Prepared for
National Ceramic Industries Australia
ABN: 83 100 467 267

2021 Annual Environmental Management Report

1 August 2020 - 31 July 2021

29-Oct-2021

Commercial-in-Confidence

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Client: National Ceramic Industries Australia

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Prepared by

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A	27-Oct-2021	Draft for client review	Cye Buckland Project Manager	
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1.0 Introduction

National Ceramic Industries Australia Pty Ltd (NCIA) operates a tile manufacturing facility located in Rutherford, New South Wales. This Annual Environmental Management Report (AEMR) describes and discusses NCIA's environmental performance for the period between 1 August 2020 and 31 July 2021 (hereafter referred to as the '2021 reporting period').

1.1 NCIA Background

1.1.1 Current Operations

NCIA manufactures ceramic wall and floor tiles for the Australian market from its facility located off Racecourse Road, Rutherford, within the Rutherford Industrial Estate, NSW. The facility has been operating since its commissioning in 2004. Prior to NCIA's operations, the majority of Australia's domestic ceramic tile consumption was imported from China, South East Asia, Italy, Spain and Brazil.

Tiles are manufactured from raw materials including a mixture of clay, white granite, rhyolite and glazes. Clay, granite and rhyolite are naturally occurring and are supplied by quarries within Australia, whilst glazes and other consumables are either supplied locally or imported. The tile manufacturing process involves mixing and preparing raw materials in specified proportions, pressing the prepared mix into the desired shape, and then drying prior to decorating and glazing. The tiles are then fired in the facility's kilns prior to sorting, packaging and dispatch. Finished tiles are stored and loaded for distribution outside of the building in the south western corner of the site. All transport to and from the site is via road, with semi-trailers and B-double trucks transporting the raw materials and finished product.

The operation currently comprises one spray drier, a clay mill, two tile production lines and two kilns, all housed within a single factory building approximately 488 m long and 80 m wide. The current operations represent the first two of eight approved stages of the facility. With these two operational stages the maximum production of the facility is approximately 6.4 million m^2 of ceramic tiles per annum. The facility operates 24 hours per day, 7 days per week, and currently employs 55 full time staff.

1.1.2 Future Planned Operations

NCIA currently holds approval for the development of Stages Three–Eight of the facility, none of which are yet constructed or commissioned. Stages Three–Four would see the commissioning of an additional two production lines within the existing factory building for an increased production of up to 12.8 million m^2 of tiles per annum. Stages Five–Eight would involve the construction and operation of a second factory building with four additional production lines on the adjacent parcel of land to the east of the existing facility. Once all eight development stages are operational, the facility's production capacity would increase to 25.6 million m^2 of tiles per annum.

The approval for the facility's expansion was sought by NCIA in response to the anticipated continuing increase in tile demand, both domestically and internationally. Stage Three is currently under consideration as there is a strong demand for locally made tiles, due to supply chain disruptions in China and solid Australian market conditions. From approval of the facility, management estimates it would take between 18 to 24 months before production would commence.

1.1.3 Historic and Current Production Volume

Tile production volume since commissioning and inclusive of the 2021 reporting period is presented in **Figure 1**. Production volume is reported (and presented here) annually in accordance with the Environmental Protection Licence (EPL) annual reporting period, that is 1 August to 31 July each year.

NCIA's Project Approval (MP 09_0006) provides a staged approach to production limit in m^2 per annum, while NCIA's EPL No. 11956 provides for production in tonnes per annum.

Between 1 August 2020 and 31 July 2021, the facility operated 344 days, for a total output of 89,711 tonnes of ceramic tiles (or approximately 5.66 million m^2). These production levels are below the maximum production authorised under NCIA's current approvals (refer to **Section 1.2**) and are commensurate to the current stage of development of the facility (i.e. Stage Two).

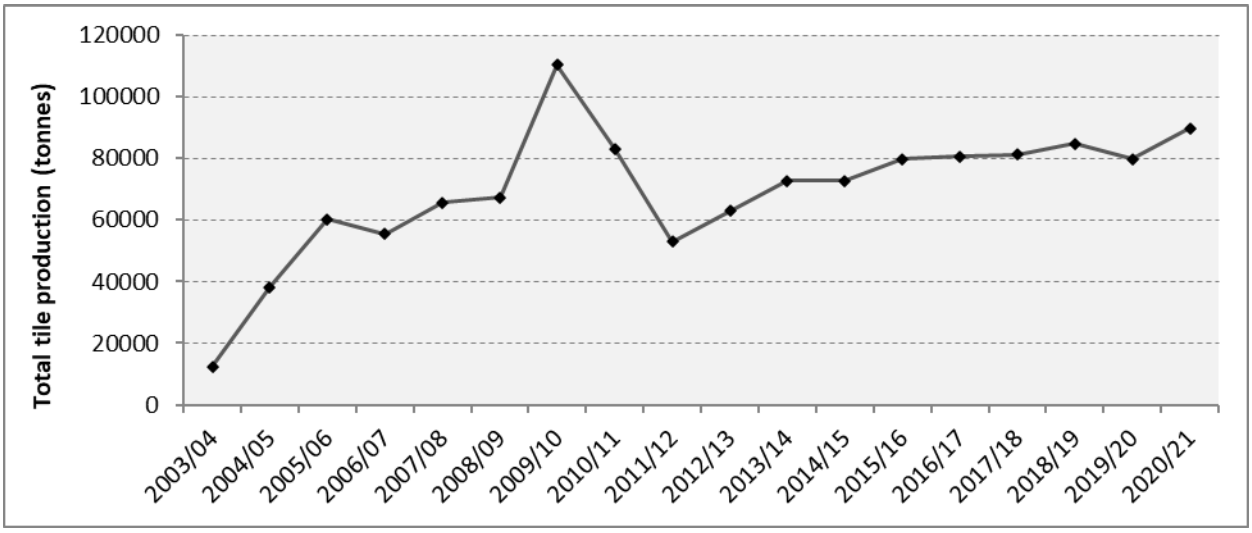


Figure 1 Production volume since 2004

1.2 Regulatory Context

1.2.1 Current Approvals

On 19 January 2012 NCIA was granted Project Approval (MP 09_0006), which rationalised and consolidated the development as approved under the previous Development Consent (DA 449-12-2002-i), and the proposed expansion of the facility. Subsequently, NCIA relinquished the previous Development Consent with effect from 19 January 2013.

The NCIA facility is therefore currently operating in accordance with the conditions of Project Approval (MP 09_0006), issued by the Department of Planning Industry and Environment (DPIE).

The facility also operates in accordance with EPL No. 11956 issued by the NSW Environment Protection Authority (EPA), which authorises NCIA to produce 50,000 - 200,000 tonnes of ceramic tiles per annum.

It is noted that many of the requirements of the Project Approval are required prior to commencement of construction of the next stage of the approved operation (i.e. Stages Three–Eight). As commencement of construction of the next stage of the approved operation has not yet commenced, these conditions have not yet been activated.

Notably, an Operation Environmental Management Plan (OEMP) was prepared in accordance with the previous Development Consent to provide an environmental management framework for the facility. The current Project Approval does not require an OEMP, but instead requires the preparation of an Environmental Management Strategy (EMS) prior to commencement of construction works associated with development Stages Three–Eight. As this condition is not yet activated, NCIA continues to operate in accordance with the OEMP.

1.2.2 AEMR Requirement

This AEMR has been prepared in accordance with Schedule 4, Condition 60 of the Project Approval. The AEMR outlines the environmental compliance and performance of the NCIA facility in relation to the conditions of the Project Approval and NCIA's EPL No. 11956.

The requirements of Condition 60 of the Project Approval and the cross-reference to the AEMR section where the requirement is addressed are provided in **Table 1-1**.

Table 1-1 Schedule 4, Condition 60 of Project Approval (MP 09_0006)

Condition	Requirement	AEMR Section
60	Every year from the date of this approval[1], unless the Director-General agrees otherwise, the Proponent shall submit an AEMR to the Director-General and relevant agencies. The AEMR shall:	This AEMR
60 (a)	be conducted by suitably qualified team whose appointment has been endorsed by the Director-General;	Quality Information
60 (b)	be submitted within 3 months of the period being assessed by the AEMR;	See comment 1 below
60 (c)	identify the standards and performance measures that apply to the development;	**Section 2.0**
60 (d)	include a summary of the complaints received during the past year, and compare this to the complaints received in previous years;	**Section 3.0**
60 (e)	include a summary of the monitoring results for the development during the past year;	**Section 4.0**
60 (f)	include an analysis of these monitoring results against the relevant: • impact assessment criteria • monitoring results from previous years • predictions in the EA.	**Section 5.0**
60 (g)	identify any trends in the monitoring;	**Section 5.0**
60 (h)	identify any discrepancies between the predicted and actual impacts of the project, and analyse the potential cause of any significant discrepancies;	**Section 5.0**
60 (i)	identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance; and	**Section 6.0**
60 (j)	identify continuous improvement measures, outlining new developments in air quality and noise control, and detailing practices that have been implemented on the site during the previous year, to reduce air quality and noise impacts.	**Section 7.0**

Note on timeline:

NCIA sought DPIE's approval (during a meeting with Leah Cook of DPIE held on 15 July 2015) to amend the AEMR reporting timeframes to align it with that of the EPL. The request was granted by DPIE on 17 July 2015. Therefore, this AEMR and all subsequent AEMRs will cover the same reporting periods as the EPL, and report on NCIA's environmental performance between 1 August and 31 July each year.

[1] This condition is now superseded by DPIE's approval to amend the AEMR reporting period so that it is aligned with that of the EPL reporting timeline. The AEMR now covers the period between 1 August and 31 July.

2.0 Standards and Performance Measures

The NCIA OEMP provides the environmental management framework to guide the operation and environmental performance of the facility. The OEMP defines the environmental management practices, procedures and personnel responsibilities to ensure compliance with conditions of statutory approvals and licences.

Specific environmental standards and performance measures used to assess the achievement of environmental objectives are drawn from requirements, obligations and initiatives listed within:

- Project Approval (MP 09_0006), granted by the Minister for Planning
- EPL 11956, issued by the NSW EPA
- The *National Ceramic Industries Australia Expansion - Environmental Assessment* (AECOM, 5 July 2010) hereafter referred to as '2010 EA'.

Commitments made within the 2010 EA have been incorporated into the Project Approval and EPL for the facility as compliance criteria. These compliance criteria are used to assess the environmental performance of the facility and to monitor the environmental impact on the surrounding environment. Compliance criteria and the monitoring results for the current reporting period are presented in **Section 4.0** of this AEMR.

3.0 Complaints

Condition 60(d) of the Project Approval requires that the AEMR include a summary of complaints received during the current reporting period compared to complaints received in previous years.

The history of complaints received by NCIA is presented in **Table 3-1**. Only one complaint was received for the monitoring period. Overall, the history of complaints shows that very few community complaints are received in relation to NCIA operations.

Table 3-1 Historical complaints received by NCIA

Year	Number	Issue	Details
2021	1	Air Quality	Complaint made from resident of Heritage Parc concerned with what is being emitted from the stacks after being told it is damaging his guttering. No details were left to contact the resident, so no action was taken.
2020	Nil	Nil	None Required.
2019	1	Noise	Complaint made from resident of Heritage Parc wondering whether alarm noise ongoing since 9am. was NCIA as it could be heard from Heritage Parc. NCIA supervisor confirmed the alarm was not from NCIA. Supervisor drove down Gardiner St and noted an alarm from a business at the South West corner of NCIA.
2018	Nil	Nil	None Required.
2017	Nil	Nil	None Required.
2016	Nil	Nil	None Required.
2015 (partial)	Nil	Nil	None Required.
2014	Nil	Nil	None Required.
2013	1	Air Quality	Complaint made via email on 24 July 2013 regarding air quality in Rutherford area.
2012-13	1	1	Complaint made from neighbouring Heritage Green Residential Estate regarding storage of waste tiles causing visual nuisance. It is noted that this was previously considered to be a legal issue and therefore not previously recorded as a complaint.
2011-12	Nil	Nil	None Required.
2010-11	Nil	Nil	None Required.
2009-10	1	Air Quality	Complaint made from neighbouring Heritage Green Residential Estate regarding non-compliances identified in the Environment Audit.
2008-09	Nil	Nil	None Required.
2007-08	1	Air Quality	Anonymous complaint to EPA regarding visible black smoke. Report submitted to EPA on 25 March 2008. Visible black smoke unlikely to have originated from NCIA. No further action required.
2006-07	1	Odour	Anonymous complaint to EPA regarding odour. Discussed with EPA. Odour unlikely to have originated from NCIA. No further action required.
2005-06	2	Air Quality / Odour	Complaint made regarding visible plume. Complainant contacted and issue discussed. No further action required. Anonymous complaint to EPA regarding odour. Discussed with EPA. Odour unlikely to have originated from NCIA. No further action required.
2004-05	1	Air Quality	Complaint made regarding visible plume. Complainant contacted and issue discussed. No further action required.

4.0 Environmental Monitoring Results

The following environmental parameters are monitored in accordance with the conditions of the Project Approval and / or the EPL and / or for internal due diligence requirements:

- Ambient air monitoring (northwest and southeast of the facility):
  - Fine Particulates (PM_{10})
  - Fluoride (particulate, gaseous and total).
- Fluoride Impact on Vegetation:
  - Quarterly visual assessment of vegetation
  - Quarterly fluoride content in vegetation.
- Meteorological monitoring:
  - Wind speed at 10 metres
  - Wind direction at 10 metres
  - Temperature at 5 metres
  - Rainfall.
- Stack emission testing (all stacks):
  - Total particulates
  - Fine particulates (PM_{10}).
- Additionally, for the kiln stacks:
  - Mercury (Hg)
  - Cadmium (Cd)
  - Nitrogen Oxides (NOx)
  - Hazardous substances (metals)
  - Hydrogen Fluoride (HF)
  - Sulfuric acid mist (H_2SO_4 as SO_3)
  - Sulfur Dioxide (SO_2 as SO_3).
- Noise monitoring:
  - L_{Aeq}(15 minute)
  - L_{A1}(1 minute).

In addition to the above-listed parameters, NCIA also keeps internal records of water usage and waste production. Water quality monitoring is also undertaken of the stormwater contained in the water retention basins.

A summary of the monitoring results for these parameters during the current reporting period is provided below.

4.1 Ambient Air Monitoring Results

The ambient air quality monitoring program commenced on 12 March 2004 to record background data prior to commencement of Stage One operations. The program was designed and implemented in accordance with the requirements of NCIA's EPL. The monitoring program also satisfies the requirements of the Project Approval.

In accordance with EPL condition M2.1, PM_{10} (24-hour) and Fluoride (24-hour and weekly) are monitored at two locations: northwest and southeast of the facility (refer **Figure 2**).

For PM_{10} monitoring, two sampling locations have been established to determine concentrations at the NCIA property boundary, along the dominant southeast-northwest wind axis. The monitors are sited in accordance with *AS/NZS 3580.1.1:2016 Guide to siting air monitoring equipment*. Sampling and analyses of PM_{10} are undertaken as per *AS/NZS 3580.9.6:2015 Determination of suspended particulate matter*. Discrete 24-hour samples are collected every 6 days according to the NSW EPA schedule.

Two fluoride monitoring units (manual, double filter paper samplers) have been sited at each of the two locations identified for monitoring of PM_{10} and are operated in accordance with *AS3580.13.2:2013 Determination of gaseous and acid-soluble particulate fluorides*. At each location, one monitor operates continuously over a 7-day period to provide weekly fluoride concentration averages. These units are designated 'Northwest HF_7' and 'Southeast HF_7'. The remaining unit at each site operates continuously for discrete 24-hour periods according to the NSW EPA 6-day cycle to provide 24-hour averages for sampler operation days. Units are designated 'Northwest HF' and 'Southeast HF'.

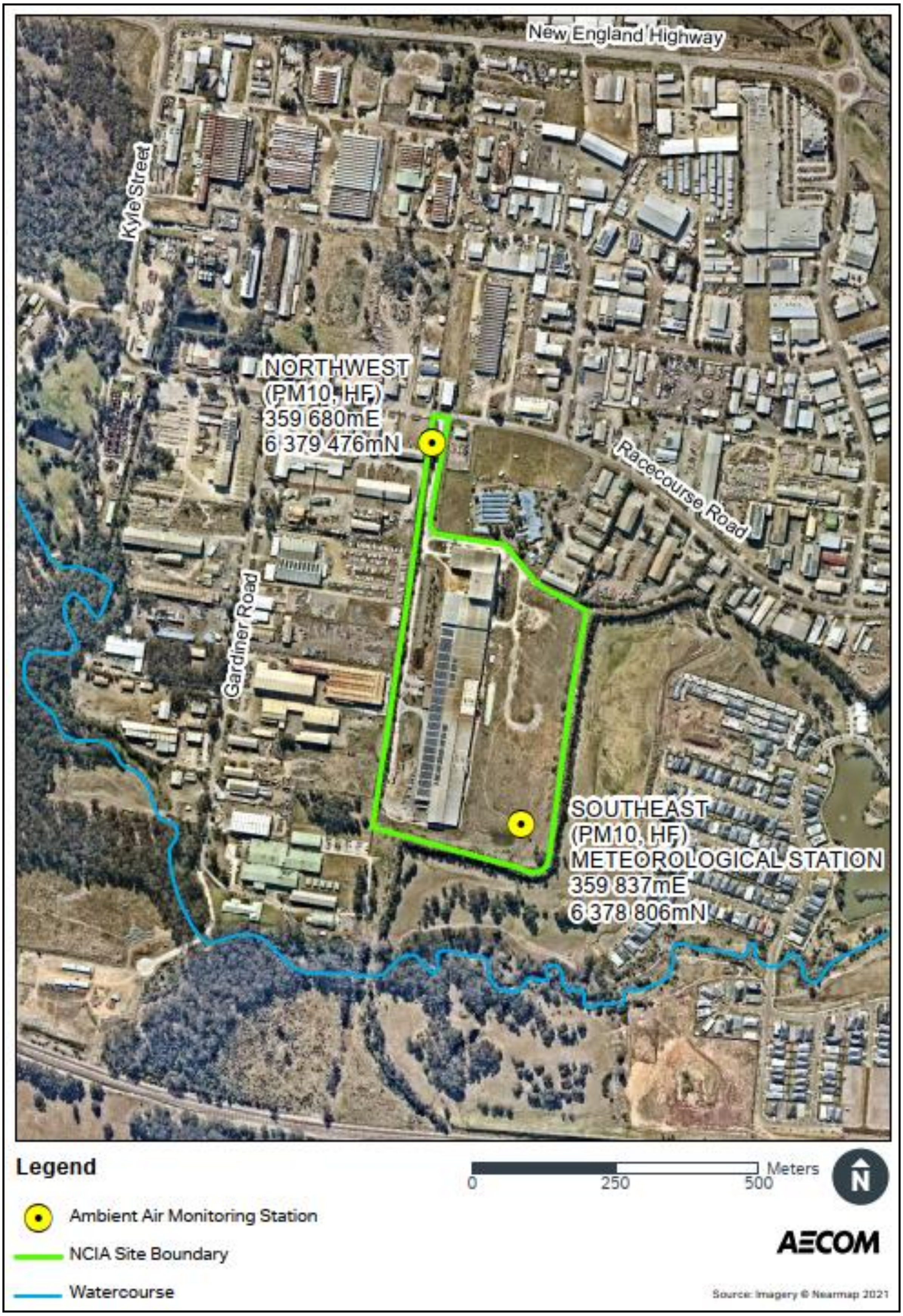


Figure 2 Ambient air monitoring locations

4.1.1 PM_{10} – Monitoring Results

The EPL does not specify ambient air concentration limits, however Condition 15 of the Project Approval defines criteria for PM_{10}.

A summary of PM_{10} monitoring results from both monitoring locations for the current reporting period is provided in **Table 4-1**, alongside the relevant criteria. The PM_{10} results for the NW and SE locations are also graphed in **Figure 3** and **Figure 4** respectively.

Table 4-1 Summary of ambient air monitoring: PM_{10} results

Parameter	NW Location	SE Location	Criteria
Annual Average Concentration (µg/m^3)	23.3	15.7	30
Standard Deviation (µg/m^3)	10.5	6.6	-
24-hour Minimum Concentration (µg/m^3)	4.3	3.6	-
24-hour Maximum Concentration (µg/m^3)	**52.4**	33.7	50

*Note: **Bold** font indicates an exceedance of the criteria.*

4.1.2 PM_{10} – Assessment against Annual Criteria

The North West and South East locations returned an average annual concentration of 23.3 µg/m^3 and 15.7 µg/m^3 respectively, which are below the 30 µg/m^3 annual criteria. This annual average remained below this criterion for the duration of the 12-month monitoring period.

4.1.3 PM_{10} – Assessment against 24 Hour Criteria

This section details any exceedances of the PM_{10} 24-hour maximum concentration. Any elevated PM_{10} monitoring results were promptly notified to DPIE upon receipt of the validated laboratory results, in accordance with the reporting requirements specified in the Project Approval.

One minor exceedance of the PM_{10} 24-hour maximum concentration occurred at the NW monitoring location on 28 November 2020 when a PM_{10} concentration of 52.4 µg/m^3 was recorded. Ambient and meteorological conditions on this day were reviewed and are discussed below.

On 28 November 2020 the EPA Beresfield monitoring station recorded a 24hr PM_{10} average of 27.4 µg/m^3 while the EPA Singleton monitoring station recorded a result of 34.3 µg/m^3. These results are the 3rd highest, and 7th highest 24-hour concentrations measured at these respective EPA stations during November 2020. This demonstrates above average regional particulate levels on 28 November 2020. Supporting this, the NCIA South East PM_{10} sampler returned an above average result for this day of 30.9 µg/m^3 indicating the North West sampler was likely influenced by a localised dust source.

Winds for this day were predominantly from the Northwest quadrant with an average wind speed of 3.14 m/s. This included several hours of relatively strong north westerly winds above 6 m/s.

Apart from this isolated exceedance, the remainder of PM_{10} monitoring results for the NW and SE monitoring locations during the reporting period were below the 24-hour guideline criteria.

Comparison to historical monitoring results and analysis of trends is discussed further in **Section 5.1**.

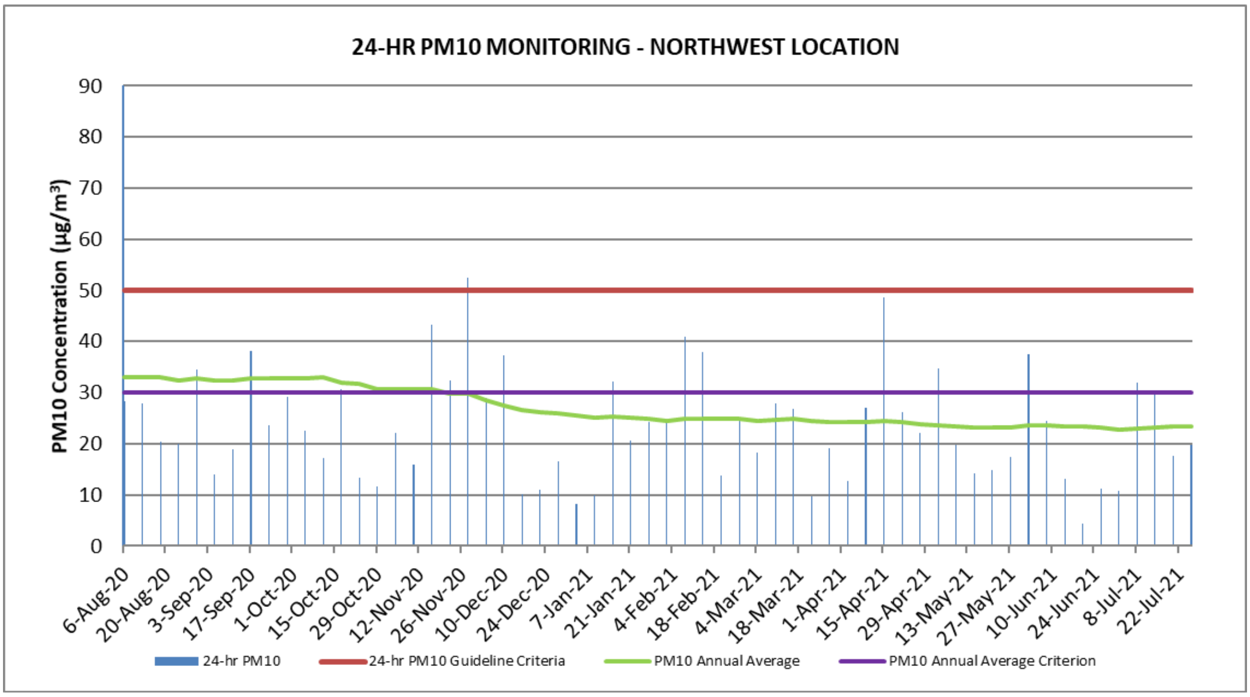


Figure 3 PM$_{10}$ monitoring – northwest location

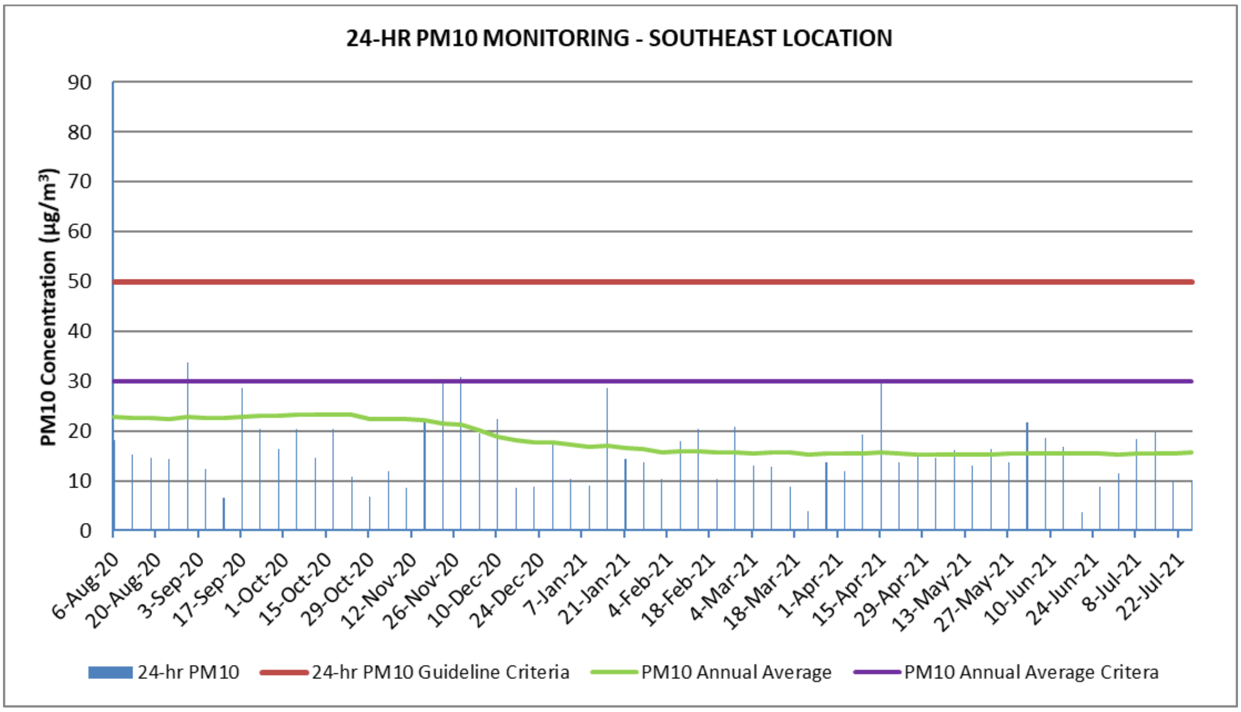


Figure 4 PM$_{10}$ monitoring – southeast location

4.1.4 Fluoride – 24 Hour Monitoring Results

There is no ambient air fluoride concentration limit specified in the EPL or Project Approval. To provide context for the ambient air monitoring results, guideline levels have been taken from the NSW EPA's *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (EPA, 2016).

A summary of 24-hour fluoride monitoring results from both monitoring locations for the current reporting period is provided in **Table 4-2**. The 24-hour fluoride monitoring results for the NW and SE locations are also graphed in **Figure 5** and **Figure 6** respectively.

Table 4-2 Summary of ambient air monitoring: 24-hour fluoride results

Parameter	NW Location	SE Location	Guideline Criteria
Annual Average Concentration (µg/m^3)	0.24	0.39	-
Standard Deviation (µg/m^3)	0.22	0.34	-
24-hour Minimum Concentration (µg/m^3)	0.032	0.048	-
24-hour Maximum Concentration (µg/m^3)	0.92	1.55	2.9

*Note: **Bold** font indicates an exceedance of the guideline criteria.*

The results in **Table 4-2** indicate that both the NW and SE monitoring locations results for the 24-hour total fluoride emissions satisfied the EPA (2016) guideline criterion for the entire reporting period.

Comparison to historical monitoring results and analysis of trends is discussed further in **Section 5.1**.

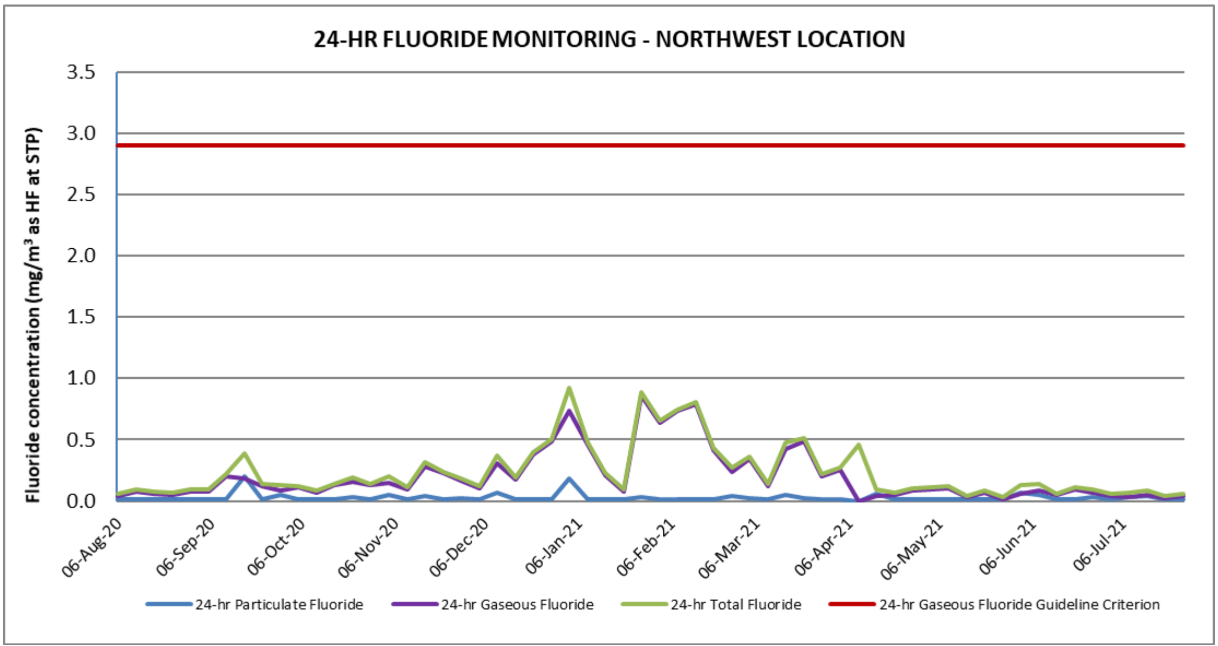


Figure 5 24-hour fluoride monitoring – northwest location

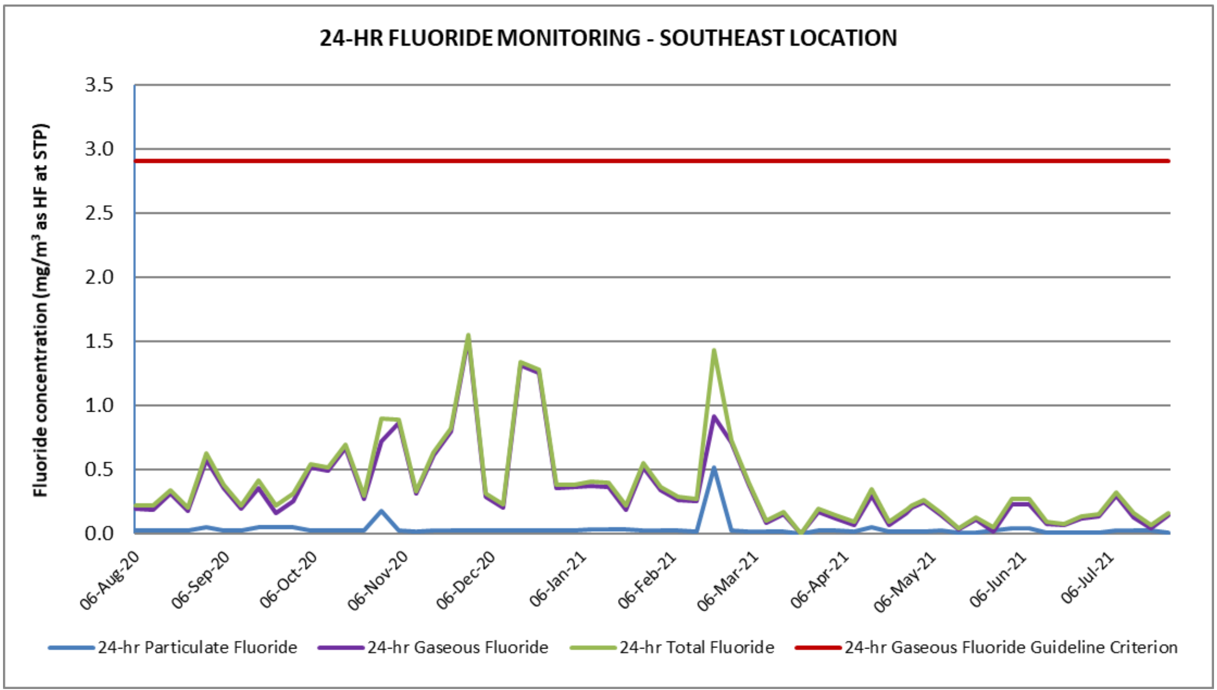


Figure 6 24-hour fluoride monitoring – southeast location

4.1.5 Fluoride – Weekly (7-Day) Monitoring Results

There is no ambient air fluoride concentration limit specified in the EPL or Project Approval. To provide context for the ambient air monitoring results, guideline levels have been taken from the NSW EPA's *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (EPA, 2016).

A summary of weekly fluoride monitoring results from both monitoring locations for the current reporting period is provided in **Table 4-3**. The weekly Fluoride monitoring results for the NW and SE locations are also graphed in **Figure 7** and **Figure 8** respectively.

Table 4-3 Summary of ambient air monitoring: weekly fluoride results

Parameter	NW Location	SE Location	Guideline Criteria
Annual Average Concentration (µg/m^3)	0.12	0.19	-
Standard Deviation (µg/m^3)	0.082	0.12	-
Weekly Minimum Concentration (µg/m^3)	0.013	0.002	-
Weekly Maximum Concentration (µg/m^3)	0.40	0.47	1.7

The results in **Table 4-3** indicate that both the NW and SE weekly Fluoride levels satisfied the EPA (2016) guideline criterion for the entire reporting period.

Comparison to historical monitoring results and analysis of trends is discussed further in **Section 5.1**.

