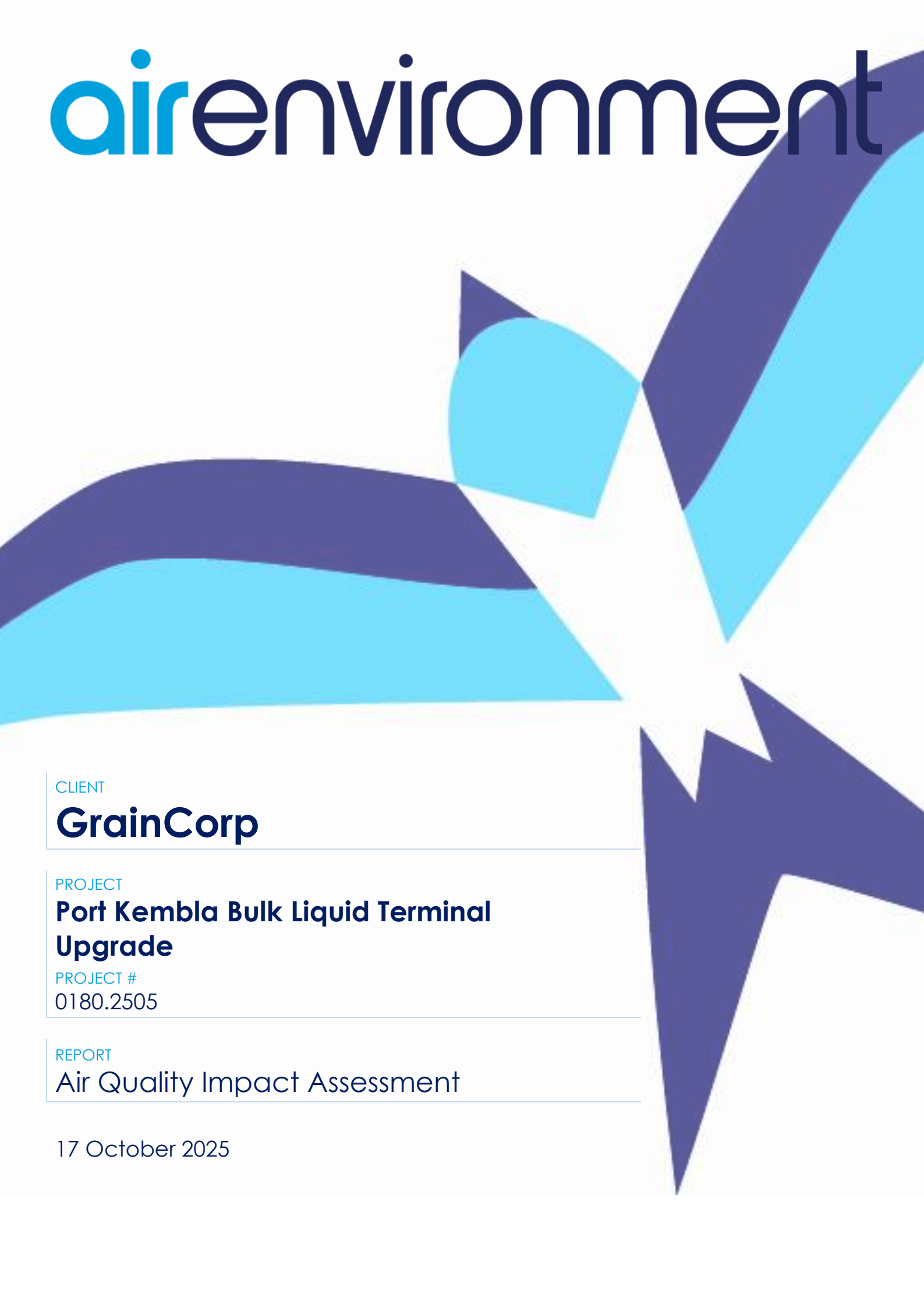


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CLIENT

GrainCorp

PROJECT

**Port Kembla Bulk Liquid Terminal
Upgrade**

PROJECT #

0180.2505

REPORT

Air Quality Impact Assessment

17 October 2025

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Glossary

Term	Definition
Units of measurement	
Am ³ /s	actual cubic metres per second (volumetric flow rate at actual temperature and pressure)
Atm	Atmosphere (unit of air pressure)
d	day
h	hour
K	Kelvin (unit of temperature)
km	kilometre
km/h	kilometres per hour
m	metre
m/s	metres per second (velocity)
m ²	square metres
m ³	cubic metres
m ³ /s	cubic metres per second (volumetric flow rate)
min	minute
Nm ³ /s	normalised cubic metres per second (volumetric flow rate at 0 °C and 1 Atm)
ou	odour unit
°C	degrees Celsius
s	second
rad	radians (unit of angle)
Sm ³ /s	standard cubic metres per second (volumetric flow rate at 25 °C and 1 Atm)
yr	year

Abbreviations/Definitions

3D	three-dimensional
AWS	automatic weather station
BOM	Bureau of Meteorology
CALMET	A diagnostic meteorological model currently developed by Exponent Inc.
CALPUFF	A Gaussian puff dispersion model currently developed by Exponent Inc.
DEM	digital elevation model
EN	European norm (refers to a European standard number). German "Europäische Norm"
ENSO	El Nino, Southern Oscillation
masl	Metres above sea level
PG	Pasquill-Gifford Scheme
SRTM1	near-global 1-arc second (~30 m) Digital Elevation Model produced by the Shuttle Radar Topography Mission (SRTM1 version 3)
SRTM3	global 3-arc second (~90 m) Digital Elevation Model produced by the Shuttle Radar Topography Mission
TAPM	The Air Pollution Model. Prognostic meteorological and air dispersion model developed by the Australian Government's Commonwealth Scientific and Industrial Research Organisation (CSIRO).
UCO	Used cooking oil
USEPA	United States Environmental Protection Agency



Term	Definition
Statistical terms	
IOA	Index of agreement
MAE	Mean absolute error
ME	Mean error
RMSE	Root Mean Square Error



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Executive Summary

Project description

Air Environment was commissioned by GrainCorp to prepare an air quality impact assessment of the proposed upgrade of their Bulk Liquid Terminal at Port Kembla, NSW. Fifteen 1,250 m³ bulk storage tanks will be upgraded so that their contents can be heated, allowing the tanks to be used to store tallow and used cooking oil prior to export for use as a biofuel.

The upgrade requires the existing 250 kW boiler to be replaced by a 3.8 MW heating plant comprising 2.5 MW and 1.3 MW diesel-fired boilers.

Assessment approach

An air quality impact assessment of boiler exhaust and fugitive tank emissions was conducted based on industry standard emission inventory development techniques and a dispersion modelling study that utilised the combined TAPM / CALMET / CALPUFF meteorological and dispersion modelling system. The models combined the site-specific details of the GrainCorp Bulk Liquid Terminal with pollutant emissions and source characteristics provided by suppliers of the proposed boilers. This approach meets the requirements of the NSW EPA Approved Methods (2022).

The critical emission sources assessed included a:

- Bosch 2.5 MW UT-M 18 hot water boiler,
- Bosch 1.3 MW UT-M 10 hot water boiler, and
- 60 kL diesel storage tank.

Mass emission rates were estimated using:

- EN emission standards for NO₂ and CO
- Emission factors drawn from the NPI EET Manual for Combustion in Boilers
- Emission factors drawn from the NPI EET Manual for Fuel and Organic Liquid Storage.

It was assumed that all emissions were constant, occurring as a result of both boilers simultaneously operating at their peak load. This represents a worst-case assessment scenario. The emission factors used, and the selection of constant peak emissions, ensures that the modelling predictions are conservative. Hourly-varying background concentrations were prepared using NSW EPA ambient air quality monitoring observations collected at the closest monitoring sites (Kembla Grange and Albion Park).

It was determined that the boilers emitted a completely different group of pollutants from those emitted by the diesel storage tank, with no single pollutants emitted by both the boilers and diesel storage tanks. This allowed boiler and diesel storage tank emissions to be assessed separately.

Results - Boiler emissions

Nitrogen dioxide is the most significant emission from the proposed boilers, with predicted incremental ground-level concentrations reaching 81% of the 1-hour criterion (164 µg/m³) at the site boundary. Cumulative concentrations, including background, reached 93% of the criterion. At sensitive receptors, the highest impact was at Receptor 3 (Incitec Pivot) with 49% of the 1-hour criterion. Annual average impacts were substantially lower, with maximum cumulative concentrations representing 39% of the annual criterion.

Both PM_{2.5} and PM₁₀ showed minimal incremental impacts arising from boiler emissions alone ($\leq 4.2\%$ of the relevant assessment criteria), however cumulative concentrations were dominated by high regional



background levels. The PM₁₀ background concentrations already exceed the 24-hour criterion on some days, with the direct incremental impacts from the GrainCorp site adding little to the background. The hourly-varying background particle concentrations can vary from year to year, so the selection of a different meteorological year, and hence background concentration year, may significantly impact the cumulative model predictions.

Other pollutants such as sulfur dioxide, carbon monoxide, and trace metals showed low impacts relative to their criteria. Beryllium presented the highest relative impact among trace metals at 95% of the criterion at the site boundary, though absolute concentrations remain very low (0.0038 µg/m³).

Results - Diesel Storage Tank Emissions

The 60 kL diesel storage tank was determined to represent a minor emission source with all pollutant concentrations well below 2% of their respective criteria. Cumene showed the highest relative impact at 1.5% of its criterion (0.31 µg/m³ against a criterion of 21 µg/m³).

Final assessment

The air quality impact assessment demonstrates that GrainCorp's proposed Bulk Liquid Terminal upgrade can proceed without significant adverse air quality impacts. The comprehensive assessment approach, conservative assumptions, and detailed analysis provide confidence that the facility will operate in compliance with all applicable air quality standards.

Predicted pollutant concentrations for the proposed Bulk Liquid Terminal upgrade were compared against those for the existing consent sources. The investigation determined that the proposed alterations and additions satisfy the requirements of Clause 48 of the *Environmental Planning and Assessment Regulation 2021*, and do not significantly increase the environmental impacts. Full details are provided in Appendix H.



1 Introduction

Air Environment was commissioned by TfA Project Group (TfA) on behalf of the GrainCorp Bulk Liquid Terminal at Port Kembla (GrainCorp) to prepare an air quality impact assessment of the operation of their Bulk Liquid Terminal at Tom Thumb Rd, Port Kembla NSW.

The site currently stores Class C1 and C2 combustible liquids for export. It is proposed to upgrade ten 1,250 m³ bulk storage tanks (identified as Tanks TK-01 to TK-10) and construct an additional five tanks (TK-11 to TK-15) so that their contents can be used to store tallow and used cooking oil (UCO), which would be exported for use as a biofuel. Tallow solidifies at ambient temperatures (less than 40 - 45°C), meaning that the upgraded tanks must have facilities to melt, agitate and heat the tallow to 65°C to allow for transport to ship via a ship's line. In the future, five additional tanks would be constructed to facilitate storage of tallow and UCO.

The project involves the following elements:

- Replacement of an existing 250 kW diesel-fired boiler with a 3.8 MW heating plant comprising a 2.5 MW and a 1.3 MW hot water boiler
- Upgrade the existing outload stations to allow road tanker truck unloading
- Addition of a pump to the existing ships line to allow export functionality, including minor upgrades to some internal pipework
- Upgrades to the ten existing 1.25 ML unheated tanks¹ (Tanks TK-01 to TK-10) to allow for storage of both tallow and UCO by adding:
 - heating coils
 - external insulation and extending the cladding (splash guarding) all the way around to cover the insulation on all vertical surfaces
 - tank agitators
- Upgrades to five of the approved 1.25 ML tanks to allow for tallow and UCO.
- Establishment of heat tracing around pipework in proximity to tanks
- Addition of a 20 kL hot water tank
- Repurposing an existing 60 kL slops tank for use as a diesel storage tank containing boiler fuel
- Repurposing an existing 25 kL diesel storage tank for use as a slops tank
- Addition of four 100 kL tanks (three immediate, one future) for product pre-treatment/conditioning upon receipt (Tanks DW-20 to DW-23)
- Construction of a new laboratory and sample storage facility.

This air quality impact assessment aims to predict and estimate the emissions from the proposed 3.8 MW heating plant and associated losses from the diesel storage tank, under peak load. It incorporates the following key elements:

- Estimation of emissions from:
 - the proposed 3.8 MW heating plant
 - the repurposed 60 kL diesel storage tank containing boiler fuel

¹ Tank TK-01 is already heated, but the heating system will be upgraded



- Preparation of a hybrid TAPM/CALMET meteorological model incorporating the meteorology of the Port Kembla region
- Atmospheric dispersion modelling of peak load emissions from the proposed 3.8 MW heating plant.
- Atmospheric dispersion modelling of peak load emissions from the proposed 60 kL diesel storage tank containing boiler fuel.

This air quality impact assessment report provides a detailed description of the methods employed and its results.



2 Overview of the Assessment Method

This air quality impact assessment is based on a dispersion modelling study that combines the site-specific details of the GrainCorp Port Kembla Bulk Liquid Terminal with boiler and diesel storage emissions estimated using information provided by manufacturers, and appropriate European Standard (EN) and National Pollutant Inventory (NPI) emission factors.

A CALPUFF Gaussian puff atmospheric dispersion model was developed to simulate and assess the dispersion and impact of pollutant ground-level concentrations in the local area surrounding the facility. The approach combines source emission rates and source emission characteristics with local meteorology, land use and terrain to assess the potential for any ambient air quality impact.

The following approach to the impact assessment has been adopted:

- A representative year of regional meteorology for simulation was determined from an analysis of inter-annual meteorological variability during the five-year period spanning 1 March 2020 and 28 February 2025. Meteorological observations were obtained from the Bureau of Meteorology (BoM) automatic weather station (AWS) located at Bellambi. The one-year period between 1 March 2020 and 28 February 2021 was determined to be the most representative of normal meteorological conditions and was selected for the modelling simulation.
- A three-dimensional meteorological dataset was developed using the TAPM (version 4.0.5) prognostic meteorological model and CALMET (version 6.5.0) diagnostic meteorological model, to represent the three-dimensional flows and meteorology of the region.
- Emissions for the proposed 3.8 MW heating plant were estimated as follows:
 - nitrogen dioxide (NO₂) and carbon monoxide (CO) emissions were calculated using emission factors for boilers meeting EN emission classes (Class 2) running on light oil (EN 267)
 - boiler emissions for other pollutants were calculated using emission factors drawn from the NPI Emission Estimation Technique (EET) Manual for Combustion in Boilers (V 3.6, Dec 2011).
 - boiler release conditions and stack dimensions provided by manufacturers
 - estimated breathing and working losses from the diesel storage tank were estimated using peak fuel usage rates and emission factors drawn from NPI EET Manual for Fuel and Organic Liquid Storage (NPI, 2012).
- The emission rates and source characteristics were combined with the three-dimensional meteorological fields generated by CALMET in the CALPUFF Gaussian puff dispersion model (version 7.2.1) to predict time varying ground-level pollutant concentrations over a Cartesian computational grid covering the region surrounding the bulk liquid terminal site.
- Separate modelling scenarios were prepared showing dispersion from the two boilers, and diesel storage tank emissions.

The impact assessment was carried out in accordance with the following guidelines and guidance documents:

- Environment Protection Authority (EPA) Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (EPA, 2022)
- Generic Guidance and Optimum Model Settings for the CALPUFF modelling system for inclusion into the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW, Australia 2011.

Background concentrations from surrounding industrial sources were accounted for using observations collected at the NSW EPA Kembla Grange and Albion Park ambient air quality monitoring sites.



Monitoring results from these sites were used to prepare CALPUFF contemporaneous background concentration files.



3 Legislative Requirements, Context and Air Quality Assessment Criteria

3.1 National Environment Protection Measure

The National Environment Protection Council defines national ambient air quality standards and goals in consultation with, and with agreement from, all state and territory governments. The air quality standards and goals were first published in 1998 in the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM). The AAQ NEPM standards were last updated in May 2021.

The AAQ NEPM is an ambient monitoring-based measure that sets out compliance standards and goals for specific large urban locations. The AAQ NEPM has identified air quality standards for seven criteria pollutants that are important to consider for the protection of human health, i.e., CO, NO₂, ozone (O₃), sulfur dioxide (SO₂), lead (Pb), and particulate matter as PM₁₀ and PM_{2.5}.

Where possible, the current (as updated in 2021) AAQ NEPM standards have been applied in this report in preference to other assessment criteria. The proposed updated standards for PM_{2.5}, which come into effect in 2025, have been adopted in preference to the 2021 criteria.

The AAQ NEPM standards apply at sensitive receptor locations. The AAQ NEPM standards that are relevant to this assessment are provided in Table 3-1.

Table 3-1 AAQ NEPM standards for relevant pollutants

Pollutant	Averaging period	Statistic (percentile)	Standard, µg/m ³
Particles, as PM _{2.5} ¹	24 hours	100 th	20
	Annual	-	7
Particles, as PM ₁₀ ²	24 hours	100 th	50
	Annual	-	25
Nitrogen dioxide	1 hour	100 th	164 (0.08 ppm)
	Annual	-	31 (0.15 ppm)
Photochemical oxidants (as ozone)	8 hour	100 th	139 (0.065 ppm)
Sulfur dioxide	1 hour	100 th	214 (0.075 ppm)
	24 hours	100 th	57 (0.02 ppm)
Carbon monoxide	1 hour	100 th	30,000 (25 ppm)
	8 hours	100 th	11,247 (9.0 ppm)

Table note: ¹ Particulate matter smaller than 2.5 microns. Standard applying from 2025.

² Particulate matter smaller than 10 microns.



3.2 NSW Approved Methods

NSW EPA (2022) sets out the ambient air quality impact assessment criteria under which air quality impacts in NSW are to be assessed. Impact assessment criteria for the key air pollutants associated with project activities are outlined in Table 3-2.

Table 3-2 NSW Approved Methods impact assessment criteria

Pollutant	Averaging period	Statistic (percentile)	Impact assessment criterion, $\mu\text{g}/\text{m}^3$
Particles, as $\text{PM}_{2.5}$	24 hours	100 th	25
	Annual	-	8
Particles, as PM_{10}	24 hours	100 th	50
	Annual	-	25
Nitrogen dioxide	1 hour	100 th	164 (0.08 ppm)
	Annual	-	31 (0.15 ppm)
Carbon monoxide	1 hour	100 th	30,000 (30 mg/m^3)
	8 hours	100 th	10,000 (10 mg/m^3)
PAH as benzo[a]pyrene	1 hour	100 th	0.4
Benzene	1 hour	100 th	29
Cumene	1 hour	100 th	21
Cyclohexane	1 hour	100 th	19,000
Ethylbenzene	1 hour	100 th	8,000
n-Hexane	1 hour	100 th	3,200
Toluene	1 hour	100 th	360
Xylenes	1 hour	100 th	190
Arsenic and compounds	1 hour	100 th	0.09
Beryllium and Beryllium compounds	1 hour	100 th	0.004
Chromium III	1 hour	100 th	9
Cadmium and cadmium compounds	1 hour	100 th	0.018

3.3 Adopted ambient air quality criteria

The air quality assessment criteria (AQAC) provided in Table 3-3 have been adopted for use in this impact assessment.



Table 3-3 Adopted ambient air quality assessment criteria for relevant pollutants

Pollutant	Averaging period	Statistic (percentile)	AQAQ, $\mu\text{g}/\text{m}^3$	Source
Carbon monoxide	1 hour	100 th	30,000 (25 ppm)	Air NEPM Standards
	8 hours	100 th	10,000 (9.0 ppm)	Air NEPM Standards
Nitrogen dioxide	1 hour	100 th	164 (0.08 ppm)	Air NEPM Standards
	Annual	-	31 (0.15 ppm)	Air NEPM Standards
Sulphur dioxide	1 hour	100 th	214	Air NEPM Standards
	24 hours	100 th	57	Air NEPM Standards
Particles, as PM _{2.5}	24 hours	100 th	20	Air NEPM Standards ¹
	Annual	-	7	Air NEPM Standards ¹
Particles, as PM ₁₀	24 hours	100 th	50	Air NEPM Standards
	Annual	-	25	Air NEPM Standards
Arsenic and compounds	1 hour	100 th	0.09	Approved Methods
Benzene	1 hour	100 th	29	Approved Methods
Beryllium and compounds	1 hour	100 th	0.004	Approved Methods
Cadmium and compounds	1 hour	100 th	0.018	Approved Methods
Chromium III	1 hour	100 th	9	Approved Methods
Copper fumes	1 hour	100 th	3.7	Approved Methods
Cumene	1 hour	100 th	21	Approved Methods
Cyclohexane	1 hour	100 th	19,000	Approved Methods
Dioxins and furans	1 hour	100 th	0.000002	Approved Methods
Ethylbenzene	1 hour	100 th	8000	Approved Methods
Lead	Annual	100 th	0.5	Approved Methods
Mercury (inorganic)	1 hour	100 th	1.8	Approved Methods
n-Hexane	1 hour	100 th	3200	Approved Methods
Nickel and nickel compounds	1 hour	100 th	0.18	Approved Methods
PAH as benzo[a]pyrene	1 hour	100 th	0.4	Approved Methods
Toluene	1 hour	100 th	360	Approved Methods
Xylenes	1 hour	100 th	190	Approved Methods

Table notes: ¹Reduced Air NEPM standards applying from 2025



3.4 In-stack standards of concentration

The *Protection of the Environment Operations (Clean Air) Regulation 2022*, which was made under the *Protection of the Environment Operations Act 1997*, prescribes standards of concentrations to be met for individual emission sources. The standards of concentration are grouped according to the date of commencement of the activity or operation of the plant. Given that the proposed boilers will be brand new, they will be assessed against the Group 6 standards of concentration (plant operation commencing after the commencement of the Regulation on 16 December 2022). The adopted standards of concentration are provided in Table 3-4 for each pollutant.

Table 3-4 Standards of concentration applying to boiler emissions

Air impurity	Activity or plant	Group 6 Standard of concentration ¹	Emission type ^{2,3}
Nitrogen dioxide	A boiler operating on a fuel other than gas	500 mg/m ³	-
Solid particles (Total)	An activity or plant	50 mg/m ³	-
Volatile organic compounds (VOCs), as n-propane	An activity or plant involving combustion	40 mg/m ³	-
Cadmium	An activity or plant	0.2 mg/m ³	Type 1
Arsenic	An activity or plant	-	Type 1
Lead,	An activity or plant	-	Type 1
Mercury	An activity or plant	0.2 mg/m ³	Type 1
Beryllium	An activity or plant	-	Type 2
Chromium	An activity or plant	-	Type 2
Manganese	An activity or plant	-	Type 2
Nickel	An activity or plant	-	Type 2
Selenium	An activity or plant	-	Type 2
Type 1 and Type 2 substances (in aggregate)	An activity or plant	1 mg/m ³	-

Table notes: ¹*Protection of the Environment Operations (Clean Air) Regulation 2022*, Schedule 2, Standards of concentration, Part 2, Scheduled Premises, Division 3, General activities and plant.
²Type 1 substance means the elements antimony, arsenic, cadmium, lead or mercury, or a compound containing 1 or more of those elements.
³Type 2 substance means the elements beryllium, chromium, cobalt, manganese, nickel, selenium, tin or vanadium, or a compound containing 1 or more of those elements.



