	1.72
Site 5 - Burrup Road	2/11/2021	16/11/2021	0.25	5.07	0.04	0.09
Site 5 - Burrup Road	16/11/2021	30/11/2021	0.36	0.08	0.01	0.03
Site 5 - Burrup Road	30/11/2021	15/12/2021	0.43	11.45	0.51	0.64
Site 5 - Burrup Road	15/12/2021	31/12/2021	0.66	4.27	0.16	0.40
Site 5 - Burrup Road	31/12/2021	17/01/2022	1.66	3.23	0.12	0.23
Site 5 - Burrup Road	17/01/2022	31/01/2022	0.24	2.56	0.32	0.52
Site 5 - Burrup Road	31/01/2022	15/02/2022	0.86	2.16	0.20	0.38
Site 5 - Burrup Road	15/02/2022	1/03/2022	0.86	4.44	0.21	0.56
Site 5 - Burrup Road	1/03/2022	16/03/2022	0.99	4.47	0.09	0.12
Site 5 - Burrup Road	16/03/2022	31/03/2022	1.56	4.70	0.09	0.23
Site 5 - Burrup Road	31/03/2022	14/04/2022	0.61	3.28	0.07	0.14
Site 5 - Burrup Road	14/04/2022	29/04/2022	1.18	5.70	0.09	0.51
Site 5 - Burrup Road	29/04/2022	13/05/2022	2.04	7.15	0.07	0.30
Site 5 - Burrup Road	13/05/2022	1/06/2022	2.21	4.53	0.15	0.18
Site 5 - Burrup Road	1/06/2022	17/06/2022	2.42	4.40	0.13	0.21
Site 5 - Burrup Road	17/06/2022	1/07/2022	2.41	7.77	0.03	0.10
Site 6 - Water Tanks	30/06/2021	16/07/2021	0.74	3.82	0.06	0.34
Site 6 - Water Tanks	16/07/2021	30/07/2021	0.56	3.98	0.08	0.44
Site 6 - Water Tanks	30/07/2021	16/08/2021	1.21	2.22	0.08	0.35
Site 6 - Water Tanks	16/08/2021	31/08/2021	0.54	3.07	0.28	1.14
Site 6 - Water Tanks	31/08/2021	15/09/2021	0.86	4.72	0.36	0.67
Site 6 - Water Tanks	15/09/2021	30/09/2021	0.58	4.08	0.06	0.26
Site 6 - Water Tanks	30/09/2021	14/10/2021	1.22	4.08	0.14	0.62
Site 6 - Water Tanks	14/10/2021	2/11/2021	0.61	4.33	0.25	0.56
Site 6 - Water Tanks	2/11/2021	16/11/2021	0.48	5.13	0.12	0.20
Site 6 - Water Tanks	16/11/2021	30/11/2021	0.84	5.39	0.06	0.17
Site 6 - Water Tanks	30/11/2021	15/12/2021	1.19	5.69	0.07	0.10
Site 6 - Water Tanks	15/12/2021	31/12/2021	1.36	4.95	0.17	0.32
Site 6 - Water Tanks	31/12/2021	17/01/2022	0.68			
Site 6 - Water Tanks	17/01/2022	31/01/2022	0.54	1.98	0.10	0.21
Site 6 - Water Tanks	31/01/2022	15/02/2022	1.03	2.69	0.22	0.28
Site 6 - Water Tanks	15/02/2022	1/03/2022	1.25	4.46	0.15	0.48
Site 6 - Water Tanks	1/03/2022	16/03/2022	2.19	3.36	0.05	0.30
Site 6 - Water Tanks	16/03/2022	31/03/2022	4.47	3.59	0.10	0.50
Site 6 - Water Tanks	31/03/2022	14/04/2022	1.82	3.46	0.04	0.14
Site 6 - Water Tanks	14/04/2022	29/04/2022	1.30	3.46	0.04	0.11
Site 6 - Water Tanks	29/04/2022	13/05/2022	0.40	2.89	0.07	0.28
Site 6 - Water Tanks	13/05/2022	1/06/2022	0.87	1.36	0.08	0.05
Site 6 - Water Tanks	1/06/2022	17/06/2022	0.20	1.53	0.13	0.61
Site 6 - Water Tanks	17/06/2022	1/07/2022	0.42	2.39	0.07	0.41
Site 7 - Hearson Cove	30/06/2021	16/07/2021	0.28	1.52	0.01	0.21
Site 7 - Hearson Cove	16/07/2021	30/07/2021	0.24	3.15	0.04	0.37
Site 7 - Hearson Cove	30/07/2021	16/08/2021	0.14	2.02	0.46	1.30
Site 7 - Hearson Cove	16/08/2021	31/08/2021	0.43	3.90	0.06	0.25