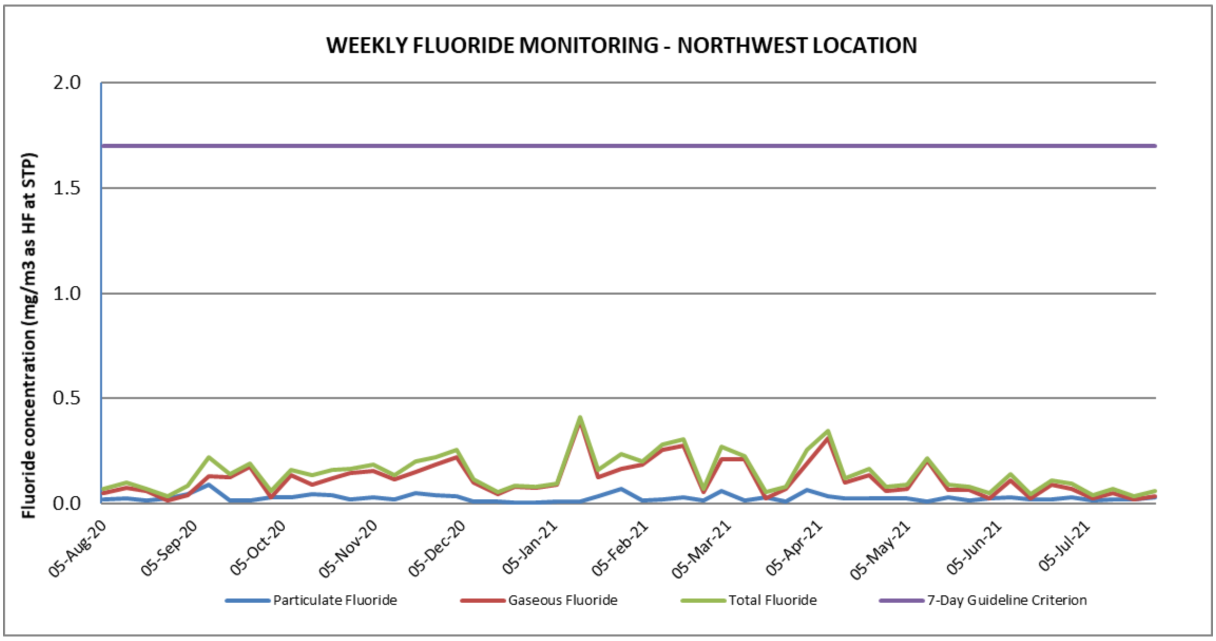


Figure 7 **Weekly fluoride monitoring – northwest location**

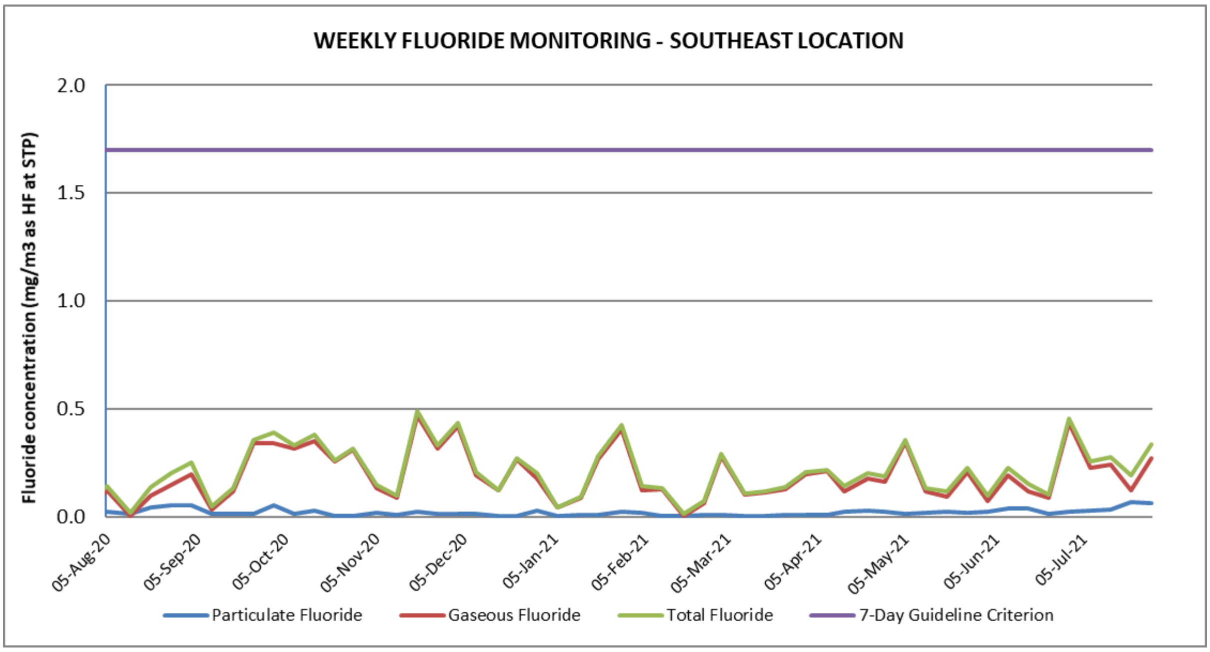


Figure 8 **Weekly fluoride monitoring – southeast location**

4.2 Fluoride Impact on Vegetation

Monitoring the impact of atmospheric fluoride on vegetation in the area surrounding the NCIA facility commenced in 2004. The monitoring program was designed by AECOM based on the assessment methods developed by Dr David Doley of the University of Queensland.

In accordance with condition M4.1 of the EPL, the impact of fluoride on vegetation was monitored by undertaking visual assessments of the condition of local vegetation surrounding the NCIA facility and by foliar sampling of selected flora species for laboratory analysis of fluoride content. Samples chosen for fluoride content analysis were selected on the basis of known species sensitivity toward fluoride, representation of certain species and vegetation type (over storey, cultivated vegetation and forage crops). Generally, the species assessed in the monitoring program were selected based on their known sensitivity to atmospheric fluoride impacts.

Quarterly vegetation assessments were conducted during the reporting period (September 2020, December 2020, March 2021, and June 2021) with the December 2020 round doubling as an Annual Vegetation Condition Assessment.

A detailed report summarising the findings of each vegetation assessment can be found attached in **Appendix A**.

4.3 Meteorological Monitoring

Meteorological data is recorded at the meteorological station established at the South East air monitoring location. The station is sited and operated in accordance with approved methodologies (EPA, 2016) for the continuous measurement of wind speed (10 m), wind direction (10 m), sigma theta (10 m) and temperature (5 m). A tipping bucket rain gauge is also deployed to record daily rainfall rates.

The monthly data for temperature and rainfall are provided in **Figure 9**. Monthly wind roses representing the wind speed and direction for the reporting period are provided in **Appendix B**. A summary of the dominant wind patterns throughout the reporting period is provided below.

Review of the monthly wind roses for the reporting period indicates the following:

- In August 2020 winds were blowing predominantly from the northwest.
- From September 2020 to December 2020 winds were blowing predominantly from the northwest and southeast.
- From January 2021 to March 2021 winds were predominantly from the southeast to south with some northwest components.
- In April 2021 winds were predominately from the northwest with some southeast component.
- During May 2021 to July 2021 winds were predominately from the northwest.

Wind speeds recorded over the year were generally low to medium with an average wind speed of 2.0 m/s during the reporting period. The maximum hourly average wind speed during the reporting period was recorded at 9.6 m/s on 29 November 2020.

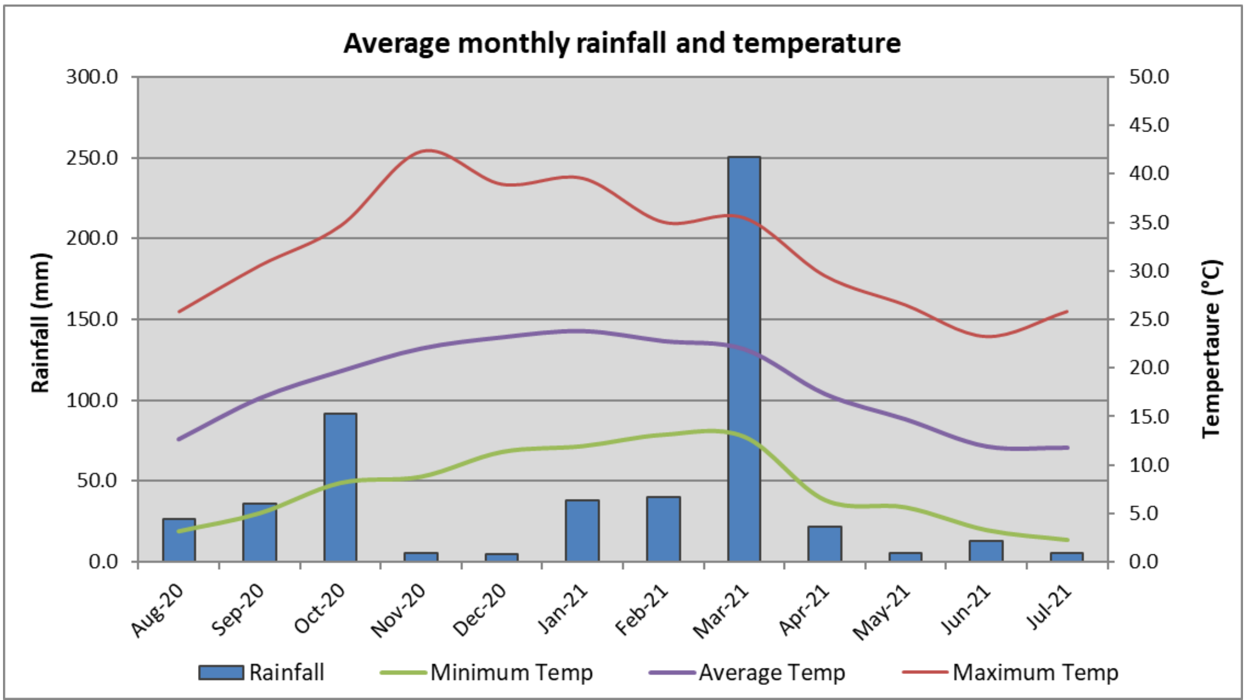


Figure 9 **Average monthly rainfall and temperature range (1 August 2020 – 31 July 2021)**

4.4 Stack Emissions Testing

Stack emissions testing is undertaken annually in accordance with the EPL requirements. Stack emissions testing was conducted during April, May and June 2021. Emission sources assessed during the testing period were those defined in the EPL and listed in **Table 4-4**.

Table 4-4 **Emission source descriptions**

EPL Identification Number	Emission Source Description
1	Clay Preparation (CP1)
3	Pressing and Drying (PD1)
5	Dryer (D1)
6	Dryer (D2)
9	Glaze Line
10	Selection Line (SL 1,2,3,4)
12	Spray Dryer (SD1)
14	Kiln 1 (KP1)
15	Kiln 2 (KP2)
18	Hot Air Cooler 1 (HAC1)
19	Hot Air Cooler 2 (HAC2)

Each source was tested for Total Particulates and Fine Particulates (PM_{10}). Testing conducted on the Kiln 1 and Kiln 2 stacks also measured concentrations of Total Fluoride (as HF), Sulfuric Acid Mist (H_2SO_4 as SO_3), Sulfur Dioxide (SO_2), Total Hazardous Substances (metals), Nitrogen Oxides (NO, NO_2, NO_x and Equivalent NO_2), Cadmium and Mercury. All sampling was conducted in accordance with the applicable EPA test methods with analyses conducted by a NATA-accredited laboratory.

The Project Approval does not specify pollutant concentration limits for the facility. Pollutant concentration limits are specified in Condition L3 of the EPL. Summaries of the emission testing results, along with the EPL pollutant discharge limits, are provided in **Table 4-5** and **Table 4-6**.

All emission concentrations are converted to standard conditions of 0°C, dry gas and 1 atmosphere pressure for comparison with appropriate regulatory limits. The Nitrogen Oxides, Total Particulate and PM_{10} emission concentrations from the Kiln stacks are corrected to 18% O_2 for comparison with EPL requirements.

Table 4-5 Summary of particulate emission monitoring results (April-June 2021)

Stack	Fine Particulate (PM_{10}) (mg/m^3)	Total Particulate (mg/m^3)	Regulatory Limit (mg/m^3)*
Clay Preparation (CP1) (EPL 1)	<0.14	0.49	20
Pressing and Drying (PD1) (EPL 3)	1.7	8.4	20
Dryer (D1) (EPL 5)	2.0	8.6	20
Dryer (D2) (EPL 6)	4.6	11	20
Glaze Line (EPL 9)	<0.088	0.24	20
Selection Line (SL 1,2,3,4) (EPL 10)	<0.12	<0.13	20
Spray Dryer (SD1) (EPL 12)	6.0	2.8	20
Hot Air Cooler (HAC 1) (EPL 18)	0.26	1.2	5
Hot Air Cooler (HAC 2) (EPL 19)	0.52	1.3	5

[1]*Note: Regulatory limit only applies to Total Particulate.*

Table 4-6 Summary of emission monitoring results – Kiln 1 and Kiln 2 (April-June 2021)

Pollutant	Kiln 1 (EPL 14) (mg/m^3)	Kiln 2 (EPL 15) (mg/m^3)	Regulatory Limit (mg/m^3)
Fine Particulate (PM_{10}) (at 18% O_2)	12	11	N/A
Total Particulate (at 18% O_2)	16	15	20
Gaseous Fluoride (as HF)	6.4	6.4	N/A
Particulate Fluoride (as HF)	3.1	1.7	N/A
Total Fluoride (as HF)	**9.5**	**8.1**	5
Sulfuric Acid Mist (H_2SO_4 as SO_3)	32	24	100
Sulfur Dioxide (SO_2)	190	290	NA
Oxides of Nitrogen (as equivalent NO_2) (at 18% O_2)	81	76	100
Total Hazardous Substances (Metals)	0.21	0.16	1
Cadmium	0.0081	0.0050	0.1
Mercury	0.0024	0.0033	0.1

*Note: **Bold** font indicates an exceedance of the criteria.*

4.5 Noise Monitoring

Noise limits set out in NCIA's Project Approval are more stringent than those set out in the EPL and therefore the Project Approval limits are used to assess compliance with noise requirements. The Project Approval states that noise generated from NCIA should not exceed 35 dB(A), $L_{eq(15\ min)}$ during the day, evening or night periods at the Kenvil Close and Wollombi Road noise monitoring locations (as specified in Condition 26 of the Project Approval). The Project Approval also sets a night-time sleep disturbance criteria of 45 dB(A) L_{max}.

Noise levels are measured in accordance with NCIA's Project Approval, EPL, and the procedures set out in the *Noise Policy for Industry 2017 (NPfI)*. In accordance with the *NPfI* the noise criteria apply under all meteorological conditions except during rain, wind speeds greater than 3m/s (at 10 m above ground level) and intense temperature inversions (greater than +3°/100) between 6 pm and 7 am. Data obtained during these meteorological conditions were omitted.

The noise monitoring was undertaken by AECOM in June 2021. A series of attended noise measurements of 15 minutes duration were made in Kenvil Close and Wollombi Road on Tuesday 1st and Thursday 24th June 2021 during the day, evening and nighttime periods. Measurements were also made at the NCIA site boundary during these periods. Operator field notes allow for individual noise sources and events to be isolated, and the contributions of the various noise sources can then be quantified. At the time of the monitoring operational activities at NCIA were being carried out under typical conditions.

The results of the attended noise measurements at each location and time are summarised in **Table 4-7**.

Table 4-7 Received noise levels during attended noise monitoring (1 and 24 June 2021)

Location	Date/ Time	dB(A), $L_{eq\ (15\ min)}$	Wind speed / direction	Identified Noise Sources	dB(A), L_{max}
Kenvil Pl Daytime	24/6/21 12:20	**47**	(<1 m/s) and generally from the east south east	• Site inaudible • Highway traffic and birds dominant • Dog barking occasionally but minimal local residential noise	n/a
Kenvil Pl Evening	1/6/21 20:35	**45**	(<1 m/s) and generally calm.	• Unable to determine whether site audible • Highway traffic dominant with minimal local traffic • Trucks on the highway particularly audible. • Some local residential noise • Paused for passing trains and loud vehicles	n/a
Kenvil Pl Night	1/6/212 2:40	**42**	(<1 m/s) and generally calm.	• Site barely audible • Highway traffic the dominant source • Some industrial noise from other sites on Racecourse Rd • Very minimal local noise • Paused for loud vehicles and passing trains	n/a
Wollombi Rd Day	24/6/21 13:02	**65**	(<1 m/s) from the east south east.	• Site inaudible • Traffic on Wollombi Rd dominant • Birds and trees rustling	n/a
Wollombi Rd Evening	1/6/21 21:40	**41**	(<1 m/s) and generally calm.	• Some industrial noise audible, likely some site contribution • Crickets at times but otherwise minimal local noise • Paused for regular traffic on Wollombi Rd • Paused for passing trains	n/a
Wollombi Rd Night	1/6/21 22:01	**40**	(<1 m/s) and generally calm.	• Some industrial noise audible, likely some site contribution • Crickets at times but otherwise minimal local noise • Paused for regular traffic on Wollombi Rd • Paused for passing trains	n/a

The results show that the measured $L_{Aeq(15\ min)}$ noise levels at both the Kenvil Place and Wollombi Rd monitoring locations are above the 35 dB(A) Project Approval limit for each of the three time periods.

In most cases traffic was noted to be the dominant noise source with the site noted to be inaudible during the day, potentially audible in the evening and barely audible at night.

In order to determine the noise contribution from the facility alone at the receiver locations, an alternative method of determining compliance, in accordance with the NPfI was considered appropriate. In this case site boundary measurements were used to predict noise impacts for each receiver location.

4.5.1 Site Boundary Monitoring

Boundary noise measurements were conducted during the day, evening and night-time periods at a single location considered to be representative on the eastern boundary of the site. Results from the site boundary monitoring carried out on 1 and 24 June 2021 are presented in **Table 4-8** below.

Table 4-8 June 2021 Site Boundary Measurement Results

Location	Time		Measured Noise Level, $L_{Aeq(15\ min)}$ and $L_{A90(15\ min)}$ dB(A)		Site Operation
			$L_{Aeq(15\ min)}$	$L_{A90(15\ min)}$	
Boundary	Day	24/6/21 10:59	51.1	50.2	• Site dominant with majority of noise generated by continuous processes. • Highway traffic occasionally audible • Birds • Minimal extraneous noise
	Evening	1/6/21 19:24	52.8	52.1	• Plant noise dominant and very constant • Dogs occasionally barking at nearby RSPCA facility • Paused for passing trains and planes
	Night	1/6/21 23:13	52.6	51.9	• Plant noise dominant • Very little other noise • Paused for passing trains

The results of the site boundary measurements demonstrate there is very little extraneous noise present at this location with the L_{A90} results relatively close to the LA_{eq} results for all three time periods. The LA_{90} represents the lowest 10% of the noise measured.

4.5.2 Predicted Noise Levels

In order to predict resultant noise levels at each receiver from the NCIA facility alone, a 'flat ground' model was used based on hemispherical spreading, conservatively assuming no topographical shielding, ground or air absorption, directivity or meteorological effects. Calculated noise levels at each receiver location are presented in **Table 4-9**.

Table 4-9 June 2021 – Calculated Noise Levels at the Receiver Locations

Receiver Location	Time	Calculated noise impact, dB(A)	Project Approval Limit, dB(A)	Comply
Kenvil Place	Day	35	35	Yes
	Evening	37	35	Yes*
	Night	37	35	Yes*
Wollombi Road	Day	33	35	Yes
	Evening	35	35	Yes
	Night	34	35	Yes

* Calculated noise level within 2dB of statutory noise limit and considered negligible as per the NPfI

Calculated results show that with the exception of the Kenvil Place evening and night results, all predicted results are either below or equivalent to the 35dB Project Approval limit at both receiver locations.

A result within 2dB of the criteria was calculated at the Kenvil Place receiver for the evening and night-time periods with a 2dB exceedance considered negligible by the NPfI. The calculation also assumes a flat ground model with direct line of site between the source and receiver. In this case the site is not visible from Kenvil Place, with a significant amount of infrastructure between the site and this location as well as a line of trees at the site boundary. It was unable to be determined if the site was audible during the evening period, while the site was noted to be barely audible during the night-time measurements. As a result, it is likely that the site contribution at this location was compliant with the 35dB limit.

4.5.3 Assessment Against Short-Term Night-time Criteria

Both the Project Approval and EPL state that a 45dB short term limit applies during the nighttime period (10pm – 7am). The Project Approval stipulates the L_{AMax} must not exceed 45 dB at the two receiver locations (Kenvil Place and Wollombi Road) while the EPL stipulates that the L_{A1} must not exceed 45 dB at the nearest residential receiver most affected by noise from activities at the premises (deemed to be 26 Fairway Street).

L_{AMax} measurements performed at the Project Approval locations were elevated due to localised noise sources and are not representative of the site contribution. While an L_{A1} measurement was not directly obtained at 26 Fairway Street, the L_{AMax} measured at this location was 47 dB, The L_{Amax} reading is a shorter time period than the L_{A1} and provides a conservative assessment of short-term noise potentially impacting sleep. An exceedance within 2 dB of the criteria is considered negligible under the NPfI and it is likely that an L_{A1} result if available would be compliant. For reference the L_{A10} result of 44dB at this location is below the 45dB L_{A1} criteria.

Due to the proximity of the Fairway Street location to the site (357m) and the significant distance between the two Project Approval locations and the site (1050m and 1350m), a compliant result at Fairway Street implies the L_{AMax} is also compliant at both the Kenvil Place and Wollombi Road locations.

4.6 Water

4.6.1 Water Usage

Water usage at NCIA is principally for use in the tile manufacturing process and wash down requirements. Water is also required for staff amenities, landscaping and firefighting if required.

Although there is no regulatory limit on water usage, Schedule 3 Condition 44 of the Project Approval stipulates that NCIA needs to seek approval from Hunter Water Corporation (HWC) before its water consumption is expected to exceed 92ML/year.

NCIA used a total of approximately 51.5 ML of process water during the current reporting period. This is well below the threshold value of 92ML/year for which HWC approval is required.

4.6.2 Stormwater Quality

Stormwater quality is monitored on a weekly basis within Pond 4, which is located in the South East corner of the site. The channel outlet connected to Pond 4 is the location of potential stormwater discharge from the site. Monitoring is therefore undertaken within Pond 4 in order to ascertain water quality data in the event of such discharge occurring. Monitoring started in 2009 and is ongoing with the following parameters monitored: pH value, Electrical Conductivity (EC) (as a measure of salinity) and water temperature, as well as visual observations of turbidity levels, odour and colour.

The results of the stormwater quality monitoring during the reporting period for pH and EC are presented in **Figure 10** and **Figure 11** respectively. For assessment purposes the monitoring results are compared against the *ANZG Guidelines for Fresh and Marine Water Quality* (ANZG 2018). The adopted ANZG 2018 guidelines for pH and conductivity are the default trigger values for slightly disturbed aquatic ecosystems in NSW lowland rivers. The data for the current monitoring period shows that pH values ranged between 6.1 and 10.0 with a varying trend throughout the reporting period. Results generally exceeded the ANZG guidelines.

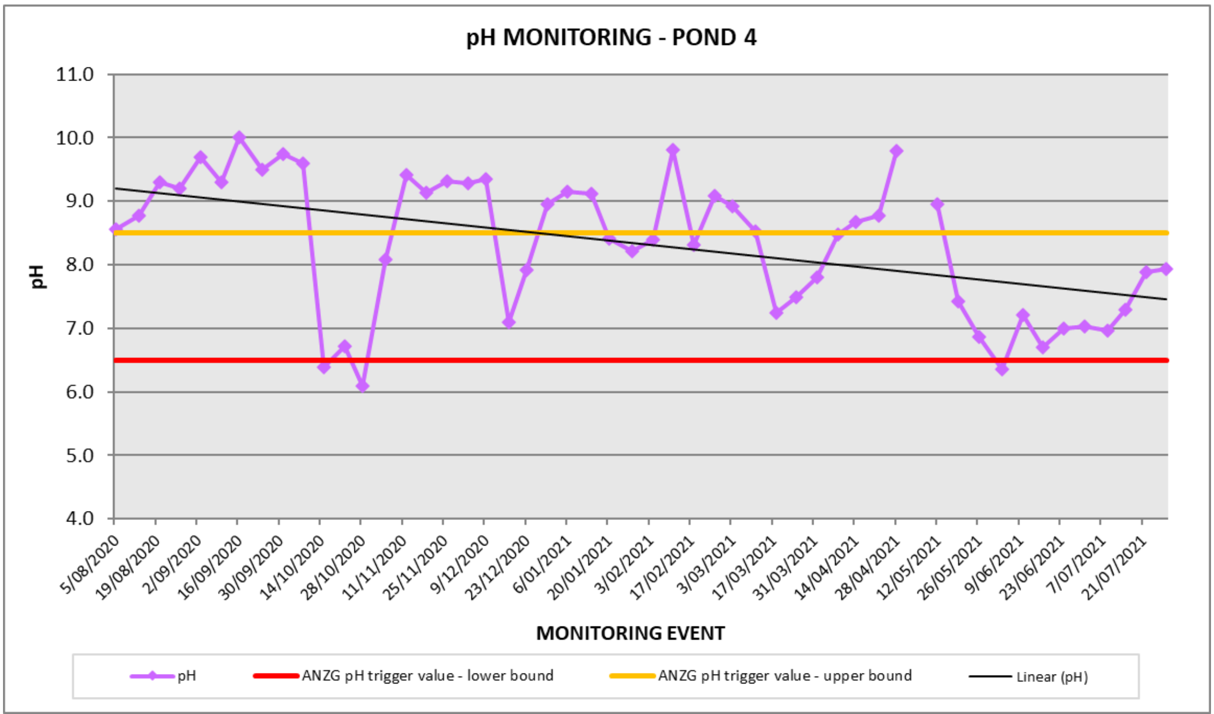


Figure 10 Stormwater quality monitoring – pH

EC values were low and show a very slight decreasing trend throughout the reporting period with levels generally around 160 to 500 µS/cm indicating that the water is non-saline. The EC values were within the ANZG guidelines for the entire reporting period.

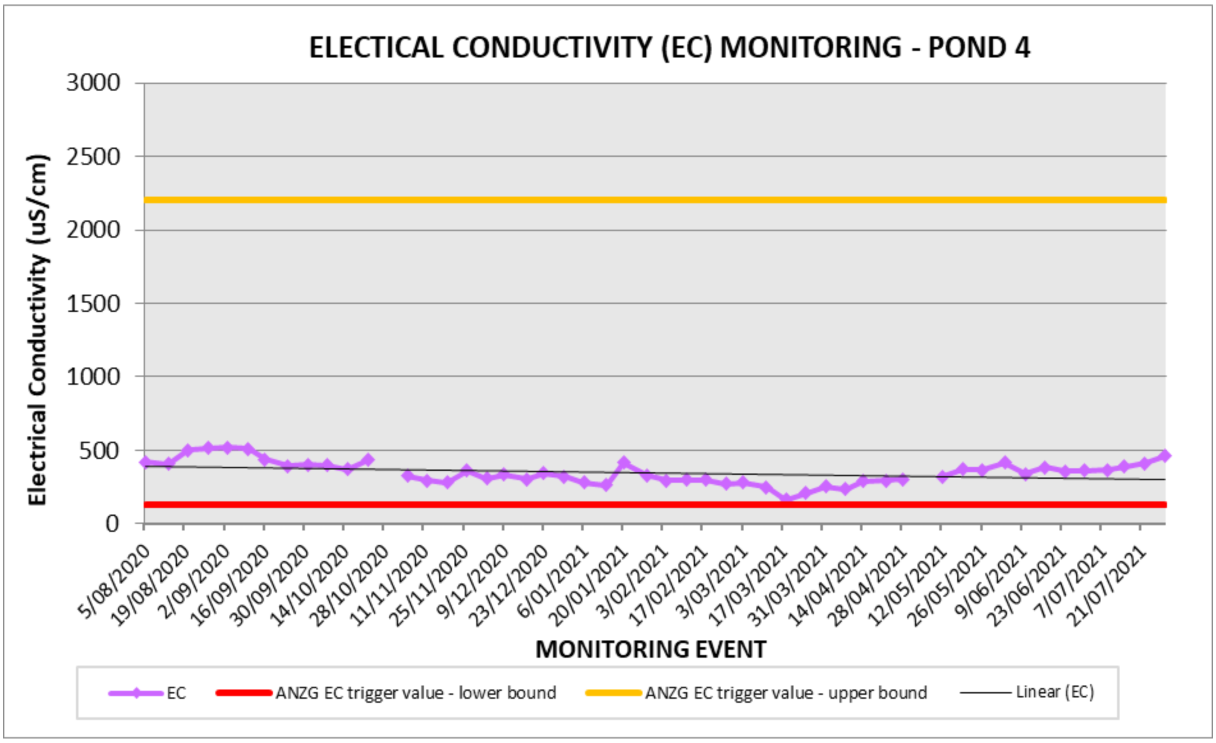


Figure 11 Stormwater quality monitoring – EC

4.7 Waste Generation

There are no regulatory requirements in terms of waste generation quantities, types or production efficiency targets pertaining to NCIA's operations. The Project Approval simply stipulates that a designated area for the storage and collection of waste and recyclable material must be provided at the facility (Schedule 3 Condition 52). Designated areas are provided on site for the storage of fired waste and other wastes (e.g. general office and packaging wastes) in accordance with the requirements of the Project Approval.

The main waste generated from the operation is tile waste. Tile waste comprises both green tiles (i.e. raw material waste from unfired tiles) and broken fired tiles. Other types of waste generated from the facility include consumables, packaging waste and general domestic waste generated within the office and lunchroom; however, these wastes represent an extremely minor part of the total waste stream.

The amounts of tile waste generated during the current reporting period (shown as a proportion of the total tile production) are presented in **Figure 12**.

NCIA's targets for tile wastes were lowered in July 2018 to not exceed 1% (for green tile waste) and 7% (for fired tile waste) of the total tile production, respectively. From the previous reporting period the amount of green waste has increased as a result of capturing more defective product prior to firing resulting in all months (except for June 2021) exceeding the green tile waste target. It must be noted that all green waste is recycled. The increased capture of green waste has resulted in the reduced amount of fired tile waste from a monthly average of 8.0% recorded in the previous reporting period to a monthly average of 7.8% with all the months exceeding the target in the 2020-21 reporting period.

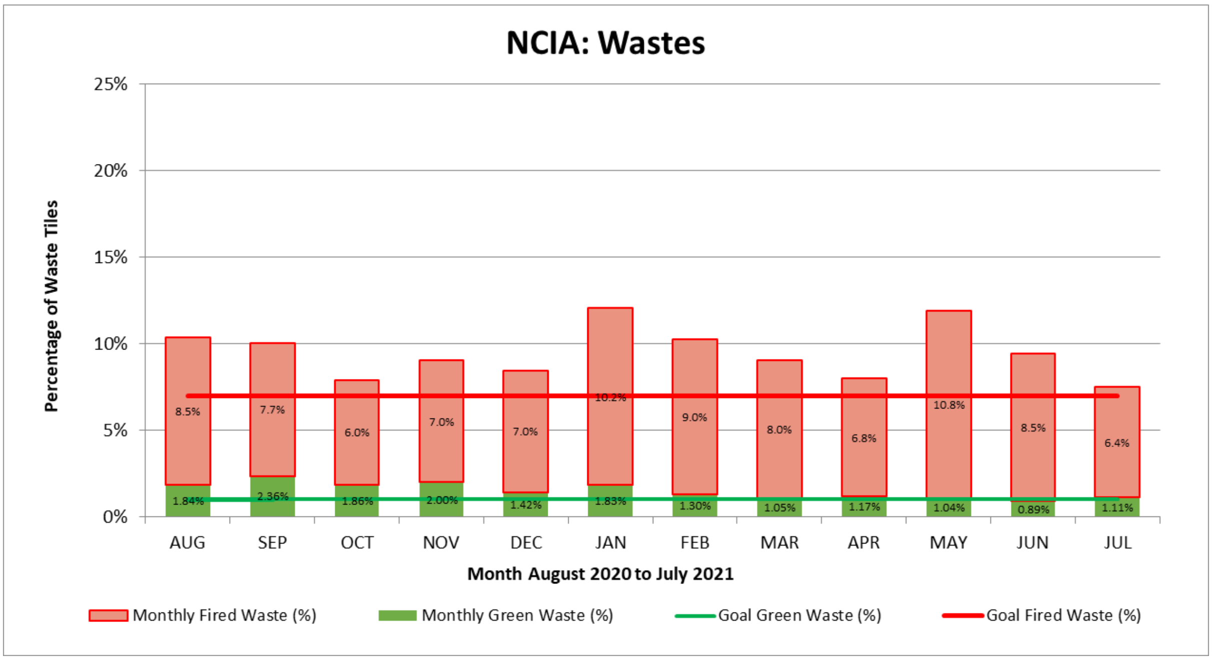


Figure 12 Tile waste (green and fired) generation during the 2021 reporting period

5.0 Discussion of Environmental Performance

This section provides an assessment of the monitoring results for the reporting period against the criteria set out in the Project Approval and EPL, predictions made in the 2010 EA, and the monitoring results from previous years. Trends observed in the monitoring results or discrepancies between predicted and actual impacts are discussed.

5.1 Ambient Air Quality

The 2010 EA predicted that, with the exception of PM_{10}, emissions from NCIA would meet all of the ambient air criteria. The 2010 EA stated that existing background 24-hour PM_{10} concentrations already exceeded the EPA criterion. While it was predicted that the annual average PM_{10} criterion would be met, the 2010 EA indicated that the 24 hour average PM_{10} concentrations may exceed the criteria under worst case dispersion conditions. Specifically, predictions made in the 2010 EA for the project included the following:

- The maximum cumulative 24 hour average PM_{10} concentration at the closest existing private receptor was predicted to be 53.4 µg/m^3 (compared to the criterion of 50 µg/m^3);
- The maximum cumulative 24 hour average PM_{10} concentration for residential receptors within the Heritage Parc subdivision (located at 99 Racecourse Road, Rutherford) was predicted to be 57.7 µg/m^3 (compared to the criterion of 50 µg/m^3);
    - The cumulative impact of predicted maximum PM_{10} concentrations at all existing residential receptors was considered to be minor despite the predicted cumulative results being above the guidelines. It was not expected that the predicted PM_{10} impacts would be beyond levels already experienced due to the minor contribution of the project when compared to the elevated background PM_{10} levels.
    - No exceedances of 24 hour or weekly Fluoride concentrations at existing residential receptors were predicted.
    - The maximum cumulative 24 hour Fluoride concentration for future residential receptors within Heritage Parc was predicted to be 3.2 µg/m^3 (compared to the criterion of 2.9 µg/m^3).
    - The above exceedance of the 24 hour Fluoride criterion was predicted during a worst case scenario with NCIA operating all eight Stages. Only two Stages of the development are currently operational.

Ambient air quality monitoring during the reporting period (presented in **Section 4.1**) indicated that the levels of 24 hour PM_{10}, annual average PM_{10}, 24 hour fluoride and weekly fluoride were generally compliant with the relevant guidelines criteria, with one exceedance of the 24 hour PM_{10} criteria of 50 µg/m^3 recorded. NCIA were not considered to be a major contributor to any of these exceedances (as discussed in **Section 4.1.1**). The monitoring results for the reporting period are considered to be consistent with the predictions made in the 2010 EA.

Historical ambient air monitoring results recorded since commencement of operations (15 March 2004 to current) are shown in **Figure 13** to **Figure 18**. An analysis of historical trends in air pollutant concentrations (and where relevant comparisons against the current reporting period) reveals the following:

- Historical PM_{10} concentrations are variable with results generally oscillating around a relatively stable annual average and isolated elevated concentrations occurring episodically. PM_{10} concentrations during the 2021 reporting period were consistent with historical data and there is a decreasing linear trend in PM_{10} concentrations, which is more apparent at the NW monitoring location compared to the SE monitoring location.
- Following seven years of relatively low and steady levels of fluoride emissions between 2004 and 2011 (despite isolated and episodic increases), gaseous fluoride levels have slightly increased since 2012 in both the 24-hour and weekly fluoride levels. Fluoride emissions during the 2021 reporting period were similar to the previous five years. Nonetheless, there is an overall increasing linear trend in 24 hour and weekly fluoride levels at both monitoring locations.