4 Existing Environment

The GrainCorp Bulk Liquid Terminal site is located at the Port Kembla Grain Terminal, situated on the corner of Tom Thumb Road. The surrounding area is mainly occupied by industries and port related activities, with residential areas located further away from the site location. The location of the site and the surrounding uses are illustrated in Figure 4-1. The GrainCorp site is separated into two land parcels, with the upgrade occurring on the northern parcel.

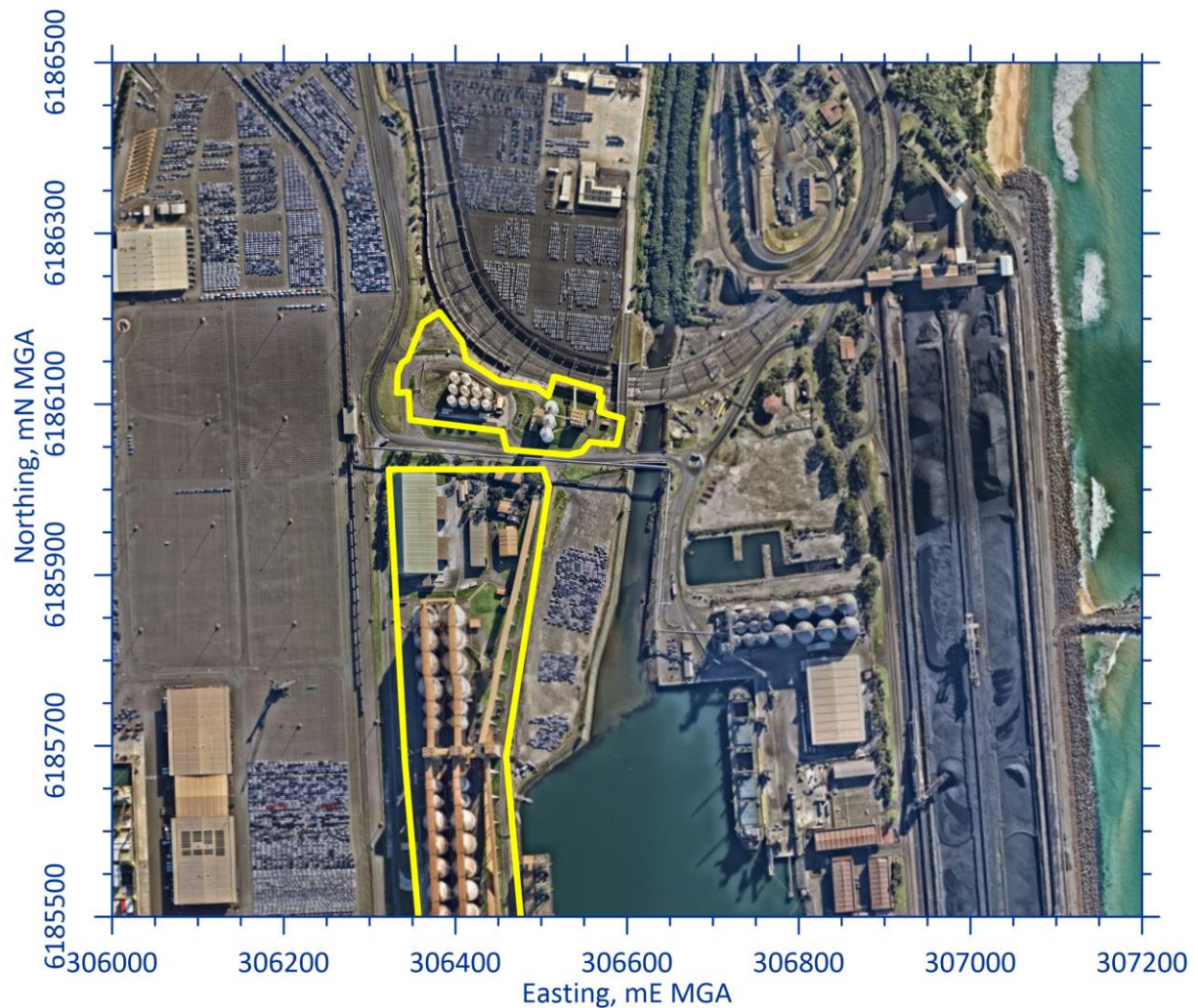


Figure 4-1 Location of the GrainCorp Bulk Liquid Terminal

Figure notes: The GrainCorp bulk liquid terminal site boundary is shown in yellow. The upgrade is occurring on the northern parcel.



5 Emissions Inventory

5.1 Boiler emissions

5.1.1 Boiler characteristics

GrainCorp plans to commission two modulating diesel-fuelled hot water boilers, used to heat water for use in heating the bulk storage tank contents. The performance requirements for each boiler are as follows:

- Discharge water temperature 80°C
- Return water temperature 35 - 65°C
- Pressure requirement 5 bar
- Boiler efficiency >80%.

The characteristics of each boiler are summarised in Table 5-1.

Table 5-1 Boiler characteristics

Parameter	1.3 MW Boiler	2.5 MW Boiler	Comments
Make	Bosch	Bosch	Manufacturer's specifications
Model	UT-M 10	UT-M 18	Manufacturer's specifications
Nominal capacity, MW	1.3	2.5	Manufacturer's specifications
Stack diameter, m	0.253	0.40	Manufacturer's specifications
Stack height, m	21	21	3 m above bulk storage tank
Actual volumetric flow rate, m ³ /s	0.443	0.863	Manufacturer's specifications
Exit velocity, m/s	8.8	6.9	Calculated
In-stack temperature, °C	185	214	Manufacturer's specifications
In-stack moisture content, %	12	12	Assumed
Peak fuel usage rate, t/h	0.118	0.230	Manufacturer's specifications

5.1.2 Boiler emissions using EN emission factors

The Bosch UT-M 10 and UT-M 18 vertical water tube modulating boilers are constructed in Germany, and are designed to meet EN emission standards for NO₂ and CO. The EN standard provides emission factors for Class 2 boilers running on light oil (diesel) as provided in Table 5-2. Boiler mass emission rates are determined by multiplying the appropriate emission factor by the nominal boiler capacity (in kW) and converting the result from mg/h to g/s.

Table 5-2 Determination of boiler emissions using EN emission factors for Class 2 boilers running on light oil

Pollutant	Emission factor ¹ (mg/kWh)	1.3 MW Boiler		2.5 MW Boiler	
		(mg/h)	(g/s)	(mg/h)	(g/s)
Oxides of nitrogen (as NO ₂)	185	240,500	0.067	462,500	0.128
Carbon monoxide	1300	1,690,000	0.469	3,250,000	0.903

Table Note: ¹Weishaupt boilers statement for standard boilers



5.1.3 Boiler emissions using NPI emission factors

Boiler emissions for the remaining pollutants were estimated using emission factors drawn from the NPI EET Manual for Combustion in Boilers (version 3.6, NPI, 2011), and the manufacture-supplied peak fuel usage rates for each boiler, as shown in Table 5-3.

Table 5-3 Determination of boiler emissions using NPI emission factors for two boilers ≤ 30 MW running on distillate oil (diesel)

Pollutant	Emission factor ¹ (kg/t fuel burnt)	Mass emission rate 1.3 MW Boiler ²		Mass emission rate 2.5 MW Boiler ³	
		(kg/h)	(g/s)	(kg/h)	(g/s)
Particulate matter as PM ₁₀	1.400E-01	1.652E-02	4.589E-03	1.400E-01	8.944E-03
Particulate matter as PM _{2.5}	3.000E-02	3.540E-03	9.833E-04	3.000E-02	1.917E-03
Polycyclic aromatic hydrocarbons (B[a]P _{eq})	2.250E-04	2.655E-05	7.375E-06	2.250E-04	1.438E-05
Sulfur dioxide	1.930E-02	2.277E-03	6.326E-04	1.930E-02	1.233E-03
Arsenic and compounds	7.720E-05	9.110E-06	2.530E-06	7.720E-05	4.932E-06
Beryllium and compounds	5.790E-05	6.832E-06	1.898E-06	5.790E-05	3.699E-06
Cadmium and compounds	5.790E-05	6.832E-06	1.898E-06	5.790E-05	3.699E-06
Chromium (III) compounds	5.790E-05	6.832E-06	1.898E-06	5.790E-05	3.699E-06
Copper and compounds	1.160E-04	1.369E-05	3.802E-06	1.160E-04	7.411E-06
Lead and compounds	1.740E-04	2.053E-05	5.703E-06	1.740E-04	1.112E-05
Mercury and compounds	5.790E-05	6.832E-06	1.898E-06	5.790E-05	3.699E-06
Nickel and compounds	5.790E-05	6.832E-06	1.898E-06	5.790E-05	3.699E-06
Polychlorinated dioxins and furans (TEQ)	4.490E-10	5.298E-11	1.472E-11	4.490E-10	2.869E-11
Manganese and compounds	1.160E-04	1.369E-05	3.802E-06	1.160E-04	7.411E-06

Table note: ¹Taken from Table 28, NPI (2011), p.42.

²The Bosch UT-M 10 (1.3 MW) boiler has a peak fuel usage rate of 0.118 t/h

³The Bosch UT-M 18 (2.5 MW) boiler has a peak fuel usage rate of 0.230 t/h

5.1.4 Assessment against the general in-stack standards of concentration

In-stack concentrations of relevant pollutants were calculated from the boiler characteristics and mass emission rates provided in Sections 5.1.1 to 5.1.3 above. These were compared against the general in-stack standards of concentration provided in the *Protection of the Environment Operations (Clean Air) Regulation 2022* as described in Section 3.4, as shown in Table 5-4.

The in-stack concentrations of all assessed air impurities were found to easily meet their respective standards of concentration for each of the two proposed boilers.



Table 5-4 Assessment of boiler emissions against the general standards of concentration

Air impurity	Group 6 Standard of concentration ¹	Emission type ^{2,3}	Bosch UT-M 18 (2.5 MW)	Bosch UT-M 10 (1.3 MW)
Nitrogen dioxide	500 mg/m ³	-	169	172
Solid particles (Total)	50 mg/m ³	-	11.8 (as PM ₁₀)	11.8 (as PM ₁₀)
Volatile organic compounds (VOCs), as n-propane	40 mg/m ³	-	2.3	2.3
Cadmium	0.2 mg/m ³	Type 1	0.005	0.005
Arsenic	-	Type 1	0.006	0.006
Lead,	-	Type 1	0.015	0.015
Mercury	0.2 mg/m ³	Type 1	0.005	0.005
Beryllium	-	Type 2	0.005	0.005
Chromium	-	Type 2	0.005	0.005
Manganese	-	Type 2	0.010	0.010
Nickel	-	Type 2	0.005	0.005
Selenium	-	Type 2	0.025	0.025
Type 1 and Type 2 substances (in aggregate)	1 mg/m ³	-	0.080	0.080

Table notes: ¹Protection of the Environment Operations (Clean Air) Regulation 2022, Schedule 2, Standards of concentration, Part 2, Scheduled Premises, Division 3, General activities and plant.
²Type 1 substance means the elements antimony, arsenic, cadmium, lead or mercury, or a compound containing 1 or more of those elements.
³Type 2 substance means the elements beryllium, chromium, cobalt, manganese, nickel, selenium, tin or vanadium, or a compound containing 1 or more of those elements.

5.2 60 kL diesel storage tank

GrainCorp plans to repurpose the existing slops tank for use in storing diesel fuel for the proposed boilers. The dimensions of the diesel storage tank are as follows:

- Outer diameter (OD) = 3.46 m
- Height = 8.16 m

Emission factors for the storage of diesel fuel in vertical fixed roof tanks in NSW (Zone 10) were selected from the NPI Emission Estimation Technique Manual for Fuel and Organic Liquid Storage (NPI, 2012). Emission rates for seven pollutants were determined using the NPI emission factors and a maximum total diesel fuel usage rate of 418.8 L/h (0.348 t/h) as shown in Table 5-5.



Table 5-5 Emission factors and emission rates from a fixed vertical diesel storage tank in NSW under a fuel usage rate of 0.348 t/h

Pollutant	Emission Factor, kg/t ¹	Emission Rate, kg/h	Emission Rate, g/s
Benzene	0.00042	0.00015	0.000041
Cumene	0.00064	0.00022	0.000062
Cyclohexane	0.00014	0.00005	0.000014
Ethylbenzene	0.00015	0.00005	0.000015
n-Hexane	0.00023	0.00008	0.000022
Toluene	0.00041	0.00014	0.000040
Xylenes	0.00039	0.00014	0.000038

Table Note: ¹Source NPI, 2012, Appendix F.1: Fuel storage- vertical fixed roof tank, p. 41, Zone 10 NSW.

These emission rates were conservatively applied as constant emissions within the CALPUFF model to ensure that worst case emissions were applied under poor dispersion conditions.

5.3 Odour from bulk storage, oil receipt, and wash-water treatment tanks

Breathing and working losses from Tanks TK-01 to TK-10 occurring whilst storing tallow or UCO were considered to represent a potential minor odour source and were therefore not assessed. Tallow and UCO arriving onsite has usually been cleaned and pre-processed. These products are decanted into the storage tanks in liquid form and are subsequently allowed to solidify during storage, thereby minimising odour emissions. Individual tanks are re-heated and agitated approximately ten days prior to shipping. Breathing losses are therefore assumed to be intermittent and minor.

The four oil receipt and wash-water treatment tanks (DW-20 to DW-23) were also not assessed as they are only in intermittent use and are similarly not considered to represent a significant odour source.



6 Background Concentrations

6.1 NSW EPA requirements

Section 5.1 of the Approved Methods (NSW EPA, 2022) requires background concentrations for the following pollutants to be accounted for:

- NO₂
- SO₂
- PM₁₀
- PM_{2.5}.

Level two assessments require “at least one year of continuous measurements [*that are*] contemporaneous with the meteorological data used in the dispersion modelling” (EPA, 2022, p. 18).

6.2 Available monitoring data

The closest two NSW EPA ambient air quality monitoring sites to the GrainCorp site are located at Kembla Grange and Albion Park as shown in Figure 6-1 and Table 6-1. The Kembla Grange monitoring site is located approximately 7.3 km to the west-southwest of the GrainCorp site. Monitoring results from this site are used as the primary source of contemporaneous background concentrations. The Kembla Grange site does not monitor SO₂, so background SO₂ concentrations were derived from the more distant Albion Park South monitoring site, approximately 17.6 km to the southwest of the GrainCorp site. All observations were collected for the 1 March 2020 to 28 February 2021 meteorological year as required by Section 5.1 of the Approved Methods.

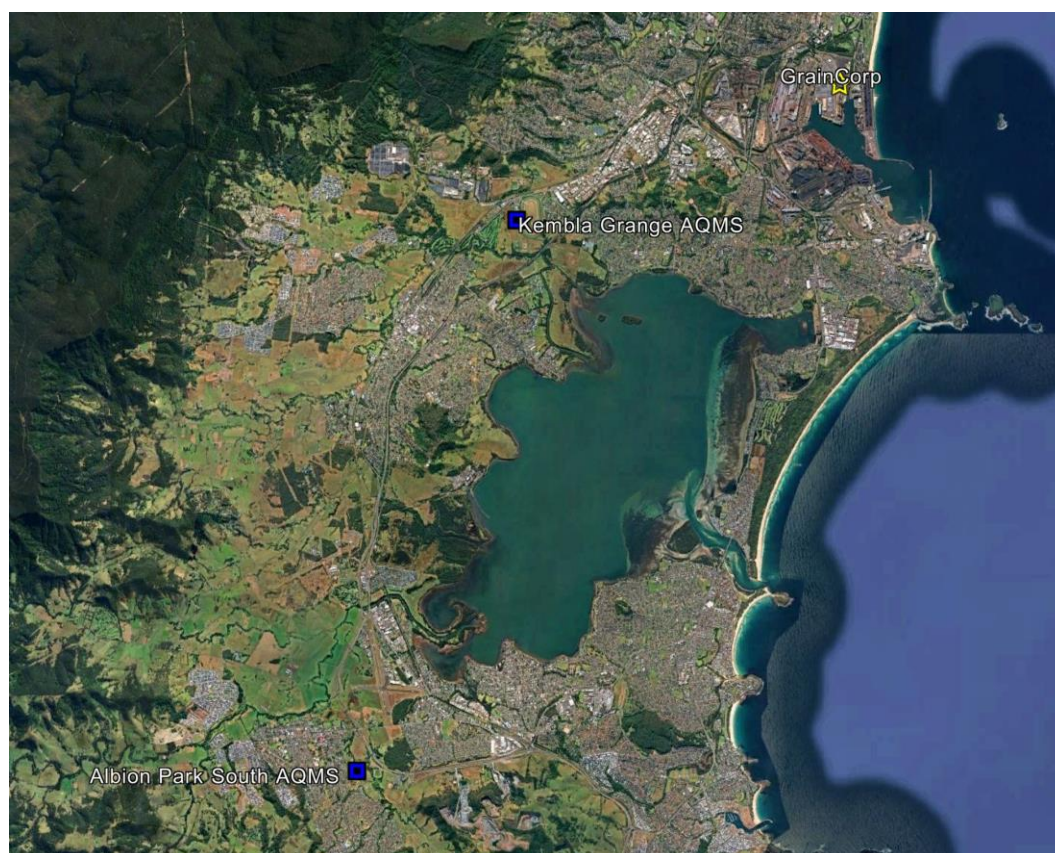


Figure 6-1 NSW EPA ambient air quality monitoring stations in relation to the GrainCorp site



Table 6-1 NSW EPA ambient air quality monitoring station locations and monitored pollutants

Air quality monitoring station	Location (Lat. & Long.)	Distance & bearing from GrainCorp site	Monitored pollutants
Kembla Grange	-34.47408 °S 150.81913 °E	7.34 km 247° (WSW)	PM ₁₀ ; PM _{2.5} ; NO _x ¹ ; O ₃ ; NEPH ²
Albion Park South	-34.57781 °S 150.78252 °E	17.57 km 215° (SW)	PM ₁₀ ; PM _{2.5} ; NO _x ¹ ; SO ₂ ; O ₃ ; NEPH

Table Note: ¹ NO; NO₂; & total NO_x
² Nephelometer (visibility)

Pollutant observations collected at the two NSW EPA sites for the meteorological year, were downloaded from the NSW EPA Data Download Facility (available at <https://www.airquality.nsw.gov.au/air-quality-data-services/data-download-facility>). EPA reports that this data has been fully validated.

6.3 Data gap filling

Like all monitoring stations, the observed contemporaneous dataset contains gaps. In particular, NO₂ and SO₂ observations are systematically unavailable for Hour 2 at both AQMS sites. It is assumed that instrument zero and span tests are automatically run during this hour each day, thus invalidating the data.

The median observed pollutant concentration for each pollutant was calculated by hour of day, as provided in Table 6-2, for use in filling data gaps. For pollutants where no observations were collected during Hour 2, the Hour 2 median concentration was estimated as the average of the Hour 1 and 3 median concentrations.

Table 6-2 The median 1-hour average background concentrations by hour of day, used to fill gaps in the raw dataset

Hour	NO ₂ , µg/m ³	SO ₂ , µg/m ³	PM ₁₀ , µg/m ³	PM _{2.5} , µg/m ³
0	4.1	0.0	12.4	6.2
1	6.2	0.0	11.2	5.4
2 ¹	5.1	0.0	10.9	4.7
3	4.1	0.0	10.3	3.6
4	4.1	0.0	10.4	4.3
5	6.2	0.0	11.5	5.2
6	8.2	0.0	13.8	5.4
7	10.3	0.0	15.9	5.2
8	6.2	0.0	16.4	3.1
9	4.1	0.0	15.4	1.3
10	2.1	0.0	15.8	1.6
11	2.1	0.0	14.9	1.8
12	2.1	0.0	15.5	1.7
13	2.1	0.0	17.3	2.1
14	2.1	0.0	18.3	3.4



Hour	NO ₂ , µg/m ³	SO ₂ , µg/m ³	PM ₁₀ , µg/m ³	PM _{2.5} , µg/m ³
15	2.1	0.0	17.5	3.9
16	2.1	0.0	18.6	4.6
17	2.1	0.0	20.5	5.1
18	4.1	0.0	20.4	5.9
19	4.1	0.0	18.5	6.7
20	6.2	0.0	17.1	6.3
21	6.2	0.0	16.1	6.8
22	6.2	0.0	15.1	7.8
23	4.1	0.0	13.1	7.0

Table Note: Calculated using the median observed values for each hour of the day. The NO₂ and SO₂ values for Hour 2 were derived using the average of those calculated for Hours 1 and 3.

The available gap-filled background concentration time-series for cumulatively-assessed pollutants are plotted in Figure 6-2.

6.4 CALPOST (BACK.DAT) background concentration files

Background concentrations for each cumulatively-assessed pollutant were formatted into CALPOST BACK.DAT files to allow a cumulative modelling assessment to be made.

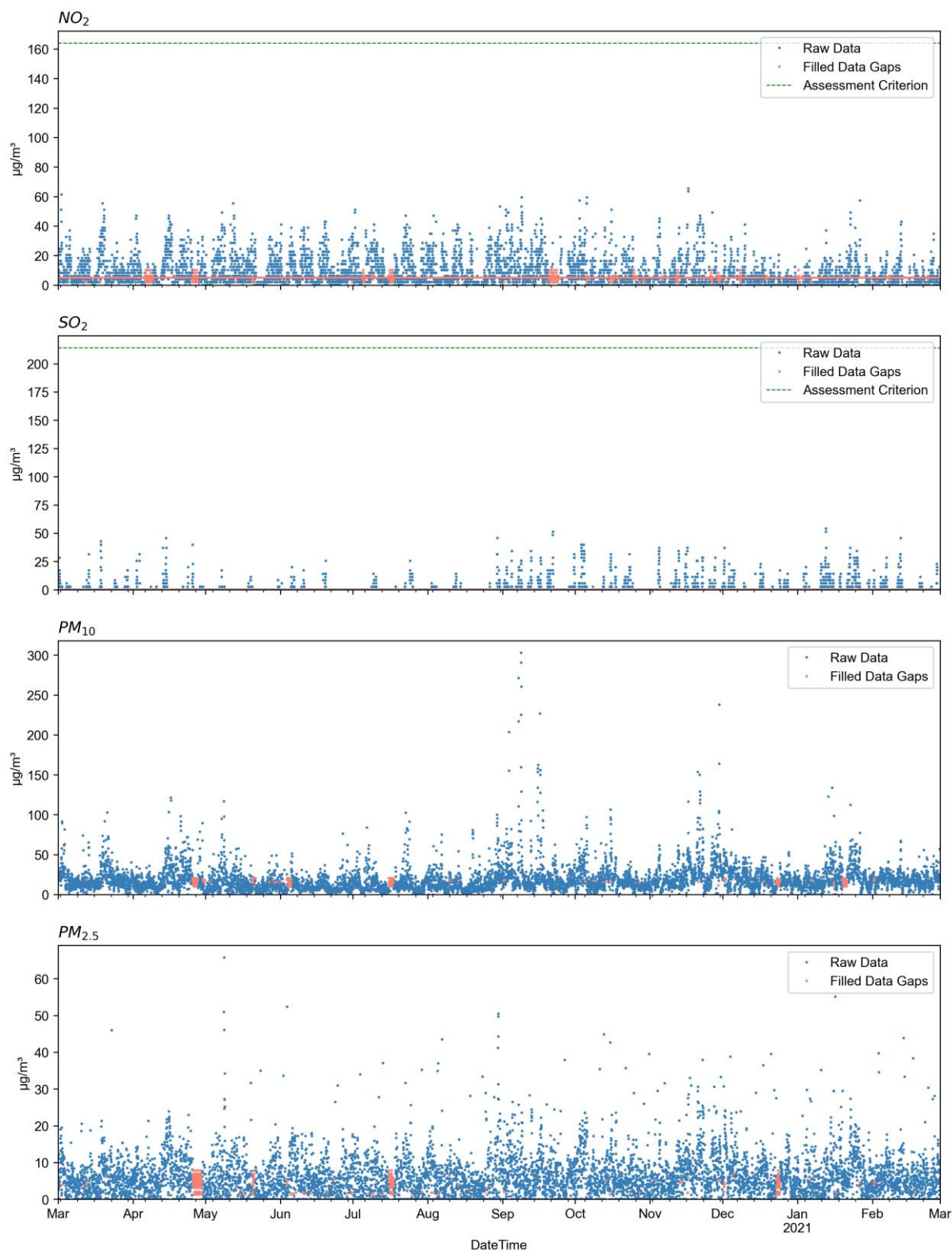


Figure 6-2 Contemporaneous background concentrations observed during the year selected for the modelling assessment (1 March 2020 to 28 February 2021)

Figure Note: Missing data for each pollutant has been filled using the observed median concentration for that pollutant by hour of day. Filled data gaps are highlighted in orange.