Site	Date on	Date off	NH_3 µg/m³	NO_2 µg/m³	SO_2 µg/m³	HNO_3 µg/m³
Site 7 - Hearson Cove	31/08/2021	15/09/2021	0.35	3.37	0.04	0.30
Site 7 - Hearson Cove	15/09/2021	30/09/2021	0.23	3.94	0.14	0.52
Site 7 - Hearson Cove	30/09/2021	14/10/2021	0.30	2.84	0.07	0.43
Site 7 - Hearson Cove	14/10/2021	2/11/2021	0.40	3.26	0.09	0.38
Site 7 - Hearson Cove	2/11/2021	16/11/2021	0.53	2.61	0.01	0.09
Site 7 - Hearson Cove	16/11/2021	30/11/2021	2.30	0.08	0.01	0.03
Site 7 - Hearson Cove	30/11/2021	15/12/2021	1.57	4.05	0.09	0.13
Site 7 - Hearson Cove	15/12/2021	31/12/2021	2.00	2.61	0.11	0.11
Site 7 - Hearson Cove	31/12/2021	17/01/2022	10.37	2.73	0.24	0.77
Site 7 - Hearson Cove	17/01/2022	31/01/2022	9.14	2.56	0.04	0.13
Site 7 - Hearson Cove	31/01/2022	15/02/2022	2.35	2.47	0.27	0.58
Site 7 - Hearson Cove	15/02/2022	1/03/2022	5.08	2.98	0.07	0.24
Site 7 - Hearson Cove	1/03/2022	16/03/2022	1.88	2.78	0.09	0.27
Site 7 - Hearson Cove	16/03/2022	31/03/2022	2.56	2.74	0.06	0.18
Site 7 - Hearson Cove	31/03/2022	14/04/2022	0.73	2.74	0.04	0.08
Site 7 - Hearson Cove	14/04/2022	29/04/2022	1.11	1.44	0.06	0.24
Site 7 - Hearson Cove	29/04/2022	13/05/2022	0.89	1.90	0.01	0.09
Site 7 - Hearson Cove	13/05/2022	1/06/2022	0.48	0.31	0.54	0.37
Site 7 - Hearson Cove	1/06/2022	17/06/2022	0.12	1.15	0.01	0.09
Site 7 - Hearson Cove	17/06/2022	1/07/2022	0.22	2.20	0.03	0.10

Appendix B Results from monitoring of TSP for 2021-2022

Period start date	Site 5 -Burrup Road TSP µg/m³	Site 6 - Water Tanks TSP µg/m³	Site 7 – Hearson Cove TSP µg/m³
03-Jul-21	17	16	22
09-Jul-21	16	17	16
15-Jul-21	10	13	10
21-Jul-21	18	15	16
27-Jul-21	20	20	15
02-Aug-21	32	19	21
08-Aug-21	47	30	26
14-Aug-21	14	17	7
20-Aug-21	32	19	26
26-Aug-21	29	34	18
01-Sep-21	23	28	23
07-Sep-21	31	31	27
13-Sep-21	27	27	25
19-Sep-21	29	27	24
25-Sep-21	33	37	37
01-Oct-21	25	25	32
07-Oct-21	33	32	34
13-Oct-21	44	32	36
19-Oct-21	21	26	23
25-Oct-21	37	34	30
31-Oct-21	32	39	30
06-Nov-21	31	35	36
12-Nov-21	27	28	29
18-Nov-21	24	34	27
24-Nov-21	26	32	-
30-Nov-21	37	33	36
06-Dec-21	46	56	56
12-Dec-21	30	35	24
18-Dec-21	30	39	32
24-Dec-21	55	53	55
30-Dec-21	29	47	46
05-Jan-22	76	89	89
11-Jan-22	36	36	41
17-Jan-22	44	54	54
23-Jan-22	39	45	48
29-Jan-22	36	40	40
04-Feb-22	36	36	38
10-Feb-22	12	16	15
16-Feb-22	27	29	22
22-Feb-22	24	27	29
28-Feb-22	51	45	43
06-Mar-22	15	16	19
12-Mar-22	12	14	13
18-Mar-22	20	28	22
24-Mar-22	22	22	25
30-Mar-22	15	12	16
05-Apr-22	18	13	9
11-Apr-22	18	15	25
17-Apr-22	22	24	28
23-Apr-22	17	23	13
29-Apr-22	16	21	13
05-May-22	19	24	30
11-May-22	13	12	13
17-May-22	19	10	11
23-May-22	12	9	8

Period start date	Site 5 -Burrup Road TSP µg/m³	Site 6 - Water Tanks TSP µg/m³	Site 7 – Hearson Cove TSP µg/m³
29-May-22	13	13	14
04-Jun-22	8	8	8
10-Jun-22	12	21	13
16-Jun-22	10	16	14
22-Jun-22	10	11	12
28-Jun-22	12	20	15

Appendix C Results from dust deposition monitoring 2021-2022

Date collected	Site 5 - Burrup Road		Site 6 - Water Tanks		Site 7 – Hearson Cove	
	Soluble solids	Insoluble solids	Soluble solids	Insoluble solids	Soluble solids	Insoluble solids
	g/m²/month	g/m²/month	g/m²/month	g/m²/month	g/m²/month	g/m²/month
30/07/2021	<0.7	<0.8	1.0	1.0	<0.7	0.9
31/08/2021	<0.7	1.5	1.3	<0.8	<0.7	<0.8
30/09/2021	<0.7	1.0	<0.7	<0.8	<0.7	<0.8
2/11/2021	<0.7	0.9	1.1	1.3	<0.7	<0.8
30/11/2021	<0.7	<0.8	1.7	1.4	0.9	1.9
31/12/2021	1.4	1.8	<0.7	1.6	0.7	1.6
31/01/2022	0.9	1.5	<0.7	1.8	0.9	1.7
1/03/2022	1.9	1.3	1.4	1.3	1.7	1.3
31/03/2022	<0.7	1.5	0.8	1.7	<0.7	1.7
29/04/2022	1.1	0.9	1.6	0.8	0.9	1.4
1/06/2022	<3	<0.8	6.3	0.8	6	1.1
1/07/2022	1.1	1.1	1	<0.8	1.3	<0.8

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