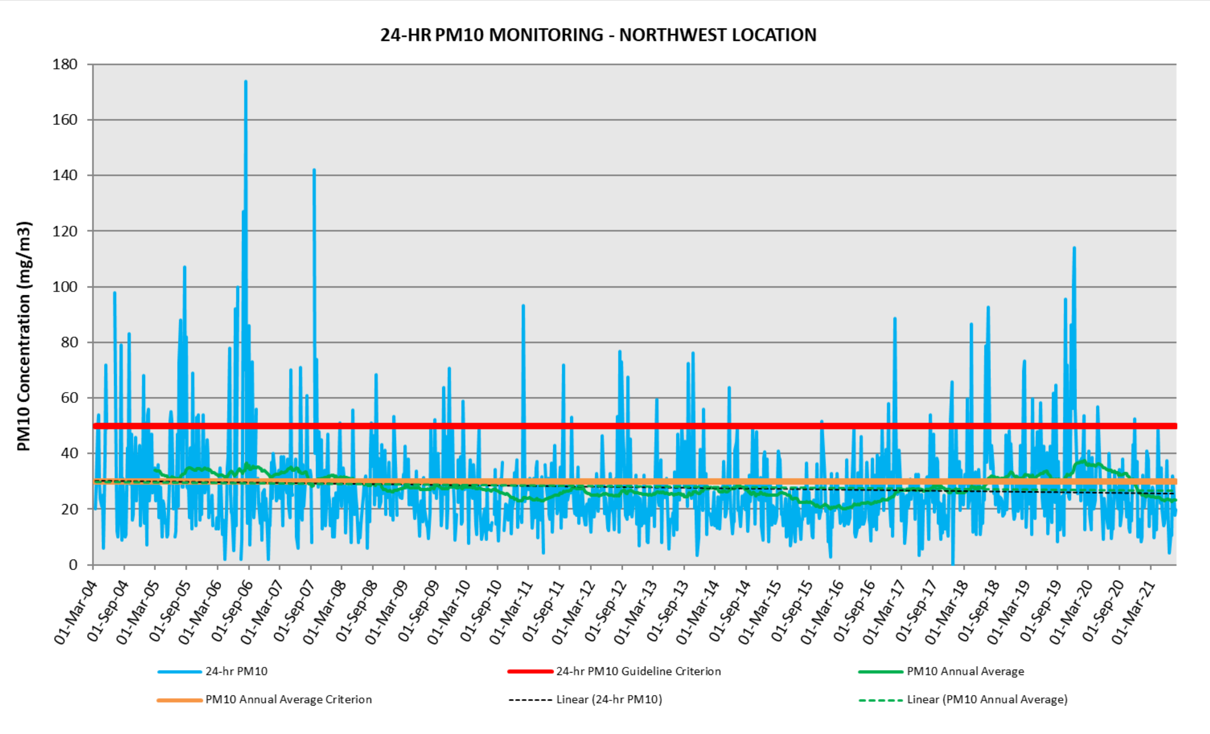


Figure 13 24-hour PM_{10} monitoring – northwest location (2004 – 2021)

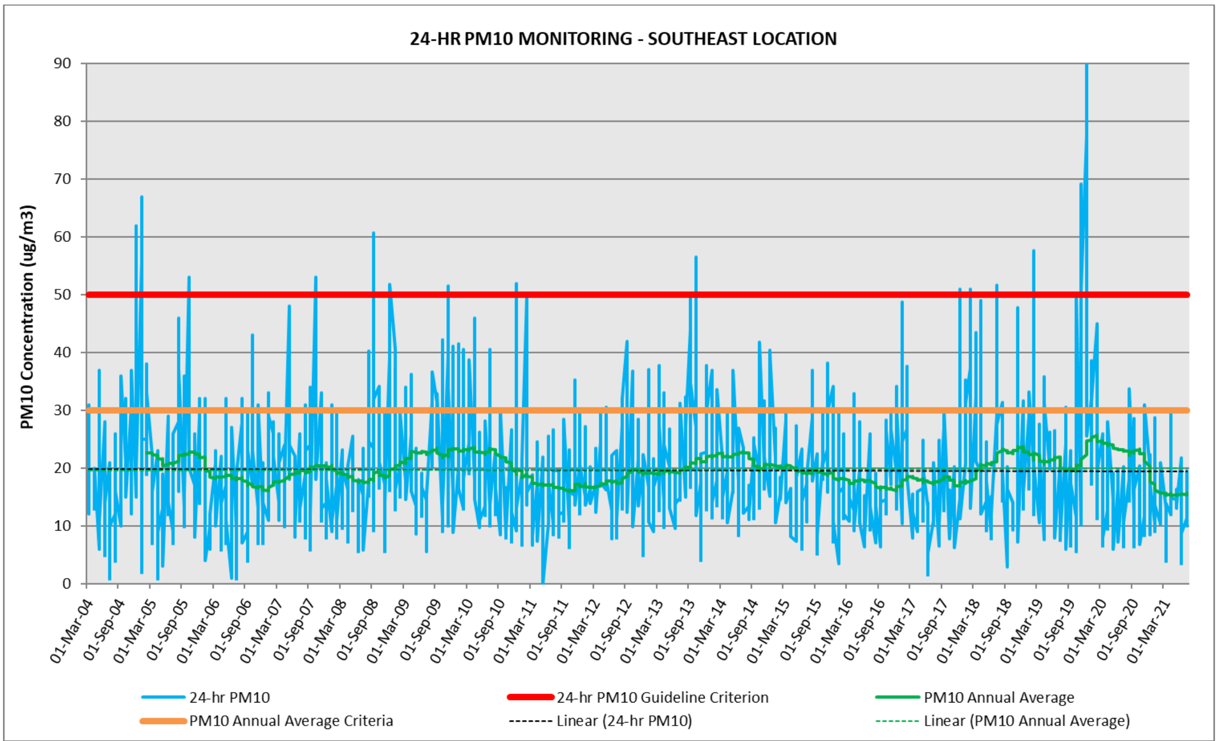


Figure 14 24-hour PM_{10} monitoring – southeast location (2004 – 2021)

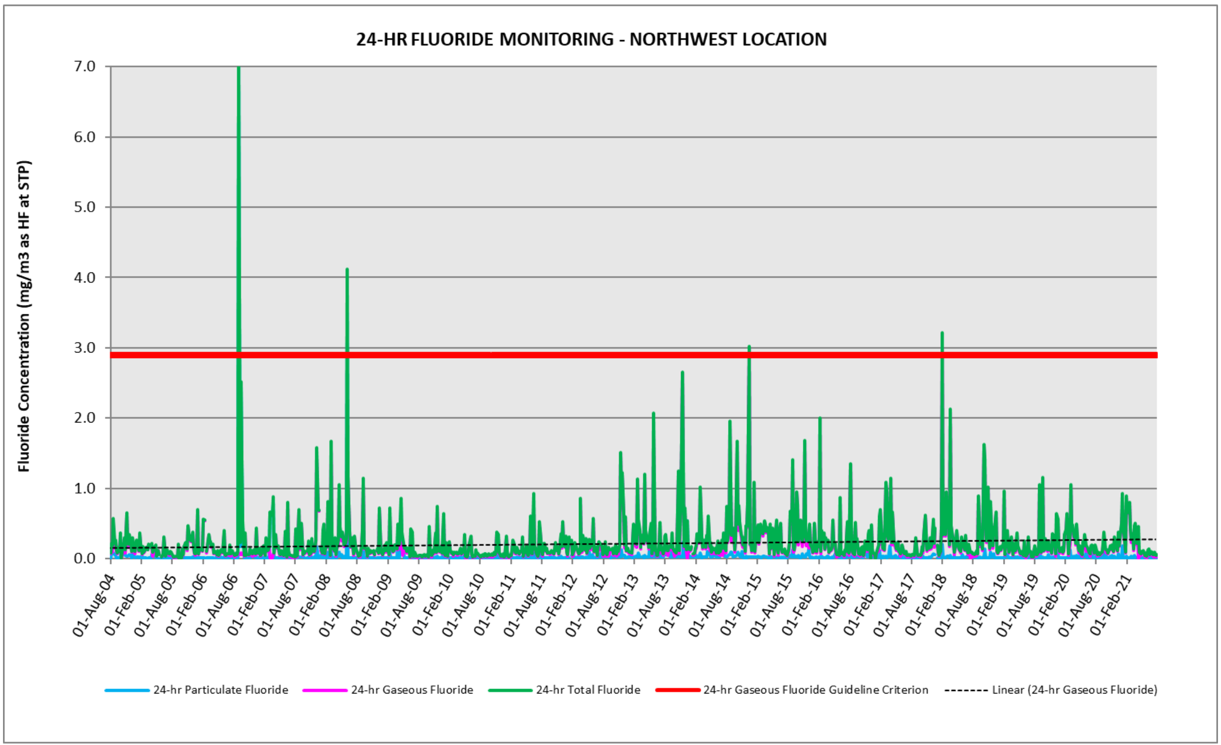


Figure 15 24-hour fluoride monitoring – northwest location (2004 – 2021)

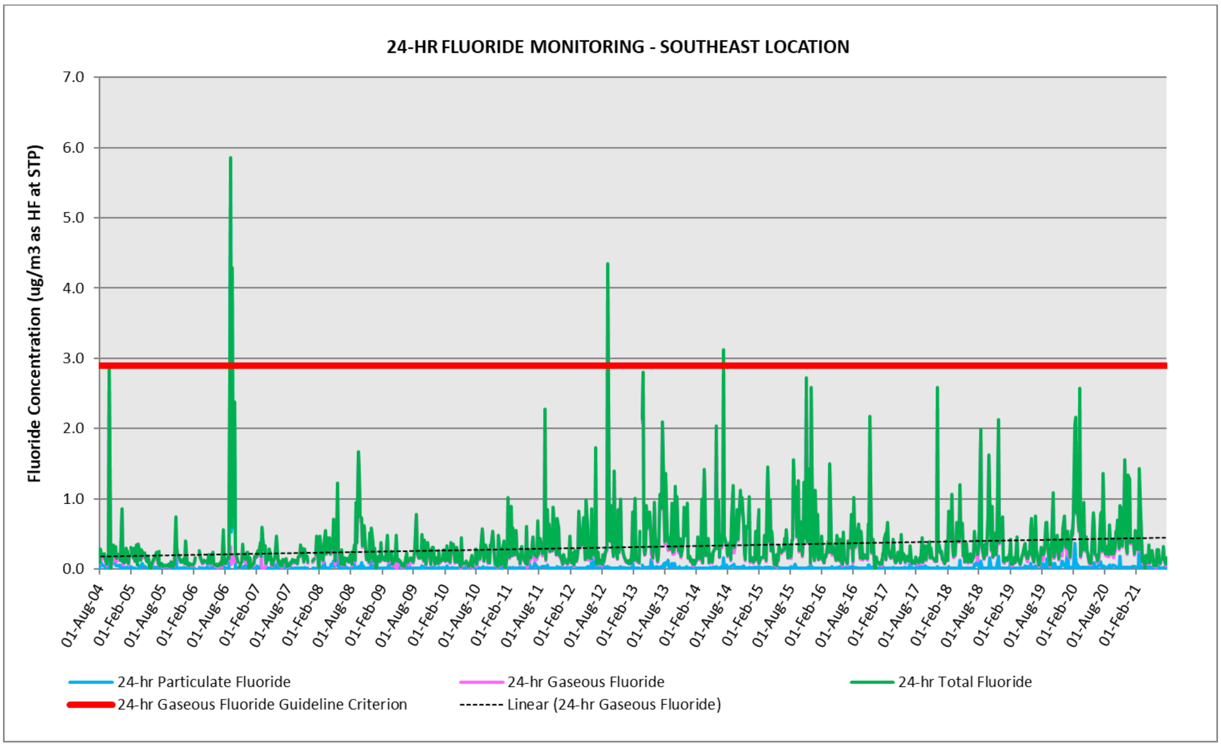


Figure 16 24-hour fluoride monitoring – southeast location (2004 – 2021)

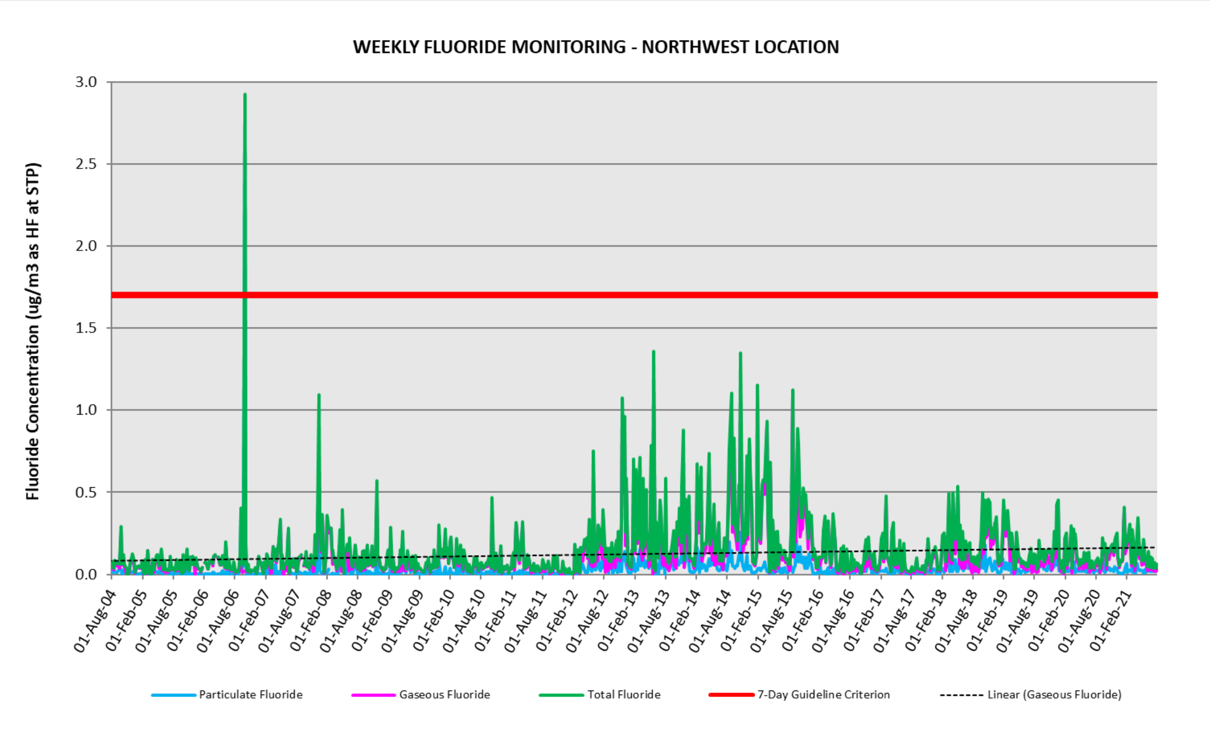


Figure 17 Weekly fluoride monitoring – northwest location (2004 – 2021)

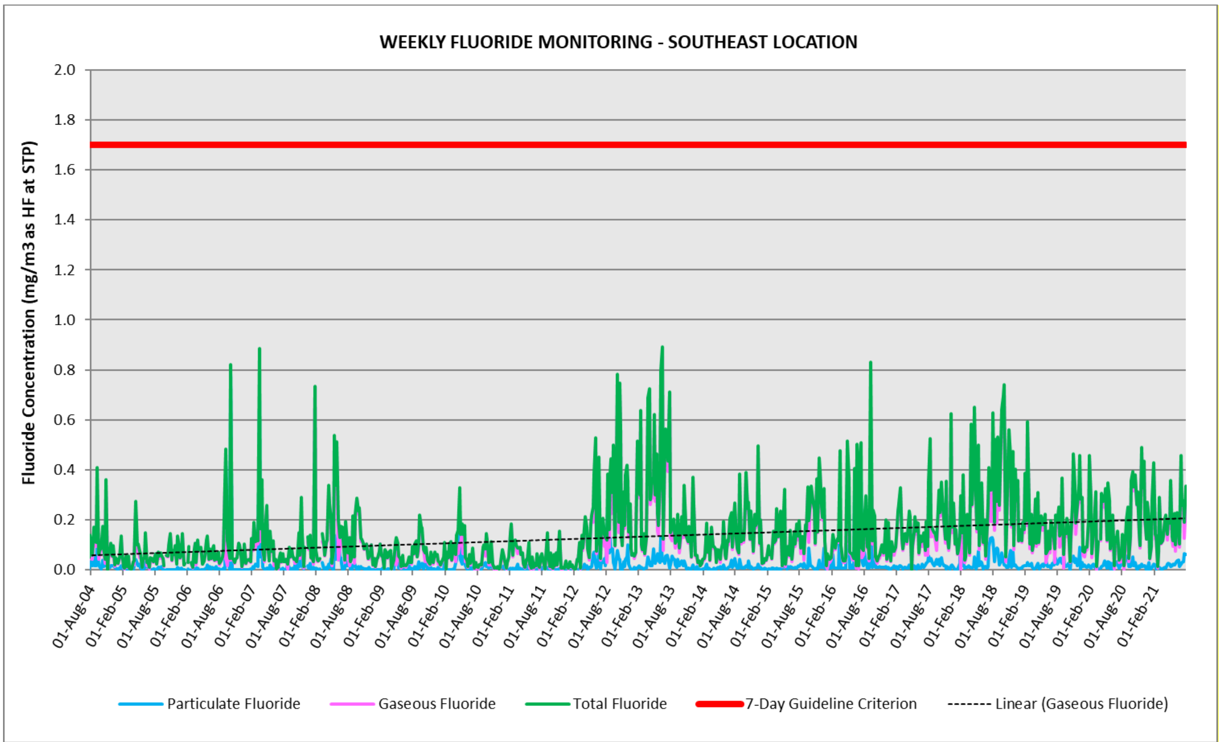


Figure 18 Weekly fluoride monitoring – southeast location (2004 – 2021)

5.2 Fluoride Impact on Vegetation

As required by the EPL the potential impact of NCIA's operations on vegetation surrounding the facility is monitored through assessment of fluoride impacts on local vegetation, including visual assessments of injury symptoms to leaves and foliar fluoride content. There are no limits or criteria set out in the EPL or Project Approval by which to assess compliance. Likewise, the 2010 EA did not specifically discuss fluoride impact on vegetation and therefore no predictions are available for comparison. Instead, the assessments are used to provide an indication of trends in fluoride injury and concentrations at set locations surrounding the facility and for a suite of particular species.

A total of 19 locations were surveyed during the current reporting period over the course of four surveys (one survey per calendar quarter). A total of 60 plant specimens were assessed for fluoride-related visual injury symptoms to foliage, and foliar sampling undertaken on six plant specimens and analysed for fluoride concentration levels.

Monitoring locations were selected based on the modelling in the EIS (Parsons Brinkerhoff 2002) and EA (AECOM 2010) and an understanding of the prevailing meteorological conditions. The specimens chosen to be sampled for foliar fluoride content were selected by Dr David Doley for their sensitivity to plant fluoride interactions.

Elevated regional background fluoride concentrations are found in air within the Lower Hunter Region. As a result, foliar fluoride concentrations in the vicinity of NCIA may be influenced by the elevated background fluoride concentration. The existing sampling regime provides an acceptable data set that may, over time, together with other data sets which relate to other fluoride source points indicate any long-term trends in fluoride emissions impacts in the local area.

Results of the field-based visual assessment of vegetation condition during the current reporting period were generally within historical values and long-term trend. The majority of specimens assessed displayed at least some level of fluoride-related visual injury symptoms. Of all specimens surveyed, on average ~10.1% displayed no injury symptoms, ~59.2% displayed only very slight or slight injury symptoms, ~30.4% distinct or marked injury symptoms and only ~0.4% severe or greater injury symptoms. The collected data support no statistically significant long-term trends (increasing or decreasing) since the start of the monitoring program, and any potential impact from NCIA on the health of local vegetation would be inconclusive.

Emissions related injury can be mimicked by natural environmental impacts such as climatic conditions and insect attack. Insect attack was variable and evident at most locations during the reporting period.

Results of foliar fluoride content for the reporting period were generally consistent with long-term seasonal patterns and consistently within the lower range of historical values for all sampled specimens, which may have been influenced by to the above-average rainfall received in the region in 2020-2021.

Overall, long-term observations and results highlight an inherent level of unpredictability in the expression of visual symptoms between monitoring events as well as an obvious variability in sensitivity to fluoride impacts both inter and intra-species, with different individuals clearly being more resistant or sensitive to emission related impacts than others.

5.3 Meteorological Monitoring

NCIA have been monitoring the local meteorological conditions in accordance with Condition M5 – Weather Monitoring of the EPL. **Table 5-1** demonstrates the percentage uptime of monitoring equipment achieved throughout the reporting period. The meteorological monitoring equipment achieved continuous monitoring of 100.0% for wind speed, 99.8% for wind direction, 100.0% for ambient temperature and 100.0% for rainfall during the reporting period.

Table 5-1 Meteorological station data capture

Meteorological Parameter	Frequency	Percentage up-time during reporting period
Wind speed @10m (m/s)	Continuously	100.0%
Wind direction @ 10m (degrees)	Continuously	99.8%
Sigma theta @ 10m (degrees)	Continuously	99.8%
Ambient temperature @ 5m (degrees Celsius)	Continuously	100.0%
Rainfall (mm)	Continuously	100.0%

5.4 Air Emissions

The 2010 EA included dispersion modelling to predict ground level pollutant concentrations. The source emission concentrations used in the modelling (Table 17 of the 2010 EA) were based on the results of stack emission testing conducted between 2007 and 2009. A comparison of the measured in-stack emission concentrations for the reporting period and the emission concentrations used in the 2010 EA modelling is provided in **Table 5-2**. The results are variable with some of the measured emission concentrations during the reporting period lower and some higher than those used in the 2010 EA modelling. However, where measured stack concentrations were higher than those used in the 2010 EA, these did not result in an exceedance of the EPL limits (refer to **Section 4.4**) with the exception of total fluoride.

Table 5-2 Comparison of emission concentrations used in 2010 EA modelling and measured in stack emission concentrations for the current reporting period

Source	Emission Concentration (mg/m^3)							
	Fine particulate (PM_{10})*	Total Particulate *	Total Fluoride (as HF)	Sulfuric acid mist (H_2SO_4 as SO_3)	Total Hazardous substances (Metals)	Total Oxides of Nitrogen*	Cadmium	Mercury
Kiln 1 (EPL 14)	**12** (5.3)	**16** (5.3)	**9.5** (5.0)	**32** (9.6)	**0.21** (0.2)	**56** (50)	**0.0081** (0.003)	0.0024 (0.01)
Kiln 2 (EPL 15)	**11** (5.3)	**15** (5.3)	**8.1** (5.0)	**24** (9.6)	0.16 (0.2)	**51** (50)	**0.0050** (0.003)	0.0033 (0.01)
Clay preparation (CP1) (EPL 1)	<0.14 (2.0)	0.49 (2.3)	-	-	-	-	-	-
Pressing and Drying (PD1) (EPL 2)	1.7 (2.5)	**8.4** (4.8)	-	-	-	-	-	-
Dryer (D1) (EPL 5)	2.0 (8.4)	8.6 (12.8)	-	-	-	-	-	-
Dryer (D2) (EPL 6)	4.6 (8.4)	11 (12.8)	-	-	-	-	-	-
Glaze Line (EPL 9)	<0.088 (1.9)	0.24 (4.3)	-	-	-	-	-	-
Selection Line (SL 1,2,3,4) (EPL 10)	<0.12 (6.3)	<0.13 (6.3)	-	-	-	-	-	-
Spray Dryer (SD1) (EPL 12)	6.0 (13.1)	2.8 (13.1)	-	-	-	-	-	-
Hot Air Cooler 1 (HAC1) (EPL 18)	0.26 (0.3)	1.2 (2.3)	-	-	-	-	-	-
Hot Air Cooler 2 (HAC2) (EPL 19)	**0.52** (0.3)	1.3 (2.3)	-	-	-	-	-	-

Note: Emissions concentrations used in 2010 EA modelling are shown in parentheses.
***Bold** text identifies where measured in stack emission concentrations during the reporting period are greater than emission concentrations used in 2010 EA modelling.*
**Results corrected to 18% O2.*

Trends in the air quality pollutants discharged to air as a result of NCIA operations over time can be established using the assessable pollutant loads reported to the EPA in the Annual Returns since 2003. The actual load of assessable pollutants reported in the Annual Returns is calculated in accordance with the relevant Load Calculation Protocol for ceramics production. **Table 5-3** provides the assessable pollutant loads discharged by NCIA during the reporting period. The maximum load limits set out in both the EPL and Project Approval and the historical pollutant loads discharged (2004-present) have also been included for comparison purposes and are presented graphically in **Figure 19** to **Figure 23**.

The load limits specified in the Project Approval and EPL differ. Condition 16 of the Project Approval states:

> *Unless the OEH specifies otherwise, the Proponent shall ensure that the annual total load discharged from the site does not exceed the load limit specified for that pollutant in Table 3.*

As the EPA has 'specified otherwise' by specifying different load limits in the EPL (that are equivalent to Stage Two operations), the load limits in the EPL prevail over those in the Project Approval.

For the current reporting period, fine particulates (PM_{10}), coarse particulates, sulfur oxides and nitrogen oxides were all within the pollutant load limits. However, fluoride discharged to air exceeded the EPL load limit during the reporting period. It is noted that all weekly and 24 hour fluoride ambient monitoring to the North West and South East of the facility returned results below the relevant EPA guideline criteria.

Historical data show that there is a high level of variability in pollutant emissions between reporting years with no clear trend or consistency in results. This renders difficulty in any comparison of this year's emission results against the long term data. The following points are made in relation to the current load limit results:

- PM_{10} emissions recorded a decrease from the previous reporting period, with levels remaining less than the permitted EPL load limit.
- Coarse particulate emissions remained relatively consistent with the previous reporting period, with levels less than the permitted EPL load limit.
- Total fluoride recorded an increase from the previous reporting period to a level above the EPL load limit.
- Sulfur oxides recorded an increase from the previous reporting period, with levels less than the permitted EPL load limit.
- Nitrogen oxides recorded an increase from the previous reporting period, with levels less than the permitted EPL load limit.

Table 5-3 Maximum pollutant load limits and assessable pollutant loads

Pollutants loads		Pollutant				
		Fine particulates (PM_{10})	Coarse particulates	Fluoride	Sulfur oxides[3]	Nitrogen oxides
Current Maximum Load Limit (kg)	EPL	26,629	14,338	1,850	36,828	36,828
Actual Load (kg) in reporting period	2020-2021	7,805	4,650	**3,034**	8,782	35,962
	2019-2020	12,966	4,482	1,563	6,678	18,293
	2018-2019	7,140	8,346	**2,076**	5,699	20,996
	2017-2018	10,145	2,878	**2,239**	6,059	25,165
	2016-2017	13,028	5,800	**2,411**	14,835	19,023
	2015-2016	5,816	11,310	**4,146**	16,835	21,360
	2014-2015	4,963	2,302	1,400	15,240	24,016
	2013-2014	5,369	3,289	928	4.280[4]	25,059
	2012-2013 1	1,249	1,640	1,109	1,235[4]	4,704
	2011-2012	997	5,550	91	26,946	20,306
	2010-2011	2,902	1,774	295	7,699	18,322
	2009-2010 2	6,524	475	621	**86,704**	**79,375**
	2008-2009	5,476	2,564	1,529	**70,565**	**62,426**
	2007-2008	4,449	3,881	336	16,633	18,073
	2006-2007	7,289	12,657	**1,989**	15,850	12,423
	2005-2006	21,751	11,986	**4,085**	13,239	13,887
	2004-2005	4,034	2,100	**2,154**	21,335	6,721
	2003-2004	1,028	1,089	150	5,813	1,151

Note: ***Bold*** *represents an exceedance*

1. *The Project Approval came into effect on January 2013 and the previous Consent was relinquished.*
2. *2009-2010 marked the commencement of stage 2 of the development.*
3. *Sulfur oxides (as sulphuric acid mist and sulfur trioxide (as SO3).*
4. *Sulfur oxide loads from the 2012-13 reporting year have been corrected to only include sulfuric acid mist as sulfur trioxide, as agreed with regulatory authorities, and not sulfur dioxide as previously calculated and reported.*

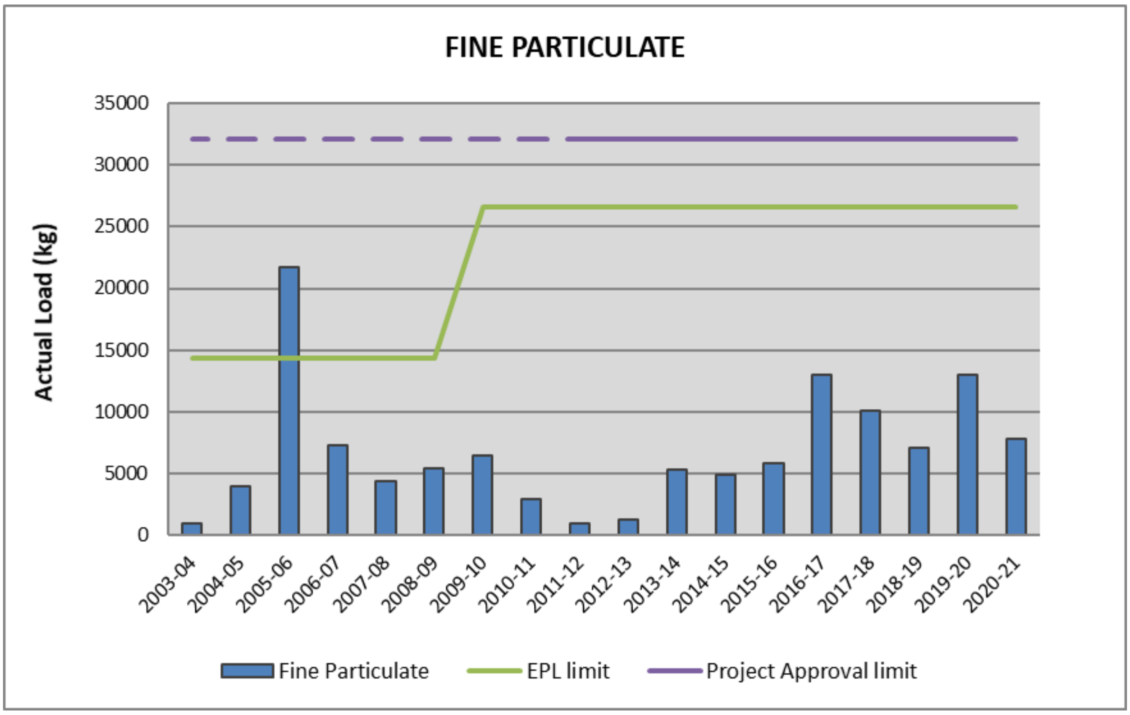


Figure 19 Fine particulate annual load (2004 – 2021)

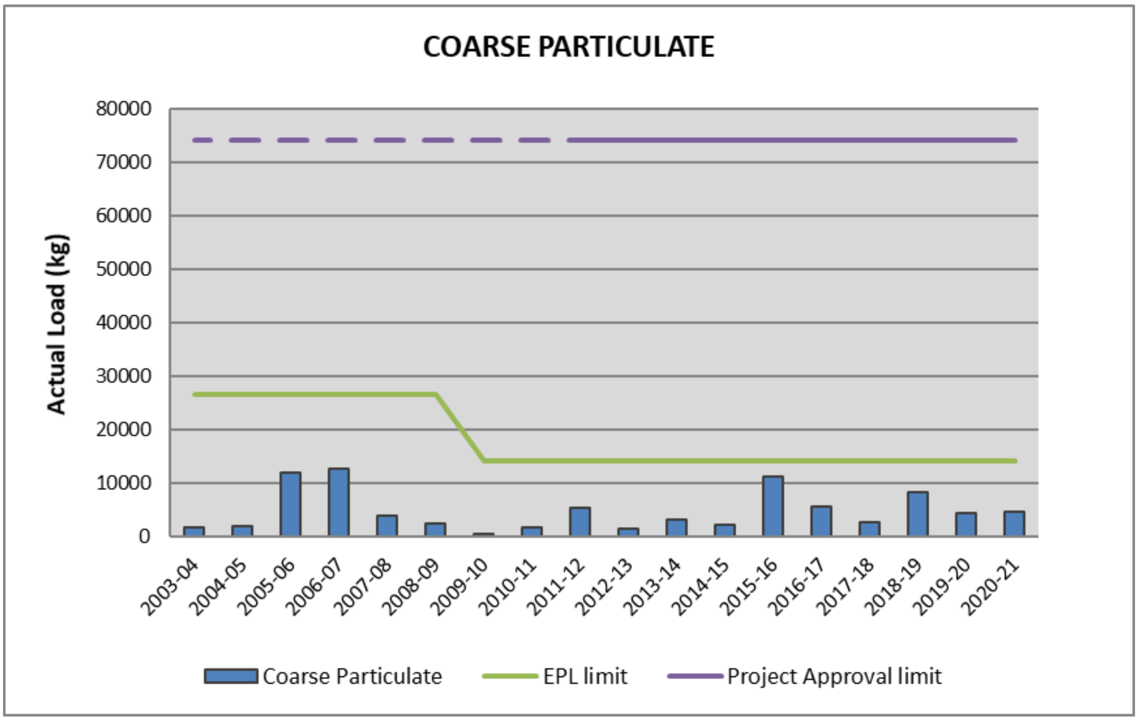


Figure 20 Coarse particulate annual load (2004 – 2021)

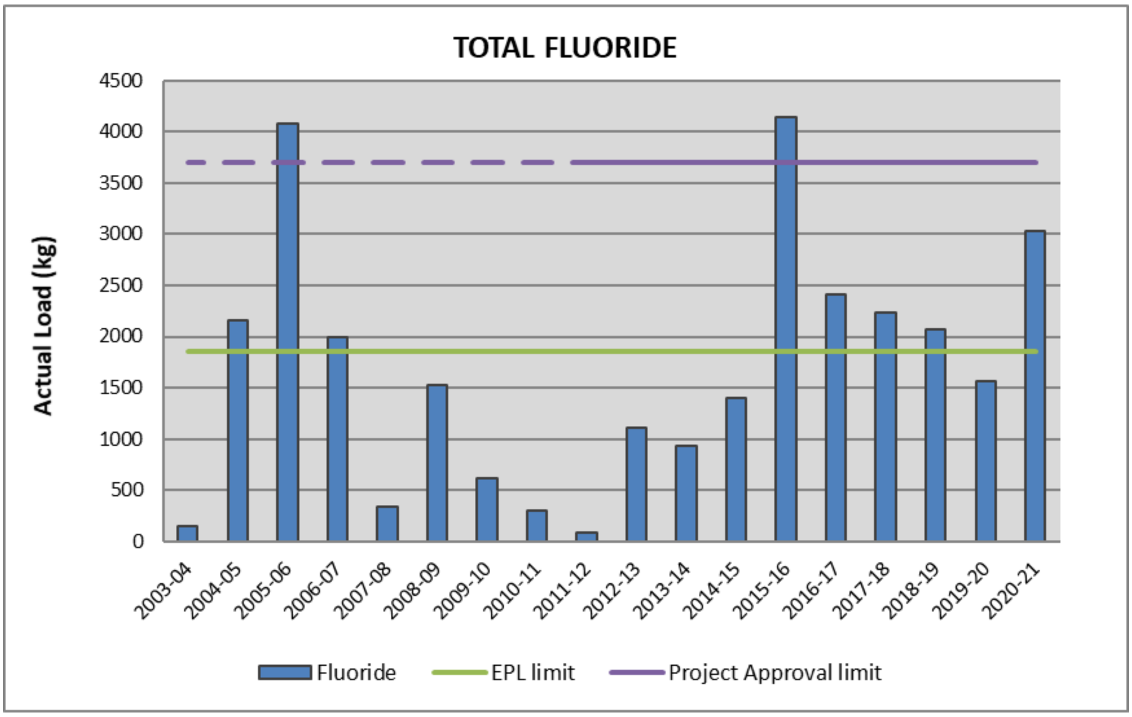


Figure 21 Fluoride annual load (2004 – 2021)

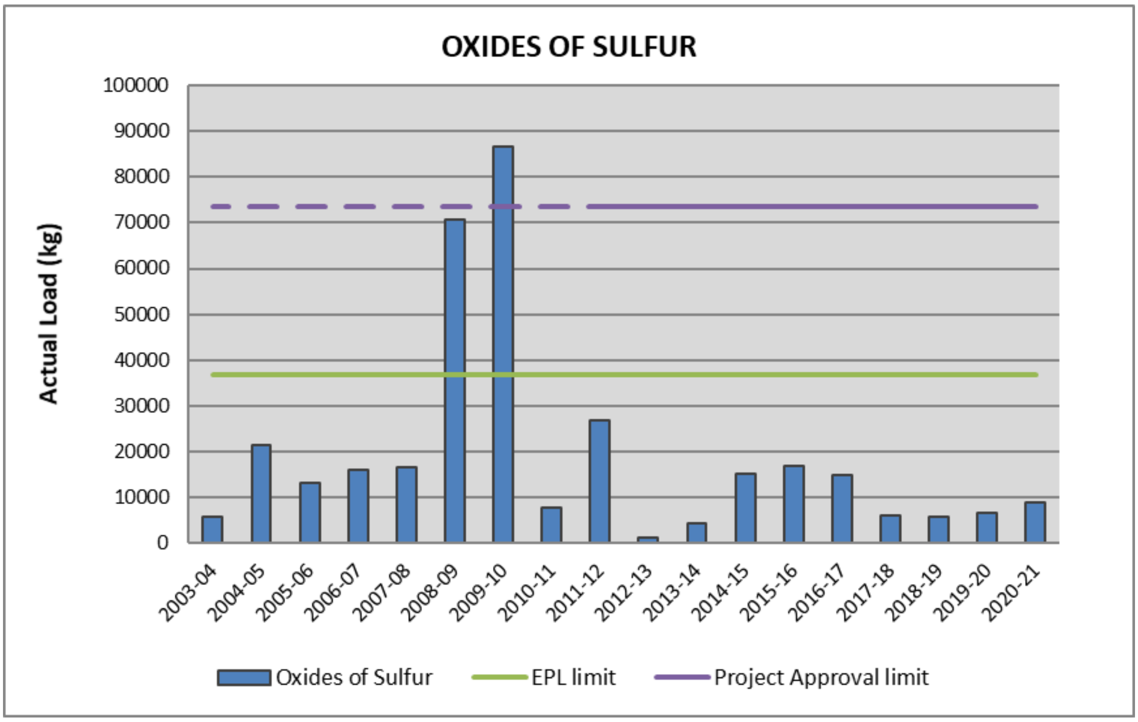


Figure 22 Sulfur oxides (as sulphuric acid mist and sulfur trioxide (as SO_3)) annual load (2004 – 2021)

Note: Sulfur oxide loads from the 2012-13 reporting year have been corrected to only include sulfuric acid mist as sulfur trioxide, as agreed with regulatory authorities in 2012, and not sulfur dioxide as previously calculated.

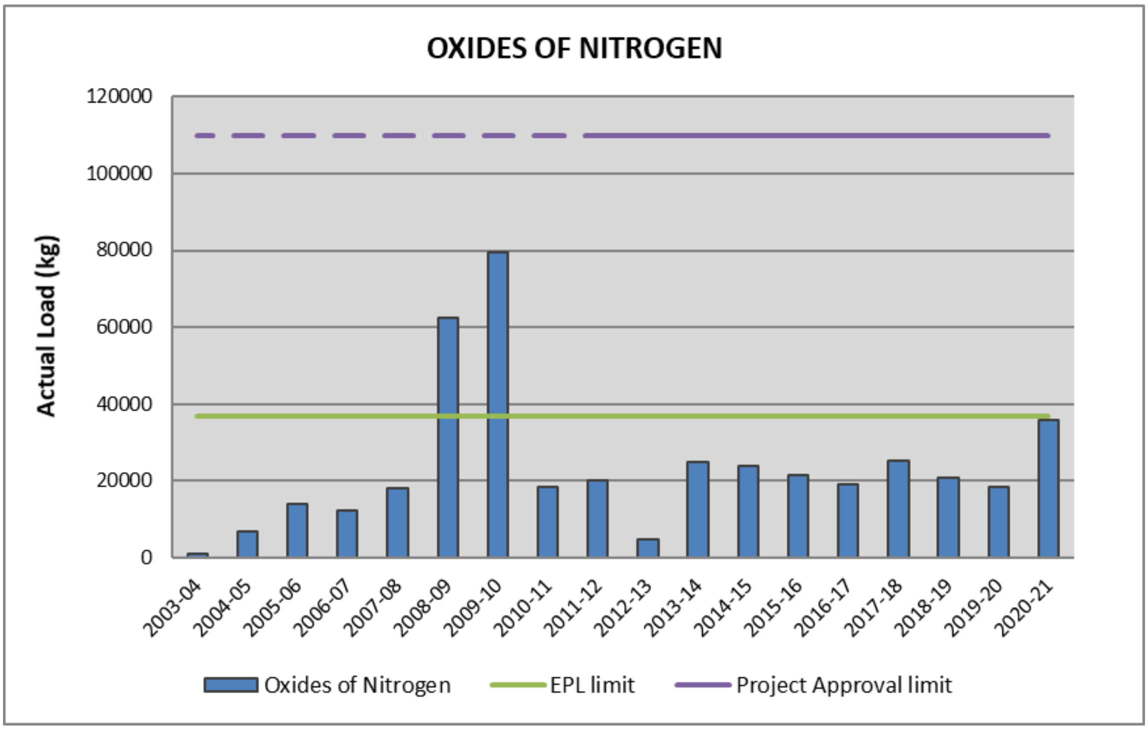


Figure 23 Nitrogen oxides annual load (2004 – 2021)

5.5 Noise

The 2010 EA indicated that the increase in background levels in the Rutherford region was likely to be due to the development of new industrial facilities in the Rutherford Industrial Estate. The 2010 EA predicted that the operational noise levels from the expanded facility would not change considerably from that already approved and would be below the project specific noise criteria at all existing receptors under calm and prevailing weather conditions.