7 Dispersion Modelling and Impact Assessment Methodology

7.1 Selection of a representative year of meteorology

The closest Bureau of Meteorology (BoM) automatic weather station (AWS) site to the GrainCorp site is located at Port Kembla NTC AWS (Station 068253) approximately 3.5 km southeast from the site. However, this station does not record the full suite of meteorological parameters necessary to determine the representative meteorological year. The next closest BoM station (Bellambi AWS, Station 068228), located approximately 9.4 km to the north-northeast of the GrainCorp site, was therefore selected for the assessment of the meteorological inter-annual variability.

A detailed analysis of the regional meteorology collected at the Bellambi AWS over the five-year period between 1 March 2020 and 28 February 2025 was conducted to select a representative year to use for the meteorological simulation. This analysis is presented in full in Appendix A.

The selection of months based on a conventional calendar year (1 January to 31 December) would separate the summer season into two periods, nine months apart. This can be critical in some instances where the El Niño Southern Oscillation (ENSO) climatic phenomenon significantly affects the meteorology of consecutive summer seasons. The use of the March to February sequence of months provides for the inclusion of complete seasonal periods and acknowledges that the ENSO trend tends to build annually from approximately June through to March. During the autumn period between March and May, ENSO tends to transition towards the neutral state before the next cycle begins.

Based on the outcomes of the analysis, the representative one-year period between 1 March 2020 to 28 February 2021 was selected for modelling.

7.2 Meteorological modelling

The meteorological file used in the air dispersion model was prepared using the hybrid TAPM-CALMET two-stage modelling approach.

7.2.1 TAPM

The Air Pollution Model (TAPM) was developed by CSIRO for use in simulating regional meteorological and air pollution events. TAPM is a coupled mesoscale prognostic meteorological and air dispersion modelling system designed to operate on a standard desktop computer.

The TAPM model configuration is described in detail in Appendix B.

7.2.2 CALMET

CALMET is an advanced non-steady-state diagnostic three-dimensional meteorological model with micro-meteorological modules for overwater and overland boundary layers. The model is the meteorological pre-processor for the CALPUFF modelling system. CALMET can read hourly meteorological data as data assimilation from multiple sites within the modelling domain but can also be initialised with the gridded three-dimensional prognostic output from other meteorological models such as TAPM.

CALMET (version 6.5.0) was used to simulate meteorological conditions in the region.

A detailed summary of the CALMET configuration options selected is provided in Appendix C.



7.2.3 Meteorological model performance evaluation

To assess model performance, TAPM model predictions were compared against observations collected during the selected modelling period (1 March 2020 to 28 February 2021) at the BoM Bellambi site (site number 068228). This is the closest AWS site to the plant collecting a suitable range of meteorological parameters for assessment. The Bellambi AWS site lies beyond the CALMET 100 m meteorological grid, however it is within the TAPM inner (300 m) nest.

Details of the model evaluation are presented in full in Appendix D. The evaluation found that the TAPM model was considered to be suitable for use in providing initial-guess fields for the CALMET meteorological model used to drive the CALPUFF dispersion model.

7.3 Analysis of dispersion meteorology at the site

This section describes the meteorology used in the CALPUFF model that is important to the dispersion of airborne pollutants in the region surrounding the GrainCorp Port Kembla site.

Hourly CALMET meteorological predictions were extracted from the closest model grid point to the centre of the bulk liquid terminal site as follows:

- Column 36 (306.317 km E),
- Row 36 (6,185.931 km N),
- 10 m grid level,
- Modelling period: 1 March 2020 to 28 February 2021.

A detailed analysis, presented below, was conducted to describe the dispersion meteorology of the Port Kembla region, with further details provided in Appendix E.

7.3.1 Wind speed and direction

The annual distribution of winds at the GrainCorp Port Kembla site from 1 March 2020 to 28 February 2021 is presented in Figure 7-1.

- The prevailing winds arrive from the north-northeast (10.9%) and northeast (10.2%), with the second-most frequent winds arriving from the west-southwest (9.0%) and west (8.3%) directions. Together these winds account for 38.3% of all winds.
- Most winds (97.4%) are below 4 m/s in speed, ranging from calm to gentle breeze conditions.
- Calm periods (winds < 0.5 m/s) occur on 2.8% of occasions.
- Light winds (0.5-2.0 m/s) arrive from all cardinal wind directions and are most prominent from the north-northeast (9.5%).
- The highest predicted wind speeds were in the 4 to 6 m/s range (gentle to moderate breezes) and were largely confined to the southwest quadrant. The overall maximum predicted wind speed

In summary, the wind distribution is skewed towards light to gentle breezes arriving from the north-northeast and west-southwest sectors.

The mean annual, seasonal and diurnal wind speeds, and the frequency of calms at the GrainCorp site, are presented in Table 7-1.

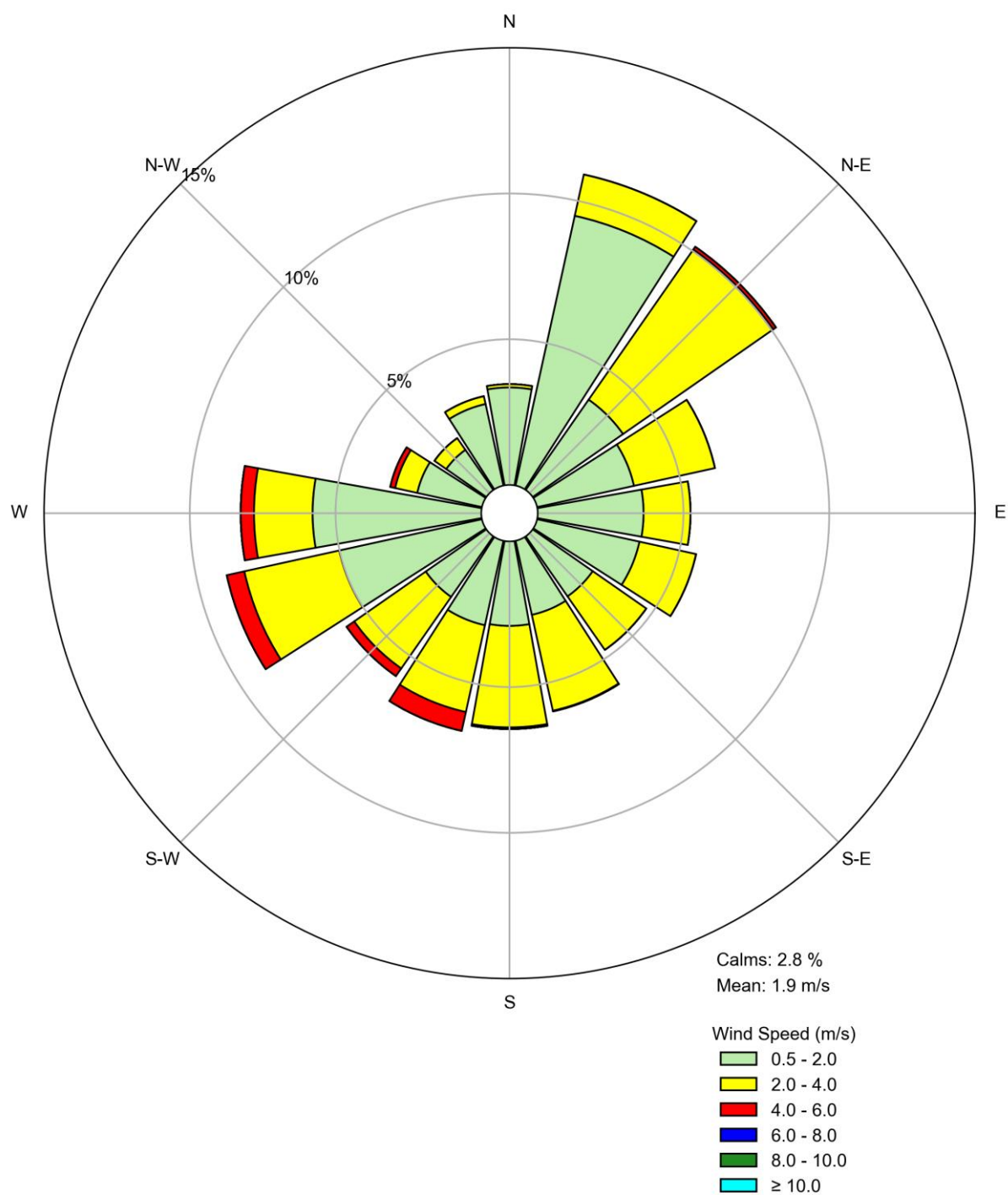


Figure 7-1 Annual distribution of winds at the GrainCorp Port Kembla site, 1 March 2020 to 28 February 2021



Table 7-1 Annual, seasonal and diurnal mean wind speeds at the GrainCorp Port Kembla site, 1 March 2020 to 28 February 2021

Period	Mean Wind Speed (m/s)	Calms (%)
Annual	1.9	2.8
Summer	1.8	2.5
Autumn	1.8	2.5
Winter	1.9	2.4
Spring	1.8	3.7
Night: Midnight to 6am	1.5	4.6
Morning: 6am to Midday	2.0	2.6
Afternoon: Midday to 6pm	2.3	0.1
Evening: 6pm to midnight	1.5	3.7

7.3.2 Air temperature

The diurnal and monthly variation in air temperature at the GrainCorp site is presented in Figure 7-2. The figure shows temperatures varying between 7 °C and 38 °C. The predicted mean and median temperatures are 17.8 °C and 17.9 °C respectively. High daytime temperatures, those above 31 °C, tend to occur between December and April. The coldest nights occur between June and October.

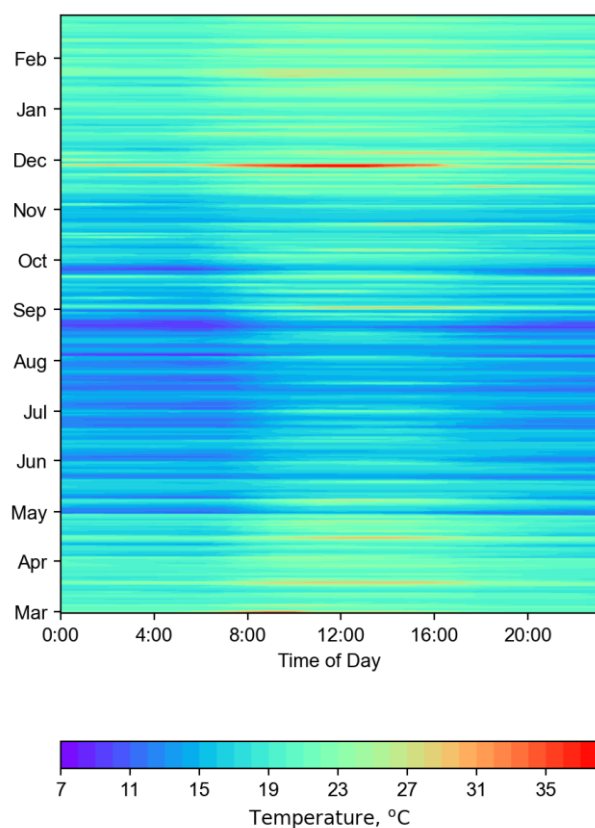


Figure 7-2 Diurnal and monthly variation in air temperature at the GrainCorp Bulk Liquid Terminal site, 1 March 2020 to 28 February 2021



7.4 CALPUFF model and pollutant emission source configuration

7.4.1 Model configuration

CALPUFF is a non-steady-state Gaussian puff model containing parameterisations for complex terrain effects, overwater transport, coastal interaction effects, building downwash, and wet and dry removal processes. CALPUFF employs the three-dimensional meteorological fields generated from the CALMET model by simulating the effects of time and space-varying meteorological conditions on plume transport, transformation and depletion.

Emission sources, their characteristics, and emission rates were incorporated into the CALPUFF dispersion model. The model was configured following recommended settings defined in the NSW Modelling Guidance document (TRC, 2011).

A detailed description of the CALPUFF configuration options selected is provided in Appendix F.

7.4.2 Configuration of emission sources within the model

Three emission sources were configured within the CALPUFF dispersion model. The proposed two boiler stacks were each modelled as point sources, rising to a height of 21 m (three metres above the adjacent bulk storage tanks). The 21 m boiler stack heights were determined on the basis of a stack sizing study, as described in Appendix G. The diesel storage tank was modelled as a single volume source. These sources are shown in Figure 7-3, with the detailed model configuration options provided in Table 7-2 (volume source characterising the diesel storage tank), and Table 7-3 (point sources characterising the proposed boiler stacks).



Figure 7-3 Emission sources included in the model

Figure note: The proposed two boiler stacks are modelled as point sources and are shown in red. The diesel storage tank is modelled as a volume source and is shown in blue.



Table 7-2 Volume source configuration

Parameters of diesel storage tank	Value
Source ID	TK-102
Effective height (m)	8.12
Sigma Y ₀ (m)	0.8
Sigma Z ₀ (m)	3.78
Easting (mE, WGS-84)	306,421.6
Northing (mN, WGS-84)	6,186,121.4
Base elevation (m)	6.05

Table 7-3 Point source configuration

Parameters of the boiler stacks	Boiler 1 (2.5 MW)	Boiler 2 (1.3 MW)
Source ID	BOIL1	BOIL2
Stack height (m)	21	21
Stack Diameter (m)	0.40	0.253
Exit Velocity (m/s)	6.87	8.81
Exit Temperature (K)	487	458
Easting (mE, WGS-84)	306450	306451
Northing (mN, WGS-84)	6186098	6186101
Base elevation (m)	6.77	6.57

Each source was configured with a unit emission rate (1 g/s) to allow detailed modelling scenarios to be developed during post-processing stages by multiplying model predictions for each source by the adopted source emission rate.

7.4.3 Buildings and structures

Twenty-one buildings and structures were configured within the model to account for building wake effects possibly affecting dispersion of emissions from the proposed boiler house stack as described in Table 7-4. These buildings are shown in Figure 7-4 in relation to the proposed southern-most boiler stack (Boiler 1). The additional five bulk storage tanks proposed for the upgrade were not included within the building model as the boiler house stacks lie beyond the area of influence of each of these proposed tanks.

Table 7-4 Building dimensions and locations

Building ID	Description	Base elevation (m)	Building height (m)	X length (m)	Y length (m)	Rotation angle (°)	SW corner easting (mE, WGS-84)	SW corner northing (mN, WGS-84)
BOILER	Boiler House	6.78	4.6	6	12	-4	306,448.4	6,186,094.8
SITEHUT	Site Hut	6.85	2.7	3	6	-4	306,448	6,186,088.8
LABHUT	Laboratory Hut	6.88	2.7	3	6	-4	306,451	6,186,088.6



Building ID	Description	Base elevation (m)	Building height (m)	X length (m)	Y length (m)	Rotation angle (°)	SW corner easting (mE, WGS-84)	SW corner northing (mN, WGS-84)
SWITCH	Switchboard Building	6.8	2.1	3.45	8.78	-4	306,444.2	6,186,090.6
GANTRY 1	Gantry 1	6.85	6.3	11.85	7.21	-4	306,427.8	6,186,081.4
GANTRY 2	Gantry 2	6.82	6.3	11.78	6.94	-4	306,385.2	6,186,086.7
TK-01	Bulk Storage Tank: TK-01	6.65	18.2	-	-	-	306,437.0	6,186,095.9
TK-02	Bulk Storage Tank: TK-02	6.44	18.2	-	-	-	306,438.6	6,186,109.2
TK-03	Bulk Storage Tank: TK-03	6.54	18.2	-	-	-	306,423.7	6,186,097.5
TK-04	Bulk Storage Tank: TK-04	6.21	18.2	-	-	-	306,425.2	6,186,110.7
TK-05	Bulk Storage Tank: TK-05	6.43	18.2	-	-	-	306,410.4	6,186,099.0
TK-06	Bulk Storage Tank: TK-06	6.18	18.2	-	-	-	306,411.9	6,186,112.3
TK-07	Bulk Storage Tank: TK-07	6.02	18.2	-	-	-	306,413.5	6,186,125.6
TK-08	Bulk Storage Tank: TK-08	6.54	18.2	-	-	-	306,397.1	6,186,100.5
TK-09	Bulk Storage Tank: TK-09	6.28	18.2	-	-	-	306,398.6	6,186,113.8
TK-10	Bulk Storage Tank: TK-10	6.16	18.2	-	-	-	306,400.2	6,186,127.2
TK-101	Slops Tank: TK-101	6.09	7.79	-	-	-	306,425.8	6,186,120.2
TK-102	Diesel Storage Tank: TK-102	6.05	8.12	-	-	-	306,421.6	6,186,121.4
ADJ_TK1	Adjacent Tank 1	7.47	18.2	-	-	-	306,506.7	6,186,066.5
ADJ_TK2	Adjacent Tank 2: ADJ_TK2	7.14	18.2	-	-	-	306,510.0	6,186,082
ADJ_TK3	Adjacent Tank 3: ADJ_TK3	6.97	18.2	-	-	-	306,512.8	6,186,097
ADJ_TOWER	Adjacent Tower	7.01	20	8	8	-7	306,496.4	6,186,090.0
ADJ_BUILD	Adjacent Building	7.28	4.6	6	27.35	-7	306,487.3	6,186,068.4



Figure 7-4 Building and structure locations in relation to the Boiler 1 stack
 Figure note The Boiler 1 stack location is shown in red

7.4.4 Model receptors

7.4.4.1 Gridded receptors

The CALPUFF sampling grid is spaced at a 100 m grid resolution covering a 9 km by 9 km extent centred over the site. The sampling grid is fully described in Table 7-5.

Table 7-5 Characteristics of the CALPUFF sampling (receptor) grid

Parameter	Value
Columns	91
Rows	91
Grid Resolution (m)	100
Minimum Easting (mE, WGS-84)	301,817.0
Maximum Easting (mE, WGS-84)	310,817.0
Minimum Northing (mE, WGS-84)	6,181,431.2
Maximum Northing (mE, WGS-84)	6,190,431.2
West-East Extent (m)	9,100
South-North Extent (m)	9,100



7.4.4.2 Sensitive receptors

The sensitive receptors of interest surrounding the GrainCorp Bulk Liquid Terminal site are identified in Table 7-6 and Figure 7-5, which also shows the extent of the site boundary.

Table 7-6 Sensitive receptor locations

Receptor	Easting (mE, GDA2020)	Northing (mN, GDA2020)	Name
1	306,760.4	6,185,700.0	Koch Fertiliser
2	306,767.9	6,186,014.0	Quatro ports
3	306,343.0	6,186,019.0	Incitec Pivot
4	306,250.3	6,186,097.0	RORO/Car Terminal
5	306,446.6	6,186,216.0	Auto Nexus
6	306,905.5	6,186,134.0	Coal loading point
7	307,051.0	6,186,383.0	Wollongong Beach
8	306,447.0	6,186,893.0	Wollongong greenhouse park
9	305,207.0	6,186,832.0	Residential premises 1
10	305,841.0	6,187,176.0	Coniston public school
11	306,461.0	6,187,166.0	J J Kelly Park
12	306,432.0	6,187,556.0	Residential Premises 2
13	306,933.0	6,187,482.0	Residential Premises 3
14	307,013.0	6,188,118.0	Golf Club
15	306,139.0	6,188,558.0	Specialist Mental Health facility
16	305,444.0	6,188,725.0	Wollongong Hospital

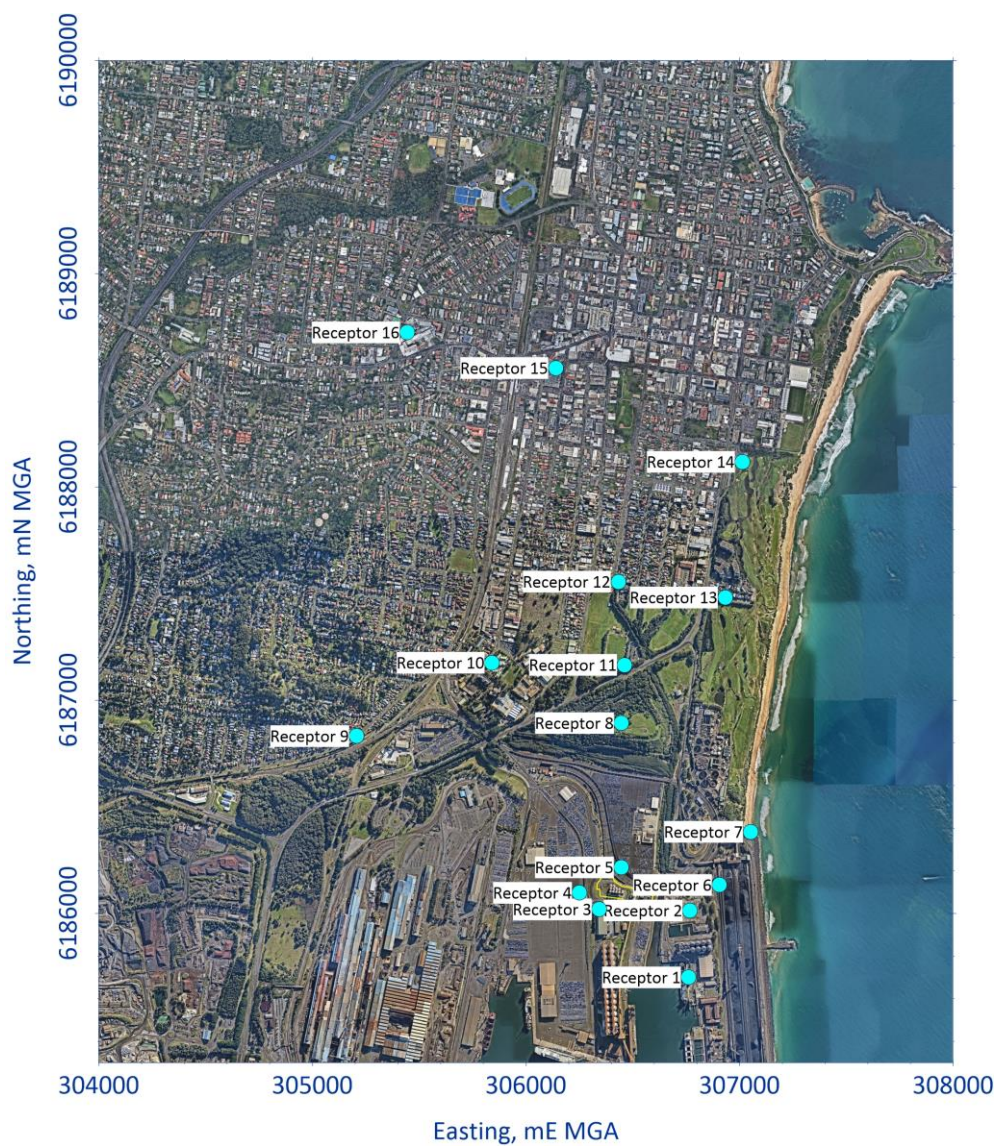


Figure 7-5 Sensitive receptor locations
Figure note: The GrainCorp site boundary is shown in yellow.



8 Air Quality Impact Assessment

The two boilers release a separate range of pollutants than the diesel storage tank, with no pollutants in common between the two sources. The boilers and diesel storage tank can therefore be assessed separately.

Given the large number of pollutants assessed, isopleth plots are only produced in cases where the maximum concentrations at and beyond the site boundary are greater than ten per cent of their respective criteria. Model predictions for the 'minor pollutants' that are not plotted are provided in tables, showing predicted impacts at sensitive receptor locations.

8.1 Boiler emissions

8.1.1 Nitrogen dioxide

The maximum 1-hour average incremental and cumulative nitrogen dioxide predictions for Boilers 1 and 2, each running at a constant peak load, are shown in Figure 8-1 and Figure 8-2 respectively. The respective annual average predictions are provided in Figure 8-3 and Figure 8-4. Model predictions for sensitive receptor locations are provided in Table 8-1.

The results show that the two boilers in isolation account for approximately 81% and 15% of the respective 1-hour and annual average assessment criteria, with the greatest impacts occurring at the site boundary. When an hourly-varying background is added, the greatest offsite cumulative impact account for approximately 93% and 39% of the respective 1-hour and annual average assessment criteria. The most exposed sensitive receptor is R3 (Incitec Pivot) reaching a cumulative 1-hour maximum prediction of $80.5 \mu\text{g}/\text{m}^3$ (49.1% of the 1-hour impact assessment criterion).

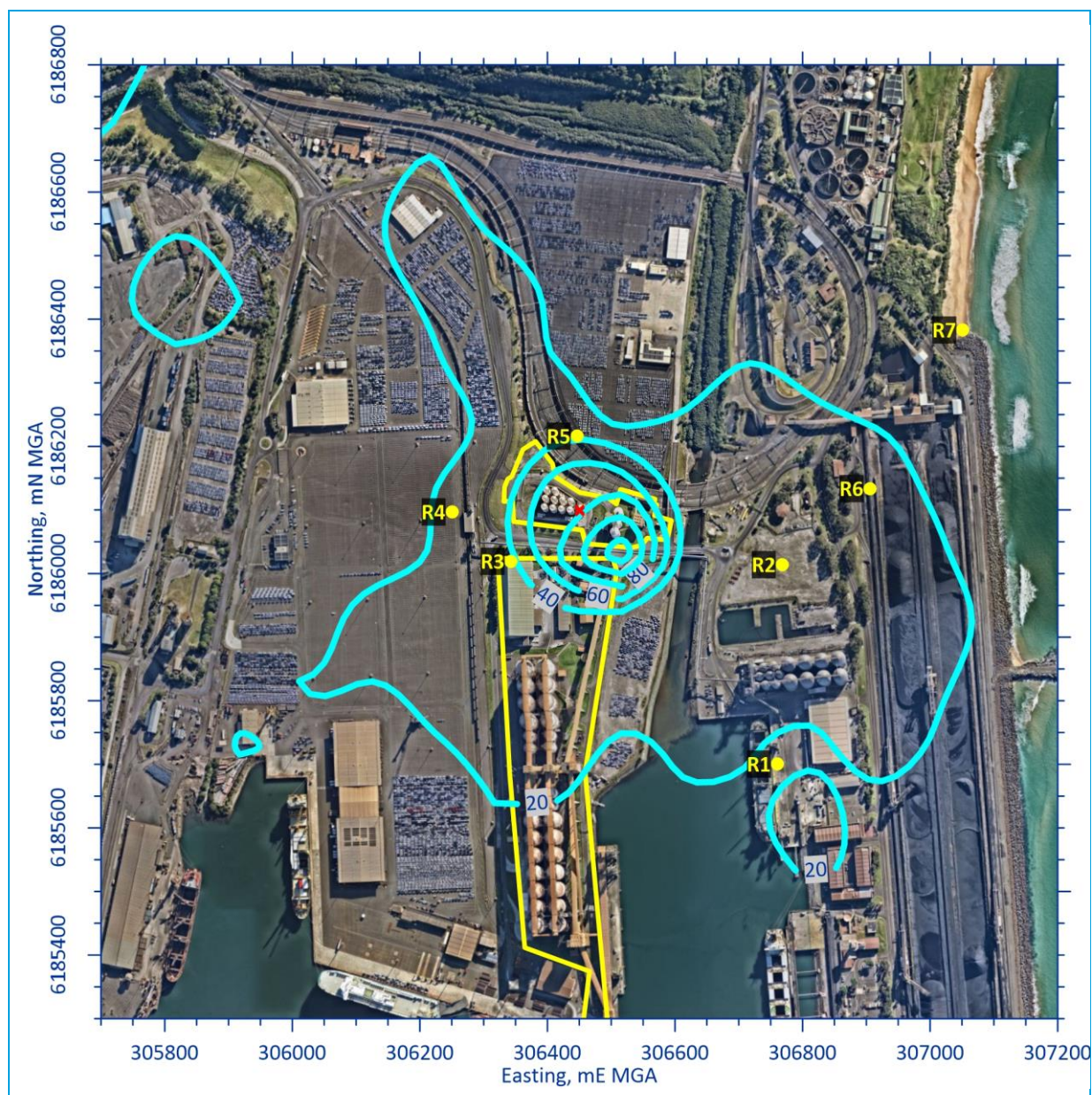


Figure 8-1 Predicted incremental 1-hour maximum ground-level NO₂ concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Incremental 1-hour maximum ground level NO ₂ concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers	Units: µg/m ³
Contours: 20, 40, 60, 80, 100, and 120 µg/m ³	Assessment criterion: 164 µg/m ³
Data source: CALPUFF	Prepared by: M. Power
Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales	Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.

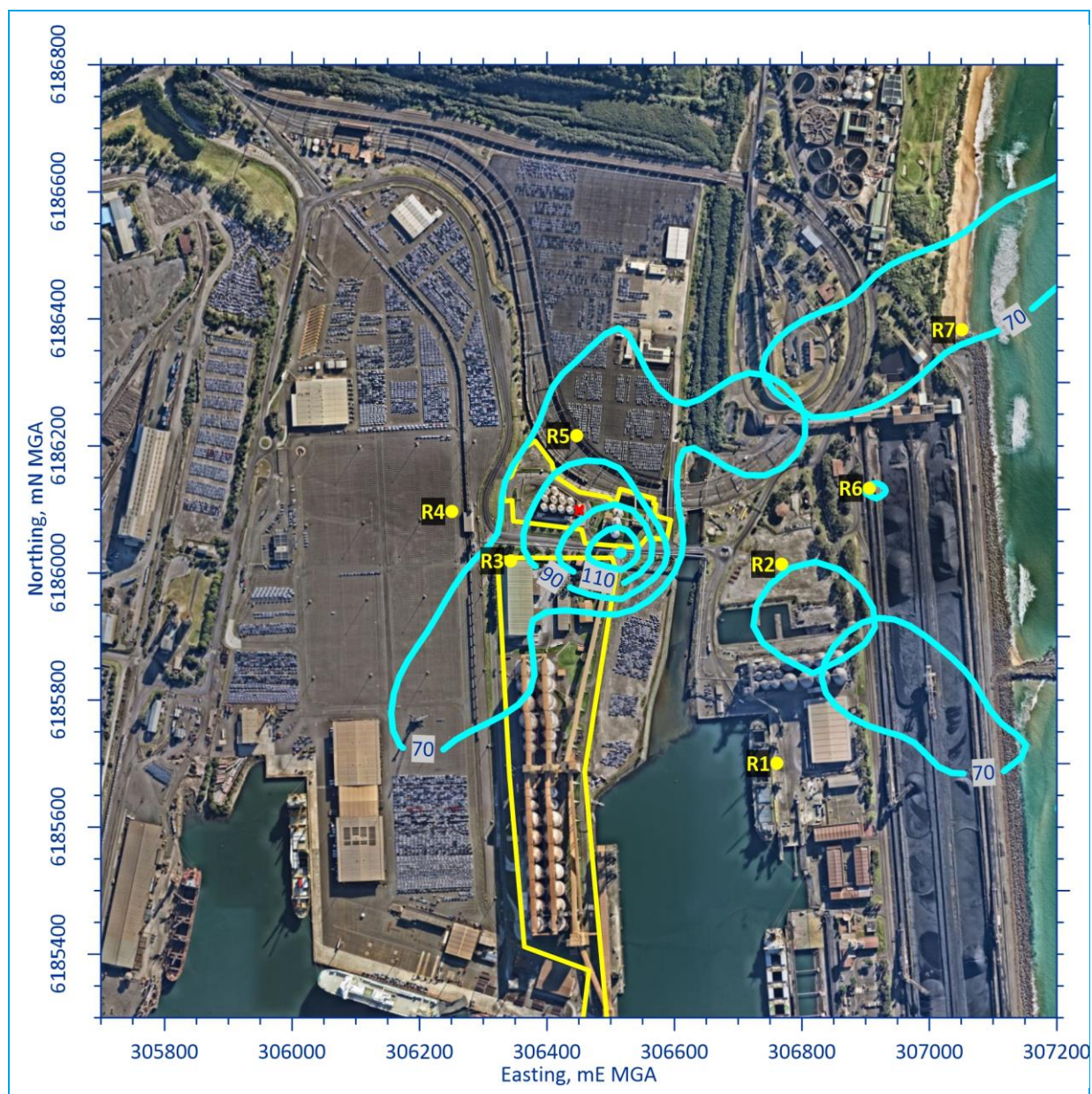


Figure 8-2 Predicted cumulative 1-hour maximum ground-level NO₂ concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Cumulative 1-hour maximum ground level NO ₂ concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers	Units: µg/m ³
Contours: 70, 90, 110, 130, 100, and 150 µg/m ³	Assessment criterion: 164 µg/m ³
Data source: CALPUFF	Prepared by: M. Power
Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales	Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.



Figure 8-3 Predicted incremental annual average ground-level NO₂ concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Incremental annual average ground level NO ₂ concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers	Units: µg/m ³
Contours: 1, 2, and 4 µg/m ³	Assessment criterion: 31 µg/m ³
Data source: CALPUFF	Prepared by: M. Power
Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales	Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.

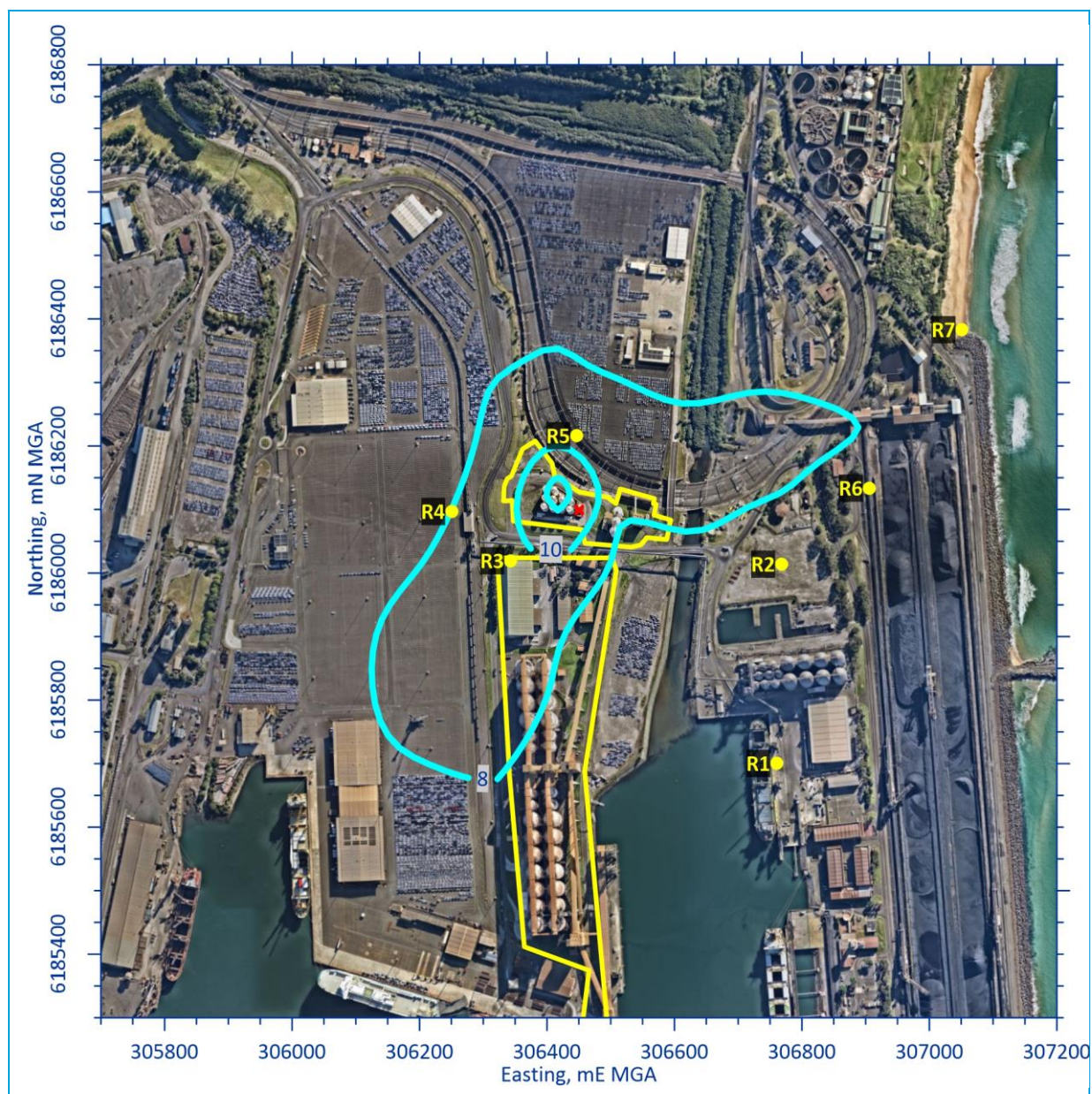


Figure 8-4 Predicted cumulative annual average ground-level NO₂ concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Cumulative annual average ground level NO₂ concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers

Units: µg/m³

Contours: 8, 10, and 12 µg/m³

Assessment criterion: 31 µg/m³

Data source: CALPUFF

Prepared by: M. Power

Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales

Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.



Table 8-1 Predicted nitrogen dioxide concentrations at sensitive receptor locations

Sensitive receptor	One-hour maximum concentration, $\mu\text{g}/\text{m}^3$		Annual average concentration, $\mu\text{g}/\text{m}^3$	
	Incremental	Cumulative	Incremental	Cumulative
Impact assessment criterion ($\mu\text{g}/\text{m}^3$)	-	164	-	31
R1	19.7 (12.0%)	65.6 (40.0%)	0.1 (0.4%)	7.4 (23.8%)
R2	31.7 (19.3%)	68.5 (41.8%)	0.4 (1.3%)	7.7 (24.7%)
R3	37.3 (22.7%)	80.5 (49.1%)	2.2 (7.0%)	9.4 (30.5%)
R4	21.3 (13.0%)	66.2 (40.4%)	0.8 (2.7%)	8.1 (26.1%)
R5	32.9 (20.0%)	76.8 (46.8%)	1.8 (5.7%)	9.0 (29.1%)
R6	24.8 (15.1%)	70.1 (42.7%)	0.5 (1.7%)	7.8 (25.1%)
R7	12.8 (7.8%)	72.8 (44.4%)	0.4 (1.2%)	7.6 (24.6%)
R8	15.2 (9.3%)	65.6 (40.0%)	0.2 (0.6%)	7.5 (24.0%)
R9	12.0 (7.3%)	65.6 (40.0%)	0.1 (0.2%)	7.3 (23.7%)
R10	18.2 (11.1%)	65.6 (40.0%)	0.1 (0.3%)	7.4 (23.7%)
R11	8.2 (5.0%)	65.6 (40.0%)	0.1 (0.3%)	7.4 (23.8%)
R12	9.8 (6.0%)	65.6 (40.0%)	0.1 (0.2%)	7.3 (23.7%)
R13	7.0 (4.3%)	65.6 (40.0%)	0.1 (0.2%)	7.3 (23.6%)
R14	10.6 (6.5%)	65.6 (40.0%)	0.0 (0.1%)	7.3 (23.6%)
R15	13.9 (8.5%)	65.6 (40.0%)	0.0 (0.1%)	7.3 (23.6%)
R16	5.0 (3.0%)	65.6 (40.0%)	0.0 (0.1%)	7.3 (23.5%)
Maximum at and beyond the site boundary	132.4 (80.7%)	152.9 (93.2%)	4.8 (15.3%)	12.0 (38.8%)

Table note: The values in brackets show the percentage of the respective impact assessment criterion

8.1.2 Sulfur dioxide

The maximum 1-hour average incremental and cumulative sulfur dioxide predictions for Boilers 1 and 2, each running at a constant peak load, are shown in Figure 8-5 and Figure 8-6 respectively. The respective 24-hour average predictions are provided in Figure 8-7 and Figure 8-8. Model predictions for sensitive receptor locations are provided in Table 8-2.

The results show that the two boilers in isolation only account for approximately 0.6% and 0.9% of the respective 1-hour and 24-hour assessment criteria beyond the site boundary. When an hourly-varying background is added, the greatest offsite cumulative impacts account for approximately 25% and 29% of the respective 1-hour and 24-hour assessment criteria. The most exposed sensitive receptor is R3 (Incitec Pivot) reaching a cumulative 1-hour maximum prediction of $54.4 \mu\text{g}/\text{m}^3$ (25.4% of the 1-hour impact assessment criterion).

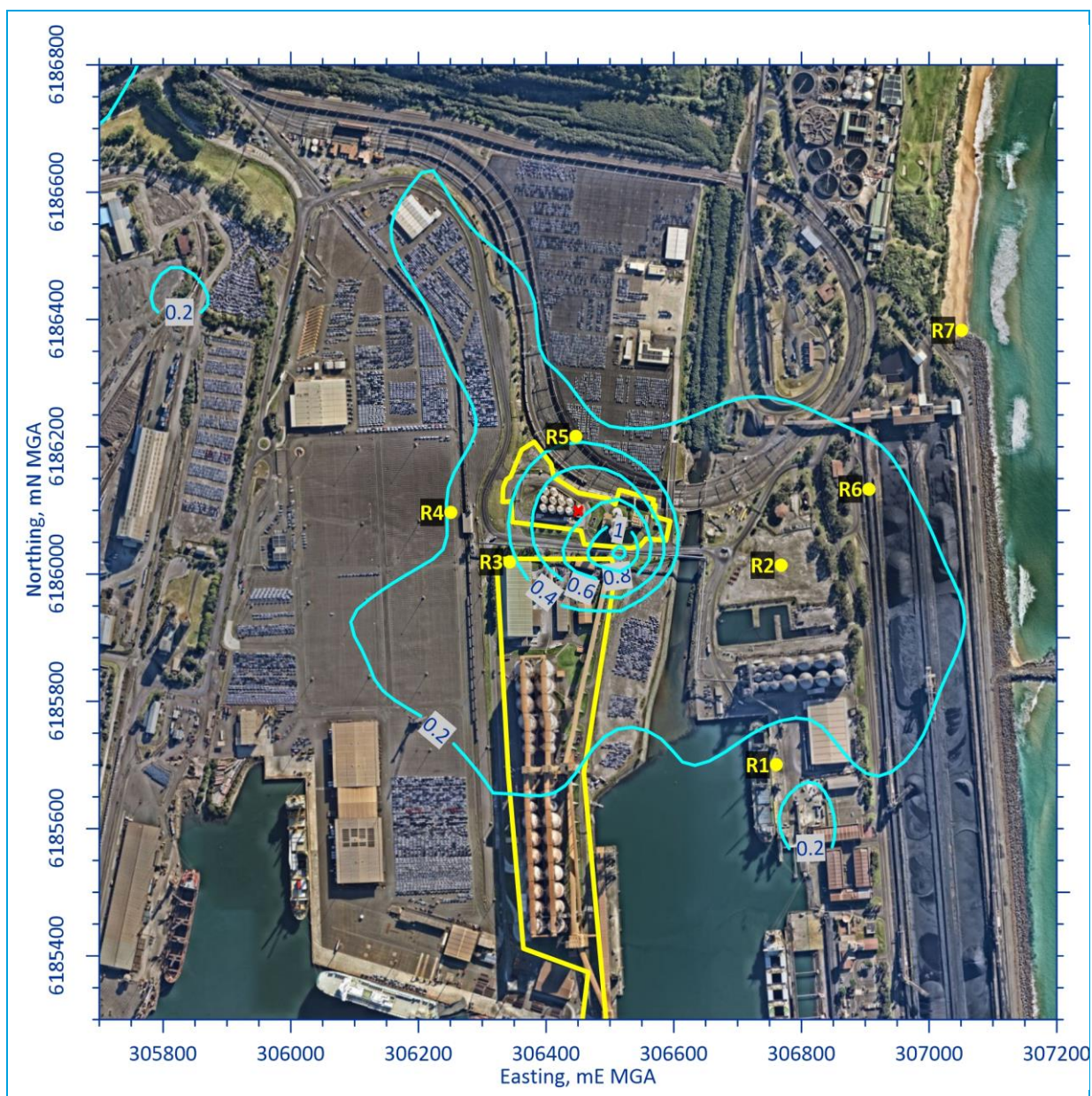


Figure 8-5 Predicted incremental 1-hour maximum ground-level SO₂ concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Incremental 1-hour maximum ground level SO₂ concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers

Units: µg/m³

Contours: 0.2, 0.4, 0.6, 0.8, 1, and 1.2 µg/m³

Assessment criterion: 214 µg/m³

Data source: CALPUFF

Prepared by: M. Power

Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales

Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.