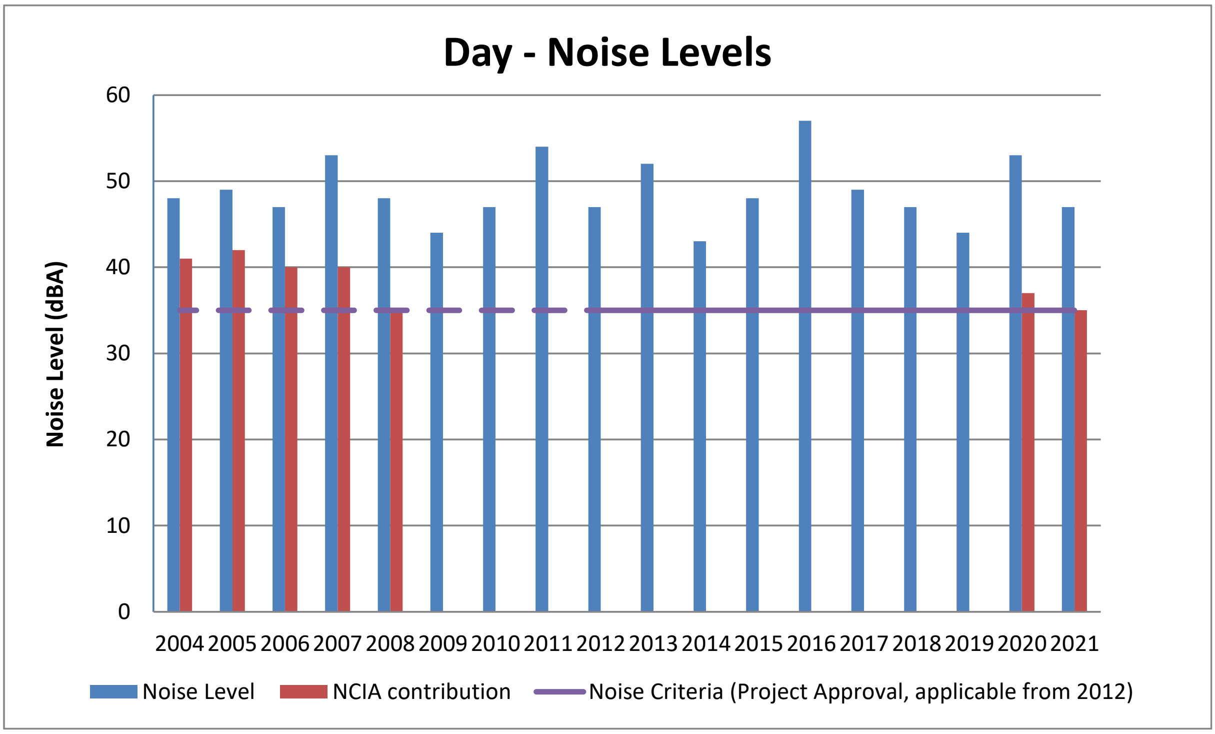
The Project Approval specifies more stringent noise limits than those set out in the EPL. Under the Project Approval noise generated from NCIA must not exceed 35 dB(A) for the day, evening and night periods.

Monitoring results for the reporting period indicate that noise emissions from NCIA were in compliance with the Project Approval noise criteria for all time periods, including the sleep disturbance criteria. It should be noted that calculated noise levels within 2dB of statutory noise limit are considered negligible as per the NPfI. Instances where there were exceedances within 2dB of the criteria are shown in **Figure 25** and **Figure 26**.

Historical noise monitoring results at the Kenvil Close monitoring location are provided in **Figure 24 – Figure 26** for the day, evening and night periods respectively. On many occasions NCIA was not clearly audible over other dominant nearby industrial and traffic noise sources.

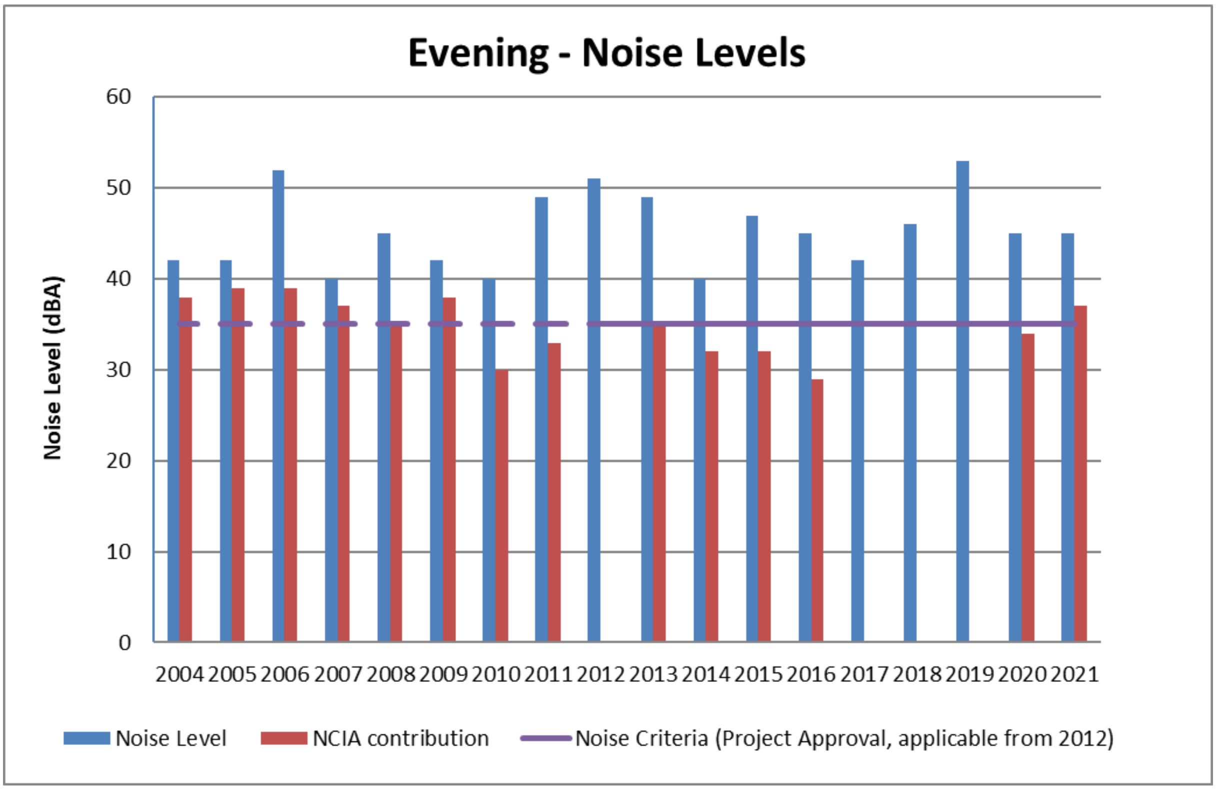
No trends in the noise monitoring are clearly discernible with historical noise emissions generally complying with noise limits. No exceedance of the day, evening or night criteria has been recorded since 2009.

The current noise monitoring report noted that traffic noise from the New England Highway contributed significantly to the background noise levels at Kenvil Close.



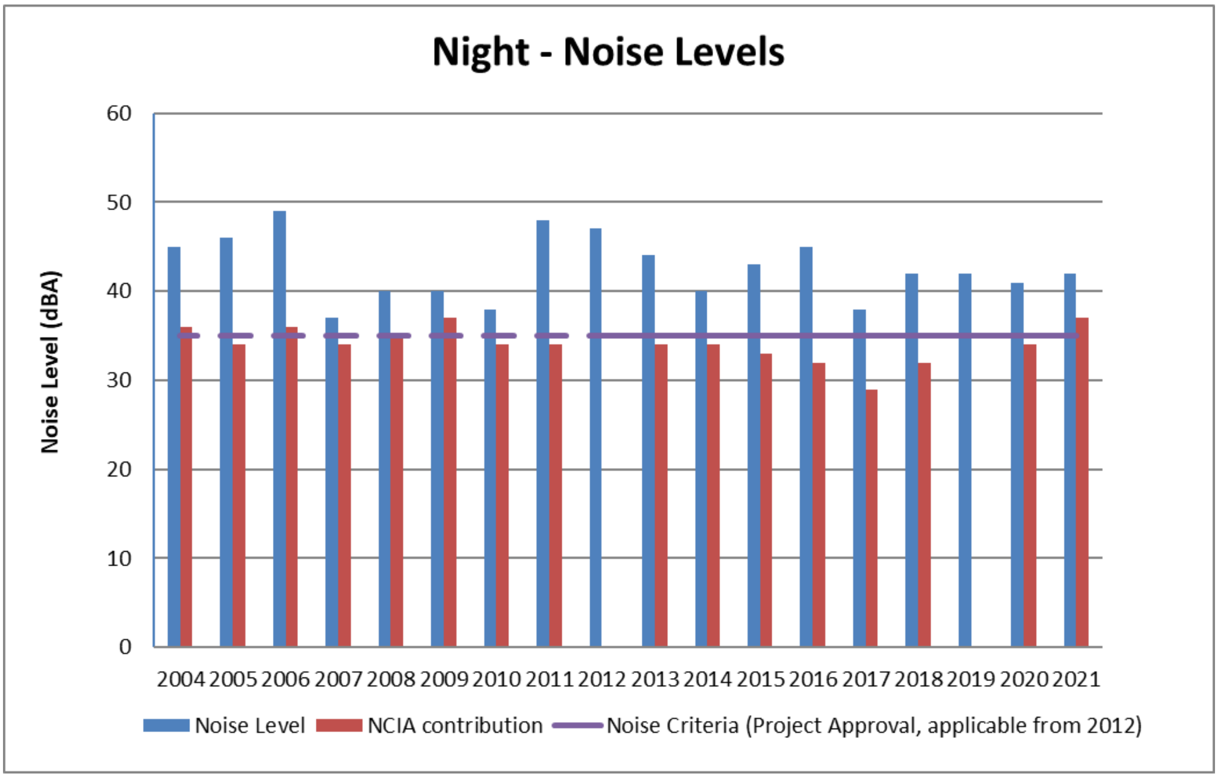
<u>Note 1:</u> 2009 to 2019: NCIA contribution was either inaudible or not measurable.

Figure 24 Day noise levels, Kenvil Close, 2004 – 2021



<u>Note:</u> 2012 and 2017 to 2019: NCIA contribution was either inaudible or not measurable.

Figure 25 Evening noise levels, Kenvil Close, 2004 – 2021



<u>Note:</u> 2012 and 2019: NCIA contribution audible but not measurable.

Figure 26 Night noise levels, Kenvil Close, 2004 – 2021

5.6 Water

5.6.1 Water Usage

The 2010 EA indicated that water consumption for the facility during Stages One–Four of the development would be approximately 1,772kL per week (approximately 92ML per annum). Stages Five–Eight of the development would be expected to use an equivalent volume of potable water as Stage One–Four for a cumulative expected consumption of up to 3,544kL per week (approximately 184ML per annum).

Consumption of potable water during the reporting period August 2020 to July 2021 was approximately 51.5 ML. The consumption of approximately 51.5ML of potable water is proportionally within the predictions of the EA given that only Stages One–Two were operational. NCIA have held preliminary discussions on site with Hunter Water representatives regarding potential Water Saving Initiatives.

It is anticipated that the 92ML/year threshold usage over which NCIA will require HWC approval will not be reached until further stages of development are constructed and commissioned. Regardless, consultation with HWC was started during the 2010 EA process in provision of future developments. NCIA will resume the consultation process as required when further development stages are planned.

5.6.2 Process Water Management

As the requirement for water from NCIA has the potential to place stress on the town-water reticulation system (particularly during periods of drought), NCIA has endeavoured to minimise its reliance and demand for town water. Particularly, all process and wash-down water is recycled within the operation of the facility.

The NCIA facility does not discharge process or washdown water to the storm water system. Water used for process requirements is only discharged in the form of steam to the atmosphere. Approximately 95% of all washdown water is captured within an internal reticulation system and recirculated for reuse as process water. The remaining 5% of washdown water evaporates.

Apart from discharges to the sewer from staff amenities there is no discharge of process or washdown water from the site other than as steam. Materials stored for the manufacturing process are housed within the building to ensure that there are no spills from the site.

Plant equipment operated at NCIA is maintained regularly and in accordance with manufacturer's specifications to ensure that water use, reuse and recycling efficiencies are optimised. The consumption of water is continually monitored via metering systems associated with plant equipment.

5.6.3 Stormwater Quality

Historical trends (2009-present) in water quality for pH and EC are presented in **Figure 27** and **Figure 28**, respectively. The 2010 EA made no provision of stormwater quality performance measures or indicators.

Long term data shows that pH levels in pond 4 have generally been on a slowly increasing trend since 2009, with the exception of the 2015 to 2018 reporting periods. On occasion since 2009 recorded pH values occurred beyond the ANZG pH trigger values, with the upper threshold limit exceeded more often than the lower limit (refer to **Figure 27**), highlighting a trend towards alkalinity. This trend has continued during the current reporting period with 26 monitoring events showing pH results higher than the ANZG trigger values and only three recorded below (refer to **Section 4.6.2**).

EC results during 2021 are comparable to previous years with a stable average and no exceedances of the criteria (refer to **Figure 28**). A review of historical EC values indicates an overall decreasing trend. EC values are generally within the ANZG guidelines trigger values and indicate that the stormwater is non-saline.

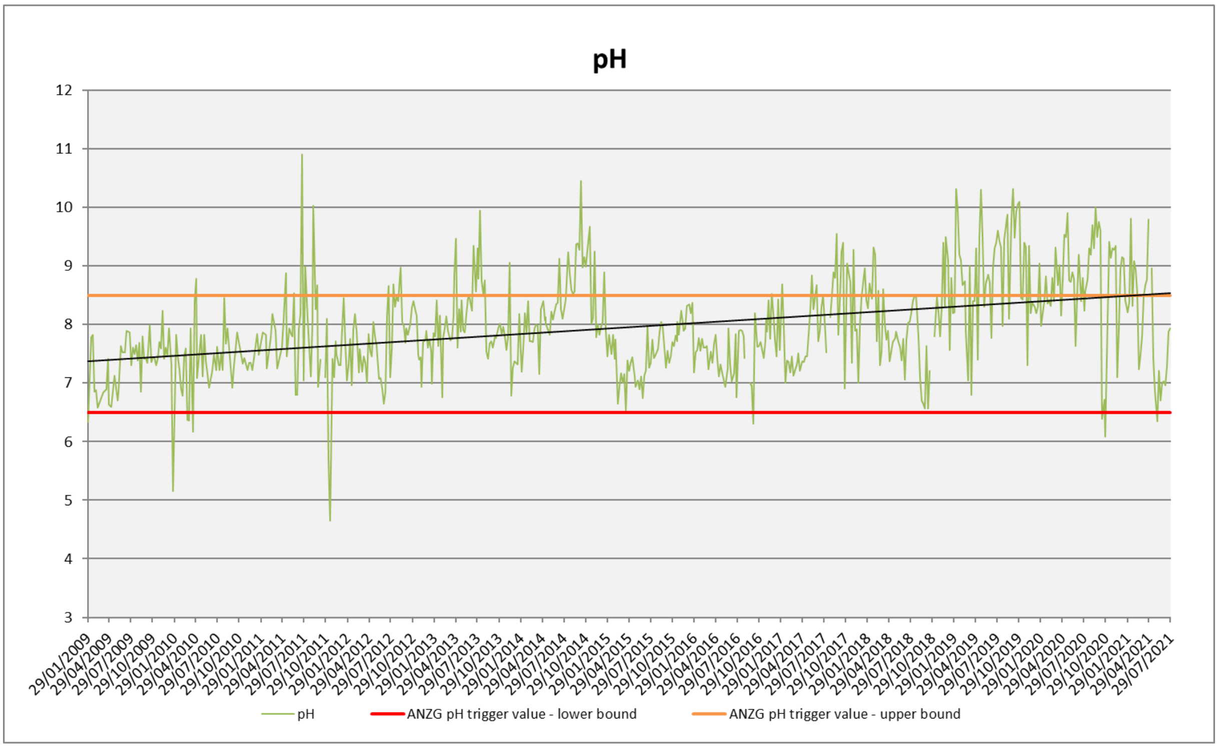


Figure 27 Stormwater quality, Pond 4 pH (2009-2021)

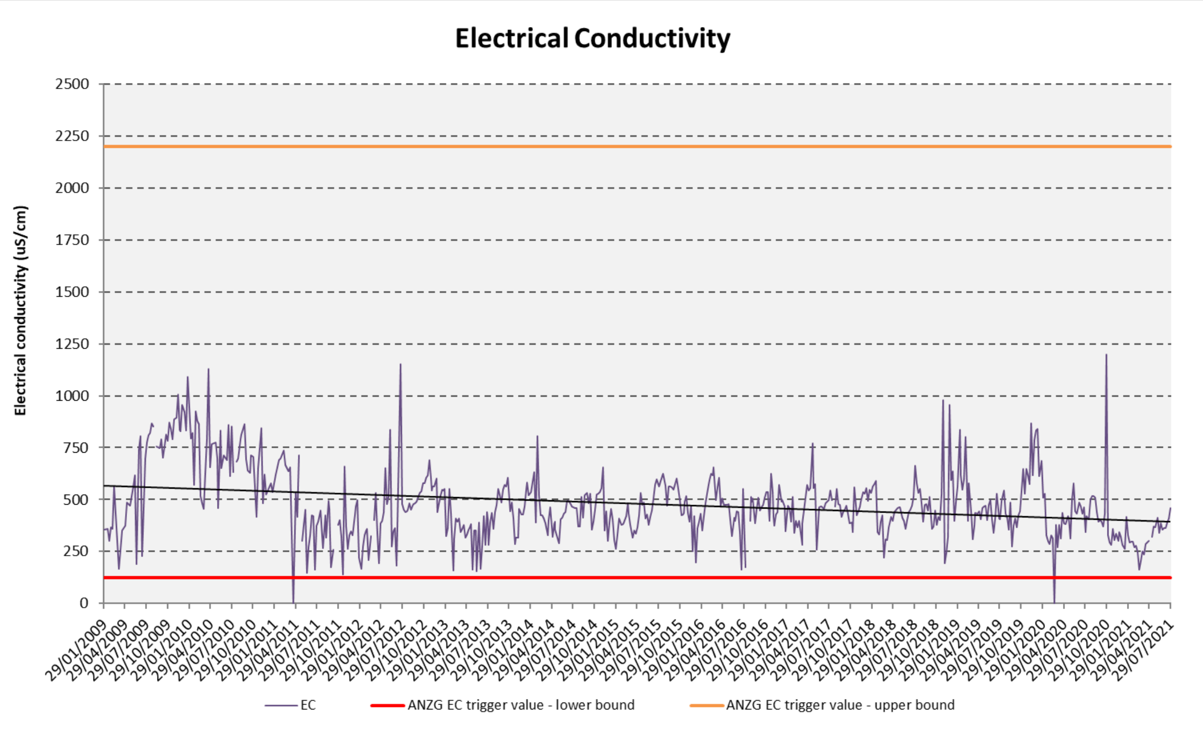


Figure 28 Stormwater quality, Pond 4 – EC (2009-2021)

5.6.4 Stormwater Management

The stormwater management system was designed to minimise the changes to the flow regime from Stages One–Four of the project. The management of stormwater at NCIA is achieved via four water detention basins which are connected by grass swales (managing surface water flows from roof, roadway and landscaped areas) and a series of pits and pipe work (servicing the car park and hardstand areas).

The grass swales have been designed to control surface flow velocities from runoff areas to no greater than 2 m/s. Final low flow stormwater discharges from the site occur at the channel outlet, located at the south eastern corner of the site (connected to Pond 4). Discharged storm water then connects directly to the existing neighbouring artificial wetland. Pond 4 is inspected on a weekly basis and was noted to be discharging on four occasion throughout the reporting period on 28 October 2020, 18 March 2021, 25 March 2021 and 8 April 2021. Pond 4 water parameters were all within relevant criteria on these dates.

The detention basins have been designed with sufficient retention to reduce peak stormwater flows and improve the quality of water ultimately discharged from the site. The combined surface area of the four water detention basins is approximately 6,600 m^2, which represents approximately 6.6% of the total catchment area. This exceeds the minimum requirement of 2% permanent water area defined in the *Constructed Wetlands Manual* (DLWC, 1998). As such, the level of water treatment offered by the wet detention system surpasses the guideline requirements.

As detailed in the 2010 EA, the existing stormwater management system will be modified and expanded if and when development Stages Five–Eight are constructed and commissioned.

5.7 Waste

5.7.1 Waste Generation

The 2010 EA stated that based on production levels at the time, approximately 1% of all fired tiles were not eligible for sale (either as broken tiles or not passing NCIA's strict quality assurance process). That figure was used to estimate the total amount of fired waste tile at maximum production rate (i.e. with Stages One – Eight operational) and predicted that approximately 2,720 tonnes of fired tiles waste would be generated per annum. The 2010 EA did not predict or specify the amount of green tile waste to be generated by the project.

The amount of fired tile waste during the reporting period (monthly average of 7.8% of total production) was higher than the predictions made in the EA, however close to NCIA's current operation target of 7% and down on previous years.

Monthly green tile waste levels have exceeded the 1% target during the reporting period except for June 2021. Green tile waste levels increased above the 1 % target due to more defect product being captured before firing. NCIA continues to focus on reducing waste and increasing operational efficiency.

5.7.2 Waste Management

One hundred percent of green tile waste generated during production is reused in the manufacturing process and as such does not enter the overall waste stream leaving the site. Fired waste is stored in a bunker on site ensuring that it is free of cardboard and other debris. It is ultimately reused in the construction industry for road base material and other developments which greatly minimises the total amount of waste NCIA sends to landfill.

All other waste (i.e. packaging waste, general office waste and lunchroom waste) is collected by a licenced recycling or waste contractor. Incoming packaging waste such as pallets are reused wherever possible.

6.0 Non-Compliances

6.1 2020-2021 Non-Compliances Record

There were two non-compliances recorded during the 2020-2021 reporting period. Details relating to the non-compliances and the actions taken to investigate or to prevent a recurrence are summarised in **Table 6-1**.

Table 6-1 Details of non-compliance with EPL or Project Approval conditions during the 2021 reporting period

Condition No / Reference	Details of Non-compliance	Action taken
Non-compliances recorded during the reporting period		
EPL Condition L2.2	The assessable pollutant load for fluoride discharged to air (3,034 kg) exceeded the pollutant load limit (1,850 kg) specified in this condition. It must be noted that the fluoride emission is below the Project Approval limit of 3,701 kg. The cause of the non-compliance is considered to be variability in process in combination with delays in the refurbishment of the kiln baghouses due to the supplier not being able to complete contractual obligations.	A new lower fluoride source material has been introduced into the clay mix. Completion of the fume scrubber upgrade independent of legal action against the supplier. Seek discussions in regard to a review of EPL limits.
EPL Condition L3.4	Annual stack emissions testing identified two exceedances. Exceedance of Total Fluoride concentration limit of 5mg/m^3: • 9.5 mg/m^3 at EPL Point 14 (Kiln 1) • 8.1 mg/m^3 at EPL Point 15 (Kiln 2)	As per EPL Condition L2.2 above

6.2 Audit Recommendations and Action Plan

In 2018, an Independent Environmental Compliance Audit of the NCIA facility was undertaken by Jacobs (Final Report dated 31 January 2019. The audit found that NCIA is generally in compliance with the conditions of its regulatory documents. A total of 159 compliance requirements were audited, of which 13 issues were identified as Not Compliant, 88 as Compliant and 58 as Not triggered.

The auditors made recommendations against each non-compliance, as well as recommendations where compliance was achieved but an improvement in performance could be made. A full summary of the non-compliances identified, recommendations made by the auditors, and the action taken by NCIA to address each of the recommendations is provided **Table 6-2**.

Table 6-2 Audit recommendations and NCIA action plan

<table>
<tr><th>#</th><th>Reference</th><th>Condition</th><th>Recommendation</th><th>Management Response</th><th>Status</th></tr>
<tr><td>1</td><td>Project Approval 16
Load Limits</td><td>Unless the OEH specifies otherwise, the Proponent shall ensure that the annual total load discharged from the site does not exceed the load limit specified for that pollutant in Table 3, of the Project Approval.

Table 3: Maximum Allowable Load Limits (Air)
<table>
<tr><th>Assessable Pollutant</th><th>Maximum Allowable Load Limit (kg/yr)</th></tr>
<tr><td>Fine Particulates</td><td>74,210</td></tr>
<tr><td>Coarse Particulates</td><td>32,073</td></tr>
<tr><td>Fluoride</td><td>3,701</td></tr>
<tr><td>Sulfur oxides (as sulphuric acid mist and sulfur trioxide (as SO_3))</td><td>73,657</td></tr>
<tr><td>Nitrogen oxides</td><td>110,000</td></tr>
</table>
Note: The total load of the assessable pollutant shall be calculated in accordance with the relevant load calculation protocol, as defined by OEH guidelines.

Load limits as prescribed in EPL 11956
<table>
<tr><th>Assessable Pollutant</th><th>Load limit (kg)</th></tr>
<tr><td>Coarse Particulates (Air)</td><td>14338.00</td></tr>
<tr><td>Fine Particulates (Air)</td><td>26629.00</td></tr>
<tr><td>Fluoride (Air)</td><td>1850.00</td></tr>
<tr><td>Nitrogen Oxides (Air)</td><td>36828.00</td></tr>
<tr><td>Sulfur Oxides (Air)</td><td>36828.00</td></tr>
</table></td><td>NCIA to implement relevant measures to ensure compliance with the Project Approval load limits. NCIA to review and address stack concentrations that are above values used in the NCIA Expansion EIS (AECOM, 2010).</td><td>Management are committed to achieving compliance. Management acknowledge ongoing compliance issues with Fluoride concentration although the testing results raise questions. Management have committed to a complete refit of the baghouse at an estimated project cost of $2.5m with a view to achieving short and long term compliance. Once compliance is demonstrated Management would like to seek discussions with the EPA in regard to EPL limits.</td><td>Following discussions with the EPA as part of the October 2020 site audit, capital works have been delayed due to the supplier being unable to meet contractual obligations. Alternate contractors have been engaged to finish the works.</td></tr>
<tr><td>2</td><td>Project Approval Discharge limits and Stack Discharge Design Requirements 18</td><td>Unless otherwise specified by the Director-General, the Proponent shall:
a. comply with all monitoring (points) requirements and pollutant discharge concentrations as specified by the OEH in the EPL</td><td>NCIA to review and address stack concentrations that are above values used in the NCIA Expansion EIS (AECOM, 2010) and this condition of the approval.</td><td>Management are committed to achieving compliance. Management acknowledge ongoing compliance issues with Fluoride concentration although the testing results raise questions. Management have committed to a complete refit of the baghouse at an estimated project cost of $2.5m with a view to achieving short and long term compliance.</td><td>Following discussions with the EPA as part of the October 2020 site audit, capital works have been delayed due to the supplier being unable to meet contractual obligations.</td></tr>
</table>

#	Reference	Condition	Recommendation	Management Response	Status
				Once compliance is demonstrated Management would like to seek discussions with the EPA in regard to EPL limits.	Alternate contractors have been engaged to finish the works
3	Project Approval Discharge limits and Stack Discharge Design Requirements 18	b. ensure that the stack discharge design requirements comply with the EPL.	Refer to recommendation above for Condition 18a).	Management are committed to achieving compliance. Management acknowledge ongoing compliance issues with Fluoride concentration although the testing results raise questions. Management have committed to a complete refit of the baghouse at an estimated project cost of $2.5m with a view to achieving short and long term compliance. Once compliance is demonstrated Management would like to seek discussions with the EPA in regard to EPL limits.	Following discussions with the EPA as part of the October 2020 site audit, capital works have been delayed due to the supplier being unable to meet contractual obligations. Alternate contractors have been engaged to finish the works
4	Project Approval 32 Lighting	The Proponent shall ensure that the lighting associated with the project: c. complies with the latest version of Australian Standard AS 4282(INT) - Control of Obtrusive Effects of Outdoor Lighting	When the construction of the project extension commences carry out a review of the existing lighting on site to determine if it complies with the relevant standards and upgrade as required. All new lighting to comply with AS 4282.	On commencement of construction of the project extension management will ensure compliance with relevant standards. Management have no reason to believe that current lighting does not meet the relevant standards	Not applicable as condition not triggered
5	Project Approval Oversized Transportation 35	The Proponent shall obtain a permit for an oversized and over mass load from the RTA, if transportation of oversized or over mass materials or machinery is required for the project.	NCIA should attempt to locate the oversized transportation approval for	One oversize load which Management disclosed to the auditor that arrived during the	Not applicable

#	Reference	Condition	Recommendation	Management Response	Status
			the one oversized load received in 2018.	period was coordinated by our customs broker, Tolsaf Cranes and Hogan's Heavy Haulage. RMS were contacted and approval gained to move the load including dates and times. Management could not source the documentation for the auditor from those coordinating the load. In future Management will appoint a project manager for such events to ensure appropriate records are maintained.	
6	Project Approval 38 Vehicle Queuing and Parking	The Proponent shall ensure that the parking dimensions, internal circulation, aisle widths, kerb splay corners, head clearance heights, ramp widths and grades of the car parking area in accordance with the current relevant Australian Standards *AS2890.1:2004*, except where amended by other conditions of this approval.	When the construction of the project extension commences car parking to be realigned to comply with AS2890. Any additional car parking will need to be in compliance with AS2890.	On commencement of construction of the project extension management will ensure compliance with relevant standards. There is enough space allocated, including marked spaces to comfortably accommodate all staff and visitors on site at all times. Management have no reason to believe that current car parking does not meet relevant standards.	Not applicable as condition not triggered
7	Project Approval 39 Vehicle Queuing and Parking	The Proponent shall ensure that disabled parking and assess is provided on-site and shall comply with Australian Standard *AS1428.1 (2001) - Design for Access and Mobility - Part 1 General Requirements for Access – Buildings*.	When the construction of the project extension commences car parking to be realigned to comply with AS2890. Any additional car	One disabled car part is provided and marked on site. This car park is adjacent to the showroom entry with a ramp provided. On commencement of construction of the project	Not applicable as condition not triggered

#	Reference	Condition	Recommendation	Management Response	Status
			parking will need to be in compliance with AS2890.	extension management will ensure compliance with relevant standards. Management have no reason to believe that current car parking does not meet relevant standards.	
8	Project Approval Environmental Reporting 59	Within 7 days of the detection of the incident, the Proponent shall provide the Director-General and any relevant agencies with a detailed report on the incident.	Continue to report incidents within the allocated timeframes.	Management will continue to report incidents as required under the project approval.	Ongoing
9	SoC Operation	Fluoride emissions would be managed within the kiln baghouses by implementing a mechanism where a fine spray of lime is injected into the kiln exhaust flow to scrub the HF emissions;	Implement the mechanism where a fine spray of lime is injected into the kiln exhaust flow to scrub the HF emissions.	Management have engaged POLEX Engineering to complete a full refit of the baghouse. The POLEX design includes mechanisms for a fine spray of lime to scrub the HF emissions	Following discussions with the EPA as part of the October 2020 site audit, capital works have been delayed due to the supplier being unable to meet contractual obligations. Alternate contractors have been engaged to finish the works
10	IER 2015 Recommendation S3.28	3.28.1 NCIA should attempt to locate the Stage 1 Noise Validation Report.	NCIA should continue to attempt to locate the Stage 1 Noise Validation Report.	Management tried to source this as part of the 2015 audit.	Future compliance to be considered on triggering next stage
11	IER 2015 Recommendation S3.32	3.32.1 NCIA should either review the construction contract for the facility to assess if lighting was required to be installed in accordance with *AS 4282:1997*; or if this information is not available or is inconclusive, commission a qualified lighting expert to undertake a survey or audit of the outdoor lighting against *AS 4282:1997* to verify its	No further recommendations provided. Refer to Project Approval 32 Lighting above.	No further comment	Refer to RAR #4 in this document

#	Reference	Condition	Recommendation	Management Response	Status
12	IER 2015 Recommendation S3.38	3.38.1 To comply with this condition, NCIA must provide markings in accordance with Australian Standard *AS2890.1:2004.*	No further recommendations provided. Refer to Project Approval 38 above.	No further comment	Refer to RAR #6 in this document
13	IER 2015 Recommendation S3.39	3.39.1 To comply with this condition, NCIA must provide markings in accordance with Australian Standard *AS1428.1:2001.*	No further recommendations provided. Refer to Project Approval 38 above.	No further comment	Refer to RAR #7 in this document

7.0 Continuous Improvement Measures

Condition 60(j) of the Project Approval requires the AEMR to identify continuous improvement measures, outlining new developments in air quality and noise control, and detailing practices that have been implemented on site during the previous year to reduce air quality and noise impacts.

Emission concentrations of pollutants were generally in accordance with EPL and Project Approval limits throughout the 2020 - 2021 reporting period. There was one exceedance of the PM_{10} 24-hour criterion however a review of processing and meteorological conditions on those days indicate that NCIA was not a major contributor to the exceedances.

Stack emissions testing identified an exceedance of the Total Fluoride discharge limit at emission source locations Kiln 1 and Kiln 2 and an exceedance of the EPL Total Fluoride mass emission limit.

Noise monitoring results for the current reporting period indicated that noise emissions from NCIA were in compliance with the EPL and Project Approval noise criteria for all time periods, including the sleep disturbance criteria. A result within 2dB of the criteria was calculated at the Kenvil Place receiver for the evening and night-time period with a 2dB exceedance considered negligible by the NPfI.

Environmental improvement measures recently implemented by NCIA are summarised in the following sections.

7.1 General Environmental Management

General environmental management actions undertaken by NCIA are outlined in **Table 7-1**.

Table 7-1 Timetable for environmental improvement actions

Area of Concern	Identified Action	Status
New Kiln Baghouse	NCIA have engaged Polex Environmental Engineering Pty Ltd to completely refurbish the original kiln baghouse. This new purpose-built baghouse together with the expertise of Polex, and a continued focus on raw materials will ensure compliance with regulatory requirements.	Ongoing after Polex Engineering suffered financial difficulties and couldn't complete the project. NCIA have sourced other contractors to complete the project
Solar Electricity	NCIA are currently installing a solar panel array that will generate 1MW of electricity during daylight hours. During operation all of this energy will be used by NCIA reducing electricity consumption by 10-12.5%. Feasibility works have been done on installing a further 2MW on the roof of the factory and ground mounted options are also being assessed.	Completed
Waste Heat Recovery	Through NCIA's manufacturing process a significant amount of hot air is exhausted into the atmosphere. NCIA are investigating piping the hot air currently exhausted through Hot Air Cooler 1 and 2 (HAC 1 and 2 / EPL 18 and EPL 19) back through insulated stainless-steel piping to the spray dryer. The spray dryer uses ambient air and a gas burner to dry water from a liquid slip into a powder which is then pressed to form the tiles. Once operational this is expected to reduce gas consumption by 10-15%.	Completed

Area of Concern	Identified Action	Status
University of NSW	Raw materials and finished products are now sent to the University of NSW for testing on a routine basis. NCIA is leveraging off the University of NSW for assistance from time to time. Samples have previously been sent to Italy for testing but sending locally expedites the process and also generates local capacity building.	Completed
Hong Lu	Hong Lu joined the NCIA team in early 2018 with a focus on internal and external compliance. Hong Lu has a PHD in Materials Science and Engineering from the University of NSW. Whilst still developing in her role at NCIA, when settled it is hoped Hong Lu will provide benefits in the environmental and compliance space.	Completed
Gas Monitoring	A project has been undertaken to monitor gas consumption on individual pieces of equipment. Information is now available in real time. From this information NCIA has been able to focus on reducing consumption while maintaining production efficiency.	Completed
Camera's	16 Cameras have been installed in and outside the factory building. The cameras can be viewed live and record history. In the event of environmental issues, the camera history is available to be reviewed	Ongoing
Formalised daily conditions	Each afternoon a snapshot of the factory conditions are recorded and sent to senior management for review. These include the raw feed being processed, the glaze's being used and environmental checks.	Ongoing
Vacuum pipes	The internal dust vacuum pipes have been replaced.	Completed
Bins	Dedicated carboard waste bins have been distributed on site. A metal waste bin has been provided to the site and is generally collected annually.	Ongoing
Energy efficiency	LED lights and energy efficient electric motors are being used to replace older redundant equipment. Working from home is encouraged at NCIA where work is practicable.	Ongoing
Waste ceramic material	Utilising old bulk raw ceramic materials that is expired or can't be used for its intended purpose anymore in the ceramic body of the tiles	Ongoing
Truck washdown pit	The truck washdown pit now captures solid waste, before entering the public roads.	Ongoing

Area of Concern	Identified Action	Status
NATA	The NCIA laboratory is now NATA accredited.	Ongoing
Transport Emissions	New input material sourced closer to the factory reducing emissions from truck haulage.	Ongoing

7.2 Energy Efficiencies

As noted in previous AEMRs, a lot of NCIA's focus in recent times has been on achieving greater efficiencies. The objective is to achieve a greater tile production output for the same amount of power consumption and raw material input. For example, NCIA currently endeavours to improve the gas efficiency of the manufacturing process. **Figure 29** shows the evolution since 2011 of the amount of gas required (in gigajoules GJ) to produce one square metre of tiles, with data showing an overall improving trend in gas efficiency.