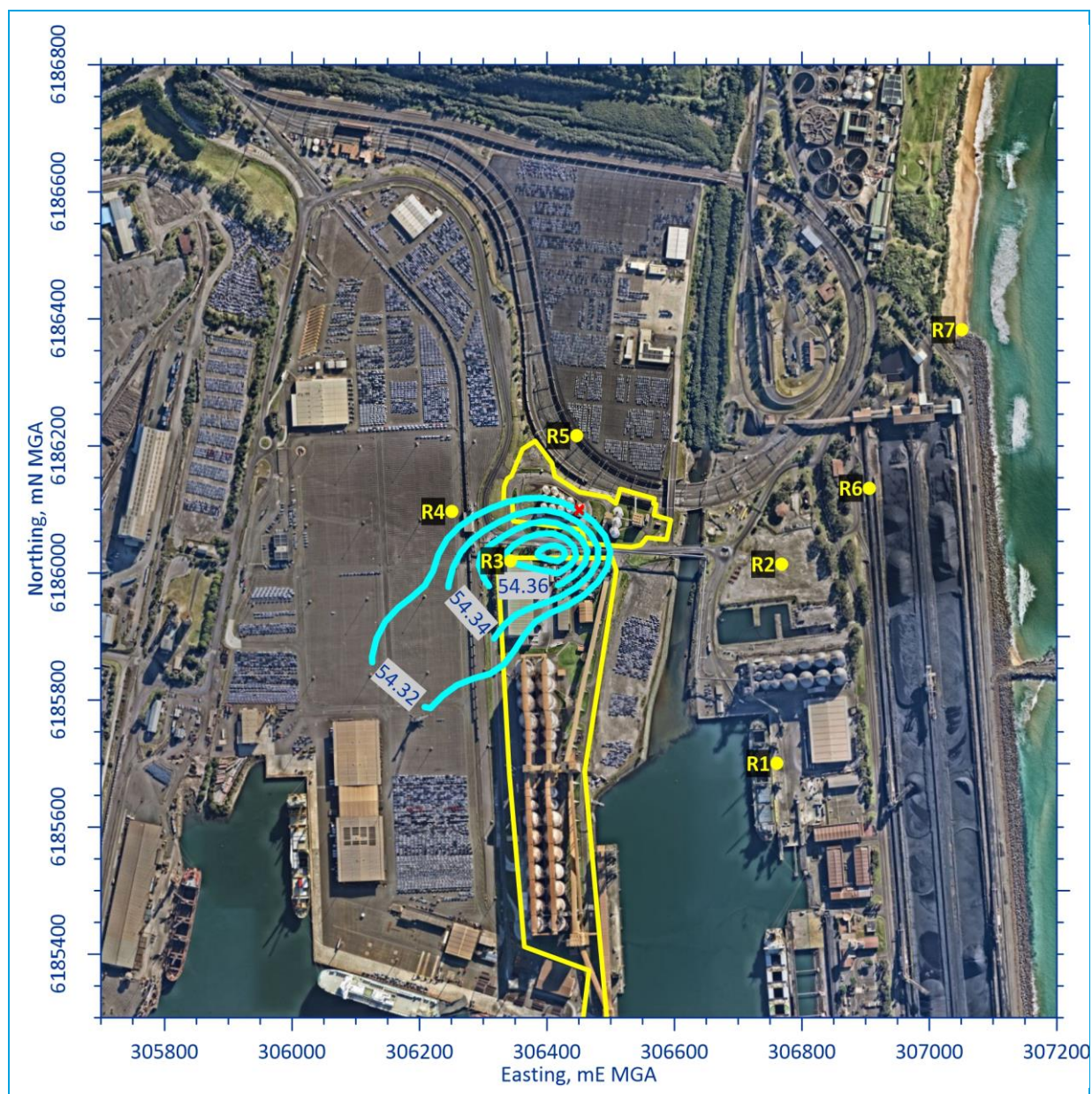


Figure 8-6 Predicted cumulative 1-hour maximum ground-level SO₂ concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Cumulative 1-hour maximum ground level SO ₂ concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers	Units: µg/m ³
Contours: 54.32, 54.34, 54.36, 54.38, and 54.40 µg/m ³	Assessment criterion: 214 µg/m ³
Data source: CALPUFF	Prepared by: M. Power
Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales	Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.

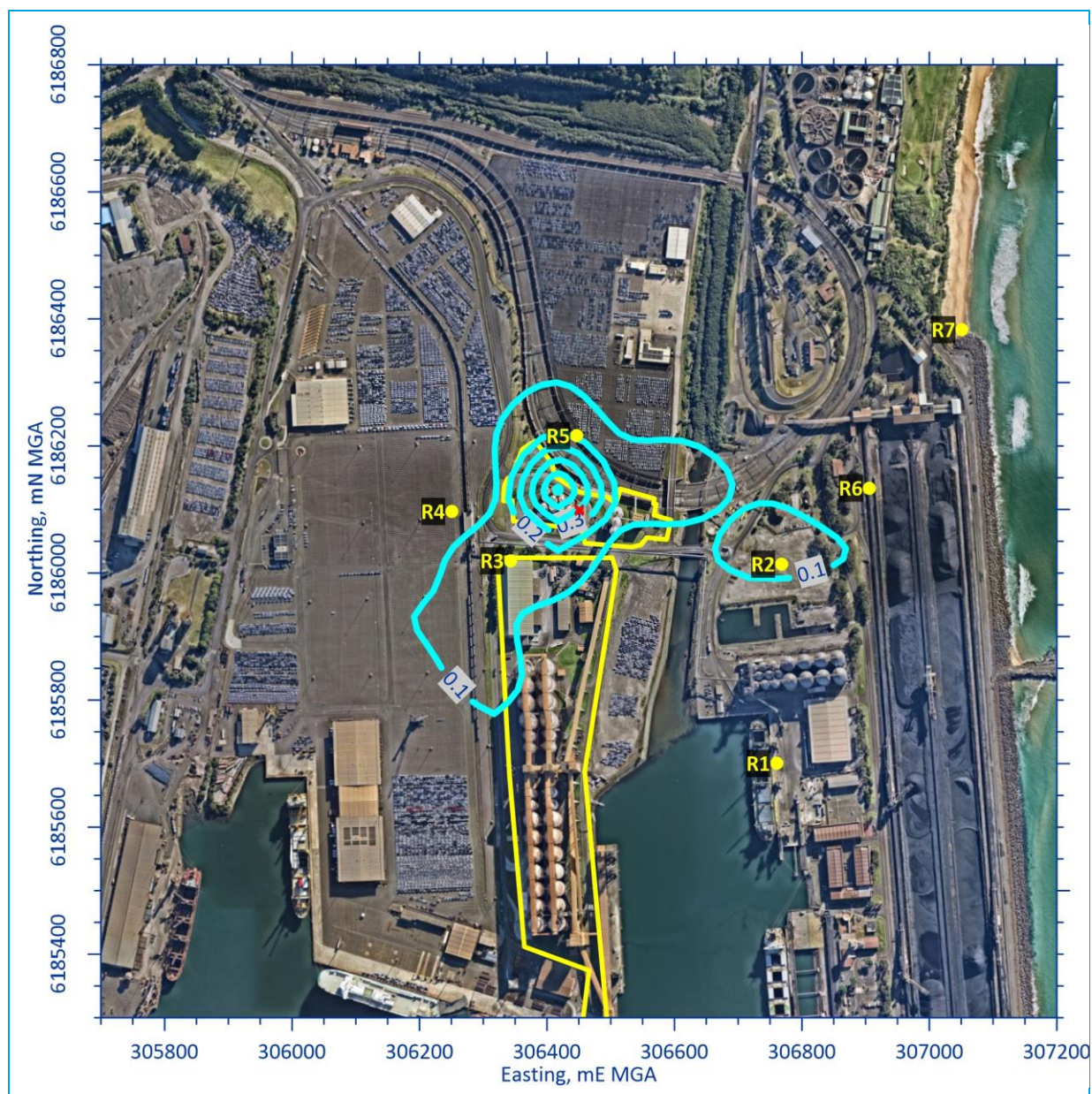


Figure 8-7 Predicted incremental 24-hour maximum ground-level SO₂ concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal:

Assessment scenario: Incremental 24-hour maximum ground level SO ₂ concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers	Units: µg/m ³
Contours: 0.1, 0.2, 0.3, 0.4, 0.5, and 0.6 µg/m ³	Assessment criterion: 57 µg/m ³
Data source: CALPUFF	Prepared by: M. Power
Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales	Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.

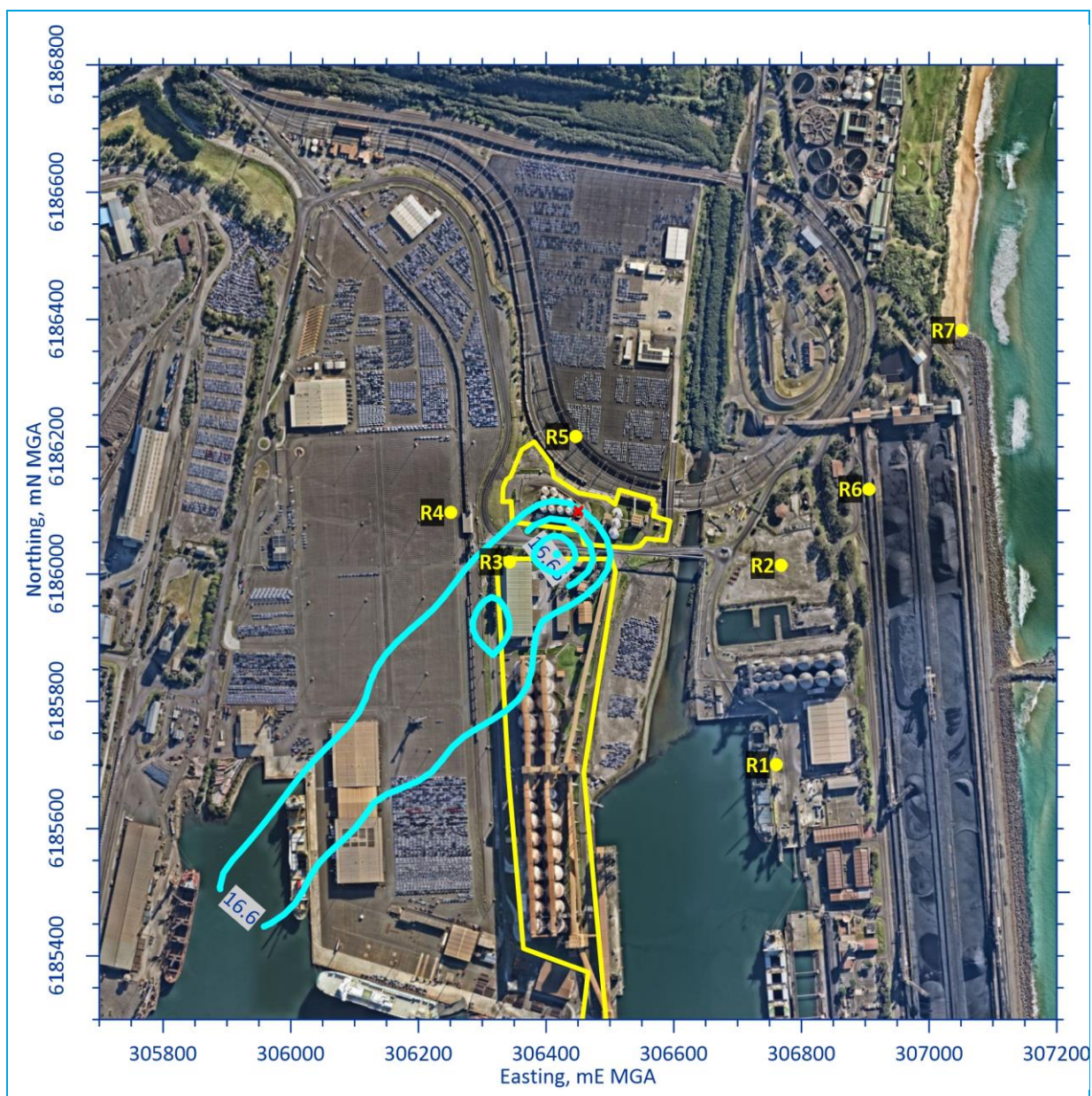


Figure 8-8 Predicted cumulative 24-hour maximum ground-level SO₂ concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Cumulative 24-hour maximum ground level SO ₂ concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers	Units: µg/m ³
Contours: 16.6, 16.65, and 16.7 µg/m ³	Assessment criterion: 57 µg/m ³
Data source: CALPUFF	Prepared by: M. Power
Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales	Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.



Table 8-2 Predicted sulfur dioxide concentrations at sensitive receptor locations

Sensitive receptor	One-hour maximum concentration, $\mu\text{g}/\text{m}^3$		24-hour average concentration, $\mu\text{g}/\text{m}^3$	
	Incremental	Cumulative	Incremental	Cumulative
Impact assessment criterion ($\mu\text{g}/\text{m}^3$)	-	214	-	57
R1	0.2 (0.1%)	54.3 (25.4%)	0.0 (0.1%)	16.6 (29.1%)
R2	0.3 (0.1%)	54.3 (25.4%)	0.1 (0.2%)	16.6 (29.1%)
R3	0.4 (0.2%)	54.4 (25.4%)	0.2 (0.3%)	16.6 (29.2%)
R4	0.2 (0.1%)	54.3 (25.4%)	0.1 (0.1%)	16.6 (29.1%)
R5	0.3 (0.1%)	54.3 (25.4%)	0.2 (0.3%)	16.6 (29.1%)
R6	0.2 (0.1%)	54.3 (25.4%)	0.1 (0.1%)	16.6 (29.1%)
R7	0.1 (0.1%)	54.3 (25.4%)	0.0 (0.1%)	16.6 (29.1%)
R8	0.1 (0.1%)	54.3 (25.4%)	0.0 (0.0%)	16.6 (29.1%)
R9	0.1 (0.1%)	54.3 (25.4%)	0.0 (0.0%)	16.6 (29.1%)
R10	0.2 (0.1%)	54.3 (25.4%)	0.0 (0.0%)	16.6 (29.1%)
R11	0.1 (0.0%)	54.3 (25.4%)	0.0 (0.0%)	16.6 (29.1%)
R12	0.1 (0.0%)	54.3 (25.4%)	0.0 (0.0%)	16.6 (29.1%)
R13	0.1 (0.0%)	54.3 (25.4%)	0.0 (0.0%)	16.6 (29.1%)
R14	0.1 (0.0%)	54.3 (25.4%)	0.0 (0.0%)	16.6 (29.1%)
R15	0.1 (0.1%)	54.3 (25.4%)	0.0 (0.0%)	16.6 (29.1%)
R16	0.0 (0.0%)	54.3 (25.4%)	0.0 (0.0%)	16.6 (29.1%)
Maximum at and beyond the site boundary	1.3 (0.6%)	54.4 (25.4%)	0.5 (0.9%)	16.8 (29.4%)

Table note: The values in brackets show the percentage of the respective impact assessment criterion

8.1.3 Particles as $\text{PM}_{2.5}$

The maximum 24-hour average incremental and cumulative $\text{PM}_{2.5}$ predictions for Boilers 1 and 2, each running at a constant peak load, are shown in Figure 8-9 and Figure 8-10 respectively. The respective annual average predictions are provided in Figure 8-11 and Figure 8-12. Model predictions for sensitive receptor locations are provided in Table 8-3.

The results show that the hourly-varying background is high compared to the incremental impact of the two boilers in isolation. The highest incremental offsite $\text{PM}_{2.5}$ concentrations only account for approximately 4.2% and 1.0% of the respective 24-hour and annual average assessment criteria. When an hourly-varying background is added, the greatest offsite cumulative impacts account for approximately 86% and 82% of the respective 24-hour and annual average assessment criteria.

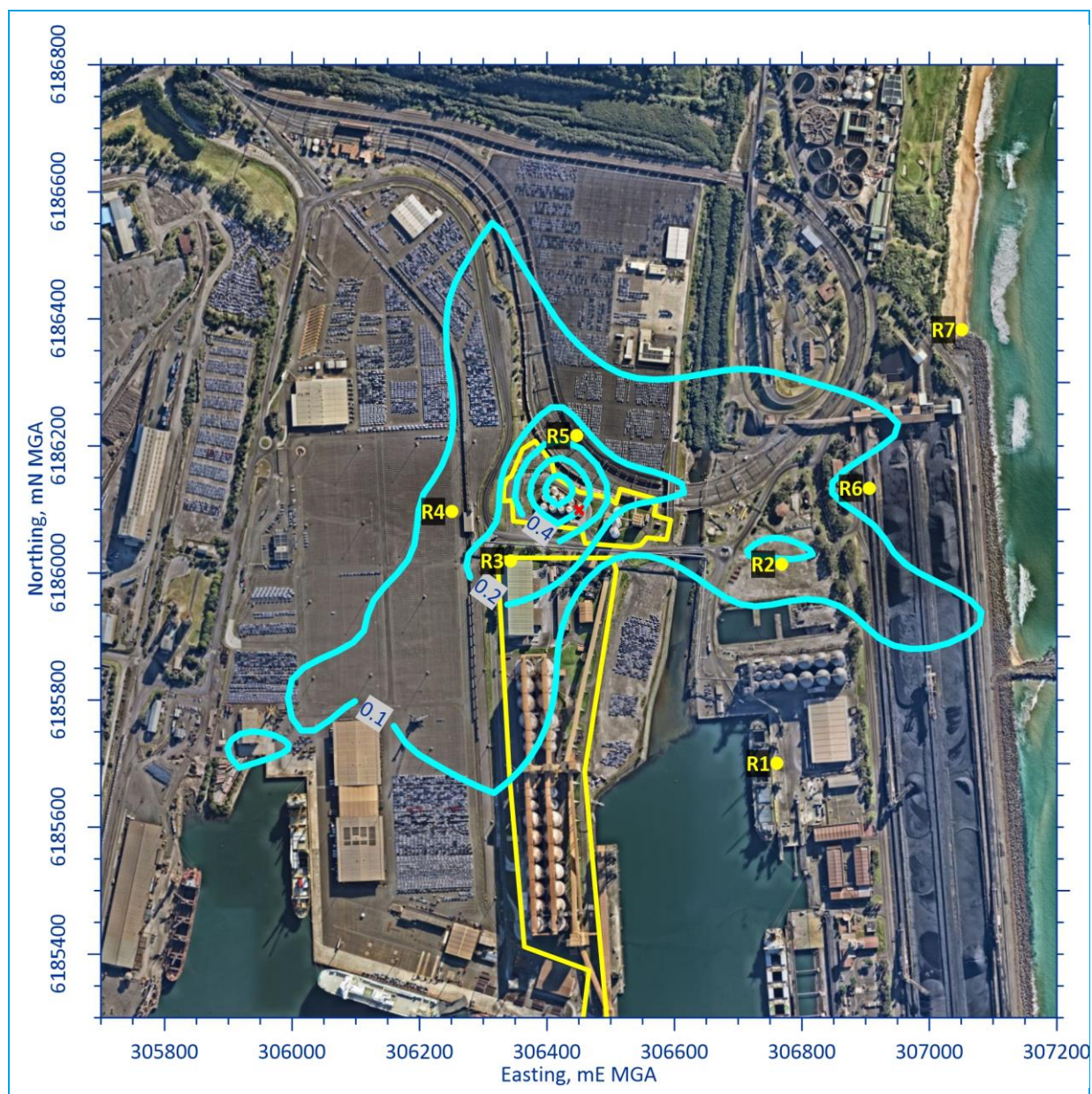


Figure 8-9 Predicted incremental maximum 24-hour average ground-level $PM_{2.5}$ concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Incremental maximum 24-hour average ground level $PM_{2.5}$ concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers

Units: $\mu g/m^3$

Contours: 0.1, 0.2, 0.4, 0.6, and 0.8 $\mu g/m^3$

Assessment criterion: 20 $\mu g/m^3$

Data source: CALPUFF

Prepared by: M. Power

Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales

Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.

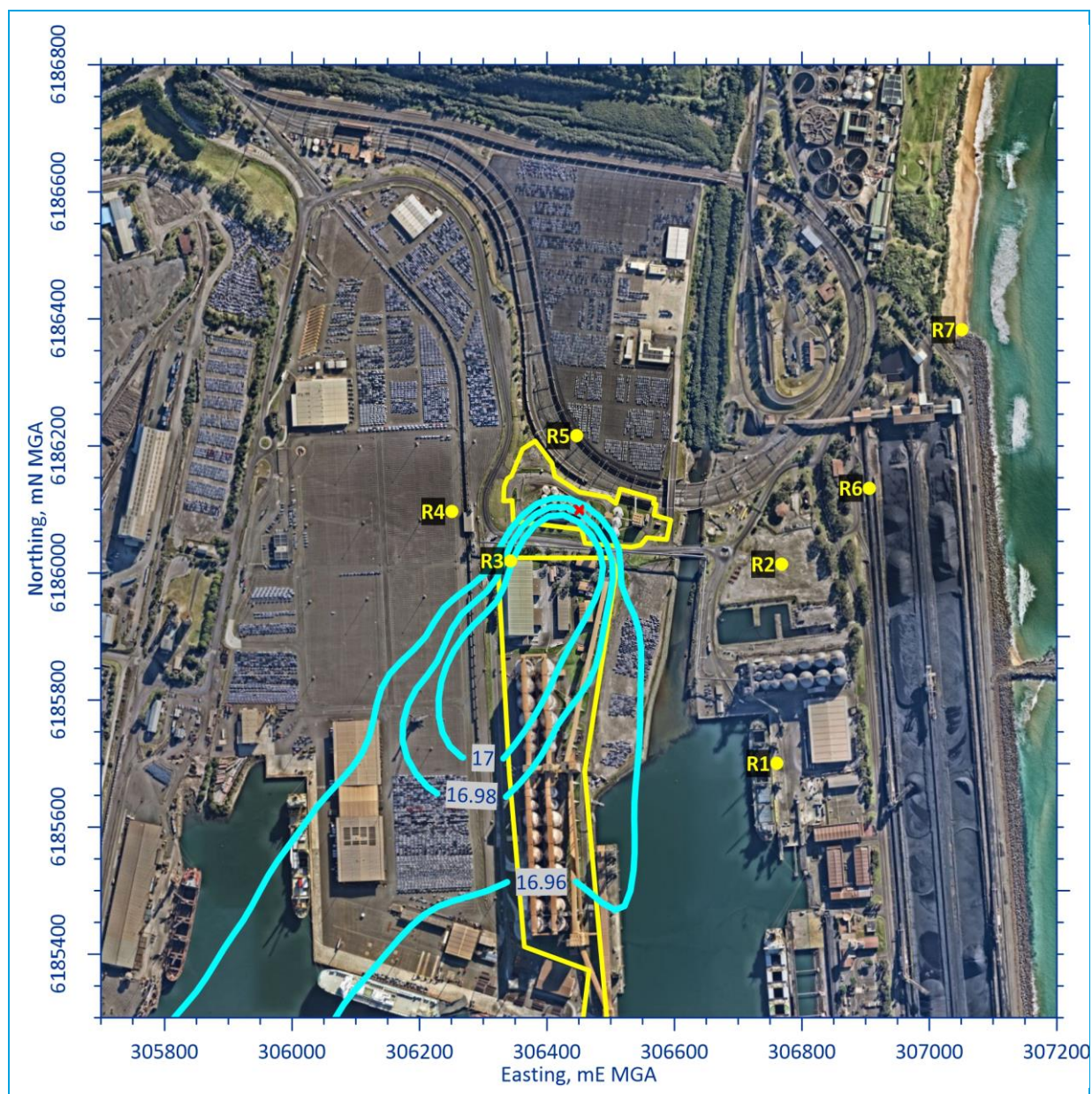


Figure 8-10 Predicted cumulative maximum 24-hour average ground-level $PM_{2.5}$ concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Cumulative maximum 24-hour average ground level $PM_{2.5}$ concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers

Units: $\mu g/m^3$

Contours: 16.96, 16.98, and 17.0 $\mu g/m^3$

Assessment criterion: 20 $\mu g/m^3$

Data source: CALPUFF

Prepared by: M. Power

Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales

Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.

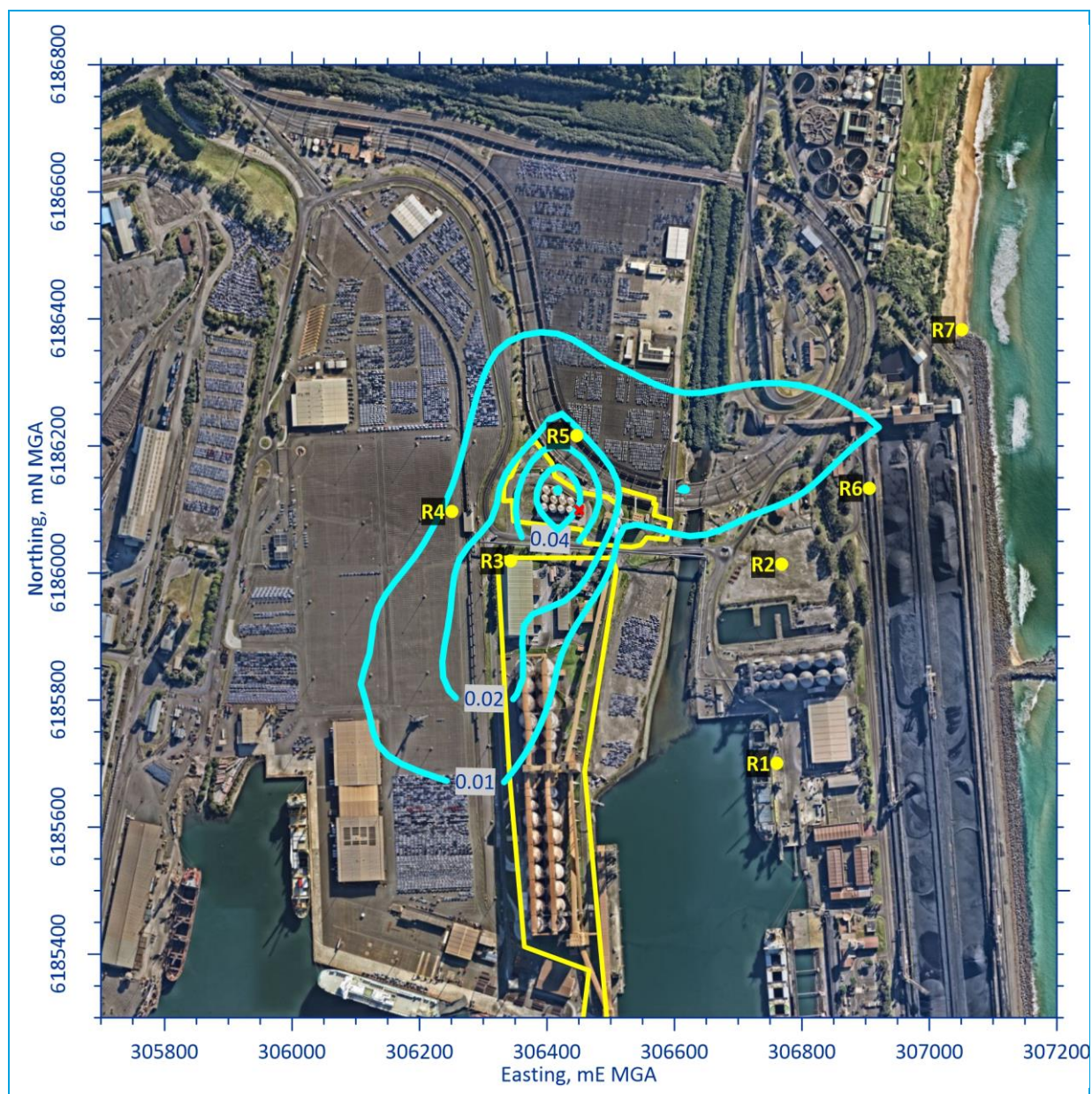


Figure 8-11 Predicted incremental annual average ground-level PM_{2.5} concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Incremental annual average ground level PM _{2.5} concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers	Units: µg/m ³
Contours: 0.01, 0.02, 0.04, 0.06, and 0.08 µg/m ³	Assessment criterion: 7 µg/m ³
Data source: CALPUFF	Prepared by: M. Power
Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales	Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.

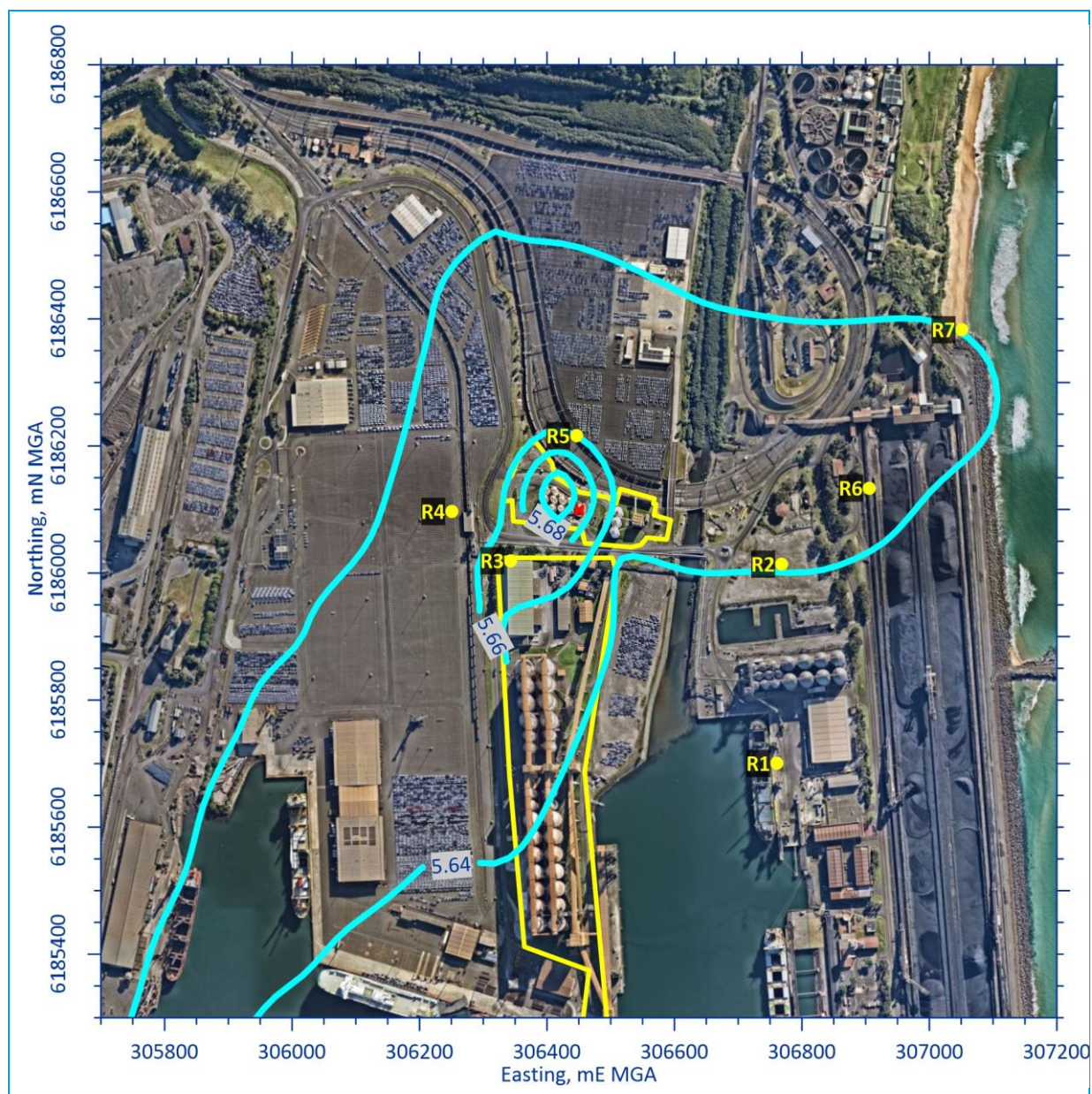


Figure 8-12 Predicted cumulative annual average ground-level PM_{2.5} concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Cumulative annual average ground level PM_{2.5} concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers

Units: µg/m³

Contours: 5.64, 5.66, 5.68, and 5.70 µg/m³

Assessment criterion: 7 µg/m³

Data source: CALPUFF

Prepared by: M. Power

Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales

Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.



Table 8-3 Predicted PM_{2.5} concentrations at sensitive receptor locations

Sensitive receptor	24-hour average concentration, µg/m ³		Annual average concentration, µg/m ³	
	Incremental	Cumulative	Incremental	Cumulative
Impact assessment criterion (µg/m ³)	-	20	-	7
R1	0.05 (0.3%)	16.94 (84.7%)	0.00 (0.03%)	5.64 (80.52%)
R2	0.18 (0.9%)	16.94 (84.7%)	0.01 (0.08%)	5.64 (80.58%)
R3	0.25 (1.3%)	16.99 (85.0%)	0.03 (0.46%)	5.67 (80.96%)
R4	0.13 (0.6%)	16.94 (84.7%)	0.01 (0.18%)	5.65 (80.67%)
R5	0.29 (1.5%)	16.94 (84.7%)	0.03 (0.37%)	5.66 (80.87%)
R6	0.08 (0.4%)	16.94 (84.7%)	0.01 (0.11%)	5.64 (80.61%)
R7	0.05 (0.3%)	16.94 (84.7%)	0.01 (0.08%)	5.64 (80.57%)
R8	0.04 (0.2%)	16.94 (84.7%)	0.00 (0.04%)	5.64 (80.53%)
R9	0.03 (0.2%)	16.94 (84.7%)	0.00 (0.01%)	5.64 (80.51%)
R10	0.03 (0.2%)	16.94 (84.7%)	0.00 (0.02%)	5.64 (80.51%)
R11	0.02 (0.1%)	16.94 (84.7%)	0.00 (0.02%)	5.64 (80.52%)
R12	0.01 (0.1%)	16.94 (84.7%)	0.00 (0.01%)	5.64 (80.51%)
R13	0.01 (0.1%)	16.94 (84.7%)	0.00 (0.01%)	5.64 (80.51%)
R14	0.01 (0.0%)	16.94 (84.7%)	0.00 (0.01%)	5.64 (80.50%)
R15	0.02 (0.1%)	16.94 (84.7%)	0.00 (0.01%)	5.64 (80.50%)
R16	0.01 (0.0%)	16.94 (84.7%)	0.00 (0.01%)	5.63 (80.50%)
Maximum at and beyond the site boundary	0.83 (4.2%)	17.09 (85.5%)	0.07 (1.01%)	5.71 (81.50%)

Table note: The values in brackets show the percentage of the respective impact assessment criterion

8.1.4 Particles as PM₁₀

The maximum 24-hour average incremental and cumulative PM₁₀ predictions for Boilers 1 and 2, each running at a constant peak load, are shown in Figure 8-13 and Figure 8-14 respectively. The respective annual average predictions are provided in Figure 8-15 and Figure 8-16. Model predictions for sensitive receptor locations are provided in Table 8-4.

Once again, the results show that the hourly-varying background is high compared to the incremental impact of the two boilers in isolation. The highest incremental offsite PM₁₀ concentrations only account for approximately 0.8% and 1.3% of the respective 24-hour and annual average assessment criteria. When an hourly-varying background is added, the greatest offsite cumulative impacts account for approximately 173% and 75% of the respective 24-hour and annual average assessment criteria, showing that regional exceedances of the daily-average PM₁₀ criterion occur in the absence of any GrainCorp sources. The hourly-varying background particle concentrations can vary from year to year, so the selection of a different meteorological year, and hence background concentration year, may significantly impact the cumulative model predictions.

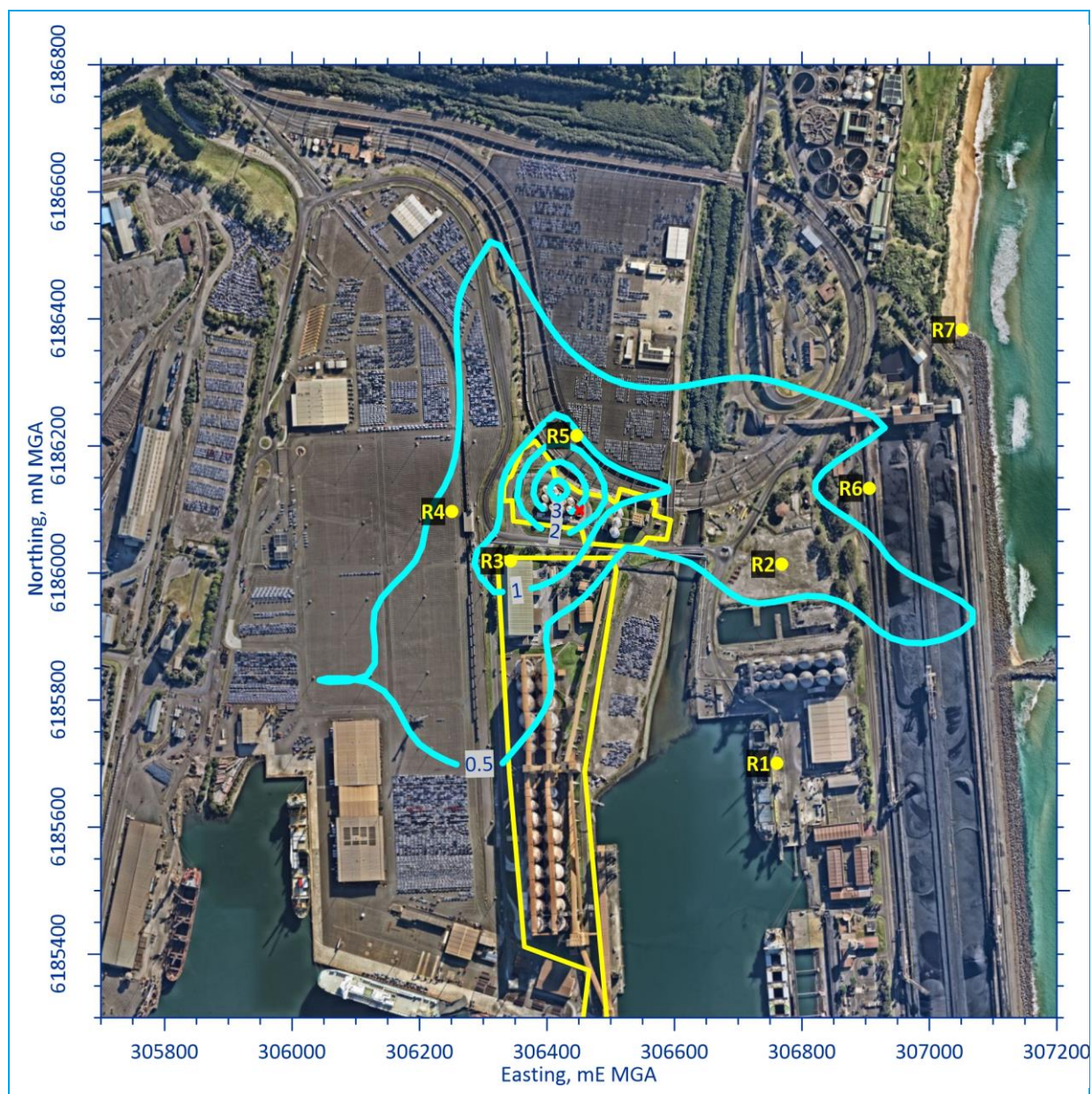


Figure 8-13 Predicted incremental maximum 24-hour average ground-level PM_{10} concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Incremental maximum 24-hour average ground level PM_{10} concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers	Units: $\mu g/m^3$
Contours: 0.5, 1, 2, 3, and $4\mu g/m^3$	Assessment criterion: $50 \mu g/m^3$
Data source: CALPUFF	Prepared by: M. Power
Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales	Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.

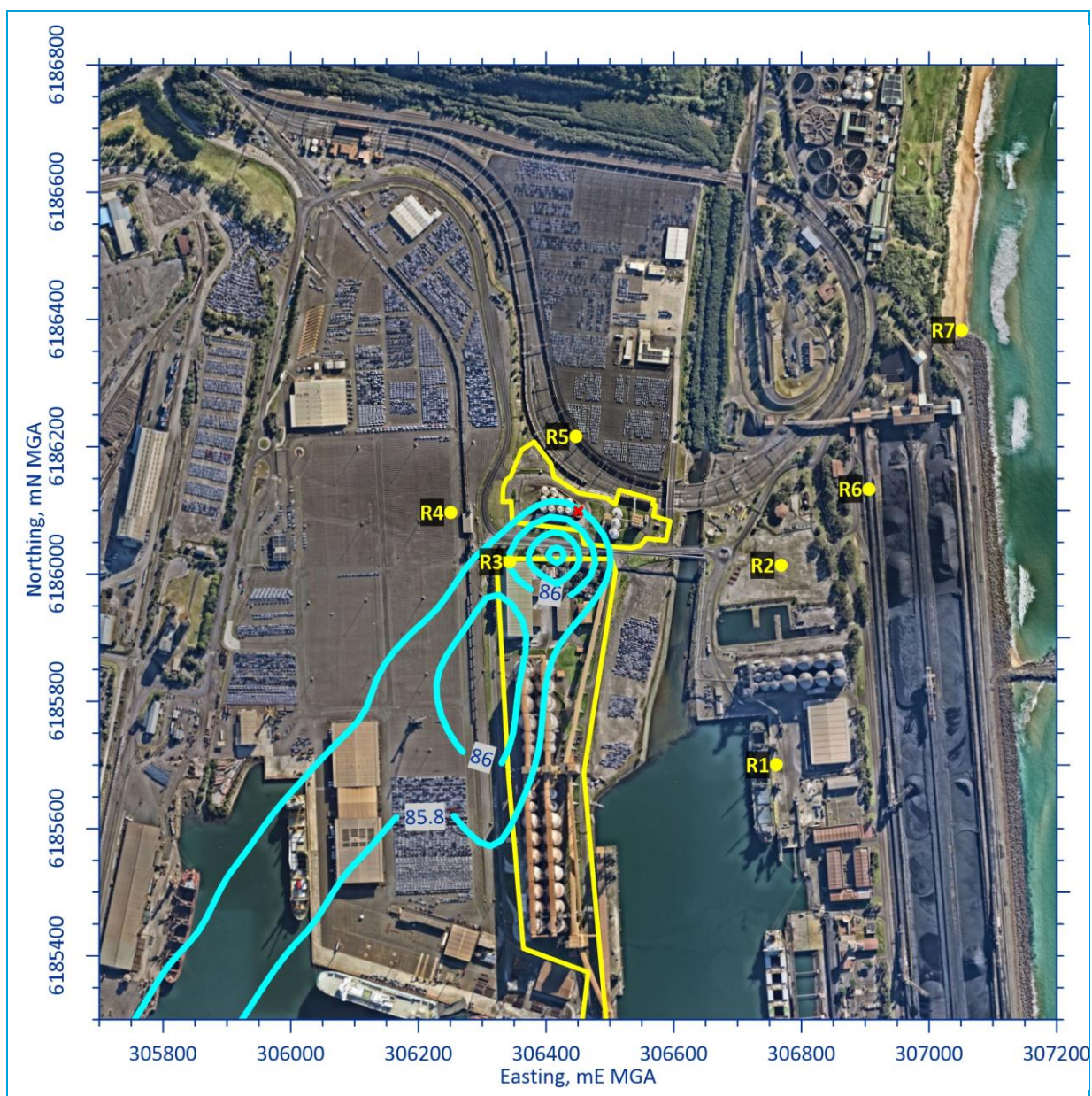


Figure 8-14 Predicted cumulative maximum 24-hour average ground-level PM_{10} concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Cumulative maximum 24-hour average ground level PM_{10} concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers

Units: $\mu g/m^3$

Contours: 85.8, 86.0, 86.2, and 86.4 $\mu g/m^3$

Assessment criterion: 50 $\mu g/m^3$

Data source: CALPUFF

Prepared by: M. Power

Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales

Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.

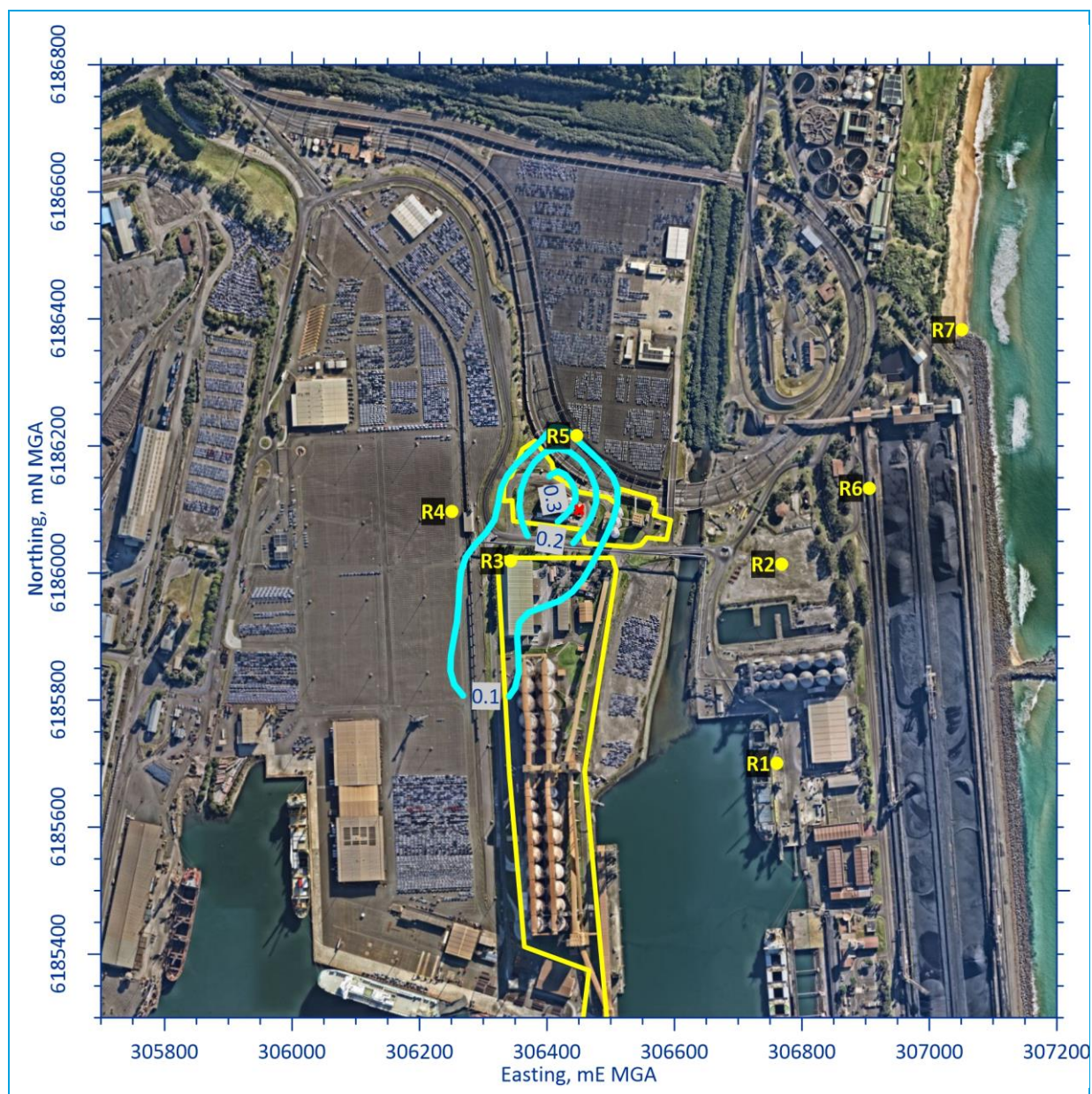


Figure 8-15 Predicted incremental annual average ground-level PM₁₀ concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Incremental annual average ground level PM ₁₀ concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers	Units: µg/m ³
Contours: 0.1, 0.2, & 0.3 µg/m ³	Assessment criterion: 25 µg/m ³
Data source: CALPUFF	Prepared by: M. Power
Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales	Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.