NCIA is currently in the process of reducing the size and weight of tiles with a view to reduce the amount of raw material inputs, energy and transport components whilst still achieving the same amount of saleable product output (m^2 of tiles).

NCIA has installed a Quality Assurance (QA) machine before the kiln on each of its production lines. This effectively reduces waste tiles going through the kiln and being fired, creating both a reduction in waste and a saving in energy consumption.

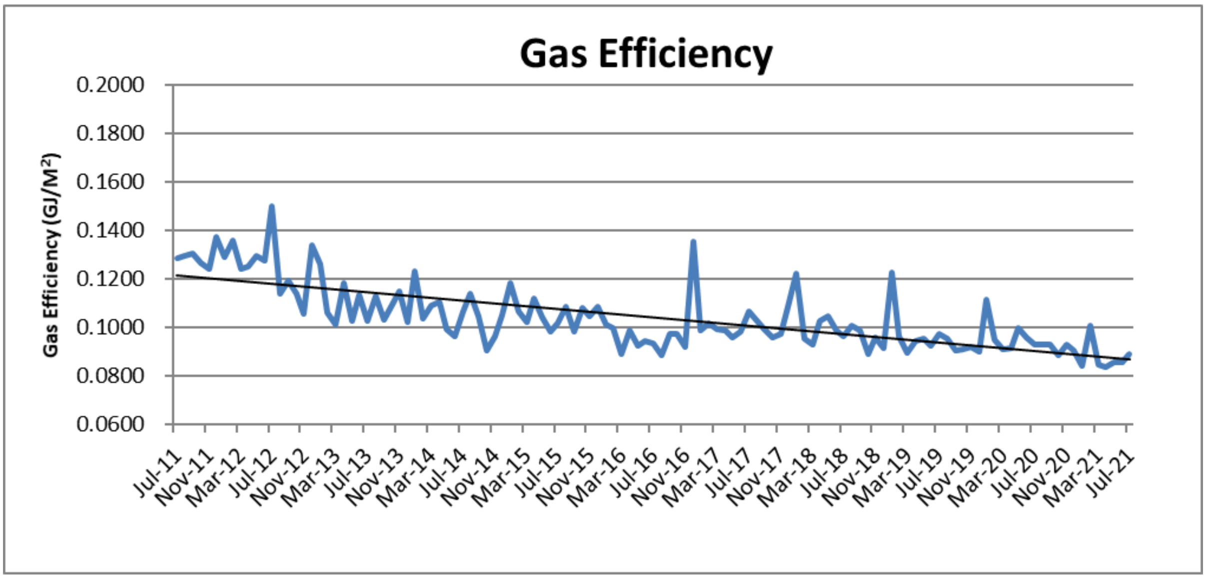


Figure 29 Gas efficiency in tile manufacturing process

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KORU (2021) Vegetation Condition Assessment Annual Report (2020-21), August 2021.

Appendix A

Vegetation Condition Assessment (2020-2021)

Vegetation Condition Assessment Annual Report (2020-21)

National Ceramic Industries Australia

Vegetation Condition Assessment Annual Report (2020-21) – National Ceramic Industries Australia

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1. Introduction

1.1 Purpose and Scope

Koru Environmental Pty Ltd (**Koru**) was engaged by AECOM Australia Pty Limited (**AECOM**) on behalf of National Ceramic Industries Australia Pty Limited (**NCIA**) to perform annual and quarterly vegetation surveys to investigate the potential effect of fluoride emissions on vegetation surrounding their Rutherford ceramic tile manufacturing facility.

Annual and quarterly visual and foliar fluoride content surveys are an integral component of regulatory environmental monitoring requirements as defined in Condition 5.8 of the Development Consent (DIPNR, 2003) and Condition M4.1 of Environment Protection Licence (**EPL**) 11956 (NSW EPA, April 2004).

Monitoring of the effects of fluoride on vegetation surrounding the NCIA premises commenced in 2004. The survey methodology was developed by Dr David Doley of the University of Queensland.

This report describes the background to fluoride impact monitoring, outlines survey assessment procedures, and summarises the results of the four vegetation surveys conducted during the 2020-2021 financial year (the '**reporting period**') – comprising:

- Quarter 3 (2020) survey (**Q3**).
- Quarter 4 (2020) survey (**Q4**, or '**Annual Survey**').
- Quarter 1 (2021) survey (**Q1**).
- Quarter 2 (2021) survey (**Q2**).

1.2 Report Structure

This report is structured as follows:

- **Section 2** – Provides the background to the monitoring program including monitoring requirements.
- **Section 3** – Details the adopted monitoring methodology.
- **Section 4** – Summarises the results of the vegetation surveys implemented during the current reporting period, inclusive of visual condition assessments and foliar fluoride content.
- **Section 5** – Discusses the results in the context of long-term trends and historical data.
- **Section 6** – Provides a summary and conclusion.
- **Section 7** – Lists the documents cited and referenced throughout this report.

2. Background to Fluoride Vegetation Impact Monitoring

2.1 Monitoring Requirements

Fluoride monitoring requirements defined in Condition M4.1 of EPL 11956 are shown below, and are based on the monitoring program proposed by AECOM on behalf of NCIA (HLA-Envirosciences – now AECOM). These monitoring requirements repeal those requirements defined in Condition 5.8 of the Development Consent, which did not acknowledge site-specific characteristics (including the simplified vegetation community structure and vegetation values) and the low contribution to background hydrogen fluoride (**HF**) concentrations predicted for the operation of the ceramic tile manufacturing facility. The proposed monitoring program has been reviewed and accepted by the Department of Infrastructure, Planning and Natural Resources (**DIPNR**; now Department of Planning, Industry and the Environment).

M4.1 The licensee must monitor the impact of fluoride on vegetation as follows:

a) Annual and quarterly visual assessment of vegetation in the area surrounding the premises as outlined in the document titled Proposed Ambient Air Quality Monitoring Programs – National Ceramic Industries Australia, Rutherford dated January 2004.

b) Quarterly monitoring of the fluoride content in vegetation in the area surrounding the premises as outlined in the document titled Proposed Ambient Air Quality Monitoring Programs – National Ceramic Industries Australia, Rutherford dated January 2004.

The licensee must maintain a list and a map of the monitoring sites used to assess the impact of the premises on the surrounding environment.

Part of each sample analysed must be carefully stored to the satisfaction of the EPA for a period of not less than 12 months and forwarded to the EPA on request.

2.2 Background Vegetation Impact Assessment

Dr David Doley undertook a background fluoride vegetation impact survey on 21st and 22nd January 2004, and subsequently developed the methodology adopted for use in the current survey.

Dr Doley's research interests were in the area of ecophysiology, with projects focusing on rainforest research, forest rehabilitation and air pollution studies. Dr Doley has been instrumental in the development and reporting of vegetation monitoring and assessments of fluoride impact for a range of industries in Australia and New Zealand, with emphasis on power generation and aluminium smelting.

Data collected during the background fluoride vegetation impact survey offer a baseline to which data from subsequent monitoring surveys may be compared. This comparison can then be used to evaluate the effect of the NCIA operations on local vegetation.

2.2.1 Implications of the Predicted Ground Level Concentrations

As described in HLA-Envirosciences (2004) (now AECOM), elevated background fluoride concentrations are found in the air around the NCIA facility at Rutherford. Major sources of fluoride in the Upper Hunter Valley include power stations and brick and ceramics works. Gaseous fluoride compounds cause damage to plants at concentrations about one thousand times lower than those that affect human health, and grapevines are particularly sensitive (Manins, 2001).

As specified in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (DEC, 2005), the impact assessment criteria for fluoride concentrations are those defined in the

National Goals for Fluoride in Ambient Air and Forage (ANZECC, 1990). The guideline value for the maximum 90-day average concentration of fluoride is of 0.25µg/m^3 for specialised land uses (i.e. all areas with vegetation sensitive to fluoride, such as grapevines and stone fruits) and of 0.5µg/m^3 for general land uses (i.e. all areas other than specialised land use).

Atmospheric fluoride concentrations associated with emissions from the ceramic tile facility were determined by AECOM as part of an Air Quality Impact Assessment undertaken during the Environmental Assessment (**EA**) for NCIA expansion (AECOM, 2010). Fluoride concentrations were monitored between 2007 and 2009 on the northwest (**NW**) and southeast (**SE**) areas of the NCIA site, which reflects prevailing wind directions in the area (NW in winter and SE in summer). The results showed that the maximum 90-day average concentrations during the monitoring period were of 0.1µg/m^3 at both the NW and SE locations. These concentrations are less than one-fifth of the ambient guideline values for general land use and less than half that of the ambient guideline values for special land uses.

Past studies have shown that fluoride concentrations higher than those emitted by NCIA (e.g. up to 0.2µg/m^3) were not associated with any detectable alteration in grape yield or quality (Doley *et al.* 2003a & b). It is therefore unlikely that NCIA activities have a detrimental effect on the surrounding sensitive vegetation and commercial crops such as grapevines.

2.2.2 Surrounding land uses

The NCIA site is located in an industrial area and is zoned 'IN1 – General Industrial' under the *Maitland Local Environmental Plan 2011* (MCC, 2011). The principal land uses in the areas of highest predicted ambient fluoride concentration (i.e. located within the prevailing wind directions) are summarised in **Table 1**.

Table 1 Existing land uses surrounding the NCIA plant

Direction	Land uses
South and south-east	• The land immediately to the east and south-east between 0 and 1km of the site includes the former Westside Golf Course (decommissioned, now a retirement village). This land is still zoned 'RE2 – Private Recreation' under the LEP 2011. • Residential areas zoned 'R1 – General Residential' occur to the east of the former golf course (1km from the NCIA plant and beyond) and to the south and south-east of NCIA beyond the main northern railway (between 0.5 and ~1km from the NCIA plant). • Beyond the residential areas to the south and south-east (>1km from the plant), land use consists of secondary agriculture and is zoned 'RU2 – Rural Landscape'.
North and north-west	• The land adjacent to the site to the north and north-west is industrial land zoned 'IN1 – General Industrial', and extends for about 0.9km from the site boundary until the New England Highway. • Beyond the industrial area to the north-west are areas allocated for business development (zoned 'B5 - Business Development'), forested areas (zoned 'E3 – Environmental Management') and Maitland airport (zoned 'SP1 – Special Activities'), respectively.

3. Methodology

The assessment procedure defined in the 2004 background survey was adopted for the monitoring undertaken during this 2020-2021 reporting period, and is highlighted in the following sub-sections.

3.1 Works Implementation

3.1.1 Surveys Timing

Three quarterly surveys and one annual survey were conducted during the reporting period, comprising:

- Q3 (2020) survey – completed 29th September 2020;
- Q4 (2020) survey – completed 23rd December 2020;
- Q1 (2021) survey – completed 30th March 2021; and
- Q2 (2021) survey – completed 30th June 2021.

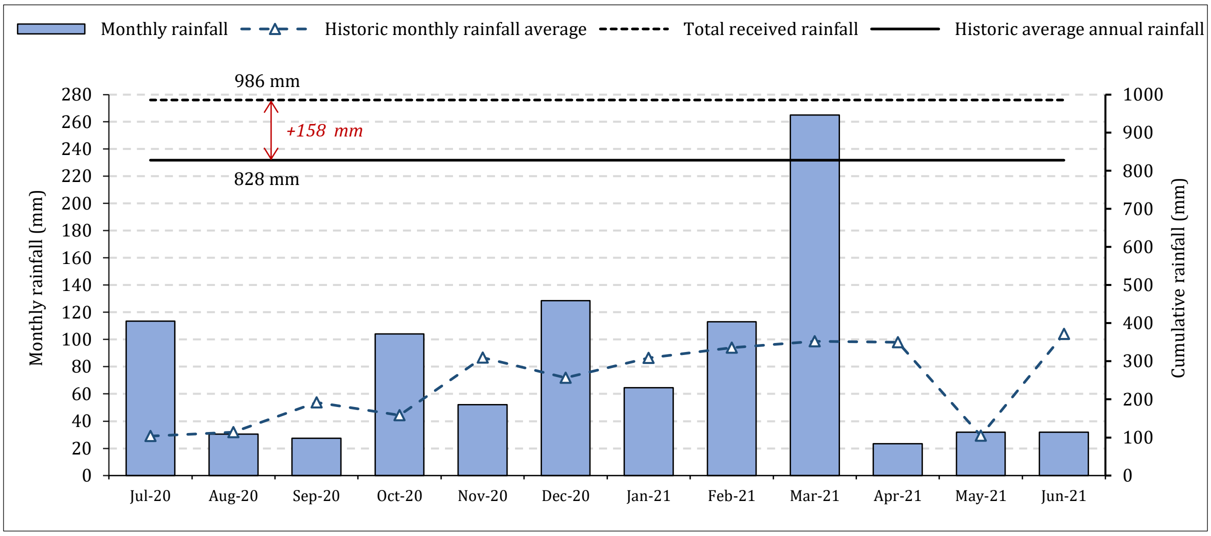
Quarterly surveys (Q1, Q2 and Q3) assessed the condition of a shortlisted selection of fluoride sensitive species from the background survey; whereas the annual survey (implemented during Q4) provides an opportunity to undertake a more comprehensive investigation and assesses a larger suite of locations and specimens including all specimens studied in the background survey (where these remain).

3.1.2 Weather Conditions

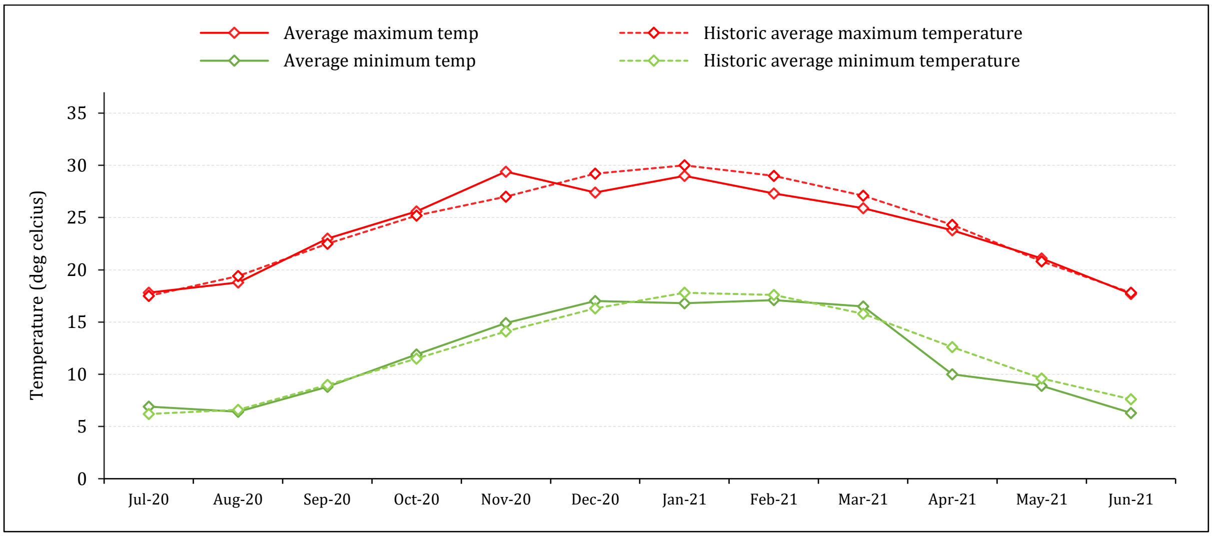
Weather data for the reporting period (i.e. July 2020 to June 2021) have been presented graphically in Error! Reference source not found. (rainfall) and Error! Reference source not found. (temperature), together with historical data ranges included for comparison purposes (rainfall data from Maitland Belmore Bridge BoM station No. 61268; temperature data from Maitland Airport BoM Station No. 61428).

Following the severe state drought between 2016 and 2019, the region experienced well-above average rainfall during the reporting period. As illustrated in Error! Reference source not found., total rainfall received by the locality during the reporting period was approximately ~20% higher than the historical average for the period (986 mm vs 828 mm), with monthly rainfall above seasonal averages in six of the 12 months, and a particularly wet March 2021.

In addition, and as shown in Error! Reference source not found., seasonal temperatures during the past 12 months were generally within or close historical averages, except for the summer months (Dec-Mar) which were on average 2°C cooler than long-term trends. This follows several years (2016-2019) during which seasonal temperatures were regularly exceeding long-term averages (further compounding the effects of the drought).



Graph 1 Local rainfall data (Jul 20-Jun 21)



Graph 2 Local temperature data (Jul 20-Jun 21)

3.2 Monitoring Locations

The survey locations were originally based on the distribution and concentrations of fluoride predicted in the Environmental Impact Statement (**EIS**) by Holmes Air Sciences (refer to Parsons Brinckerhoff, 2002). The subsequent air quality study undertaken for the 2010 EA (AECOM, 2010) did not result in any material change to the scope of the survey. The patterns of distribution of ambient fluoride concentrations reflect the prevailing wind directions (NW in winter and SE in summer). They do not take into account the existing background concentrations of fluoride in air.

Vegetation is assessed on the NCIA premises and at locations that can be accessed from public land / roadsides (i.e. 'impact sites'), plus a 'control site' on private property at Anambah. As far as possible (i.e. where specimens remain), the ongoing survey protocol (i.e. successive surveys over time) uses consistent locations and specimens to allow long-term trends in fluoride impacts to be analysed.

The sites surveyed during the 2020-2021 reporting period are listed in **Table 2** and their location shown on **Figure 1**. For further reference, photographs of each monitoring site location (at the time of the annual

Q42020 survey) is provided in **Appendix A**. All monitored locations were consistent with the previous (2019-2020) reporting period (i.e. no new monitoring site was established during 2020-2021).

Table 2 Monitoring locations used for assessment of fluoride injury in vegetation

Location	Site no.	Survey type		Distance from NCIA kiln stack	Description
		Quarterly	Annual		
NCIA premises	1		✓	280m NW	Access road north of office
	2		✓	120m W	Office car park
	3		✓	160m W	Access road south of office
	4		✓	220m SW	South-west corner of site
	5	✓	✓	300m SE	South-east corner of site
Rutherford and Farley residential area	6		✓	1.4km E	3 Palisade Street
	7	✓	✓	1.4km SE	3 Gillette Close
	8		✓	1.5km SE	Regiment Road east of Dumont Court
	9		✓	1.8kmSE	Regiment Road south-east of Squadron Crescent, Farley
	10		✓	2km SE	Wollombi Road between sewage works and creek, Farley
	11	✓	✓	1.5km SE	Hill top on Wollombi Road west of Owl Pen Lane, Farley
	12	✓	✓	2.2km S	Western end of Quarry Road, Farley
Rutherford industrial estate	13	✓	✓	480m N	NCIA entrance, Racecourse Road
	14	✓	✓	570m NW	100-104 Kyle Street
	15	✓	✓	500m NW	11 Gardiner Road
	16		✓	450m W	56 Gardiner Road
	17		✓	550 SW	Gardiner Road, southern end
	18	✓	✓	920m NW	Maitland Saleyards, Kyle Street
Control site	19	✓	✓	3.1km N	200 Anambah Road, Anambah

KORU ENVIRONMENTAL

N S W E

0 190 380 760
metres

1:26,914 (when printed at A4)

MAP SIZE:	A4 Portrait	PROJECT REF:	P2020-015
DATUM:	GDA 1994	CREATED BY:	mcatteau
PROJECTION:	MGA Zone 56	DATE CREATED:	15-Aug-2021

LEGEND

NCIA site boundary

Monitoring sites

- Quarterly + annual survey site
- Annual survey site only
- Control site

NCIA Vegetation Condition Assessment
Annual Report (2020-2021)

FIGURE 1
Survey Monitoring Locations

3.3 Species Monitored

The principal species monitored during the surveys are listed in **Table 3**. Attention was directed to plant species considered most likely to exhibit visible injury symptoms from atmospheric fluoride.

A total of 60 plant specimens were surveyed during the Q4 2021 annual survey, with a subset of 17 specimens surveyed during the Q3 2020 survey and a subset of 16 specimens during the Q1 2021 and Q2 2021 surveys (following the loss of a specimen due to land clearing and residential development).

Table 3 Flora species in the vicinity of NCIA known to exhibit visible injury symptoms from atmospheric fluoride

Species scientific name	Common name	Growth form / habit
Angophora floribunda	Rough-barked Apple	Tree
Bursaria spinosa	Blackthorn	Shrub
Casuarina glauca	Swamp Oak	Tree
Corymbia maculata	Spotted Gum	Tree
Eucalyptus amplifolia	Cabbage Gum	Tree
Eucalyptus botryoides	Southern Mahogany	Tree
Eucalyptus fibrosa	Red Ironbark	Tree
Eucalyptus moluccana	Grey Box	Tree
Eucalyptus paniculata	Grey Ironbark	Tree
Eucalyptus punctata	Grey Gum	Tree
Eucalyptus resinifera	Red Stringybark	Tree
Eucalyptus robusta	Swamp Mahogany	Tree
Fraxinus excelsior	European Ash	Tree
Fraxinus pennsylvanica	Green Ash	Tree
Grevillea robusta	Silky Oak	Tree
Hakea gibbosa	Hairy hakea	Shrub
Olea europaea subsp. cuspidata	African Olive	Shrub
Pinus radiata	Radiata Pine	Tree
Populus nigra var. *italica*	Lombardy Poplar	Tree

3.4 Assessment of Vegetation

3.4.1 Background

The monitoring of vegetation for effects of gaseous fluoride is based on the very high sensitivity of plant species, as compared with animals, to the accumulation of fluoride in tissue (Weinstein and Davison 2004). A consequence of this phenomenon is that injury may be detected in plant species under conditions that pose no risk to the health of humans and other animals. Within different plant groups, there is normally a range of sensitivities of species to fluoride, and within species, there will be some variation in the sensitivity of individual varieties or plants. Some of the more sensitive plant species are those of commercial or aesthetic interest, such as grapevines, peaches and gladiolus, or ecologically important native species, such as Spotted Gum (*Corymbia maculata*).

Vegetation monitoring is a valuable adjunct to other aspects of environmental management associated with a fluoride-emitting activity, as it can indicate the effects of both integrated fluoride exposure and under some circumstances, evidence of acute exposures. The nature of these indications will vary according to the pattern in time of ambient fluoride concentration and the presence of suitable species for monitoring purposes, namely those that are sensitive to fluoride. Visible injury to foliage is commonly used to indicate fluoride effects, as the measurement of growth in wild plants is unreliable due to the highly variable and uncontrolled effects of climatic factors, pests and disease on the patterns and amount of shoot growth in any given year. Australian plant species that are useful indicators of fluoride effects, their symptoms and some related factors are described by Doley (1986) and Doley *et al*. (2004).

3.4.2 Classification of Visual Injury Symptoms

A semi-quantitative scale of injuries was applied to selected species that occurred relatively widely over the area and expressed symptoms that could be associated reliably with fluoride exposure. Where other environmental stresses were likely to occur, attempts were made to determine their relative contributions to the categories of stress expressed in the foliage.

Grades of injury, described in **Table 4**, were used to simplify the process of assessment, to enable rapid and repeatable assessment of the extent of injury to foliage of different species, age or position at any location.

The combination of these symptoms varies between species for a given level of injury, and within species between foliage of different ages (i.e. current season vs. previous season leaves); and

Other visible injury parameters that are not attributable to fluoride impact, including insect leaf chewing index, insect sap sucking index, branch dieback and crown density, were also assessed during the survey. Whilst not explicitly defined, the symptom code/category system adopted for the assessment of these parameters is consistent with that defined for fluoride injury parameters defined in **Table 4**. Furthermore, evidence of vegetation reproduction, such as the observation of buds and/or fruits or flowers, was noted as present (designated '✓') or absent (designated '0').

Table 5 summarises the combinations for some more common groups of plant species in the Rutherford area.

Visible injury symptoms were compared with the scales of maximum injury described in **Table 4**. Categories were determined arbitrarily, and with increasing steps of injury, to reflect the range of value judgments that may be associated with the concept of aesthetic environmental harm. For each category, the value in **Table 4** indicates the maximum expression of injury associated with that category. The occurrence of injury was assessed on the one-tenth portion of leaves of a particular age class that expressed the greatest injury. This allowed for the common phenomenon that injury was confined to a relatively small portion of the growing season.

- **Injury Category 1** could be detected consistently by an experienced observer or by a person with a professional or serious interest in plant condition, such as a competitive horticulturist. It is very unlikely to have adverse effects on total plant growth or plant reproduction.
- **Injury Category 2** could be detected consistently by an inexperienced observer. It would be expected to cause offence to a person with a serious interest in plant condition, such as a competitive horticulturist. It is very unlikely to have adverse effects on total plant growth or plant reproduction.
- **Injury Category 3** would be obvious to an inexperienced observer, and that would seriously impair the aesthetic quality of the plant for purposes such as commercial floriculture. It would be expected to offend a dedicated home gardener. It is unlikely to have adverse effects on plant growth or reproduction.

- **Injury Category 4** would be obvious on casual inspection to an inexperienced observer. It could reasonably be judged to be "offensive or objectionable to such an extent that it has an adverse effect on the environment", in that an average home gardener would be likely to be offended by these conditions in horticultural specimens. The growth of a plant and the yield of foliage, fruit or other products from the plant may be impaired. If this level of injury occurred over a whole crop, it would be expected to be associated with reduced commercial yield and to be of concern to the manager of a commercial crop.
- **Injury Category 5** would be obvious to a casual observer at a distance from a plant and would be likely to result in the premature loss of foliage, loss of vigour of growth in the following season, and in some species the failure of flowering.
- **Injury Category 6** would be obvious to uninterested observers. It is likely to result in the premature death and loss of foliage, death of shoot tips, reduction in vigour of regrowth, and failure of flowering and fruit set.
- **Injury Category 7** would be very obvious from a distance to uninterested observers. It is likely to be associated with rapid death of foliage and shoot tips and, if repeated, the death of even large perennial plants.

Table 4 Symptom criteria used for visible injury to vegetation

Category	Tip necrosis or chlorosis (% length)	Marginal necrosis or chlorosis (% width)	Undulation / cupping	Anthocyanin accumulation (% area)
0	nil	nil	nil	nil
1	very slight <2%	very slight <2%	very slight	very slight <2%
2	slight < 5%	slight <5%	slight	slight <5%
3	distinct <10%	distinct <10%	distinct	distinct <10%
4	marked <25%	marked <25%	marked	marked <25%
5	severe <50%	severe <50%	severe	severe <50%
6	very severe <75%	very severe <75%	very severe	very severe <75%
7	extreme >75%	extreme >75%	extreme	extreme >75%

Other visible injury parameters that are not attributable to fluoride impact, including insect leaf chewing index, insect sap sucking index, branch dieback and crown density, were also assessed during the survey. Whilst not explicitly defined, the symptom code/category system adopted for the assessment of these parameters is consistent with that defined for fluoride injury parameters defined in **Table 4**. Furthermore, evidence of vegetation reproduction, such as the observation of buds and/or fruits or flowers, was noted as present (designated '✓') or absent (designated '0').

Table 5 Categories of visible injuries attributable to fluoride emissions in selected plant species

Species	Category	Symptoms	
		Current season leaves	Previous season leaves
All	0	No visible injury	No visible injury
Eucalyptus, *Angophora*,	1	No visible injury	Slight marginal/interveinal chlorosis and cupping or undulation

Species	Category	Symptoms	
		Current season leaves	Previous season leaves
Corymbia and *Acacia* species	2	Very slight marginal and/or interveinal chlorosis and cupping or undulation	Distinct marginal/interveinal chlorosis and cupping or undulation, tip necrosis <5%
	3	Slight marginal and/or interveinal chlorosis and cupping or undulation	Marked marginal/interveinal chlorosis, cupping, tip necrosis <10%, scattered marginal necrosis
	4	Distinct marginal and/or interveinal chlorosis and cupping or undulation, tip necrosis <5%	Marked marginal/interveinal chlorosis and cupping, tip necrosis < 20%, marginal necrosis <3 mm
	5	Marked marginal and/or interveinal chlorosis and cupping, tip necrosis <10%	Severe marginal/interveinal chlorosis and cupping, tip necrosis < 50%, marginal necrosis >3 mm
	6	Marked marginal and/or interveinal chlorosis and cupping, tip necrosis <20%, marginal necrosis <3 mm	Severe marginal/interveinal chlorosis and cupping, tip necrosis >50%, marginal necrosis >50% width
	7	Severe marginal and/or interveinal chlorosis and cupping, tip necrosis >20%, marginal necrosis > 3mm	Leaves shed
Pinus species	1	Tip necrosis <2%	Tip necrosis <5%
	2	Tip necrosis <5%	Tip necrosis <10%
	3	Tip necrosis <10%	Tip necrosis <25%
	4	Tip necrosis <25%	Tip necrosis <50%
	5	Tip necrosis <50%	Tip necrosis <75%
	6	Tip necrosis <75%	Tip necrosis >75%
	7	Tip necrosis >75%	Needles shed
Deciduous ornamental species	1	Very slight marginal and interveinal chlorosis, affecting <5% area	N/A
	2	Slight marginal and interveinal chlorosis, affecting <10% area	N/A
	3	Distinct marginal and interveinal chlorosis, <25 area, marginal necrosis <3 mm	N/A
	4	Marked marginal and interveinal chlorosis, <50% area, marginal necrosis <6 mm	N/A
	5	Severe marginal and interveinal chlorosis, <75% area, marginal necrosis >6 mm	N/A
	6	Very severe marginal and interveinal chlorosis, <90% area, marginal necrosis >6 mm	N/A
	7	Extreme marginal and interveinal chlorosis, >90% area, marginal necrosis >6 mm	N/A

Note: the combination of symptoms for each category of the code will vary with leaf age and with other stress conditions.

3.5 Interpretation of Injury Symptoms

3.5.1 Field Recording

In the application of the injury code in the field, the extent of injury to foliage affected by injury of a particular type was estimated for the one-tenth portion of leaves showing greatest injury on representative branches or plants, and this figure was applied to the species in question at that location. The one-tenth portion of leaves was selected because, in many situations, the distribution of injury within a growing season was not uniform. Expression of injury on a majority of branches or plants in a particular exposure situation was adopted, because air pollutants would be expected to cause similar injury to all leaves on one large plant of a given age and exposure situation. The extent of injury commonly varies even within leaves and an average injury estimate was used. For example, marginal chlorosis may be irregular in its occurrence throughout a leaf, and it was assessed as an average percentage of leaf width affected.

3.5.2 Injury Category

Injury ratings for necrosis, chlorosis or leaf-chewing insect injury were applied independently in each determination. An overall Injury Category was assigned to a species at a site on the basis of the highest injury category for any criterion. This was adopted in order to identify the extent of injury that could be attributed to all stresses, including non-pollutant stresses such as drought, storm winds, disease or insect attack.

3.5.3 Emission Injury

An emissions category was assigned for symptoms or for that portion of a symptom expression that was attributable to fluoride exposure. The contribution of emissions to the total injury was estimated where there were considered to be clear differences in the amount of injury attributable to natural environmental stresses and those associated with the emission source.

Symptoms including cupping or buckling of the leaf blade, necrosis of the tips or margins of the leaves may be caused by several different factors, including fluoride exposure. In addition, the combination and relative expression of different symptoms is of considerable assistance in diagnosing pollutant injury in different species. All of these considerations may result in a moderation of the estimate of pollutant injury from that recorded in the field survey.

3.5.4 Foliage Age

For evergreen species, the injury code may be applied separately for leaves of different age, as current season leaves may be uninjured whilst one-year-old or older leaves may show injury or may show a different combination of symptoms from those in current season leaves.

Where there are clear differences in the extent of injury to foliage at different positions on an annual shoot, the portions of seasonal growth may be indicated, together with the possible causes of injury. The actual ages of foliage will vary between species, depending on their major season of growth.

Foliage is classified as 0 (current season) or 1 year of age (previous season). Deciduous species have only a single leaf age class, but in many evergreen species, previous season leaves are shed or may begin to deteriorate soon after the current season shoot has completed expansion. Where 1-year-old foliage is judged to be senescent, assessment is usually restricted to current season foliage. Where examinations are made before the growing season has ended, foliage from two growing seasons may be used to provide separate estimates of injury.

For many species, there is a relatively consistent relationship between the degrees of injury expressed in current season and one-year-old foliage, with the older leaves often showing injury of one category higher than the current season leaves (roughly double the extent of injury for most classes). In order to make comparisons between leaf ages and times of inspection during the growing season, the injury category for current season leaves is generally used, or deduced from expressions of injury in one-year-old leaves.

3.5.5 Position and Orientation of Foliage

Both large-scale (hundreds of metres) and small-scale (metres) patterns of distribution of injury should be consistent with the causal agent. For example, the large-scale pattern should show a reduction in the extent of injury that reflects the distance from the source of pollution, patterns of wind speed and the constancy of wind direction, particularly during the growing season. Small-scale patterns should also reflect the direction and speed of winds from the pollutant source, the density of foliage in the crown of the plant and the existence of obstacles to air movement. The directional pattern of pollutant injury distribution around a plant will be identical with that due to wind effects in the prevailing down-wind direction from the emission source, so it may be extremely difficult to separate pollutant and non-pollutant effects.

Therefore, a careful examination of the distribution of injury around a large plant, such as a tree, is essential, bearing in mind the effects of small-scale ground relief and the conformation of vegetation on the direction and speed of local winds. In these situations, relevant information on the location of foliage should be included. Where such information is not indicated, the injury records relate to general estimates of condition for a complete plant crown or for a group of small plants.

3.5.6 Mimicking Symptoms

The use of plants as biological indicators of pollution requires that the symptoms of pollutant injury can be distinguished from those of other environmental stressors. Several environmental conditions induce visible symptoms similar to those caused by pollutants, so the appearance of a particular category of injury does not necessarily mean that it is due to a pollutant. These include necrosis tip, necrosis marginal, anthocyanin and cupping.

In particular, the effects of drought and storm winds may be very similar to those of fluoride exposure, and chlorosis induced by fluoride may closely resemble symptoms of iron or magnesium deficiency.

Insect attack can also cause injury symptoms similar to that of fluoride related injury (chlorosis and anthocyanin).

3.6 Criteria for Injury Due to Industrial Emissions

Dr Doley (HLA-Envirosciences, 2004 - now AECOM) established the following conditions for attributing foliar injury to emissions from an industrial source, which were followed during the surveys:

- The pattern of distribution of injured trees should be consistent with observed or probable patterns of distribution of emissions.
    - Modelled distribution patterns for fluoride under conditions of atmospheric stability and low to moderate wind speed are considered to be the most appropriate comparisons; and
    - The periods of exposure need not be continuous, but there should be sufficient exposure (combination of concentration and exposure duration) to result in the observed injury.
- The degree of injury should be consistent with known or probable exposure of vegetation to pollutants.
    - If fluoride were suspected of being the causal agent, ambient gaseous concentrations greater than 2.0 $\mu g/m^3$ would be required to persist for about one month in species of moderate fluoride tolerance, and greater than 2.0 $\mu g/m^3$ would be required to persist for more than one week in species that were very sensitive to fluoride injury; and

  - Individuals of a species may vary in sensitivity to a pollutant by a factor of 10.
- The distribution of injury within a large plant, such as a tree, should be consistent with probable patterns of distribution of exposure.
  - If the injury had continued for more than one growing season, the degree of injury in foliage should increase progressively with foliage age. Older leaves should show some evidence of injury in each season, commonly as banding or watermarking of zones of injury;
  - If the event resulting in injury occurred only within the current growing season in an evergreen species, current season foliage might be expected to show more injury than older foliage because it would be more exposed (higher boundary layer conductance to gas uptake), and possibly more sensitive to the pollutant; and
  - If the injury was confined to a portion of a single growing season, the pattern of distribution of injury should be consistent with known or probable patterns of release of pollutant during that season.

3.7 Foliar Sampling and Fluoride Content Analysis

Samples chosen for fluoride content analysis followed similar methodology selected during the background survey (refer to HLA-Envirosciences, 2004 – now AECOM).

Sites and species nominated for determination of foliar fluoride concentrations are indicated in **Table 6**. All collected samples were submitted to the NATA-accredited ALS Newcastle laboratory for analysis.

Where possible both current and previous season leaves were collected for analysis and mixed to create a bulk sample for each specimen sampled. Grasses at Wollombi Road (Site 11) were sampled in approximate proportion to their representation or percentage ground cover at the sampling site and were collected at a height judged to be that at which cattle would graze (thereby avoiding the inclusion of soil and roots).

Table 6 Sites and plant species selected for foliage fluoride content analysis

Site no.	Location	Species sampled
Site 5	NCIA – South-east corner of premises	*Eucalyptus amplifolia*
Site 11	Hill Top – Wollombi Rd, Farley	Grasses
Site 13	NCIA site entrance (outside premises)	*Eucalyptus amplifolia*
		Corymbia maculata
Site 15	11 Gardiner Road, Rutherford industrial estate	*Corymbia maculata*
Site 19	Control site – Anambah homestead	*Vitis vinifera*

4. Results

4.1 Visual Condition Assessments

The complete tabulated results of the visible injury assessments performed during the current reporting period's quarterly and annual surveys are provided in **Appendix B**, together with a selection of photographs of impacted foliage. The results have been summarised below.

4.1.1 Impact Sites

Proportion of affected species

The visual assessments found that inclusive of all quarterly surveys during the reporting period, emission related injury symptoms (i.e. chlorosis, cupping, necrosis, anthocyanin accumulation) were present in the foliage of approximately 83% of all species assessed, whilst approximately 77% of all species assessed displayed some level of insect attack injury symptoms (refer to **Table 7**); which is consistent with the results reported in the previous reporting period.

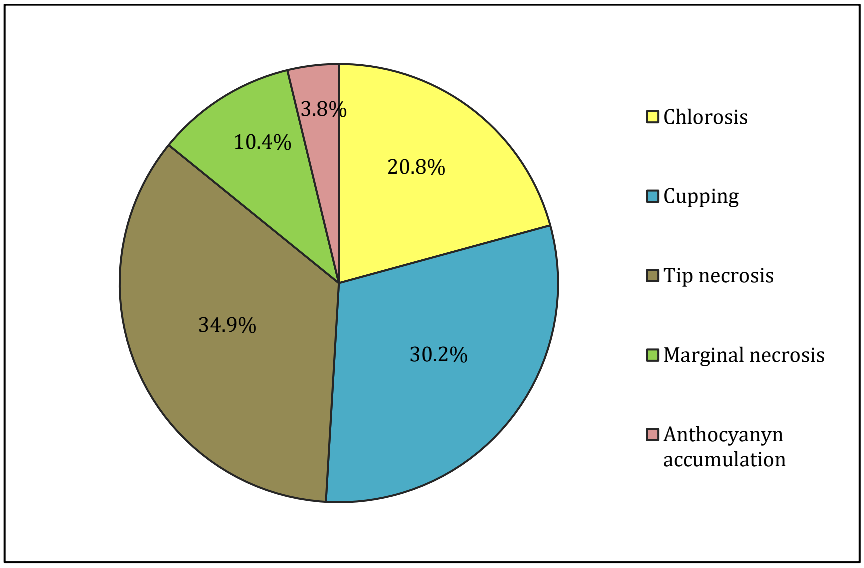
The lower prevalence of emissions and insect attack injury symptoms recorded during the Q4 annual survey was largely due the inclusion in this survey of several species that are known to be less sensitive to injury symptoms (e.g. *Acacia*, *Bursaria*, *Casuarina*, *Pinus*, and *Hakea spp*.), whereas quarterly surveys mainly focus on sensitive *Eucalypt* species.

Table 7 Proportion of surveyed plant species showing visual injury symptoms

	Emission related injury symptoms					Insect attack injury symptoms				
	Q3 2020	Q4 2020	Q1 2021	Q2 2021	Total	Q3 2020	Q4 2020	Q1 2021	Q2 2021	Total
No. species assessed	17	60	16	16	**109**	17	60	16	16	**109**
Injury symptoms present	16 (94%)	43 (72%)	16 (100%)	15 (94%)	**90 (83%)**	17 (100%)	35 (58%)	16 (100%)	16 (100%)	**84 (77%)**
Injury symptoms absent	1 (6%)	17 (28%)	0 (0%)	1 (6%)	**19 (17%)**	0 (0%)	25 (42%)	0 (0%)	0 (0%)	**25 (23%)**

Prevalence of specific injury symptoms

Graph 3 shows the relative prevalence of each visual foliage injury symptom observed in all species during the four surveys. Consistent with previous years, results indicated that tip necrosis and leaf undulation / cupping were the most commonly observed symptoms (with respectively 34.9% and 30.2% of specimens impacted), followed by chlorosis (20.8%) and marginal necrosis (10.4%), whilst symptoms of anthocyanin accumulation were generally uncommon (observed in only 3.8% of all assessments).



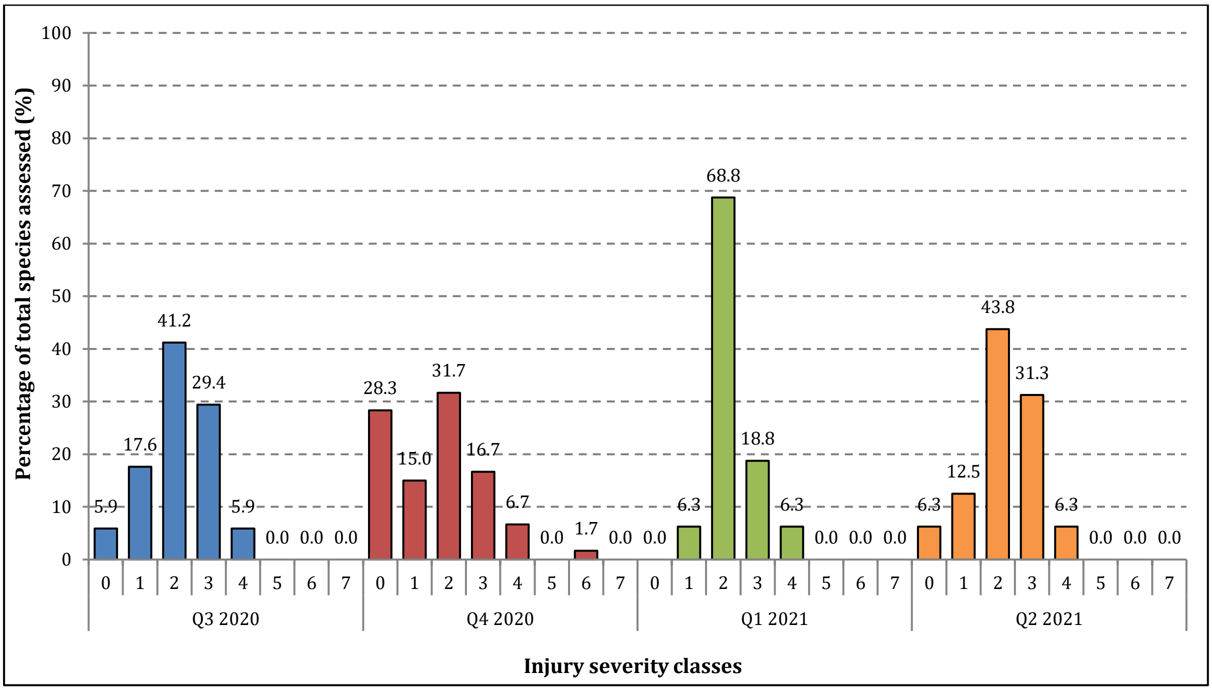
Graph 3 Prevalence of fluoride-related injury symptoms

Recorded injury severity ranges

For each survey during the current reporting period, **Graph 4** depicts the distribution of fluoride-related injury severity classes recorded in all plant specimens surveyed. The severity of visual injury symptoms overall ranged from very slight to very severe (i.e. between 2% and 75% of leaf area affected) – however higher severity injuries remained relatively uncommon; as follows:

- During each survey between 0% and 28.3% (average 10.1%) of plants surveyed displayed no injury symptoms.
- During each survey between 46.7% and 75.1% (average 59.2%) of plants surveyed were affected at worst by slight injury symptoms (i.e. injury class 1 and class 2, maximum of 5% leaf area impacted);
- During each survey between 23.4% and 37.6% (average 30.4%) of plants surveyed were affected by distinct or marked injury symptoms (i.e. injury class 3 or 4, 10-25% of leaf area impacted);
- During each survey between 0% and 1.7% (average 0.4%) of plants surveyed displayed severe to very severe visual injury symptoms (i.e. injury class 5 or 6, 50-75% of leaf area impacted); and
- No specimens displayed extreme injury symptoms (i.e. injury class 7, >75% of leaf area impacted) in any of the four surveys.

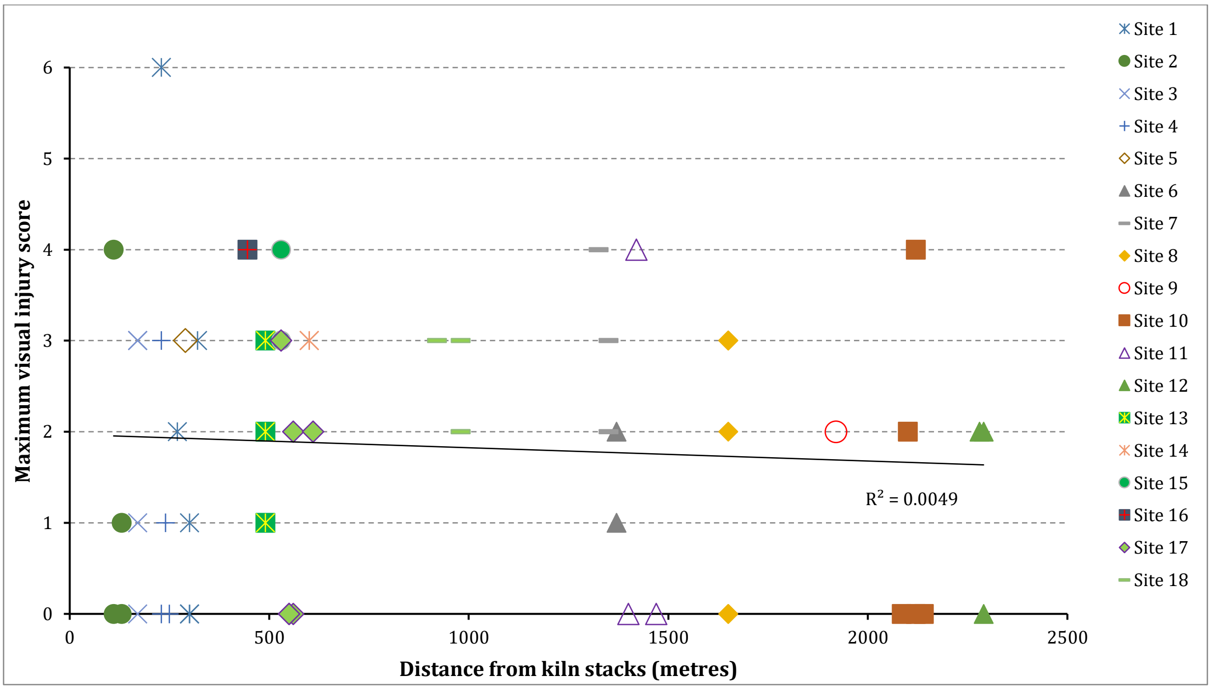
In relation to insect attack injury (not graphed), approximately 35% of surveyed specimens displayed injury symptoms of only very slight severity (i.e. less than 2% leaf area affected), 28% injury symptoms of slight severity (i.e. 2–5% leaf area affected) and 14% injury symptoms of distinct severity (i.e. 5–10% leaf area affected). No marked or severe (or higher) insect injury symptoms were recorded.



Graph 4 **Proportion of surveyed specimens affected by fluoride-related visual injury symptoms**

Correlation between severity of injury and distance from emission source

Graph 5 shows the relationship between the maximum emission-related visual injury score recorded for each surveyed specimen (inclusive of all surveys) and their distance from the kiln stacks at NCIA.



Graph 5 **Correlation between severity of injury and distance from emission source**

Consistent with previous years, the results for the current reporting period showed a very weak statistical relationship (i.e. little correlation) between foliage fluoride-injury and the distance to the emission source ($r^2 = 0.0049$).

This can indicate that emission impacts to foliage may spread further from the NCIA site than the furthest monitoring site. For instance, category 3 and category 4 injury symptoms were commonly observed at distances greater than ~1.5km from the NCIA facility (e.g. at monitoring Sites 8 and 11), and up to ~2.1km from the NCIA facility (e.g. Site 10).

This also highlights that within the current suite of monitoring sites, variables such as flora species type or the sensitivity of specific individuals are more relevant than the distance from emission source in determining atmospheric fluoride impacts on local vegetation.

However, and importantly, there are several other air pollution sources in the region which may impact vegetation and foliage condition. Therefore, the geographical extent of fluoride impacts to foliage attributable to NCIA activities alone cannot be confidently determined.

4.1.2 Control Site

A broad diversity of species was assessed at this site (17 specimens), which is located approximately 3.1km north of the kiln stacks at NCIA (i.e. slightly outside the prevailing wind directions).

The surveyed vegetation was generally in a good and healthy condition with plants typically not showing signs of chlorosis, marginal necrosis or anthocyanin accumulation. Some foliage injury symptoms were recorded including leaf cupping and tip necrosis, however those were detected in a minority of the species surveyed and their severity was typically limited to class 1 (very slight) or class 2 (slight) injuries. Few exceptions were recorded where higher severity symptoms were recorded, including:

- *Corymbia maculata* and *Macadamia integrifolia* displayed distinct (class 3) leaf cupping symptoms during the Q4 2020 survey (although for the latter leaf undulation / cupping typically appears as a natural foliage trait);
- *Eucalyptus acmenoides* displayed distinct (class 3) tip necrosis symptoms during the Q3 2020 survey, and
- *Eucalyptus tereticornis* displayed marked (class 4) tip necrosis symptoms during the Q3 2020 and Q4 2020 surveys, and (class 3) tip necrosis symptoms during the Q1 2021 survey.

Insect attack injury symptoms were recorded in 29.4% of all species assessed at the reference site (and exclusively in eucalypt species) with their severity usually ranging from very slight (class 1) to distinct (class 3), with only one observation of marked (class 4 injury) injury symptoms.

4.2 Foliar Fluoride Content

Foliar fluoride content from the samples analysed during the current reporting period are summarised in **Table 8**, with laboratory testing reports (certificates of analysis) included in **Appendix C** for further reference.

Testing results for the reporting period indicated the following key findings:

- Grasses and grape vines continue to record minimal fluoride content levels (<10.0 mg/kg) highlighting the minimal accumulation of the toxins in these species.
- In tree species, varying degrees of resistance and/or sensitivity to impacts caused by atmospheric fluoride continued to occur at both the inter and intra-species levels; with foliar fluoride concentrations ranging from <10.0 mg/kg to 43.7 mg/kg.
- For most tree species sampled at the impact sites (i.e. with the exception of *Corymbia maculata* at Site 13), foliar fluoride concentrations showed seasonal variations, reflecting the dominant wind

patterns in the area – i.e. with concentrations increasing (or decreasing) as the dominant winds blow toward (or away from) the monitoring sites from the NCIA kiln stacks.

A comparison of these results to previous years and further discussion are provided below in **Section 5**.

Table 8 Foliar fluoride content testing results for the current reporting period

Site no.	Species sampled	Fluoride content (mg/kg)			
		Q3 2020	Q4 2021	Q1 2021	Q2 2021
Site 5	*Eucalyptus moluccana*	27.6	15.1	<10.0	23.7
Site 11	Grasses	<10.0	<10.0	<10.0	<10.0
Site 13	*Eucalyptus amplifolia*	33.6	20.7	34.8	43.7
Site 13	*Corymbia maculata*	<10.0	<10.0	<10.0	<10.0
Site 15	*Corymbia maculata*	34.1	11.4	35.5	25.8
Site 19	*Vitis vinifera*	<10.0	<10.0	<10.0	N/A*

* *Vitis vinifera* is a deciduous species and is typically fully defoliated at the time of the Q2 (winter) surveys.

5. Discussion

As required by the EPL the potential impact of NCIA's operations on vegetation surrounding the facility is monitored through assessment of fluoride impacts on local vegetation, including visual assessments of injury symptoms to leaves and foliar fluoride content. However, there are no limits or criteria set out in the EPL or Project Approval by which to assess compliance. Likewise, the 2010 EA did not specifically discuss fluoride impact on vegetation and therefore no predictions are available for comparison. Instead, the assessments are used to provide an indication of trends in fluoride injury and concentrations at set locations surrounding the facility and for a suite of particular species.

5.1 Trends in Visual Impact on Vegetation

5.1.1 Impact Sites

Historical results for vegetation visual assessments since the start of the monitoring program are presented in **Graph 6**. For each quarterly survey the data has been presented to show the proportion of total species assessed that displayed fluoride-related injury symptoms of varying severity. The results were grouped into the following four categories:

- Species showing no visible fluoride injury symptoms;
- Species displaying at worst class 1 (very slight) or class 2 (slight) injury symptoms;
- Species displaying at worst class 3 (distinct) or class 4 (marked) injury symptoms; and
- Species displaying class 5 injury symptoms and above (severe to extreme).

Historical data highlight clear seasonal variations in the severity of recorded visual injury symptoms in the foliage of studied specimens surrounding the NCIA facility.

As shown in **Graph 6**, the proportions of assessed specimens displaying at worst slight to very slight (class 1 or class 2) visual injury symptoms or serve to extreme (class 5 and greater) injury symptoms have remained relatively stable since the start of the monitoring program in 2004. Conversely, the long-term data seem to highlight a slightly increasing trend in the proportion of plants displaying distinct to severe (class 3 or class 4) visual injury symptoms, combined to a slightly decreasing trend in the proportion of plants showing no visual injury symptoms. Although this could be a sign of as a slow and progressive deterioration in vegetation health surrounding the NCIA facility, in all cases the r^2 correlation coefficient remains weak to very weak (≤0.2). Consequently, the collected data support no statistically significant long-term trends (increasing or decreasing) since the start of the monitoring program, and any potential impact from NCIA on the health of local vegetation would be inconclusive.

Further interrogation of the long-term monitoring data indicates the following:

- The majority of specimens assessed since the start of the monitoring program in 2004 have commonly displayed at least some level of fluoride-related visual injury symptoms (87.6% on average during each quarterly survey). Of all plants showing emission related impacts to foliage:
  - On average 50.0% displayed only very slight or slight visual injury symptoms and 26.9% displayed at worst distinct or marked fluoride injuries.
  - Severe injury symptoms have rarely been recorded (11 instances in a total of 1,466 observations since 2004, i.e. <1.0%) and where this has been the case, injury symptoms did not persist over time; and
  - Only four instances of very severe injury symptoms (class 6) have been reported since 2004 and extreme injury symptoms (class 7).

- The majority of specimens assessed since the start of the monitoring program in 2004 have commonly displayed at least some level of insect attack injury symptoms (approximately 77.9% of all species affected on average). Of all plants showing impacts from insect attack: injury severity was very slight in 33.4% of cases, slight in 26.9% of cases, distinct in 13.8% of cases and marked in 3.3% of cases (no severe or greater insect attack symptoms have ever been recorded).

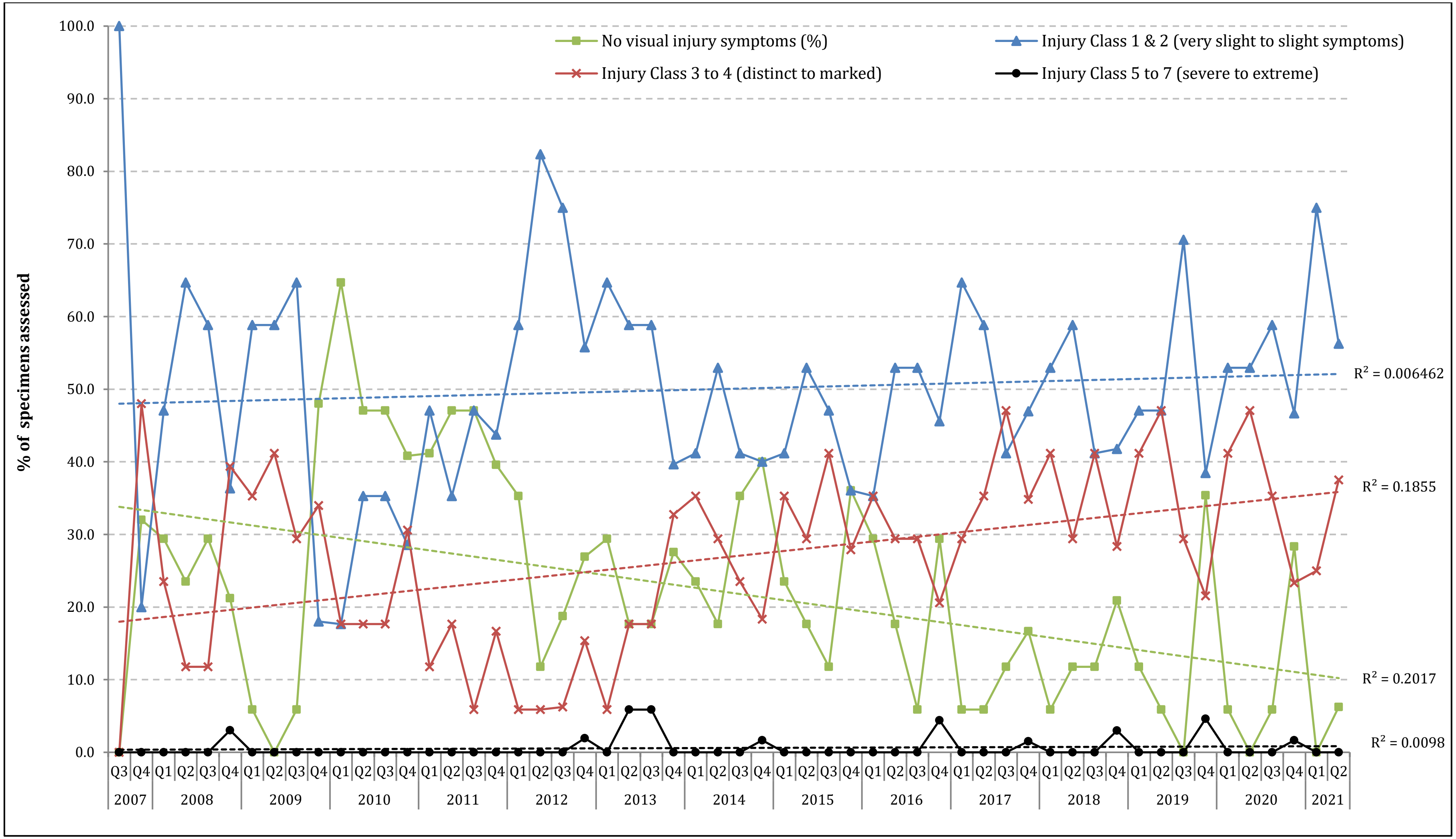
The monitoring results collected during the current reporting period (as presented in **Section 4**) are generally well aligned with these long-term trends. As is commonly observed, this year's results have shown some minor variations in foliage condition against previous year's results, with some specimens showing either slight deteriorations or slight improvements in foliage condition (whilst most showed relatively consistent symptoms). Overall, none of this year's survey results could be flagged as exceptional in the context of the long-term monitoring program and associated historical data.

5.1.2 Control Site

The control site is located approximately 3.1 km to the north of the NCIA facility thus outside the prevailing wind direction. Given its location, it is expected that there should be limited impacts to the vegetation as a result of fluoride emissions (i.e. in comparison to the impact sites).

Long-term results of the visual assessments of foliage injury symptoms undertaken at the control site show that vegetation has historically been in good and healthy condition. Nonetheless, some injury symptoms have commonly been recorded over the years, particularly symptoms of cupping and tip necrosis, albeit of very slight severity, as well as insect attack injuries.

The link to fluoride emission as a cause for these symptoms at this location cannot be confidently ascertained. For instance, it is possible that some species will exhibit foliar injury symptoms under 'natural' conditions. Other factors may also play a role in the expression of injury, which may include environmental conditions, stress (e.g. drought, wind, diseases, etc.), and pollutants from other sources or impacts from insects.



Graph 6 Proportion of plant specimens displaying fluoride-related visual injury symptoms (2007-2021)

5.2 Trends in Foliar Fluoride Content

5.2.1 Impact Sites

Historical fluoride concentrations in vegetation sampled during successive quarterly and annual surveys (since beginning of monitoring) are presented in **Graph 7** to **Graph 10**.

Interrogation of current reporting period's results against long-term data highlights the following:

- Historic data for *E. moluccana* at Site 5 indicate that a seasonal increase in foliar fluoride concentration typically occurs between late winter and summer, often with a peak recorded during the spring survey; before levels settle down during autumn and early-mid winter, which reflects changing dominant wind patterns occurring with the change of season.
  - Results for the current reporting period were generally consistent with this long term pattern, with the highest fluoride content recorded during Q3 2021 (27.6 mg/kg) and the lowest during Q1 2021 (<10.0 mg/kg).
  - Overall, fluoride concentrations recorded in this tree during the current reporting period were very consistent with the previous reporting period (2019-2020), and remained within the lowest historical range of values.
- Long-term data for grasses at Site 11 indicate that seasonal increases in fluoride concentration are often observed in response to changing wind patterns. Indeed, historical records show that fluoride concentrations often display a short spike in Q2 or Q3 (i.e. in late spring or winter when winds have been dominated by north-westerlies blowing towards the monitoring site from the NCIA kiln stacks), before settling down to very low levels for the rest of the year.
  - Results for the current reporting period consistently returned a very low fluoride content in all four surveys (i.e. ≤10.0 mg/kg, below laboratory limit of reporting).
  - Despite no recorded seasonal increase, these results were generally consistent with historical records for this site.
- Historic data for *E. amplifolia* at Site 13 indicate a high variability and relative unpredictability in seasonal foliar fluoride concentrations, with no clear pattern in response to changing prevailing winds. This specimen has displayed the greatest amplitude in fluoride levels of all sampled vegetation in the monitoring programs, and previously recorded concentrations as high as 194.0 mg/kg and as low as <10.0 mg/kg.
  - Results for the current reporting period were comprised between 20.7 mg/kg (in Q4 2020) and 43.7 mg/kg (in Q2 2021), which is within the lower range of historical values for this specimen and represent the lowest cumulative levels (all four quarterly surveys) since the start of monitoring.
- Historic data for *C. maculata* at Site 13 show that except for occasional and short-lived spikes in concentrations (usually sometimes between late winter and summer), foliar fluoride is typically and consistently low in this specimen.
  - Results for the current reporting period returned a very low fluoride content in all four surveys (i.e. ≤10.0 mg/kg, below laboratory limit of reporting), which was generally consistent with the past three years and overall with long-term historical values.
- Historic data for *C. maculata* at Site 15 indicate a very high variability in fluoride content for this specimen since 2004, with a seemingly stochastic and unpredictable pattern that appears independent from seasonal wind changes. This specimen has also displayed a high amplitude in fluoride levels over time, and previously recorded concentrations as high as 142.0 mg/kg and as low as 1.0 mg/kg.

- Results for the current reporting period were comprised between 11.4 mg/kg (in Q4 2020) and 35.5 mg/kg (in Q1 2021), which is within the lower range of historical values for this specimen and the lowest (on average) since 2011.

Overall, historical data show wide fluctuations in foliar fluoride content between quarterly surveys, and it is common for fluoride concentrations to experience and display episodic increases on a seasonal basis, usually reflecting the changing dominant wind patterns occurring with the change of season. On the longer term however, there seems to be a distinguishable annual pattern in fluctuating fluoride concentrations and historical data shows that for each species fluoride concentrations tend to oscillate within a set range of values.

Moreover, the long-term data show that there is an obvious variability in the sensitivity of different species and of different individuals of the same species to the impacts of atmospheric fluoride, and that different individuals clearly absorb varying levels of atmospheric fluoride through their leaf tissue.

It is also likely that environmental and climatic conditions play a role in foliar fluoride concentration levels – for instance higher rainfall may lead to emission particulates deposited on leaves being quickly washed from the leaf surface, and therefore not able to be absorbed and accumulated in the leaf tissue. From this perspective it is possible that the relatively low fluoride concentrations recorded during the current reporting period (i.e. compared to previous years and historical values) may have been influenced by the above-average rainfall received in the region in 2020-2021.

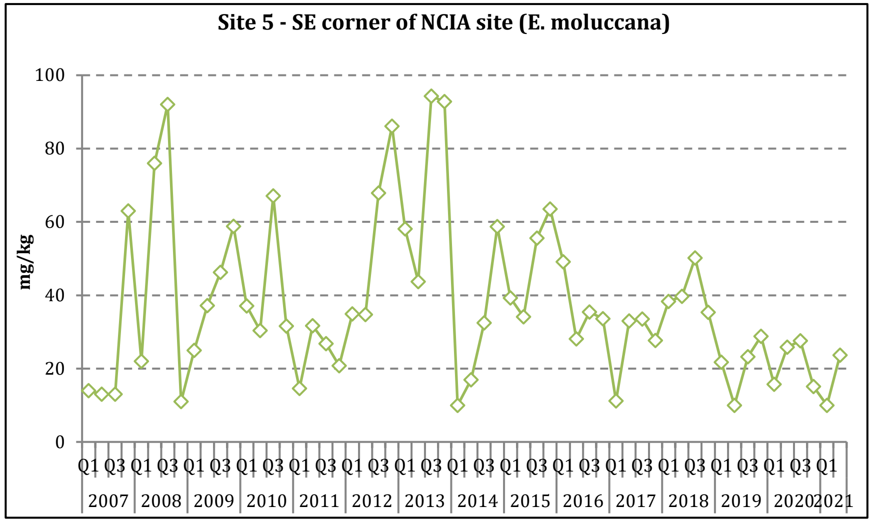
5.2.2 Control Site

Given the social and economic importance of the viticultural industry in the Hunter Valley, the potential impact of atmospheric pollutant emissions from industrial sources on the health of the grape vine *Vitis vinifera* (a known sensitive species) has traditionally been a concern for the industry. Consequently, foliar sampling and analysis of *Vitis vinifera* foliage from the control site has historically been included as part of this vegetation monitoring program.

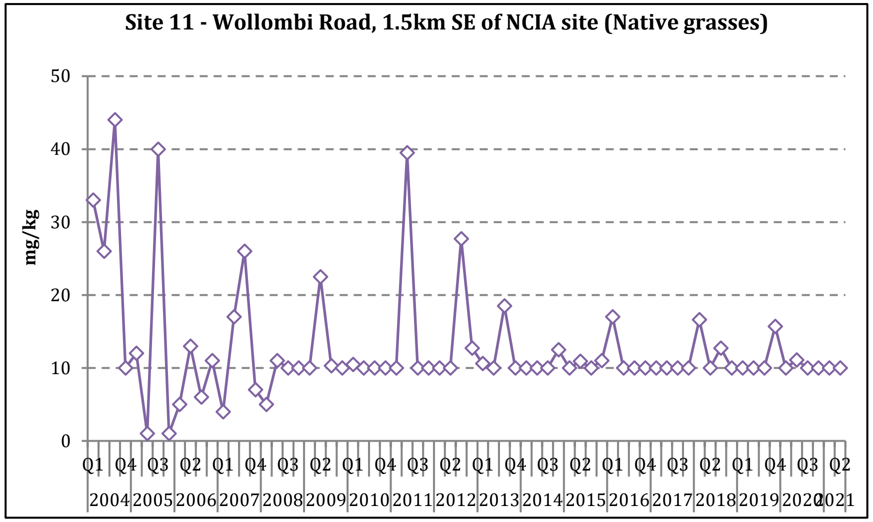
Historical concentrations since the commencement of the monitoring program are presented in **Graph 11**.

Long-term data indicate that foliar fluoride content in *Vitis vinifera* at the control site has consistently been very low. Results for the current reporting period were fully consistent with historical values with the three analysed leaf samples returning values of <10.0 mg/kg (i.e. values below laboratory limit of reporting).

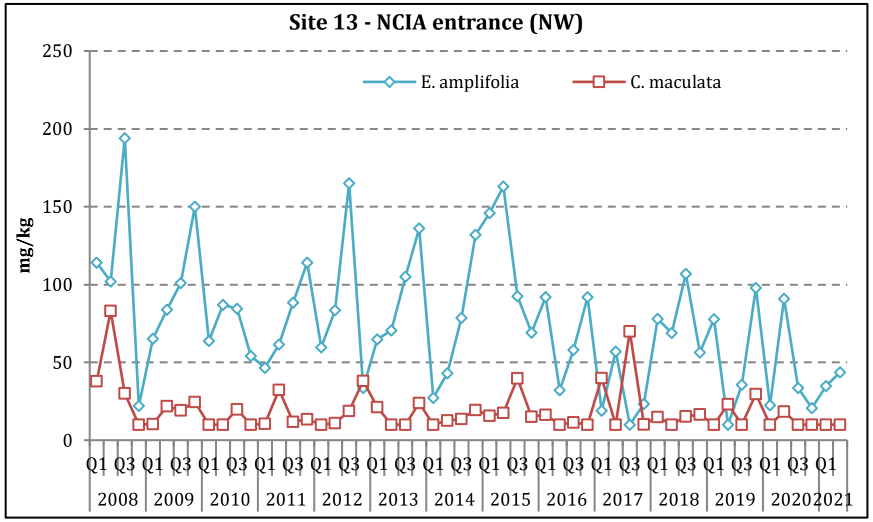
It is noted that recurrent elevated fluoride levels were recorded in the species between Q4 2014 and Q1 2016 (**Graph 11**). This was attributed to the maintenance undertaken to the grape vines at the Anambah property during this period, and particularly with the re-instatement of a functional irrigation system. Some scientific literature suggests that the use of municipal water injected with fluoride (which is the case in Australia) used for irrigation can result in toxicity symptoms on sensitive plants such as grape vines (Psheidt, 2015). The elevated foliar fluoride levels returned during that period therefore may have been linked to the maintenance activities (and irrigation) undertaken on site. Fluoride concentrations have since settle back down to low levels, which indicates that either a) the species may have adjusted to the new irrigation water or b) active irrigation is no longer implemented at the property.



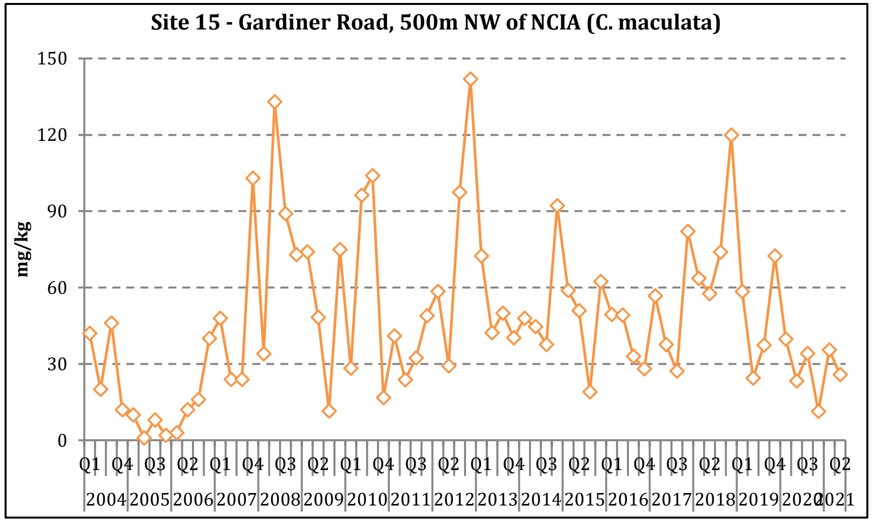
Graph 7 Trend in foliar fluoride content in *E. moluccana* at Site 5 (2007-2021)



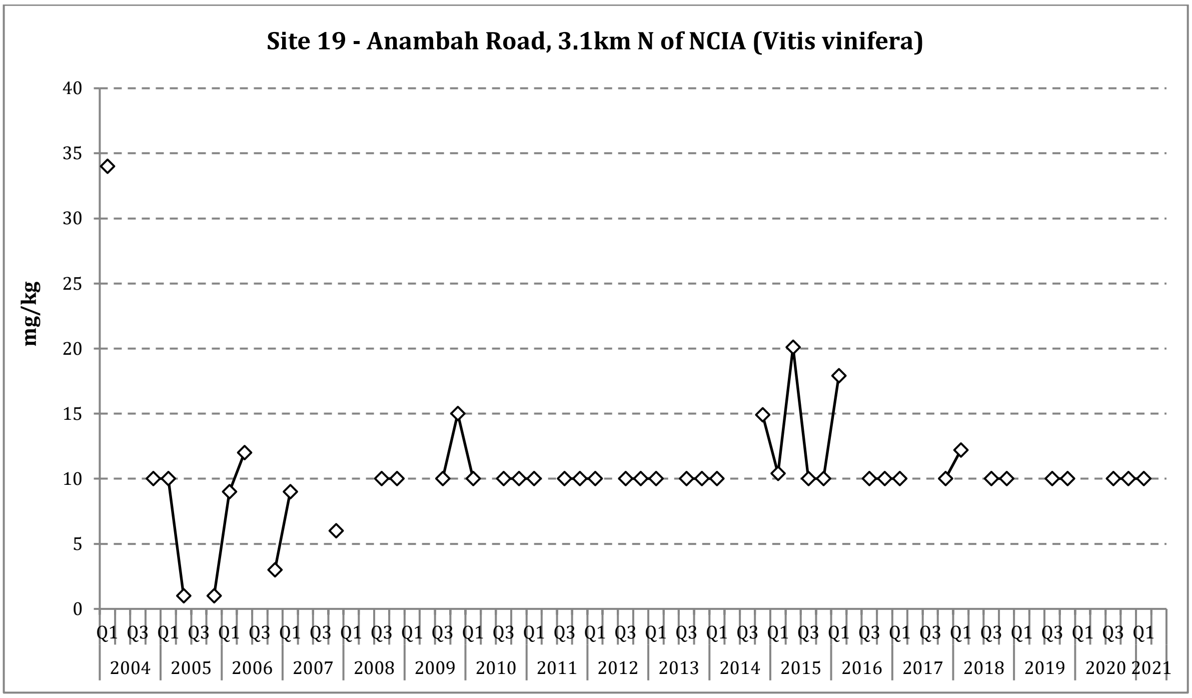
Graph 8 Trend in foliar fluoride content in roadside grasses at Site 11 (2004-2021)



Graph 9 Trend in foliar fluoride content in *E. amplifolia and C. maculata* at Site 13 (2008-2021)



Graph 10 Trend in foliar fluoride content in *C. maculata* at Site 15 (2004-2021)



Graph 11 Trend in foliar fluoride content in *Vitis vinifera* at Site 19 (2004-2021)

(Breaks in the line reflect leaf samples not being collected and analysed for a particular quarter due to the absence of foliage on the vine (i.e. the species is deciduous)).