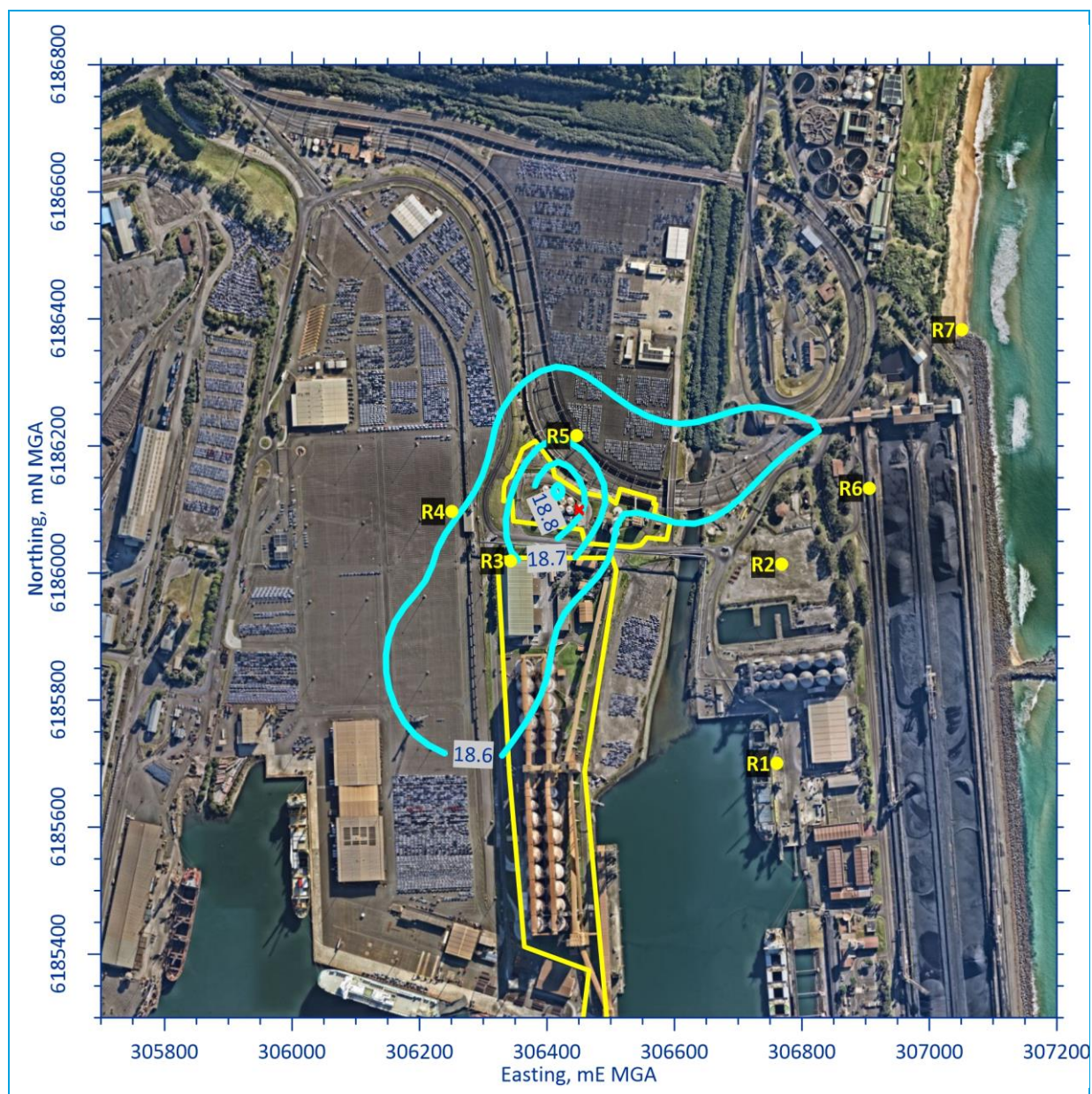


Figure 8-16 Predicted cumulative annual average ground-level PM₁₀ concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Cumulative annual average ground level PM₁₀ concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers

Units: µg/m³

Contours: 18.6, 18.7, 18.8, and 18.9 µg/m³

Assessment criterion: 25 µg/m³

Data source: CALPUFF

Prepared by: M. Power

Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales

Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.



Table 8-4 Predicted PM₁₀ concentrations at sensitive receptor locations

Sensitive receptor	24-hour average concentration, $\mu\text{g}/\text{m}^3$		Annual average concentration, $\mu\text{g}/\text{m}^3$	
	Incremental	Cumulative	Incremental	Cumulative
Impact assessment criterion ($\mu\text{g}/\text{m}^3$)	-	50	-	25
R1	0.60 (1.19%)	85.67 (171.33%)	0.01 (0.04%)	18.55 (74.20%)
R2	1.35 (2.71%)	85.67 (171.33%)	0.03 (0.11%)	18.57 (74.28%)
R3	0.39 (0.78%)	86.01 (172.02%)	0.15 (0.61%)	18.69 (74.77%)
R4	0.24 (0.49%)	85.69 (171.38%)	0.06 (0.23%)	18.60 (74.40%)
R5	0.20 (0.39%)	85.67 (171.33%)	0.12 (0.49%)	18.66 (74.65%)
R6	0.16 (0.32%)	85.67 (171.33%)	0.04 (0.15%)	18.58 (74.31%)
R7	0.15 (0.31%)	85.67 (171.33%)	0.02 (0.10%)	18.57 (74.26%)
R8	0.11 (0.23%)	85.67 (171.33%)	0.01 (0.05%)	18.55 (74.22%)
R9	0.07 (0.13%)	85.67 (171.33%)	0.00 (0.02%)	18.55 (74.18%)
R10	0.05 (0.11%)	85.67 (171.33%)	0.01 (0.03%)	18.55 (74.19%)
R11	0.04 (0.09%)	85.67 (171.33%)	0.01 (0.03%)	18.55 (74.19%)
R12	0.10 (0.20%)	85.67 (171.33%)	0.00 (0.02%)	18.55 (74.18%)
R13	0.04 (0.08%)	85.67 (171.33%)	0.00 (0.02%)	18.55 (74.18%)
R14	3.89 (7.77%)	85.67 (171.33%)	0.00 (0.01%)	18.54 (74.18%)
R15	0.60 (1.19%)	85.67 (171.33%)	0.00 (0.01%)	18.54 (74.18%)
R16	1.35 (2.71%)	85.67 (171.33%)	0.00 (0.01%)	18.54 (74.17%)
Maximum at and beyond the site boundary	0.39 (0.78%)	86.49 (172.97%)	0.33 (1.32%)	18.87 (75.48%)

Table note: The values in brackets show the percentage of the respective impact assessment criterion

8.1.5 Beryllium

The predicted maximum incremental 1-hour average beryllium predictions for Boilers 1 and 2, each running at a constant peak load, are shown in Figure 8-17. Model predictions for sensitive receptor locations are provided in Table 8-5.

The greatest predictions at and beyond the site boundary ($0.0038 \mu\text{g}/\text{m}^3$) accounts for approximately 95% of the assessment criterion. The most affected sensitive receptor is R3 with a maximum 1-hour average concentration of $0.0011 \mu\text{g}/\text{m}^3$ (26.7% of the $0.004 \mu\text{g}/\text{m}^3$ impact assessment criterion).

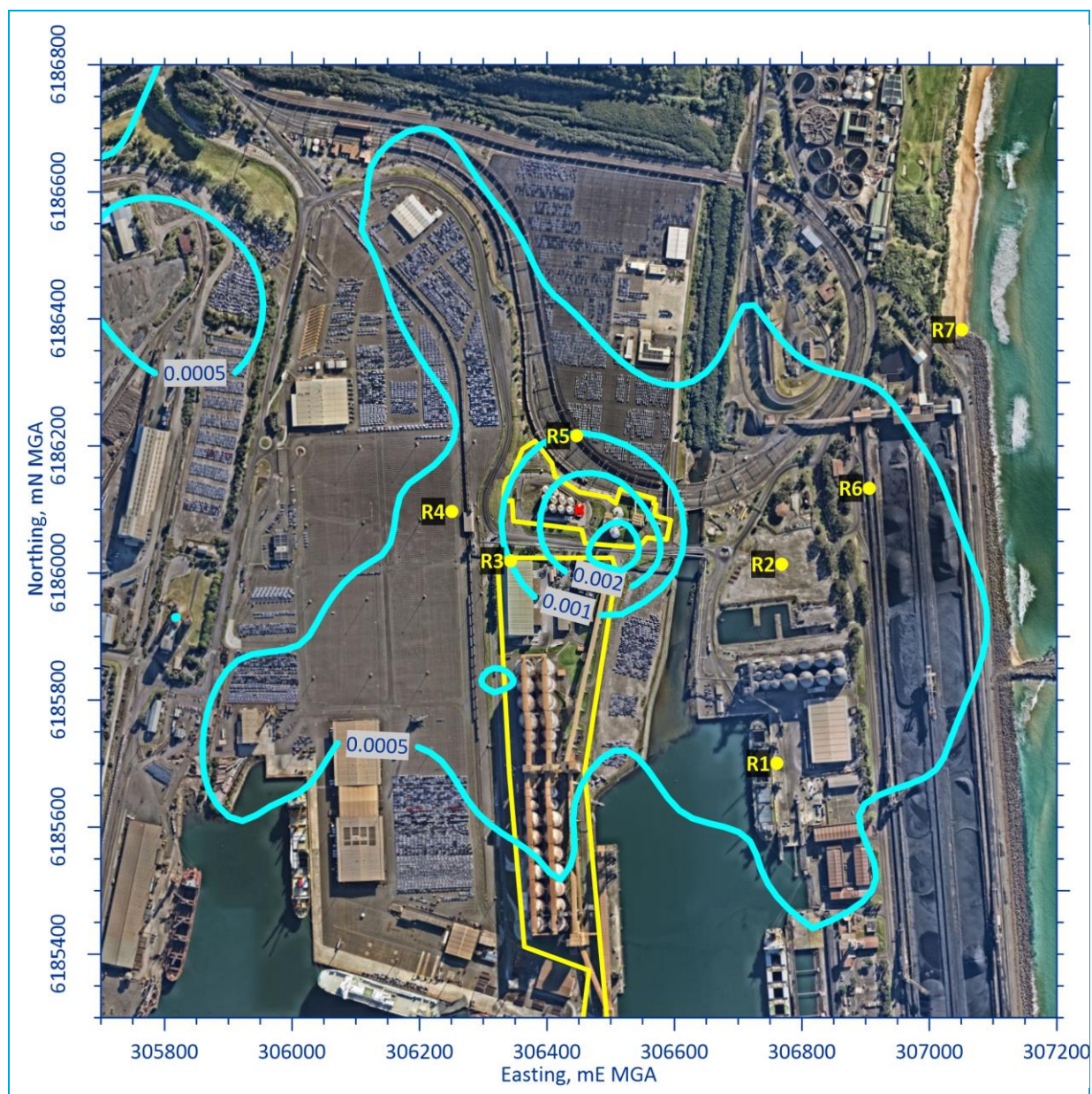


Figure 8-17 Predicted incremental 1-hour maximum ground-level beryllium concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Incremental 1-hour maximum ground level beryllium concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers	Units: $\mu\text{g}/\text{m}^3$
Contours: 0.0005, 0.001, 0.002, and 0.003 $\mu\text{g}/\text{m}^3$	Assessment criterion: 0.004 $\mu\text{g}/\text{m}^3$
Data source: CALPUFF	Prepared by: M. Power
Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales	Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.



Table 8-5 Predicted Beryllium concentrations at sensitive receptor locations

Sensitive receptor	1-hour average concentration, $\mu\text{g}/\text{m}^3$
Impact assessment criterion ($\mu\text{g}/\text{m}^3$)	0.004
R1	0.0006 (14.1%)
R2	0.0009 (22.7%)
R3	0.0011 (26.7%)
R4	0.0006 (15.3%)
R5	0.0009 (23.6%)
R6	0.0007 (17.7%)
R7	0.0004 (9.2%)
R8	0.0004 (10.9%)
R9	0.0003 (8.6%)
R10	0.0005 (13.1%)
R11	0.0002 (5.9%)
R12	0.0003 (7.0%)
R13	0.0002 (5.0%)
R14	0.0003 (7.6%)
R15	0.0004 (10.0%)
R16	0.0001 (3.6%)
Maximum at and beyond the site boundary	0.0038 (95.0%)

Table note: The values in brackets show the percentage of the respective impact assessment criterion

8.1.6 Cadmium

The predicted maximum incremental 1-hour average cadmium predictions for Boilers 1 and 2, each running at a constant peak load, are shown in Figure 8-18. Model predictions for sensitive receptor locations are provided in Table 8-6.

The highest prediction at and beyond the site boundary ($0.0038 \mu\text{g}/\text{m}^3$) accounts for approximately 21% of the assessment criterion.

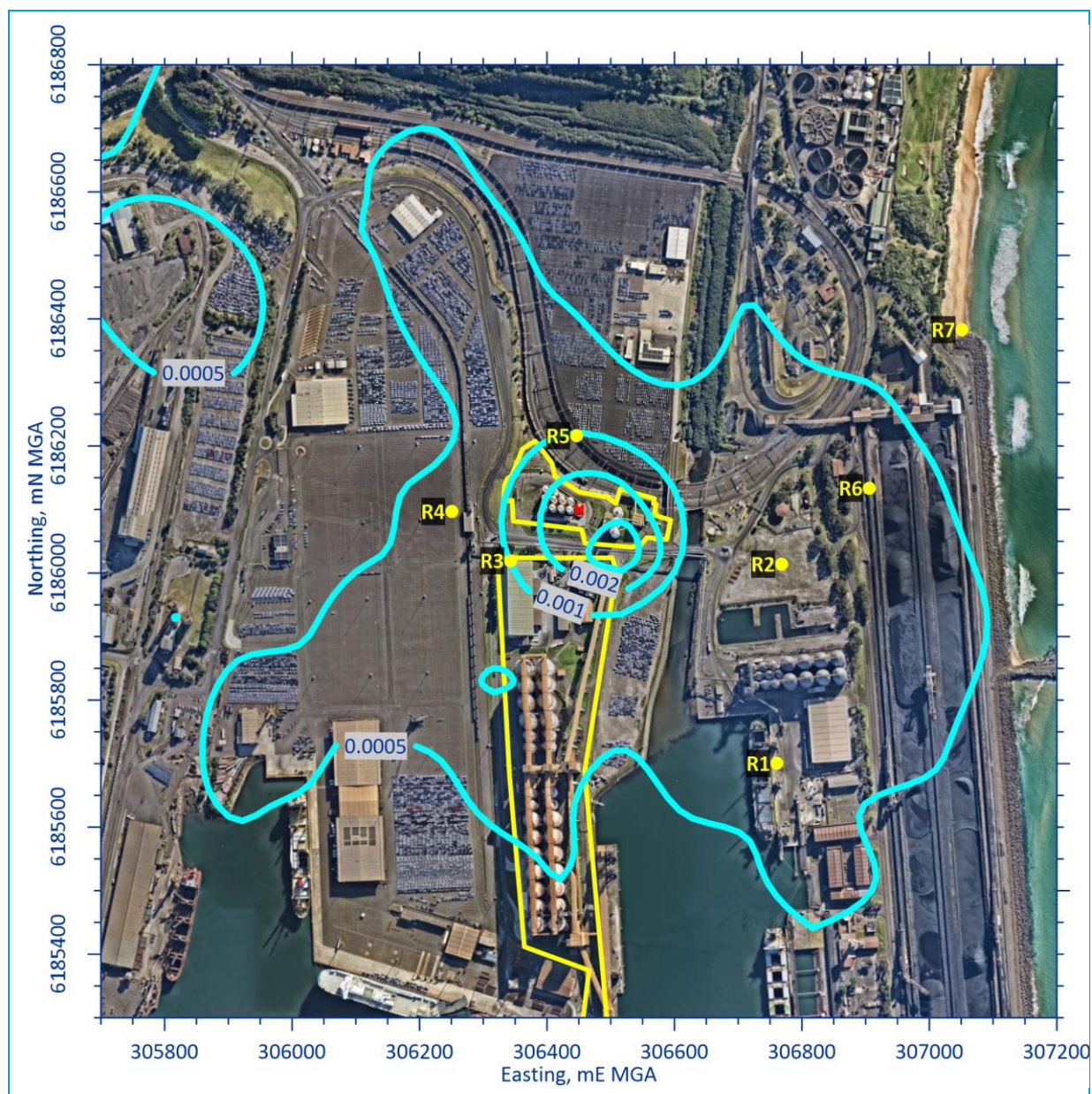


Figure 8-18 Predicted incremental 1-hour maximum ground-level cadmium concentrations arising from boiler emissions at the GrainCorp Bulk Liquid Terminal

Assessment scenario: Incremental 1-hour maximum ground level cadmium concentrations arising from simultaneous peak emissions from the 1.3 MW and 2.5 MW boilers	Units: $\mu\text{g}/\text{m}^3$
Contours: 0.0005, 0.001, 0.002, and 0.003 $\mu\text{g}/\text{m}^3$	Assessment criterion: 0.018 $\mu\text{g}/\text{m}^3$
Data source: CALPUFF	Prepared by: M. Power
Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales	Date: 5 September 2025

Figure Notes: The location of the two boiler stacks is indicated by a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots.



Table 8-6 Predicted cadmium concentrations at sensitive receptor locations

Sensitive receptor	1-hour average concentration, $\mu\text{g}/\text{m}^3$
Impact assessment criterion ($\mu\text{g}/\text{m}^3$)	0.018
R1	0.0006 (3.1%)
R2	0.0009 (5.0%)
R3	0.0011 (5.9%)
R4	0.0006 (3.4%)
R5	0.0009 (5.2%)
R6	0.0007 (3.9%)
R7	0.0004 (2.0%)
R8	0.0004 (2.4%)
R9	0.0003 (1.9%)
R10	0.0005 (2.9%)
R11	0.0002 (1.3%)
R12	0.0003 (1.6%)
R13	0.0002 (1.1%)
R14	0.0003 (1.7%)
R15	0.0004 (2.2%)
R16	0.0001 (0.8%)
Maximum at and beyond the site boundary	0.0038 (21.1%)

Table note: The values in brackets show the percentage of the respective impact assessment criterion

8.1.7 Minor pollutants

Maximum incremental 1-hour and 8-hour average carbon monoxide emissions from Boilers 1 and 2, each running at a constant peak load, are provided in Table 8-7. Model predictions for arsenic, chromium, copper, and dioxins & furans are tabulated in Table 8-8. Predictions for lead, mercury, nickel, and PAH as benzo[a]pyrene are given in Table 8-9.

Arsenic is the pollutant of most concern accounting for 5.6% of its impact assessment criterion beyond the site boundary and 1.6% of the criterion at R3.