5.3 Relationship Between Visual Injury Symptoms and Foliar Fluoride Content

The results of the vegetation surveys undertaken during the reporting period together with historical data seem to indicate a poor correlation between foliar fluoride content and the visible expression of injury symptoms in foliage. For instance, although the *E. amplifolia* at Site 13 commonly returns the highest fluoride concentrations its foliage only shows very slight visible injury symptoms (and notably no chlorosis symptoms). Conversely, the foliage of *C. maculata* at the same location consistently exhibits distinct fluoride visual injury symptoms while the laboratory results show that its foliar fluoride concentrations are the lowest of all tree species sampled.

The discrepancy between visual injury symptoms and foliar fluoride concentrations may be due to:

- A lag in the visible expression injury symptoms following exposure to atmospheric fluoride emissions;
- Varying sensitivity of individual specimens in exhibiting visible injury symptoms; and/or
- Emissions related visual injury symptoms being 'mimicked' by natural environmental impacts such as climatic conditions, insect attack or diseases.

Overall, there is an inherent level of unpredictability in the expression of visual symptoms between monitoring events as well as an obvious variability in sensitivity to fluoride impacts both inter and intra-species, with different individuals clearly being more resistant or sensitive to emission related impacts than others.

6. Conclusion

This report summarised the results of the annual and quarterly vegetation surveys to investigate the potential effect of fluoride emissions on vegetation surrounding the NCIA facility in Rutherford, as required to comply with condition M4.1 of EPL 11956.

The vegetation monitoring program commenced in 2004, with the survey methodology developed by Dr David Doley of the University of Queensland.

A total of 19 locations were surveyed during the current reporting period over the course of four surveys (one survey per calendar quarter). A total of 60 plant specimens were assessed for fluoride-related visual injury symptoms to foliage, and foliar sampling undertaken on six plant specimens and analysed for fluoride concentration levels.

Monitoring locations were selected based on the modelling in the EIS (Parsons Brinkerhoff 2002) and EA (AECOM 2010) and an understanding of the prevailing meteorological conditions. The specimens chosen to be sampled for foliar fluoride content were selected by Dr David Doley for their sensitivity to plant fluoride interactions.

Elevated regional background fluoride concentrations are found in air within the Lower Hunter Region. As a result, foliar fluoride concentrations in the vicinity of NCIA may be influenced by the elevated background fluoride concentration. The existing sampling regime provides an acceptable data set that may, over time, together with other data sets which relate to other fluoride source points indicate any long-term trends in fluoride emissions impacts in the local area.

Results of the field-based visual assessment of vegetation condition during the current reporting period were generally within historical values and long-term trend. The majority of specimens assessed displayed at least some level of fluoride-related visual injury symptoms. Of all specimens surveyed, on average ~10.1% displayed no injury symptoms, ~59.2% displayed only very slight or slight injury symptoms, ~30.4% distinct or marked injury symptoms and only ~0.4% severe or greater injury symptoms. The collected data support no statistically significant long-term trends (increasing or decreasing) since the start of the monitoring program, and any potential impact from NCIA on the health of local vegetation would be inconclusive.

Emissions related injury can be mimicked by natural environmental impacts such as climatic conditions and insect attack. Insect attack was variable and evident at most locations during the reporting period.

Results of foliar fluoride content for the reporting period were generally consistent with long-term seasonal patterns and consistently within the lower range of historical values for all sampled specimens, which may have been influenced by to the above-average rainfall received in the region in 2020-2021.

Overall, long-term observations and results highlight an inherent level of unpredictability in the expression of visual symptoms between monitoring events as well as an obvious variability in sensitivity to fluoride impacts both inter and intra-species, with different individuals clearly being more resistant or sensitive to emission related impacts than others.

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Appendix A

Monitoring Locations Photographs (Taken Q4 2020)

Site 1 - Access Road north of office	Site 2 – Office car park
	
Site 3 – Access Road south of office	**Site 4 – South-west corner of site**
	
Site 5 – South-east corner of site	**Site 6 – 3 Palisade Street**
	

Site 7 – 3 Gillette Close	Site 8 – Regiment Road east of Dumont Court
	
Site 9 – Regiment Road south-east of Squadron Crescent, Farley	**Site 10 – Wollombi Road between sewage works and creek, Farley**
	
Site 11 – Hill top on Wollombi Road west of Owl Pen Lane, Farley	**Site 12 – Western end of Quarry Road, Farley**
	

Site 13 – NCIA entrance, Racecourse Road	Site 14 – 100-104 Kyle Street
	
Site 15 – 11 Gardiner Road	**Site 16 – 56 Gardiner Road**
	
Site 17 – Gardiner Road, southern end	**Site 18 – Maitland Saleyards, Kyle Street**
	

Site 19 – 200 Anambah Road, Anambah (Control Site)


Appendix B

Visual Condition Assessments Monitoring Results

Appendix B1 – Q3 2020 Results

Site / Species	Emission injury	Total injury	Foliage age	Chlorosis	Cupping	Tip necrosis	Marginal necrosis	Anthocyanin	Leaf chewing	Sap sucking	Branch dieback	Crown density	Repro - buds/flowers	Repro - fruits
Site 5 - Southeast corner of NCIA site														
Eucalyptus moluccana	2	2	0	0	2	1	0	0	2	1	0	0	0	0
	3	3	1	0	2	1	0	3	3	1				
Site 7 - 3 Gillette close														
Eucalyptus acmenoides	2	2	0	2	1	1	0	0	1	1	0	0	✓	✓
	2	2	1	2	1	2	0	0	2	1				
Corymbia maculata	4	4	0	0	4	2	0	0	0	0	2	2	0	0
	2	2	1	0	2	1	1	0	0	1				
Site 11 - Hill top on Wollombi Road west of Owl Pen Lane, Farley														
Corymbia maculata	1	1	0	0	1	0	0	0	1	0	0	0	0	0
	2	3	1	0	2	1	0	0	3	1				
Eucalyptus paniculata	0	1	0	0	0	0	0	0	1	0	0	0	✓	0
	0	3	1	0	0	0	0	0	3	1				
Site 12 - Western end of Quarry Rd, Farley														
Corymbia maculata	1	2	0	0	1	0	0	0	2	0	0	0	0	0
	1	3	1	0	1	1	0	0	3	1				
Eucalyptus paniculata	0	0	0	0	0	0	0	0	0	0	0	0	0	✓
	1	2	1	0	0	1	0	0	2	1				
Site 13 - NCIA entrance, Racecourse Road														
Corymbia maculata	1	1	0	1	1	1	0	0	0	0	2	2	0	0
	3	3	1	1	3	3	0	0	2	3				
Eucalyptus amplifolia	n/a	n/a	0	*No new growth / foliage*							2	2	✓	0
	2	3	1	0	2	1	0	0	3	1				
Site 14 - 100-104 Kyle Street														
Angophora floribunda	2	2	0	2	2	1	0	0	0	1	0	0	0	0
	2	2	1	2	2	2	1	0	1	2				
Eucalyptus amplifolia	1	1	0	0	0	1	0	0	1	1	0	0	✓	✓
	2	2	1	0	2	2	0	0	1	1				
Site 15 - 11 Gardiner Road														
Corymbia maculata	2	2	0	2	2	1	0	0	0	0	0	0	0	0
	3	3	1	3	3	3	2	0	0	2				
Eucalyptus fibrosa	n/a	n/a	0	*No new growth / foliage*							3	3	✓	0
	2	2	1	0	0	2	0	0	1	1				
Site 18 - Maitland Salesyard, Kyle street														
Corymbia maculata	0	1	0	0	0	0	0	0	0	1	0	0	0	0
	3	3	1	0	3	1	0	0	1	1				
Eucalyptus moluccana	n/a	n/a	0	0	0	1	0	0	0	0	0	0	0	0
	1	2	1	0	1	1	0	0	1	2				
Eucalyptus amplifolia	n/a	n/a	0	*No new growth / foliage*							0	0	0	✓
	2	2	1	0	1	2	0	0	1	1				
Eucalyptus resinifera	1	1	0	0	0	1	0	0	1	0	0	0	0	✓
	3	3	1	0	0	3	0	0	1	0				
Site 19 - Analogue site, 200 Anambah Rd - Anambah														
Vitis vinifera	0	0	0	0	0	0	0	0	0	0	0	0	✓	0
Araucaria cunninghamii	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Casuarina torulosa	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Corymbia maculata	3	3	mixed	0	3	1	0	0	2	1	0	0	0	0
Eucalyptus tereticornis	4	4	1	0	2	4	2	0	1	4	0	0	0	✓
Ficus macrophylla	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Grevillea robusta	1	1	1	0	0	1	0	0	0	0	0	0	0	0
Eucalyptus acmenoides	3	3	mixed	0	2	3	1	0	2	1	0	0	0	0
Olea europea	1	1	1	0	1	0	0	0	0	0	0	0	0	0

<table>
<tr><th colspan="2">Site 5 – South-east corner of site</th></tr>
<tr><td colspan="2">Eucalyptus moluccana</td></tr>
<tr><td colspan="2"></td></tr>
<tr><th colspan="2">Site 7 – 3 Gillette Close</th></tr>
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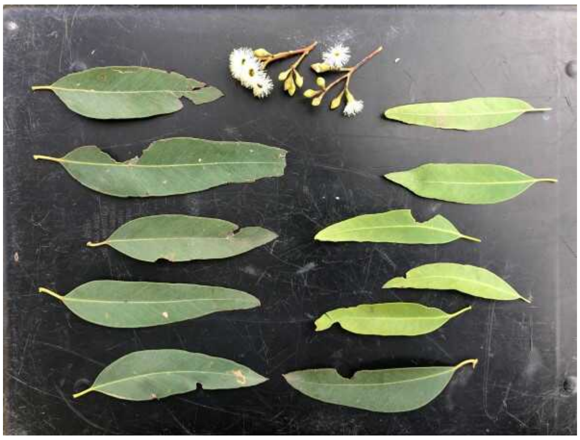
<tr><td>Corymbia maculata</td><td>Eucalyptus paniculata</td></tr>
<tr><td></td><td></td></tr>
</table>

Site 12 – Western end of Quarry Rd, Farley	
Corymbia maculata	***Eucalyptus paniculata***
	
Site 13 – NCIA entrance, Racecourse Road	
Eucalyptus amplifolia	***Corymbia maculata***
	
Site 14 – 100-104 Kyle Street	
Eucalyptus amplifolia	***Angophora floribunda***
	

Site 15 – 11 Gardiner Road	
Corymbia maculata	*Eucalyptus fibrosa*
	
Site 18 – Maitland Salesyard, Kyle Street	
Corymbia maculata	*Eucalyptus moluccana*
	
Eucalyptus amplifolia	*Eucalyptus resinifera*
	

Appendix B2 – Q4 2020 Results

Site / Species	Emission injury	Total injury	Foliage age	Chlorosis	Cupping	Tip necrosis	Marginal necrosis	Anthocyanin	Leaf chewing	Sap sucking	Branch dieback	Crown density	Repro - buds/flowers	Repro - fruits
Site 1 - Access road north of office														
Acacia filicifolia	0	0	1	0	0	0	0	0	0	0	2	2	✓	0
Olea europea	0	0	1	0	0	0	0	0	0	0	0	0	0	✓
Acacia longifolia	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Corymbia citriodora	3	3	0	3	2	3	0	0	0	0	0	0	0	0
	6	6	1	6	2	3	0	0	0	1				
Eucalyptus moluccana	2	2	0	0	2	0	0	0	1	0	0	0	✓	0
	1	1	1	0	1	1	0	0	1	1				
Eucalyptus robusta 1	3	3	0	3	0	1	0	0	0	0	0	0	0	0
	3	3	1	3	1	1	0	0	1	0				
Eucalyptus robusta 2	0	3	0	0	0	0	0	0	3	0	0	0	0	0
	2	2	1	1	2	1	0	0	0	0				
Eucalyptus amplifolia	2	2	0	0	2	1	0	0	1	2	0	0	0	✓
	2	2	1	0	2	1	1	0	1	2				
Site 2 - Office car park														
Fraxinus pennsylvanica	1	1	1	1	0	1	0	0	0	0	0	0	0	0
Acacia longifolia	0	1	1	0	0	0	0	0	0	1	0	0	0	0
Casuarina glauca	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus robusta	2	2	0	2	1	1	0	0	2	0	0	0	0	0
	4	4	1	4	3	1	0	0	0	1				
Site 3 - Access road south of office														
Acacia filicifolia	1	1	1	1	0	0	0	0	0	0	0	0	✓	1
Hakea salicifolia	0	0	1	0	0	0	0	0	0	0	0	0	0	✓
Eucalyptus sp. 1	1	1	0	1	0	1	0	0	0	0	0	0	0	0
	3	3	1	2	3	2	2	0	0	0				
Eucalyptus sp.2	0	1	0	0	0	0	0	0	1	0	0	0	0	0
	3	3	1	0	0	3	0	0	0	1				
Site 4 - Southwest corner of NCIA site														
Acacia longifolia	0	1	1	0	0	0	0	0	0	1	0	0	0	0
Bursaria spinosa	0	0	1	0	0	0	0	0	0	0	0	0	✓	0
Typha sp.	1	1	1	0	0	1	0	0	0	0	0	0	0	✓
Eucalyptus amplifolia	0	1	0	0	0	0	0	0	0	1	0	0	0	✓
	3	3	1	0	1	1	0	3	1	0				
Site 5 - Southeast corner of NCIA site														
Bursaria spinosa	0	0	*Dead. No suitable replacement specimen found*											
Eucalyptus moluccana	1	1	0	0	0	1	0	0	1	1	0	0	✓	0
	2	3	1	0	1	2	0	0	2	3				
Site 6 - 3 Palisade street														
Olea europaea	0	0	*New house now built on previously vacan block. This specimen removed.*											
Corymbia maculata	1	2	0	0	0	1	0	0	0	2	0	0	0	0
	1	2	1	0	1	1	0	0	0	2				
Eucalyptus sp.	0	1	0	0	0	0	0	0	1	0	0	0	✓	0
	2	2	1	0	0	2	0	0	0	1				
Site 7 - 3 Gillette close														
Acacia podalyriifolia	2	2	1	2	0	0	1	0	0	0	0	0	0	0
Bursaria spinosa	0	0	*Dead. No suitable replacement specimen found*											
Corymbia maculata	1	2	0	0	0	1	0	0	2	0	0	0	0	0
	1	2	1	1	0	1	0	0	2	1				
Eucalyptus acmenoides	0	2	0	0	0	0	0	0	2	0	0	0	✓	✓
	2	2	1	2	0	1	0	0	1	1				
Site 8 - Regiment Road east of Dumont Court														
Acacia baileyana	0	0	*Tree removed / cleared by owner. No suitable replacement specimen found*											
Bursaria spinosa	0	0	1	0	0	0	0	0	0	0	3	3	0	0
Corymbia maculata	0	0	0	*No new growth / foliage*							0	0	0	0
	3	3	1	2	3	2	0	0	1	2				
Eucalyptus (?)paniculata	2	2	0	1	0	2	0	0	1	1	0	0	0	✓
	3	3	1	2	0	3	0	0	2	1				
Eucalyptus acmenoides	1	1	0	0	1	0	0	0	0	0	0	0	0	0
	3	3	1	3	1	3	1	0	1	1				
Lophostemum confertus	0	0	*Tree removed / cleared by owner. No suitable replacement specimen found*											
Grevillea robusta	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Site 9 - Regiment Road southeast of Squadron Crescent														
Eucalyptus resinifera	0	1	0	0	0	0	0	0	0	1	0	0	0	✓
	2	2	1	0	2	0	0	0	1	1				
Site 10 - Wollombi Road between sewage works and Creek														
Casuarina glauca	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Fraxinus excelsior	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Grevillea robusta	0	0	1	0	0	0	0	0	0	0	2	2	0	0
Populus nigra var. italica	2	2	0	2	0	0	0	0	0	0	3	3	0	0
Acacia podalyriifolia	4	4	1	4	2	0	1	0	0	0	0	0	0	0
Bursaria spinosa	0	0	*Dead. No suitable replacement specimen found*											

Site 11 - Hill top on Wollombi Road west of Owl Pen Lane, Farley														
Bursaria spinosa	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Corymbia maculata	3	3	0	0	3	1	0	0	0	2	0	0	0	0
	4	4	1	0	4	1	0	0	1	1				
Eucalyptus paniculata	0	0	Tree cleared. No suitable replacement specimen found											
	0	0												
Site 12 - Western end of Quarry Rd, Farley														
Corymbia maculata	1	2	0	0	0	1	0	0	1	2	0	0	0	0
	2	2	1	0	1	2	0	0	2	1				
Eucalyptus paniculata	0	1	0	0	0	0	0	0	1	0	0	0	0	0
	1	1	1	0	0	1	0	0	1	1				
Pinus radiata	0	0	1	0	0	0	0	0	0	0	0	0	0	✓
Site 13 - NCIA entrance, Racecourse Road														
Olea europea	1	1	1	0	1	0	0	0	0	0	0	0	0	✓
Corymbia maculata	2	2	0	0	0	2	0	0	1	0	1	1	0	0
	3	3	1	2	3	1	0	0	0	0				
Eucalyptus amplifolia	1	1	0	0	0	1	0	0	0	1	1	1	✓	0
	2	2	1	0	0	2	0	0	0	1				
Site 14 - 100-104 Kyle Street														
Angophora floribunda	1	1	0	1	0	1	0	0	1	1	0	0	✓	0
	2	2	1	1	0	2	1	0	1	2				
Eucalyptus amplifolia	0	0	0	*No new growth / foliage*							0	0	0	✓
	2	2	1	0	2	2	0	0	0	1				
Site 15 - 11 Gardiner Road														
Corymbia maculata	3	3	0	3	3	2	0	0	0	1	0	0	0	0
	3	3	1	2	2	3	2	0	0	1				
Eucalyptus fibrosa	2	2	0	0	0	2	0	0	0	0	0	0	✓	0
	2	2	1	0	0	2	0	0	0	0				
Site 16 - 56 Gardiner Road														
Corymbia maculata	2	2	0	0	0	2	0	0	0	1	0	0	✓	0
	4	4	1	4	1	4	0	0	0	2				
Site 17 - Gardiner Road, southern end														
Bursaria spinosa	0	1	1	0	0	0	0	0	1	0	0	0	0	0
Olea europea	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Corymbia maculata 1	2	2	0	1	2	1	1	0	0	1	0	0	0	0
	2	2	1	2	2	1	1	0	2	1				
Corymbia maculata 2	0	0	0	*No new growth / foliage*							2	2	0	0
	2	3	1	0	2	2	0	0	3	1				
Eucalyptus fibrosa	0	1	0	0	0	0	0	0	1	0	0	0	0	0
	0	3	1	0	0	0	0	0	1	3				
Eucalyptus punctata	3	3	0	0	0	3	0	0	0	0	0	0	0	✓
	3	3	1	0	0	3	0	0	1	2				
Site 18 - Maitland Salesyard, Kyle street														
Corymbia maculata	0	0	0	*No new growth / foliage*							0	0	0	0
	1	1	1	0	1	1	0	0	0	1				
Eucalyptus amplifolia	0	2	0	0	0	0	0	0	2	0	0	0	0	✓
	2	2	1	0	1	2	0	0	1	1				
Eucalyptus moluccana	1	2	0	0	0	1	0	0	2	0	0	0	✓	0
	0	2	1	0	0	0	0	0	0	2				
Eucalyptus resinifera	0	0	0	0	0	0	0	0	0	0	0	0	0	✓
	2	2	1	0	1	2	0	0	0	0				
Site 19 - Analogue site, 200 Anambah Rd - Anambah														
Angophora costata	1	1	mixed	0	0	1	0	0	0	0	0	0	0	0
Araucaria cunninghamii	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Brachychiton populneus	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Casuarina torulosa	0	0	1	0	0	0	0	0	0	0	0	0	0	✓
Corymbia citriodora	1	1	mixed	0	0	1	0	0	0	0	0	0	0	0
Corymbia maculata	1	1	mixed	0	1	1	0	0	1	1	0	0	0	0
Eucalyptus acmenoides	2	2	mixed	0	0	2	0	0	2	1	0	0	0	✓
Eucalyptus dives	1	3	mixed	0	1	0	0	0	3	0	0	0	0	✓
Eucalyptus grandis	2	2	mixed	0	2	0	0	0	0	0	0	0	✓	✓
Eucalyptus robusta	1	2	mixed	0	1	1	0	0	2	2	1	1	0	0
Eucalyptus tereticornis	4	4	mixed	0	0	4	2	0	3	3	0	0	0	✓
Ficus macrophylla	0	0	1	0	0	0	0	0	0	0	0	0	0	✓
Grevillea robusta	1	1	1	0	0	1	0	0	0	0	0	0	0	0
Macademia integrifolia	3	3	1	0	3	0	0	0	0	0	0	0	0	✓
Olea europea	1	1	1	0	1	0	0	0	0	0	0	0	✓	0
Vitis vinifera - upper block	0	0	0	0	0	0	0	0	0	0	0	0	0	✓
Vitis vinifera - lower block	0	0	0	0	0	0	0	0	0	0	0	0	0	✓

Site 5 – South-east corner of site	
Eucalyptus moluccana	
	
Site 7 – 3 Gillette Close	
Eucalyptus acmenoides	*Corymbia maculata*
	
Site 11 – Hill top on Wollombi Road west of Owl Pen Lane, Farley	
Corymbia maculata	
	

Site 12 – Western end of Quarry Rd, Farley	
Corymbia maculata	*Eucalyptus paniculata*
	
Site 13 – NCIA entrance, Racecourse Road	
Eucalyptus amplifolia	*Corymbia maculata*
	
Site 14 – 100-104 Kyle Street	
Eucalyptus amplifolia	*Angophora floribunda*
	

<table>
<tr><th colspan="2">Site 15 – 11 Gardiner Road</th></tr>
<tr><td>Corymbia maculata</td><td>Eucalyptus fibrosa</td></tr>
<tr><td></td><td></td></tr>
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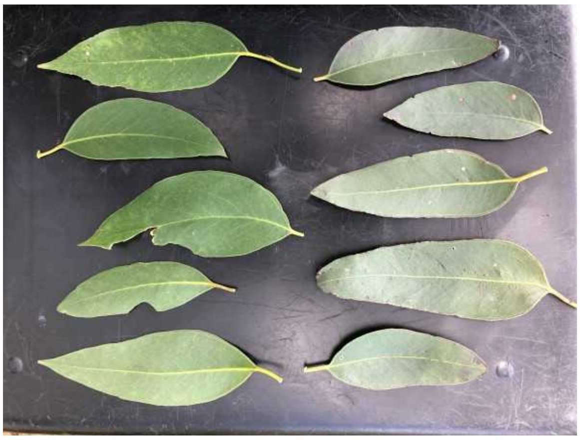
<tr><td>Corymbia maculata</td><td>Eucalyptus moluccana</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Eucalyptus amplifolia</td><td>Eucalyptus resinifera</td></tr>
<tr><td></td><td></td></tr>
</table>

Appendix B3 – Q1 2021 Results

Site / Species	Emission injury	Total injury	Foliage age	Chlorosis	Cupping	Tip necrosis	Marginal necrosis	Anthocyanin	Leaf chewing	Sap sucking	Branch dieback	Crown density	Repro - buds/flowers	Repro - fruits
Site 5 - Southeast corner of NCIA site														
Eucalyptus moluccana	2	3	0	0	2	0	0	0	3	3	0	0	✓	0
	2	3	1	0	2	0	0	0	3	1				
Site 7 - 3 Gillette close														
Eucalyptus acmenoides	0	1	0	0	0	0	0	0	0	1	0	0	✓	0
	3	3	1	3	0	1	0	0	1	1				
Corymbia maculata	n/a	n/a	0	*No new growth / foliage*							2	2	0	0
	3	3	1	0	3	1	1	0	1	1				
Site 11 - Hill top on Wollombi Road west of Owl Pen Lane, Farley														
Corymbia maculata	n/a	n/a	0	*No new growth / foliage*							0	0	✓	0
	2	2	1	0	1	2	1	0	1	1				
Eucalyptus paniculata	n/a	n/a	*Specimen lost due to new residential development*											
	n/a	n/a												
Site 12 - Western end of Quarry Rd, Farley														
Corymbia maculata	n/a	n/a	0	*No new growth / foliage*							0	0	✓	0
	2	2	1	0	2	0	0	0	2	2				
Eucalyptus paniculata	0	2	0	0	0	0	0	0	1	2	0	0	0	✓
	0	2	1	0	0	0	0	0	2	1				
Site 13 - NCIA entrance, Racecourse Road														
Corymbia maculata	2	2	0	1	0	2	0	0	1	1	2	2	✓	0
	2	2	1	2	2	2	1	0	1	2				
Eucalyptus amplifolia	1	1	0	0	1	1	0	0	1	1	2	2	✓	0
	2	2	1	0	0	2	0	0	1	2				
Site 14 - 100-104 Kyle Street														
Angophora floribunda	2	2	0	2	0	1	0	0	1	1	0	0	0	✓
	2	2	1	2	0	1	0	0	1	1				
Eucalyptus amplifolia	1	1	0	0	1	0	0	0	1	1	0	0	✓	0
	3	3	1	0	1	3	0	0	1	2				
Site 15 - 11 Gardiner Road														
Corymbia maculata	n/a	n/a	0	*No new growth / foliage*							2	2	0	0
	4	4	1	3	4	3	3	0	1	1				
Eucalyptus fibrosa	n/a	n/a	0	*No new growth / foliage*							0	0	0	✓
	2	3	1	0	0	2	0	0	1	3				
Site 18 - Maitland Salesyard, Kyle street														
Corymbia maculata	0	0	0	*No new growth / foliage*							0	0	✓	0
	2	2	1	0	0	2	0	0	1	1				
Eucalyptus moluccana	n/a	n/a	0	0	0	0	0	0	2	1	0	0	0	✓
	2	2	1	0	2	1	0	0	0	1				
Eucalyptus amplifolia	0	1	0	0	0	0	0	0	0	1	0	0	✓	✓
	2	2	1	0	0	2	0	0	1	1				
Eucalyptus resinifera	1	1	0	0	0	1	0	0	0	0	0	0	✓	✓
	2	2	1	0	0	2	0	0	1	1				
Site 19 - Analogue site, 200 Anambah Rd - Anambah														
Vitis vinifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Araucaria cunninghamii	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Casuarina torulosa	0	0	1	0	0	0	0	0	0	0	0	0	0	✓
Corymbia maculata	2	2	1	0	2	1	0	0	2	2	0	0	0	0
Eucalyptus tereticornis	3	3	1	0	0	3	0	0	3	1	0	0	✓	0
Ficus macrophylla	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Grevillea robusta	2	2	1	0	0	2	0	0	0	0	0	0	0	0
Eucalyptus acmenoides	0	3	mixed	0	0	0	0	0	3	0	0	0	0	✓
Olea europea	1	1	1	0	1	0	0	0	0	0	0	0	0	✓

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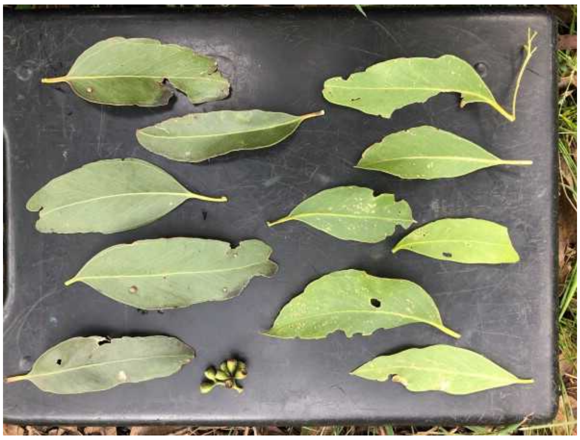
<tr><td colspan="2"></td></tr>
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<tr><td>Eucalyptus acmenoides</td><td>Corymbia maculata</td></tr>
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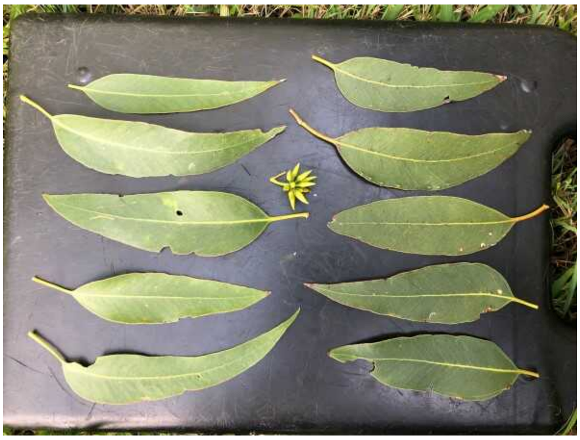
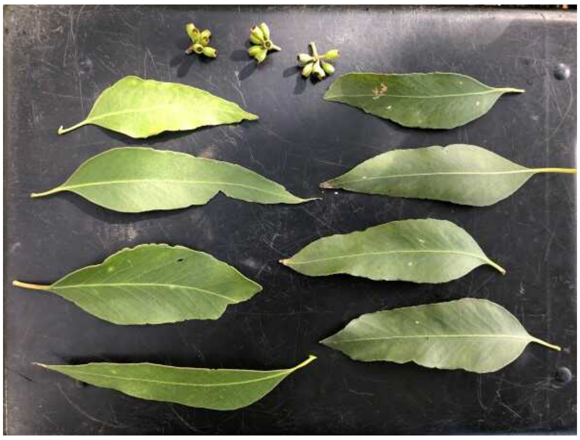
<tr><th colspan="2">Site 11 – Hill top on Wollombi Road west of Owl Pen Lane, Farley</th></tr>
<tr><td colspan="2">Corymbia maculata</td></tr>
<tr><td colspan="2"></td></tr>
</table>

<table>
<tr><th colspan="2">Site 12 – Western end of Quarry Rd, Farley</th></tr>
<tr><td>Corymbia maculata</td><td>Eucalyptus paniculata</td></tr>
<tr><td></td><td></td></tr>
<tr><th colspan="2">Site 13 – NCIA entrance, Racecourse Road</th></tr>
<tr><td>Eucalyptus amplifolia</td><td>Corymbia maculata</td></tr>
<tr><td></td><td></td></tr>
<tr><th colspan="2">Site 14 – 100-104 Kyle Street</th></tr>
<tr><td>Eucalyptus amplifolia</td><td>Angophora floribunda</td></tr>
<tr><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="2">Site 15 – 11 Gardiner Road</th></tr>
<tr><td>Corymbia maculata</td><td>Eucalyptus fibrosa</td></tr>
<tr><td></td><td></td></tr>
<tr><th colspan="2">Site 18 – Maitland Salesyard, Kyle Street</th></tr>
<tr><td>Corymbia maculata</td><td>Eucalyptus moluccana</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Eucalyptus amplifolia</td><td>Eucalyptus resinifera</td></tr>
<tr><td></td><td></td></tr>
</table>

Appendix B4 – Q2 2021 Results

Site / Species	Emission injury	Total injury	Foliage age	Chlorosis	Cupping	Tip necrosis	Marginal necrosis	Anthocyanin	Leaf chewing	Sap sucking	Branch dieback	Crown density	Repro - buds/flowers	Repro - fruits
Site 5 - Southeast corner of NCIA site														
Eucalyptus moluccana	1	2	0	0	1	0	0	0	2	0	0	0	0	✓
	2	2	1	0	2	1	0	1	2	2				
Site 7 - 3 Gillette close														
Eucalyptus acmenoides	n/a	n/a	0	*No new growth / foliage*							0	0	✓	✓
	1	1	1	0	0	1	0	0	1	1				
Corymbia maculata	3	3	0	1	3	2	1	0	1	1	2	2	0	0
	3	3	1	0	2	3	2	0	1	1				
Site 11 - Hill top on Wollombi Road west of Owl Pen Lane, Farley														
Corymbia maculata	1	2	0	0	1	0	0	0	2	0	0	0	✓	0
	3	3	1	0	3	3	1	0	2	2				
Eucalyptus paniculata	Specimen lost due to new residential development													
Site 12 - Western end of Quarry Rd, Farley														
Corymbia maculata	2	2	0	0	2	0	0	0	1	1	0	0	✓	0
	1	2	1	0	1	1	0	0	1	2				
Eucalyptus paniculata	0	0	0	*No new growth / foliage*							0	0	0	✓
	0	3	1	0	0	0	0	0	3	1				
Site 13 - NCIA entrance, Racecourse Road														
Corymbia maculata	n/a	n/a	0	*No new growth / foliage*							1	1	0	✓
	2	3	1	1	1	2	0	0	1	3				
Eucalyptus amplifolia	n/a	n/a	0	*No new growth / foliage*							1	1	✓	0
	2	3	1	0	0	2	0	0	1	3				
Site 14 - 100-104 Kyle Street														
Angophora floribunda	2	3	0	2	2	0	0	0	3	0	0	3	0	0
	3	3	1	2	3	1	1	0	1	1				
Eucalyptus amplifolia	2	2	0	0	2	1	0	0	1	2	0	0	0	✓
	2	2	1	0	1	2	0	0	1	2				
Site 15 - 11 Gardiner Road														
Corymbia maculata	3	3	0	3	3	1	0	0	0	0	3	3	0	0
	4	4	1	4	3	4	3	0	1	2				
Eucalyptus fibrosa	n/a	n/a	0	*No new growth / foliage*							2	2	✓	0
	3	3	1	0	0	3	0	0	1	3				
Site 18 - Maitland Salesyard, Kyle street														
Corymbia maculata	2	2	0	0	2	0	0	0	0	1	0	0	0	✓
	2	2	1	0	0	2	0	0	0	1				
Eucalyptus moluccana	n/a	n/a	0	*No new growth / foliage*							1	1	0	✓
	1	1	1	0	1	1	0	1	1	1				
Eucalyptus amplifolia	n/a	n/a	0	*No new growth / foliage*							0	0	✓	0
	2	2	1	0	0	2	0	0	2	2				
Eucalyptus resinifera	1	1	0	0	1	0	0	0	0	0	0	0	✓	✓
	3	3	1	0	0	3	0	0	1	1				
Site 19 - Analogue site, 200 Anambah Rd - Anambah														
Vitis vinifera	n/a	n/a	0	Winter - deciduous species - no leaves										
Araucaria cunninghamii	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Casuarina torulosa	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Corymbia maculata	2	2	1	0	2	1	0	0	1	1	0	0	0	0
Eucalyptus tereticornis	2	2	1	0	0	2	0	0	2	1	0	0	0	0
Ficus macrophylla	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Grevillea robusta	1	1	1	0	0	1	0	0	0	0	0	0	0	0
Eucalyptus acmenoides	1	2	1	0	1	1	0	0	2	1	0	0	✓	✓
Olea europea	1	1	1	0	1	0	0	0	0	0	0	0	0	✓

<table>
<tr><th colspan="2">Site 5 – South-east corner of site</th></tr>
<tr><td colspan="2">Eucalyptus moluccana</td></tr>
<tr><td colspan="2"></td></tr>
<tr><th colspan="2">Site 7 – 3 Gillette Close</th></tr>
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<tr><th>Eucalyptus amplifolia</th><th>Eucalyptus resinifera</th></tr>
<tr><td></td><td></td></tr>
</table>

Appendix C

Analytical Laboratory Documentation

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EN2006523**	Page	: 1 of 4
Client	: **AECOM Australia Pty Ltd**	Laboratory	: Environmental Division Newcastle
Contact	: MR CYE BUCKLAND	Contact	: Tahlee Brook
Address	: 17 WARABROOK BOULEVARDE WARABROOK NSW, AUSTRALIA 2304	Address	: 5/585 Maitland Road Mayfield West NSW Australia 2304
Telephone	: +61 02 4911 4900	Telephone	: +61 2 4014 2500
Project	: 60613063 Task 2.3	Date Samples Received	: 29-Sep-2020 14:20
Order number	: 60613063 2.3	Date Analysis Commenced	: 29-Sep-2020
C-O-C number	: ----	Issue Date	: 06-Oct-2020 13:29
Sampler	: KORU ENVIRONMENTAL		
Site	: ----		
Quote number	: EN/004/20		
No. of samples received	: 6		
No. of samples analysed	: 6		

NATA

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Janice Blake	Laboratory Technician	Newcastle - Inorganics, Mayfield West, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: VEGETATION (Matrix: BIOTA)			Client sample ID	E. Moluccana - Site 5	Grasses - Site 11	E. Amlifolia - Site 13	C. Maculata - Site 13	C. Maculata - Site 15
			Client sampling date / time	29-Sep-2020 00:00	29-Sep-2020 00:00	29-Sep-2020 00:00	29-Sep-2020 00:00	29-Sep-2020 00:00
Compound	CAS Number	LOR	Unit	EN2006523-001	EN2006523-002	EN2006523-003	EN2006523-004	EN2006523-005
				Result	Result	Result	Result	Result
EK040V: Fluoride in Vegetation								
Fluoride	16984-48-8	10.0	µg/g	**27.6**	<10.0	**33.6**	<10.0	**34.1**

Analytical Results

Sub-Matrix: **VEGETATION**
(Matrix: **BIOTA)**

			Client sample ID	**Vitis vinifera - Site 19**	**----**	**----**	**----**	**----**
			Client sampling date / time	29-Sep-2020 00:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EN2006523-006**	**--------**	**--------**	**--------**	**--------**
				Result	----	----	----	----
EK040V: Fluoride in Vegetation								
Fluoride	16984-48-8	10.0	µg/g	<10.0	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EN2008672**	Page	: 1 of 4
Client	: **AECOM Australia Pty Ltd**	Laboratory	: Environmental Division Newcastle
Contact	: MR MATTHIEU CATTEAU	Contact	: Tahlee Brook
Address	: PO BOX 73 HUNTER REGION MC HRMC NSW, AUSTRALIA 2310	Address	: 5/585 Maitland Road Mayfield West NSW Australia 2304
Telephone	: ----	Telephone	: +61 2 4014 2500
Project	: 60613063 Task 2.3	Date Samples Received	: 23-Dec-2020 15:23
Order number	: 60613063 2.3	Date Analysis Commenced	: 24-Dec-2020
C-O-C number	: ----	Issue Date	: 04-Jan-2021 11:03
Sampler	: KORU ENVIRONMENTAL		
Site	: ----		
Quote number	: EN/004/20		
No. of samples received	: 6		
No. of samples analysed	: 6		

NATA

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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This Certificate of Analysis contains the following information:

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- Analytical Results

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Signatories

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Signatories	*Position*	*Accreditation Category*
Janice Blake	Laboratory Technician	Newcastle - Inorganics, Mayfield West, NSW

General Comments

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~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: VEGETATION (Matrix: BIOTA)			Sample ID	E. Moluccana - Site 5	Grasses - Site 11	E. Amplifolia - Site 13	C. Maculata - Site 13	C. Maculata - Site 15
			Sampling date / time	23-Dec-2020 00:00	23-Dec-2020 00:00	23-Dec-2020 00:00	23-Dec-2020 00:00	23-Dec-2020 00:00
Compound	CAS Number	LOR	Unit	EN2008672-001	EN2008672-002	EN2008672-003	EN2008672-004	EN2008672-005
				Result	Result	Result	Result	Result
EK040V: Fluoride in Vegetation								
Fluoride	16984-48-8	10.0	mg/kg	**15.1**	<10.0	**20.7**	<10.0	**11.4**

Analytical Results

Sub-Matrix: **VEGETATION** (Matrix: **BIOTA**)			Sample ID	**Vitis vinifera - Site 19**	----	----	----	----
			Sampling date / time	23-Dec-2020 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	**EN2008672-006**	--------	--------	--------	--------
				Result	----	----	----	----
EK040V: Fluoride in Vegetation								
Fluoride	16984-48-8	10.0	mg/kg	<10.0	----	----	----	----

CERTIFICATE OF ANALYSIS

Work Order	: **EN2102442**	Page	: 1 of 4
Client	: **AECOM Australia Pty Ltd**	Laboratory	: Environmental Division Newcastle
Contact	: MR MATTHIEU CATTEAU	Contact	: Tahlee Brook
Address	: PO BOX 73 HUNTER REGION MC HRMC NSW, AUSTRALIA 2310	Address	: 5/585 Maitland Road Mayfield West NSW Australia 2304
Telephone	: ----	Telephone	: +61 2 4014 2500
Project	: 60613063 Task 2.3	Date Samples Received	: 30-Mar-2021 14:04
Order number	: 60613063 2.3	Date Analysis Commenced	: 31-Mar-2021
C-O-C number	: ----	Issue Date	: 08-Apr-2021 13:02
Sampler	: KORU ENVIRONMENTAL		
Site	: ----		
Quote number	: EN/004/20		
No. of samples received	: 6		
No. of samples analysed	: 6		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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Signatories

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Signatories	*Position*	*Accreditation Category*
Janice Blake	Laboratory Technician	Newcastle - Inorganics, Mayfield West, NSW

General Comments

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Analytical Results

Sub-Matrix: **VEGETATION** (Matrix: **BIOTA**)			Sample ID	**E. Moluccana - Site 5**	**Grasses - Site 11**	**E. Amplifolia - Site 13**	**C. Maculata - Site 13**	**C. Maculata - Site 15**
			Sampling date / time	30-Mar-2021 00:00	30-Mar-2021 00:00	30-Mar-2021 00:00	30-Mar-2021 00:00	30-Mar-2021 00:00
Compound	CAS Number	LOR	Unit	**EN2102442-001**	**EN2102442-002**	**EN2102442-003**	**EN2102442-004**	**EN2102442-005**
				Result	Result	Result	Result	Result
EK040V: Fluoride in Vegetation								
Fluoride	16984-48-8	10.0	mg/kg	<10.0	<10.0	**34.8**	<10.0	**35.5**

Analytical Results

Sub-Matrix: VEGETATION (Matrix: BIOTA)			Sample ID	Vitis vinifera - Site 19	----	----	----	----
			Sampling date / time	30-Mar-2021 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EN2102442-006	--------	--------	--------	--------
				Result	----	----	----	----
EK040V: Fluoride in Vegetation								
Fluoride	16984-48-8	10.0	mg/kg	<10.0	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EN2105675**	Page	: 1 of 2
Client	: **AECOM Australia Pty Ltd**	Laboratory	: Environmental Division Newcastle
Contact	: MR MATTHIEU CATTEAU	Contact	: Tahlee Brook
Address	: PO BOX 73 HUNTER REGION MC HRMC NSW, AUSTRALIA 2310	Address	: 5/585 Maitland Road Mayfield West NSW Australia 2304
Telephone	: ----	Telephone	: +61 2 4014 2500
Project	: 60613063 Task 2.3	Date Samples Received	: 01-Jul-2021 13:54
Order number	: 60613063 2.3	Date Analysis Commenced	: 02-Jul-2021
C-O-C number	: ----	Issue Date	: 08-Jul-2021 16:25
Sampler	: KORU ENVIRONMENTAL		
Site	: ----		
Quote number	: EN/004/20		
No. of samples received	: 5		
No. of samples analysed	: 5		

ilac-MRA NATA

Accreditation No. 825
Accredited for compliance with ISO/IEC 17025 - Testing

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Signatories	*Position*	*Accreditation Category*
Zoran Grozdanovski	Laboratory Operator	Newcastle - Inorganics, Mayfield West, NSW

General Comments

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Analytical Results

Sub-Matrix: **VEGETATION** (Matrix: **BIOTA**)			*Sample ID*	**E. Moluccana - Site 5**	**Grasses - Site 11**	**E. Amplifolia - Site 13**	**C. Maculata - Site 13**	**C. Maculata - Site 15**
			Sampling date / time	30-Jun-2021 00:00	30-Jun-2021 00:00	30-Jun-2021 00:00	30-Jun-2021 00:00	30-Jun-2021 00:00
Compound	*CAS Number*	*LOR*	*Unit*	**EN2105675-001**	**EN2105675-002**	**EN2105675-003**	**EN2105675-004**	**EN2105675-005**
				Result	Result	Result	Result	Result
EK040V: Fluoride in Vegetation								
Fluoride	16984-48-8	10.0	µg/g	**23.7**	<10.0	**43.7**	<10.0	**25.8**

End of Report

Appendix B

Meteorological Monitoring - Wind Roses

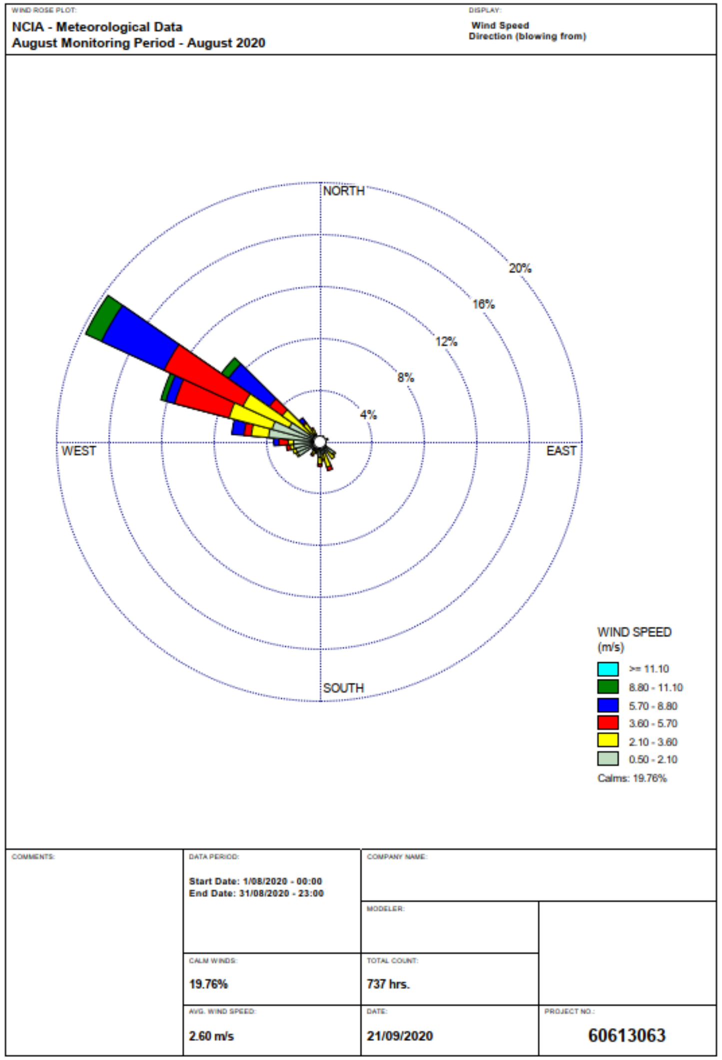

Figure B1 Wind Speed and Direction (August 2020)

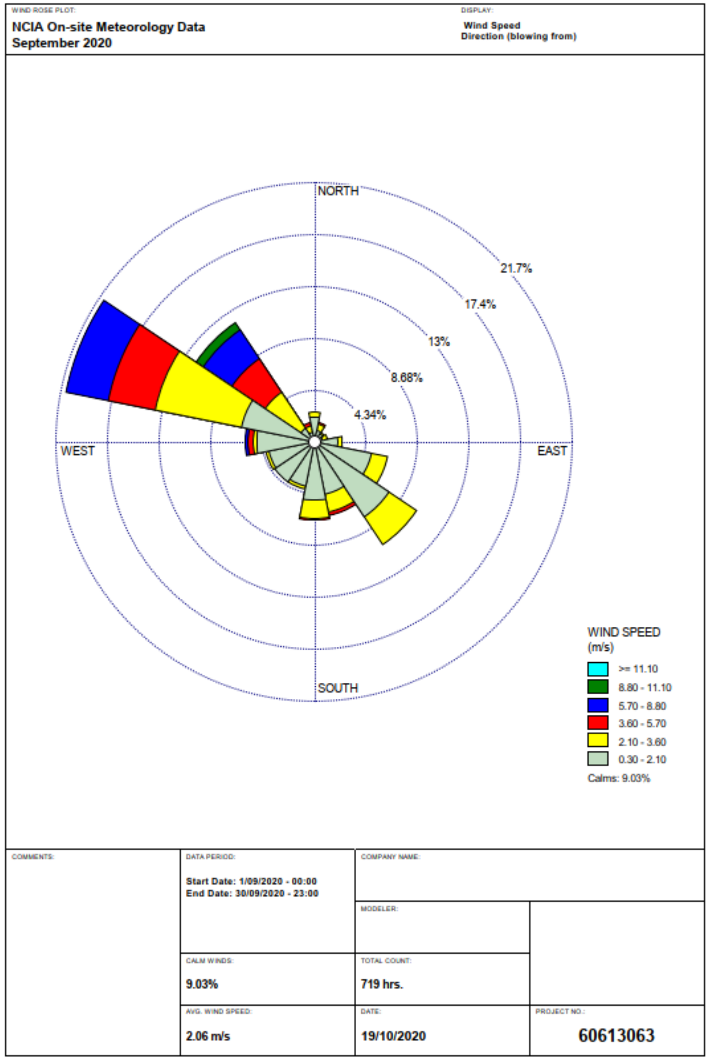

Figure B2 Wind Speed and Direction (September 2020)

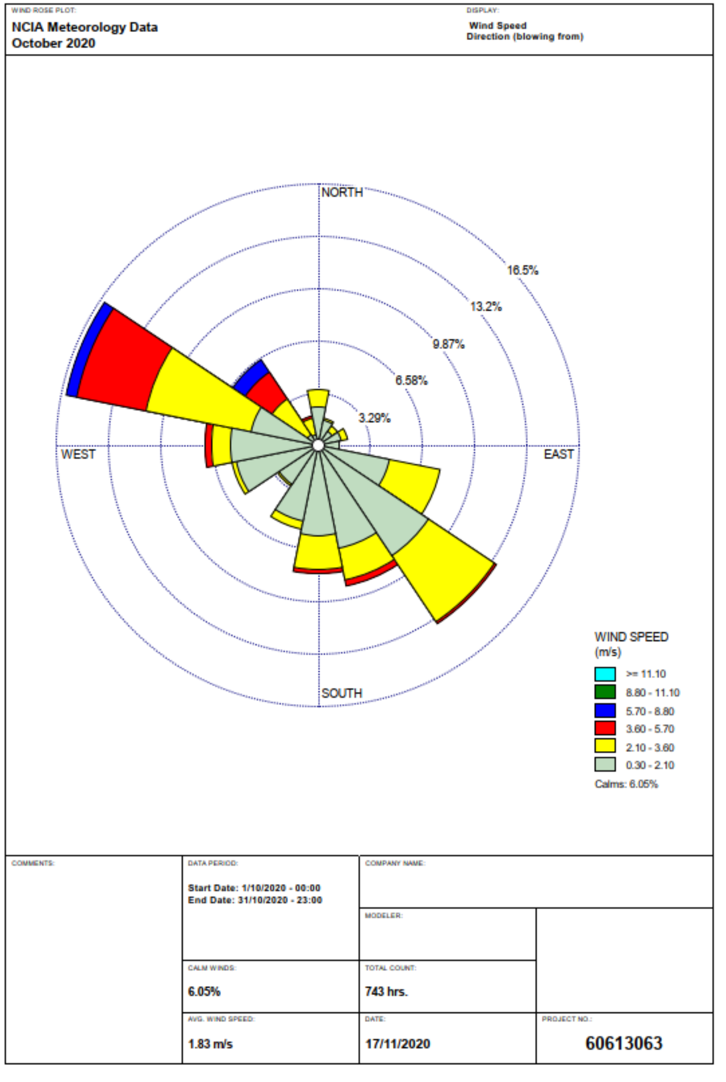

Figure B3 Wind Speed and Direction (October 2020)

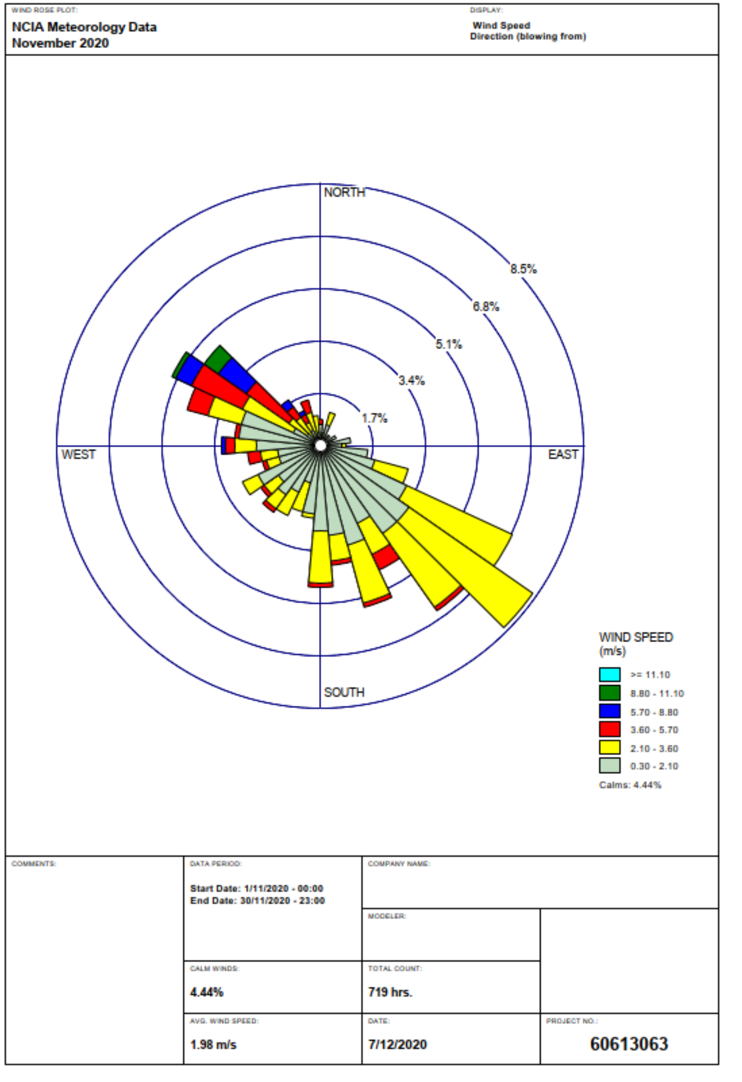

Figure B4 Wind Speed and Direction (November 2020)

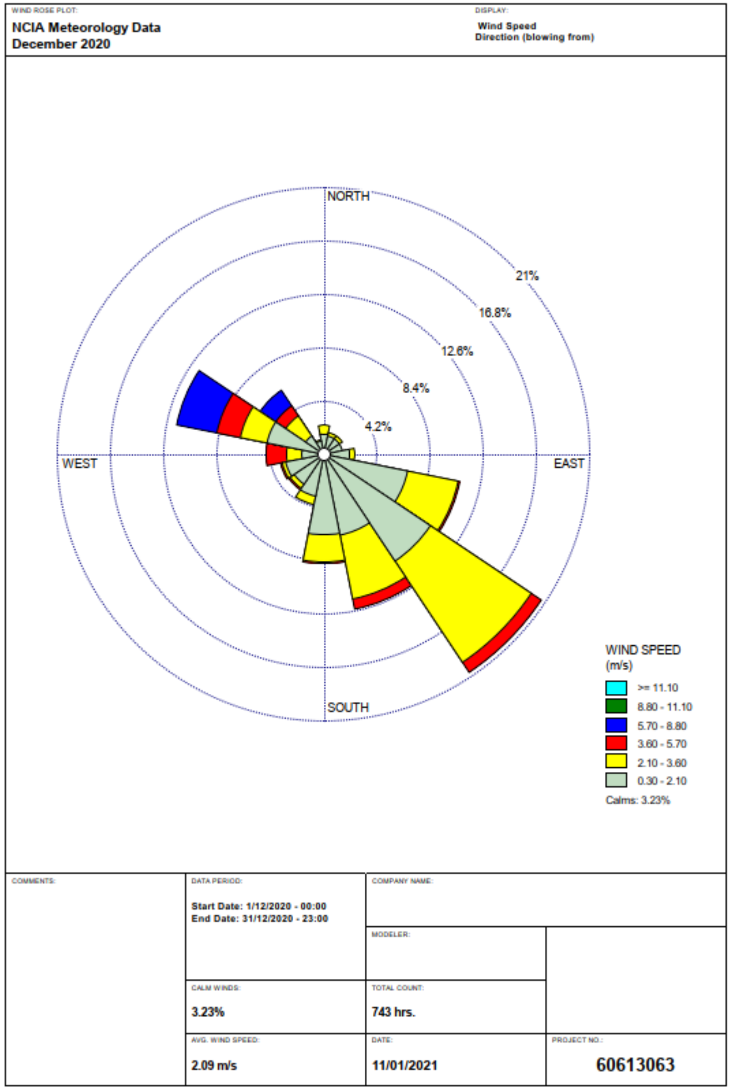

Figure B5 Wind Speed and Direction (December 2020)

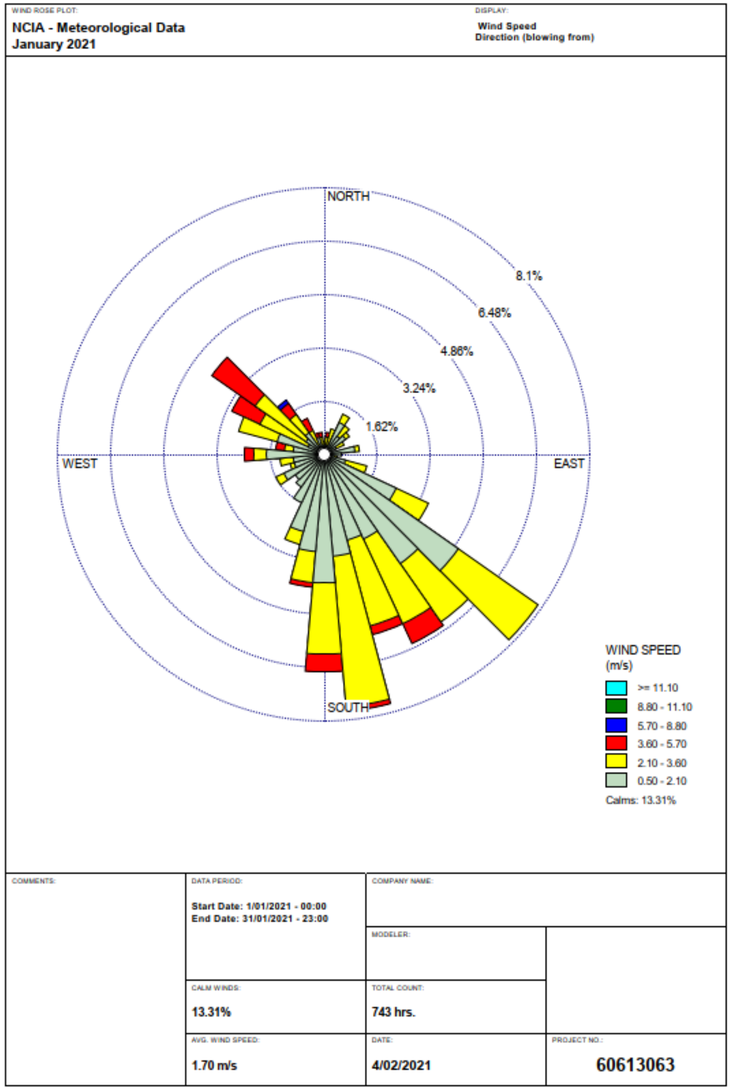

Figure B6 Wind Speed and Direction (January 2021)

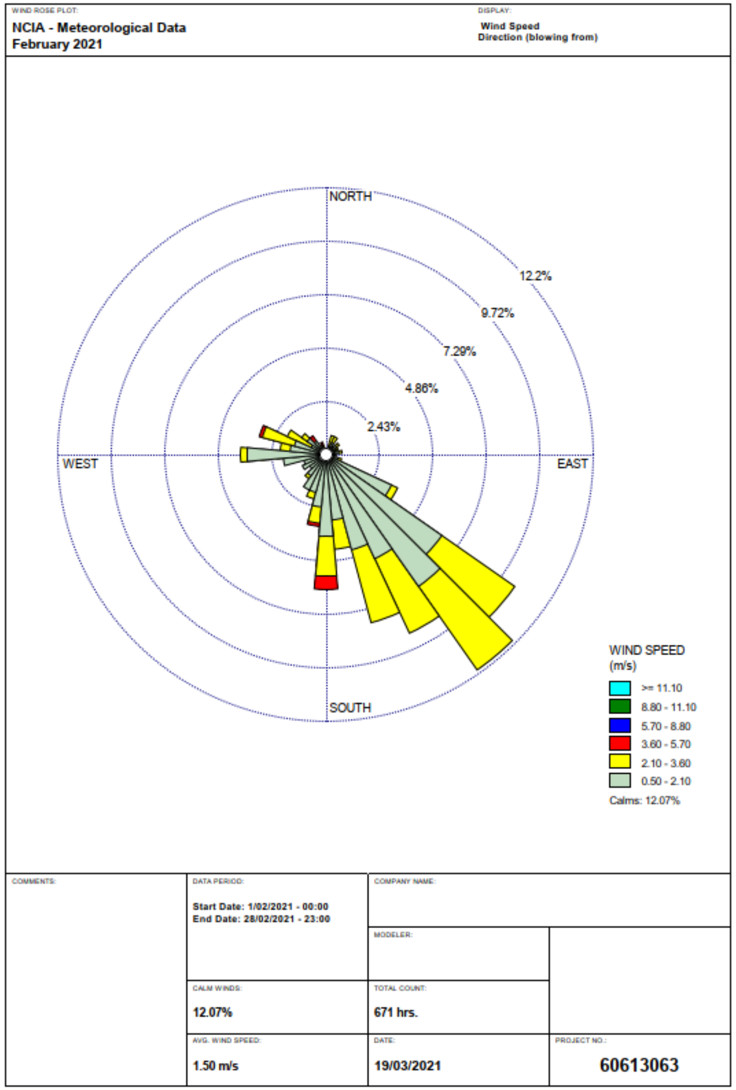

Figure B7 Wind Speed and Direction (February 2021)

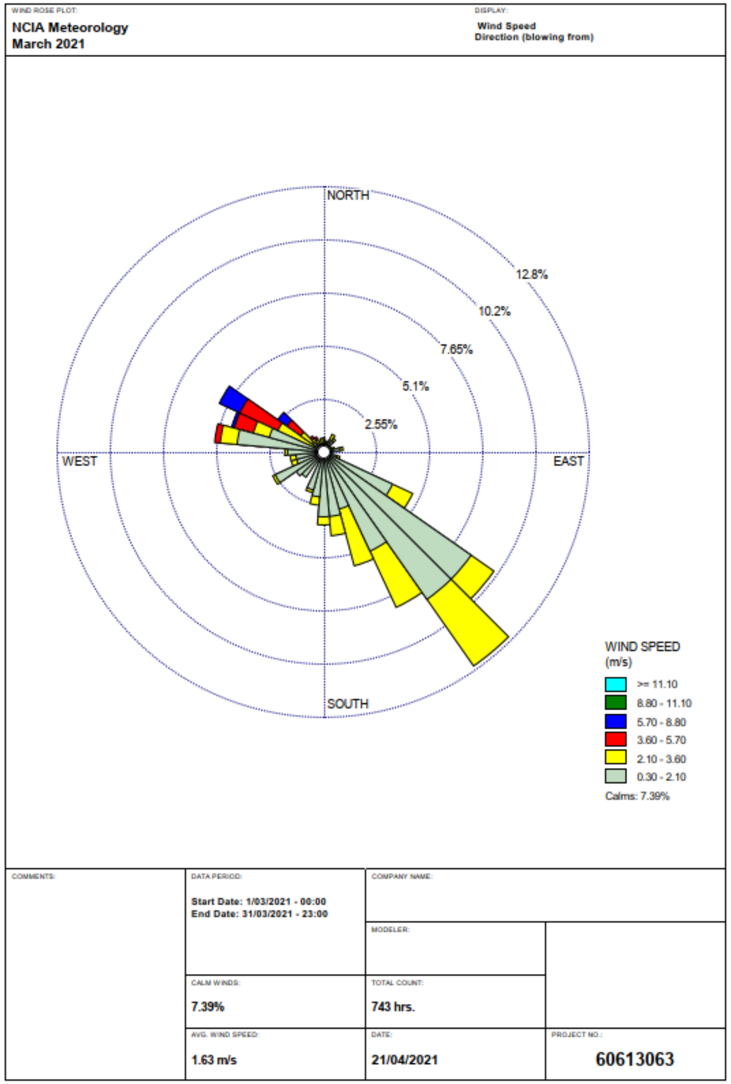

Figure B8 Wind Speed and Direction (March 2021)

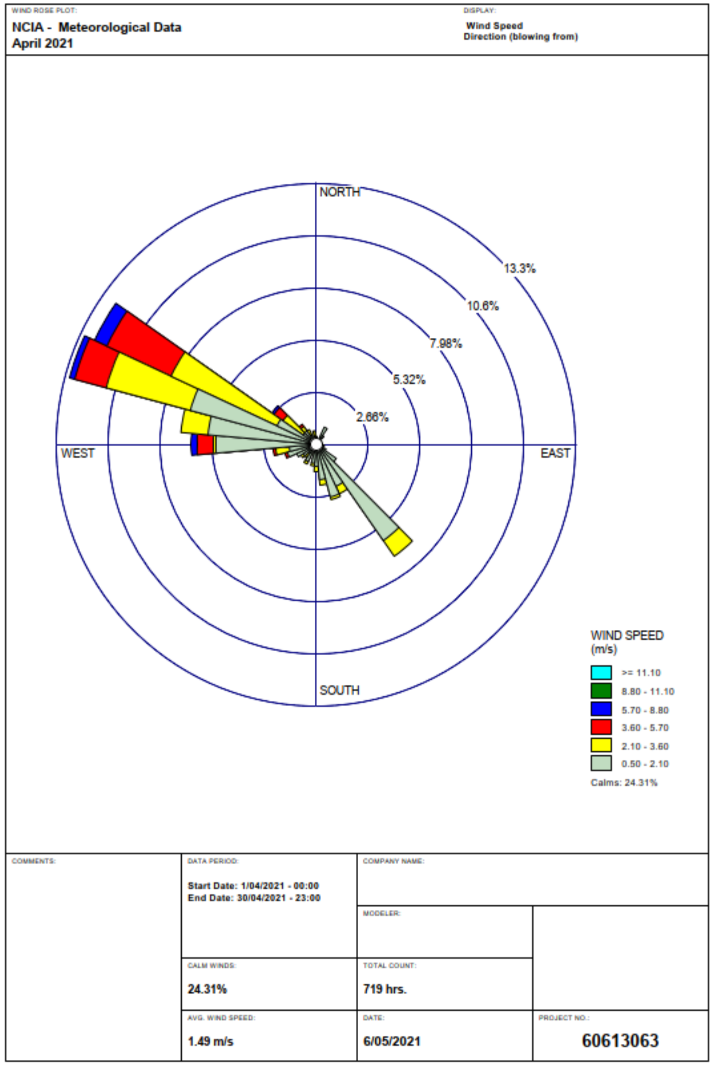

Figure B9 Wind Speed and Direction (April 2021)

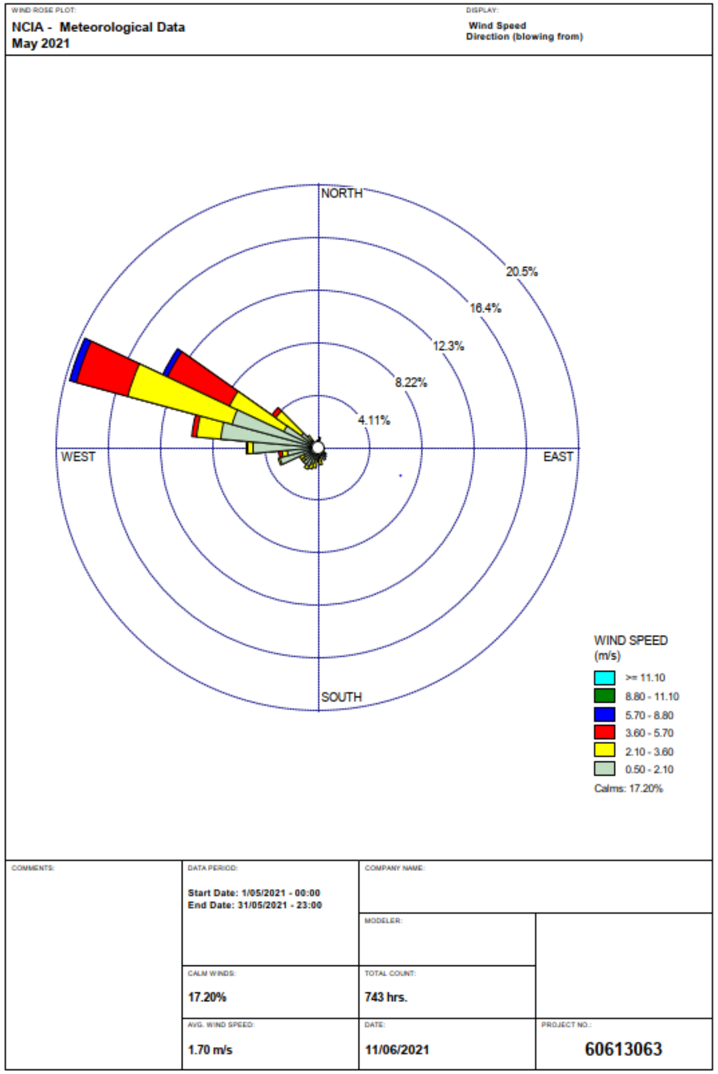

Figure B10 Wind Speed and Direction (May 2021)

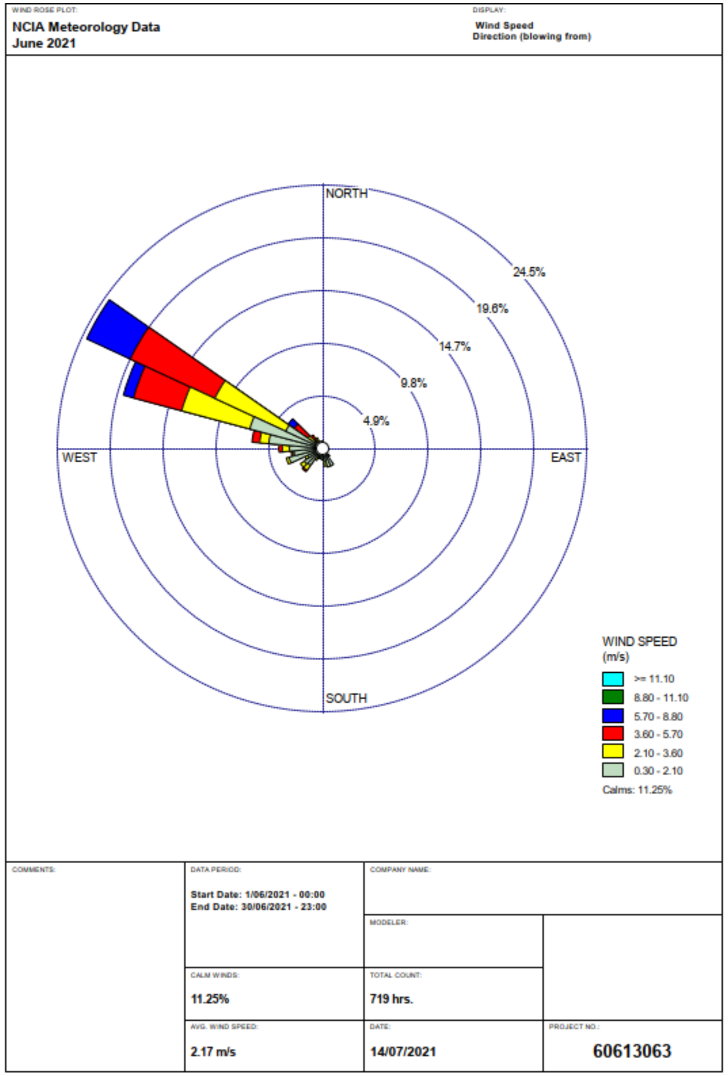

Figure B11 Wind Speed and Direction (June 2021)

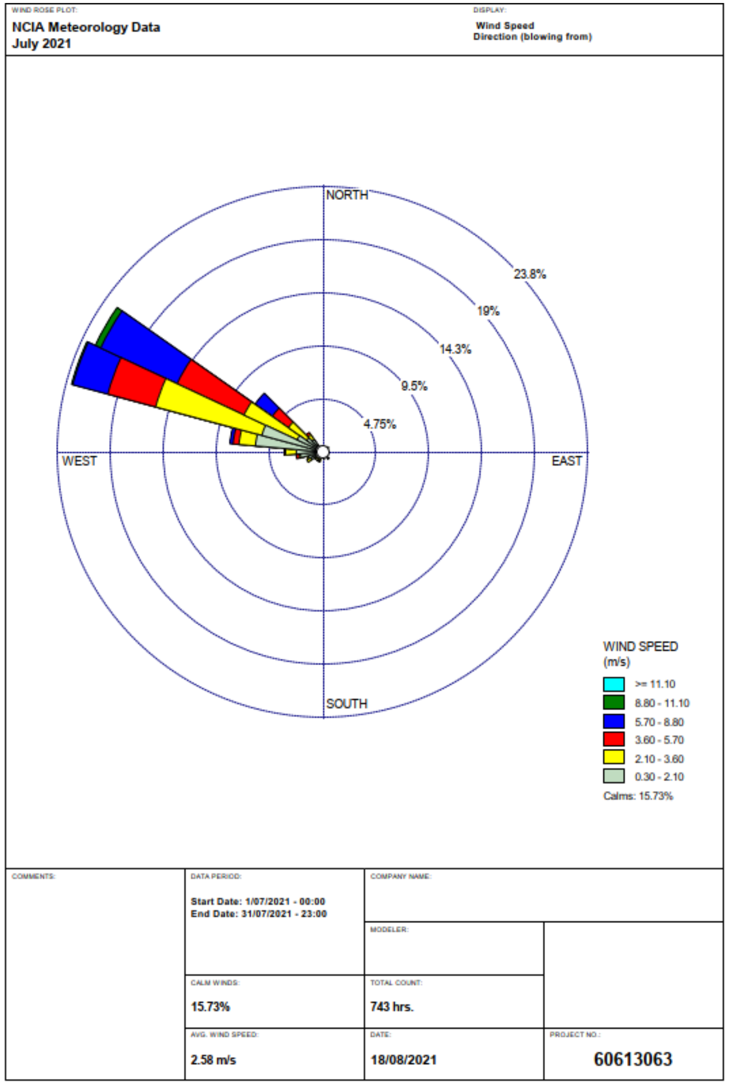

Figure B12 Wind Speed and Direction (July 2021)