Table 8-7 Predicted carbon monoxide concentrations at sensitive receptor locations

Sensitive receptor	1-hour average concentration, $\mu\text{g}/\text{m}^3$	8-hour average concentration, $\mu\text{g}/\text{m}^3$
Impact assessment criterion ($\mu\text{g}/\text{m}^3$)	30,000	10,000
R1	139 (0.46%)	68 (0.68%)
R2	223 (0.74%)	121 (1.21%)
R3	262 (0.87%)	144 (1.44%)
R4	150 (0.50%)	95 (0.95%)
R5	231 (0.77%)	156 (1.56%)
R6	174 (0.58%)	90 (0.90%)
R7	90 (0.30%)	51 (0.51%)
R8	107 (0.36%)	48 (0.48%)
R9	85 (0.28%)	39 (0.39%)
R10	128 (0.43%)	45 (0.45%)
R11	58 (0.19%)	25 (0.25%)
R12	69 (0.23%)	18 (0.18%)
R13	49 (0.16%)	14 (0.14%)
R14	75 (0.25%)	13 (0.13%)
R15	98 (0.33%)	30 (0.30%)
R16	35 (0.12%)	11 (0.11%)
Maximum at and beyond the site boundary	931 (3.10%)	407 (4.07%)

Table note: The values in brackets show the percentage of the respective impact assessment criterion



Table 8-8 Predicted minor pollutant concentrations at sensitive receptor locations

Sensitive receptor	Arsenic, $\mu\text{g}/\text{m}^3$	Chromium, $\mu\text{g}/\text{m}^3$	Copper, $\mu\text{g}/\text{m}^3$	Dioxins and furans, $\mu\text{g}/\text{m}^3$
Impact assessment criterion ($\mu\text{g}/\text{m}^3$)	0.09	9	3.7	2.00E-06
R1	0.0008 (0.84%)	0.0006 (0.01%)	0.0011 (0.03%)	4.00E-09 (0.20%)
R2	0.0012 (1.34%)	0.0009 (0.01%)	0.0018 (0.05%)	7.00E-09 (0.35%)
R3	0.0014 (1.58%)	0.0011 (0.01%)	0.0021 (0.06%)	8.00E-09 (0.40%)
R4	0.0008 (0.91%)	0.0006 (0.01%)	0.0012 (0.03%)	5.00E-09 (0.25%)
R5	0.0013 (1.39%)	0.0009 (0.01%)	0.0019 (0.05%)	7.00E-09 (0.35%)
R6	0.0009 (1.05%)	0.0007 (0.01%)	0.0014 (0.04%)	6.00E-09 (0.30%)
R7	0.0005 (0.54%)	0.0004 (0.00%)	0.0007 (0.02%)	3.00E-09 (0.15%)
R8	0.0006 (0.65%)	0.0004 (0.00%)	0.0009 (0.02%)	3.00E-09 (0.15%)
R9	0.0005 (0.51%)	0.0003 (0.00%)	0.0007 (0.02%)	3.00E-09 (0.15%)
R10	0.0007 (0.77%)	0.0005 (0.01%)	0.0010 (0.03%)	4.00E-09 (0.20%)
R11	0.0003 (0.35%)	0.0002 (0.00%)	0.0005 (0.01%)	2.00E-09 (0.10%)
R12	0.0004 (0.41%)	0.0003 (0.00%)	0.0006 (0.02%)	2.00E-09 (0.10%)
R13	0.0003 (0.30%)	0.0002 (0.00%)	0.0004 (0.01%)	2.00E-09 (0.10%)
R14	0.0004 (0.45%)	0.0003 (0.00%)	0.0006 (0.02%)	2.00E-09 (0.10%)
R15	0.0005 (0.59%)	0.0004 (0.00%)	0.0008 (0.02%)	3.00E-09 (0.15%)
R16	0.0002 (0.21%)	0.0001 (0.00%)	0.0003 (0.01%)	1.00E-09 (0.05%)
Maximum at and beyond the site boundary	0.0051 (5.63%)	0.0038 (0.04%)	0.0076 (0.21%)	2.90E-08 (1.45%)

Table note: The values in brackets show the percentage of the respective impact assessment criterion



Table 8-9 Predicted minor pollutant concentrations at sensitive receptor locations

Sensitive receptor	Lead, $\mu\text{g}/\text{m}^3$	Mercury, $\mu\text{g}/\text{m}^3$	Nickel, $\mu\text{g}/\text{m}^3$	PAH as benzo[a]pyrene, $\mu\text{g}/\text{m}^3$
Impact assessment criterion ($\mu\text{g}/\text{m}^3$)	0.5	1.8	0.18	0.4
R1	0.00001 (0.00%)	0.0006 (0.04%)	0.0006 (0.31%)	0.0024 (0.60%)
R2	0.00003 (0.01%)	0.0007 (0.04%)	0.0009 (0.50%)	0.0037 (0.92%)
R3	0.00019 (0.04%)	0.0010 (0.05%)	0.0011 (0.59%)	0.0028 (0.69%)
R4	0.00007 (0.01%)	0.0006 (0.03%)	0.0006 (0.34%)	0.0014 (0.36%)
R5	0.00015 (0.03%)	0.0009 (0.05%)	0.0009 (0.52%)	0.0017 (0.42%)
R6	0.00005 (0.01%)	0.0006 (0.03%)	0.0007 (0.39%)	0.0013 (0.34%)
R7	0.00003 (0.01%)	0.0003 (0.02%)	0.0004 (0.20%)	0.0020 (0.51%)
R8	0.00002 (0.00%)	0.0005 (0.03%)	0.0004 (0.24%)	0.0009 (0.23%)
R9	0.00001 (0.00%)	0.0004 (0.02%)	0.0003 (0.19%)	0.0011 (0.27%)
R10	0.00001 (0.00%)	0.0007 (0.04%)	0.0005 (0.29%)	0.0008 (0.19%)
R11	0.00001 (0.00%)	0.0002 (0.01%)	0.0002 (0.13%)	0.0012 (0.30%)
R12	0.00001 (0.00%)	0.0003 (0.01%)	0.0003 (0.16%)	0.0015 (0.39%)
R13	0.00001 (0.00%)	0.0002 (0.01%)	0.0002 (0.11%)	0.0006 (0.14%)
R14	0.00000 (0.00%)	0.0004 (0.02%)	0.0003 (0.17%)	0.0148 (3.70%)
R15	0.00000 (0.00%)	0.0004 (0.02%)	0.0004 (0.22%)	0.0024 (0.60%)
R16	0.00000 (0.00%)	0.0004 (0.02%)	0.0001 (0.08%)	0.0037 (0.92%)
Maximum at and beyond the site boundary	0.00041 (0.08%)	0.0048 (0.26%)	0.0038 (2.11%)	0.0028 (0.69%)

Table note: The values in brackets show the percentage of the respective impact assessment criterion

8.2 Diesel storage tank emissions

The 100th percentile (maximum) 1-hour average predictions at sensitive receptor locations for the dispersion of pollutants from the diesel storage tank are presented in Table 8-10. The table indicates that the diesel storage tank is a minor source, with all impacts at and beyond the GrainCorp site boundary estimated to be less than 1.5% of their respective impact assessment criterion. Cumene is the pollutant of most concern, with relatively higher impacts compared to the other pollutants. Despite this, the predicted 1-hour maximum cumene concentration at and beyond the site boundary is $0.31 \mu\text{g}/\text{m}^3$, accounting for only 1.5% of its impact assessment criterion ($21 \mu\text{g}/\text{m}^3$). The cumene model predictions are plotted in Figure 8-19, showing the spatial variation in dispersion of emissions from the diesel fuel tank.



Table 8-10 Predicted maximum 1-hour average ground-level concentrations arising from diesel storage tank emissions under peak load conditions

Sensitive receptor	Benzene	Cumene	Cyclohexane	Ethylbenzene	n-hexane	Toluene	Xylene
Impact assessment criterion (µg/m³)	29	21	19,000	8,000	3,200	360	190
R1	0.011 (0.04%)	0.017 (0.08%)	0.0038 (0.00002%)	0.004 (0.0001%)	0.006 (0.0002%)	0.011 (0.003%)	0.046 (0.024%)
R2	0.023 (0.08%)	0.035 (0.17%)	0.0077 (0.00004%)	0.008 (0.0001%)	0.013 (0.0004%)	0.023 (0.006%)	0.078 (0.041%)
R3	0.061 (0.21%)	0.092 (0.44%)	0.0202 (0.00011%)	0.022 (0.0003%)	0.033 (0.0010%)	0.059 (0.016%)	0.015 (0.008%)
R4	0.050 (0.17%)	0.076 (0.36%)	0.0166 (0.00009%)	0.018 (0.0002%)	0.027 (0.0009%)	0.049 (0.014%)	0.009 (0.005%)
R5	0.084 (0.29%)	0.128 (0.61%)	0.0280 (0.00015%)	0.030 (0.0004%)	0.046 (0.0014%)	0.082 (0.023%)	0.011 (0.006%)
R6	0.016 (0.06%)	0.025 (0.12%)	0.0055 (0.00003%)	0.006 (0.0001%)	0.009 (0.0003%)	0.016 (0.004%)	0.005 (0.002%)
R7	0.010 (0.03%)	0.015 (0.07%)	0.0032 (0.00002%)	0.003 (0.0000%)	0.005 (0.0002%)	0.009 (0.003%)	0.005 (0.002%)
R8	0.011 (0.04%)	0.017 (0.08%)	0.0038 (0.00002%)	0.004 (0.0001%)	0.006 (0.0002%)	0.011 (0.003%)	0.006 (0.003%)
R9	0.005 (0.02%)	0.008 (0.04%)	0.0017 (0.00001%)	0.002 (0.0000%)	0.003 (0.0001%)	0.005 (0.001%)	0.003 (0.002%)
R10	0.005 (0.02%)	0.008 (0.04%)	0.0017 (0.00001%)	0.002 (0.0000%)	0.003 (0.0001%)	0.005 (0.001%)	0.004 (0.002%)
R11	0.006 (0.02%)	0.009 (0.05%)	0.0021 (0.00001%)	0.002 (0.0000%)	0.003 (0.0001%)	0.006 (0.002%)	0.002 (0.001%)
R12	0.004 (0.01%)	0.006 (0.03%)	0.0012 (0.00001%)	0.001 (0.0000%)	0.002 (0.0001%)	0.004 (0.001%)	0.002 (0.001%)
R13	0.004 (0.01%)	0.006 (0.03%)	0.0013 (0.00001%)	0.001 (0.0000%)	0.002 (0.0001%)	0.004 (0.001%)	0.001 (0.001%)
R14	0.003 (0.01%)	0.004 (0.02%)	0.0009 (0.00000%)	0.001 (0.0000%)	0.001 (0.0000%)	0.003 (0.001%)	0.187 (0.099%)
R15	0.002 (0.01%)	0.004 (0.02%)	0.0008 (0.00000%)	0.001 (0.0000%)	0.001 (0.0000%)	0.002 (0.001%)	0.046 (0.024%)
R16	0.001 (0.00%)	0.002 (0.01%)	0.0004 (0.00000%)	0.000 (0.0000%)	0.001 (0.0000%)	0.001 (0.000%)	0.078 (0.041%)
Maximum at and beyond the site boundary	0.202 (0.70%)	0.307 (1.46%)	0.0672 (0.00035%)	0.072 (0.0009%)	0.110 (0.0035%)	0.197 (0.055%)	0.015 (0.008%)

Table note: The values in brackets show the percentage of the respective impact assessment criterion

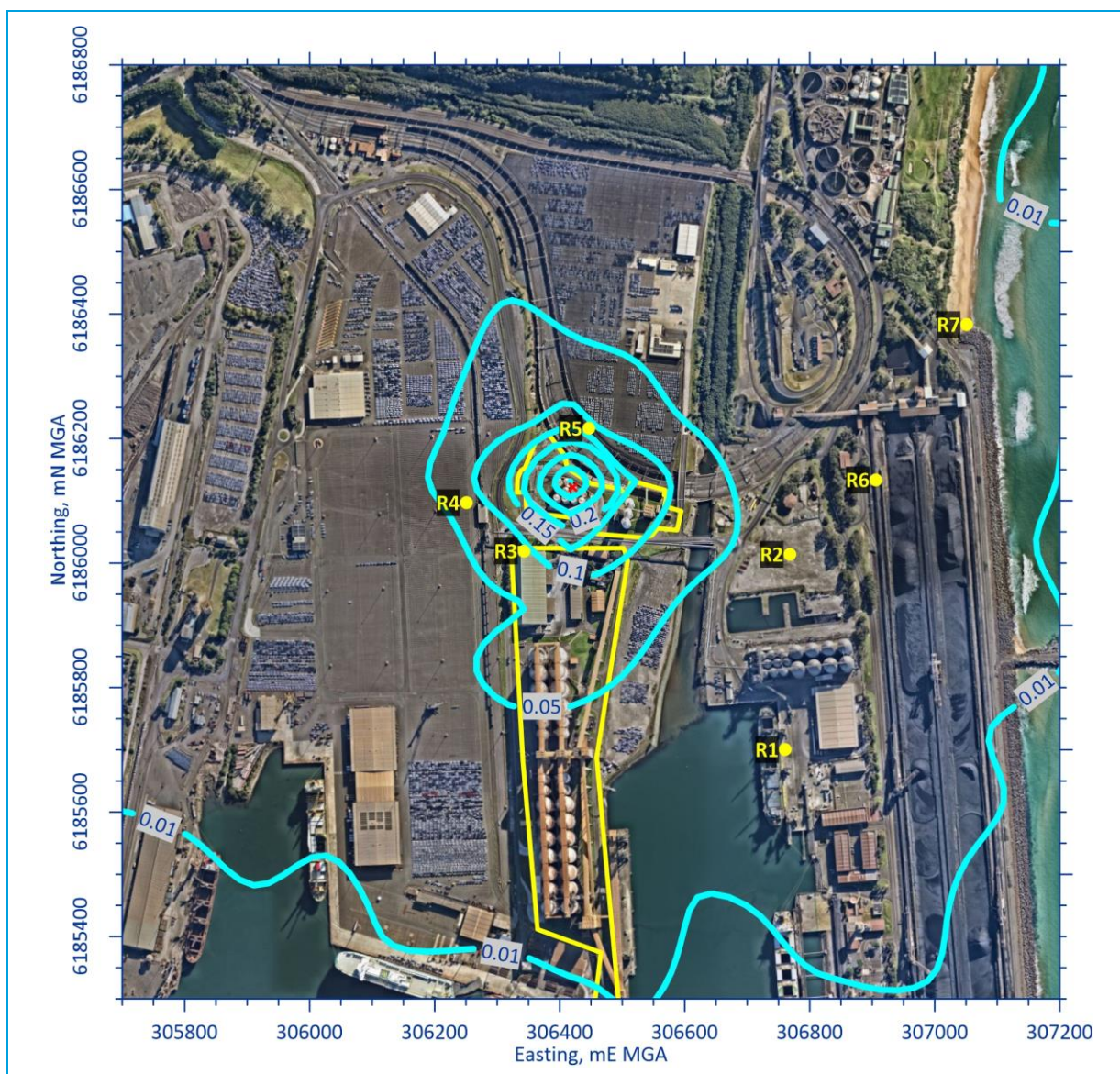


Figure 8-19 Predicted 1-hour maximum ground-level cumene concentrations for the diesel storage tank

Assessment scenario: Predicted 1-hour maximum ground-level cumene concentrations arising from diesel storage tank emissions

Units: $\mu\text{g}/\text{m}^3$

Contours: 0.01, 0.05, 0.1, 0.15, 0.2, 0.25, 0.3 $\mu\text{g}/\text{m}^3$

Assessment criterion: 21 $\mu\text{g}/\text{m}^3$

Data source: CALPUFF

Prepared by: M. Power

Location: GrainCorp Bulk Liquid Terminal, Port Kembla, New South Wales

Date: 8 September 2025



9 Conclusions

This comprehensive air quality impact assessment demonstrates that GrainCorp's proposed Bulk Liquid Terminal upgrade can proceed without causing significant adverse air quality impacts. The assessment employed rigorous methodologies in accordance with NSW EPA Approved Methods, utilising the combined TAPM/CALMET/CALPUFF meteorological and dispersion modelling system to evaluate emissions from the proposed 3.8 MW heating plant comprising two diesel-fired boilers and the repurposed 60 kL diesel storage tank. Conservative assumptions were applied throughout, including worst-case scenario modelling with both boilers operating simultaneously at peak load, ensuring the assessment represents the maximum potential impacts.

Nitrogen dioxide emerges as the most significant pollutant from the proposed boilers, with incremental concentrations reaching 81% of the 1-hour criterion at the site boundary and cumulative concentrations including background reaching 93% of the criterion. At sensitive receptors, the highest impact occurs at Receptor 3 (Incitec Pivot) with cumulative concentrations representing 49% of the 1-hour criterion, while annual average impacts remain substantially lower at 39% of the annual criterion. Particulate matter emissions ($PM_{2.5}$ and PM_{10}) from the boilers contribute minimally to ambient concentrations, with incremental impacts representing less than 4.2% of assessment criteria. However, cumulative concentrations are dominated by high regional background levels, with existing PM_{10} concentrations already exceeding the 24-hour criterion on some days, to which the GrainCorp facility adds negligible contribution. The hourly-varying background particle concentrations can vary from year to year, so the selection of a different meteorological year, and hence background concentration year, may significantly impact the cumulative model predictions.

Other assessed pollutants including sulfur dioxide, carbon monoxide, and trace metals demonstrate low impacts relative to their respective criteria. Among trace metals, beryllium presents the highest relative impact at 95% of the criterion at the site boundary, though absolute concentrations remain very low at $0.0038 \mu g/m^3$. The 60 kL diesel storage tank represents a minor emission source with all pollutant concentrations well below 2% of their respective criteria, with cumene showing the highest relative impact at 1.5% of its criterion.

The assessment approach incorporated contemporaneous background concentrations from NSW EPA monitoring sites at Kembla Grange and Albion Park, three-dimensional meteorological modelling representative of local conditions, and building wake effects to ensure accurate representation of dispersion patterns. The use of appropriate emission factors from recognized European and National Pollutant Inventory standards, combined with manufacturer-supplied boiler specifications, provides confidence in the emission estimates. All predicted pollutant concentrations remain well within established assessment criteria at sensitive receptor locations, confirming that the proposed upgrade represents an acceptable air quality risk for the Port Kembla region and can proceed as proposed without requiring additional air quality mitigation measures beyond standard operational procedures.

Breathing and working losses from Tanks TK-01 to TK-15 occurring whilst storing tallow or UCO, and the four oil receival and wash-water treatment tanks (DW-20 to DW-23), were considered to represent minor odour sources and were therefore not assessed.

Predicted pollutant concentrations for the proposed Bulk Liquid Terminal upgrade were compared against those for the existing consent sources. The investigation determined that the proposed alterations and additions satisfy the requirements of Clause 48 of the *Environmental Planning and Assessment Regulation 2021*, and do not significantly increase the environmental impacts. Full details are provided in Appendix H.



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Appendix A

Meteorological Inter-annual Variability Analysis





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1 Methodology for the Assessment of Meteorological Inter-annual Variability

1.1 Review and selection of regional meteorological observations

The closest Bureau of Meteorology (BoM) automatic weather station (AWS) site to the GrainCorp Bulk Liquid Terminal at Port Kembla is located at Port Kembla NTC AWS (Station 068253) approximately 3.5 km southeast from the site. However, this station does not record the full suite of meteorological parameters necessary to determine the representative meteorological year. The next closest BoM station (Bellambi AWS, Station 068228), located approximately 9.4 km to the north-northeast of the GrainCorp site, was therefore selected for the assessment of the meteorological inter-annual variability. The location of the Bellambi AWS site in relation to the GrainCorp site is provided in Table 1-1 and is shown in Figure 1-1.

Table 1-1 Location of the Bellambi AWS in relation to the GrainCorp site

BoM Station Number	BoM Station Name	Latitude/ Northing (GDA 2020)	Longitude/ Easting (GDA 2020)	Distance from the GrainCorp Site	Bearing from the GrainCorp Site
068228	Bellambi AWS	-34.3692 °S (6,194,961 mN)	150.9292 °E (309,581 mE)	9.40 km	20.7 ° (NNE)

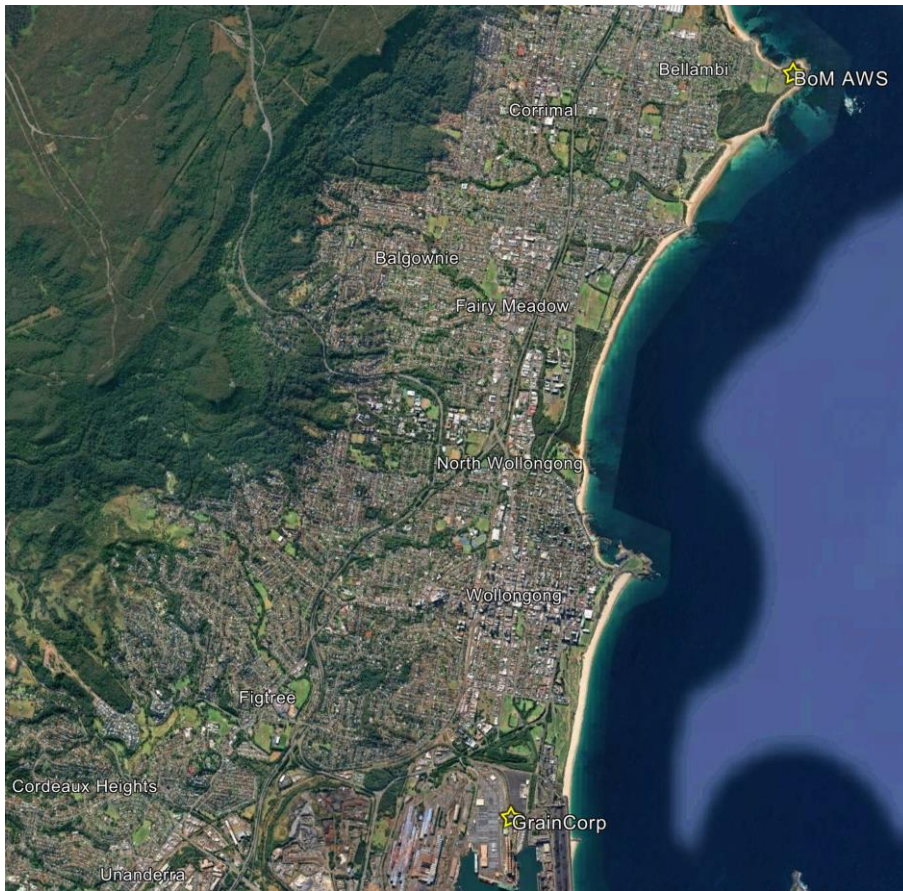


Figure 1-1 Location of the BoM Bellambi AWS site (Site 068228) in relation to the GrainCorp Site.

1.2 Analysis of regional meteorological observations

The last five years of data collected at Bellambi AWS were selected for analysis, with each year being compared against the five-year mean to determine its representativeness of long-term conditions.

Rather than using calendar years, Air Environment have defined the 'meteorological year' as the twelve-month period commencing in March (the beginning of autumn) each year and ending in February (the end of summer) the following year. If a calendar year had been selected, it would commence with the end of one year's summer season and end with the beginning of another. The adopted approach therefore ensures that a single summer season will be assessed and modelled in its entirety.

The analysis period spans the five-year time period between 1 March 2020 and 28 February 2025. The meteorological parameters analysed, dataset time interval, and analyses conducted are summarised in Table 1-1.



Table 1-1 Meteorological data assessed for Bellambi AWS (BoM station number 068228)

Parameter	Time period assessed	Data	Analysis
Wind speed	1 March 2020 to 28 February 2025	30-minute data points from BoM AWS	Comparisons of: - Frequency distributions (as probability density functions) as year-on-year and each year against the mean of all five years - Frequency distribution anomaly (as a percentage) from the mean of all five years - Correlation statistics (R^2)
Wind direction			
Wind vector U component			
Wind vector V component			
Air temperature			
Dew point temperature			
Rainfall	1 March 2020 to 28 February 2025	Annual and monthly totals (mm)	Comparison of monthly and annual rainfall totals
El Niño Southern Oscillation	1 March 2020 to 28 February 2025	Monthly Southern Oscillation Index (SOI)	SOI classification and strength

The analysis was based on determining which years provided the closest representation of the average state of the climate based on the variation of each meteorological parameter from the mean and each other year. For meteorological modelling and air quality assessment purposes, the key parameters that influence pollutant dispersion are wind speed, wind direction, atmospheric stability and mixing height, with stability a function of the atmosphere's vertical temperature profile and the wind speed. Notwithstanding this, these parameters can be strongly influenced by the overall state of the climate including the El Niño Southern Oscillation (ENSO), solar exposure, cloud cover and rainfall and the resulting soil and atmospheric moisture content.

In general, the analysis considered the following:

- A year with a moderate or strong ENSO classification should be avoided, where possible.
- A year with anomalously low or high rainfall should be avoided, where possible.
- The distributions of wind speed and direction should be as close to the mean distribution as possible, both in terms of the frequencies of low, moderate and high wind speeds, and in the overall correlation statistics. This includes the analysis of wind in its U and V vector components.
- The distributions of temperature should be as close to the mean distribution as possible, in terms of low nocturnal and daytime high temperatures.
- The distributions of dew point temperature should be as close to the mean distribution as possible.
- The distributions of mean sea level atmospheric pressure should be as close to the mean distribution as possible.



2 Analysis of Meteorological Inter-annual Variability

2.1 Wind speed

The annual and mean frequency distributions (probability density function [PDF]) of wind speed recorded at the BoM Bellambi AWS site for the five-year period, 1 March 2020 to 28 February 2025, are provided in Figure 2-1. The anomaly of each year to the mean of the five-year period is plotted in Figure 2-2.

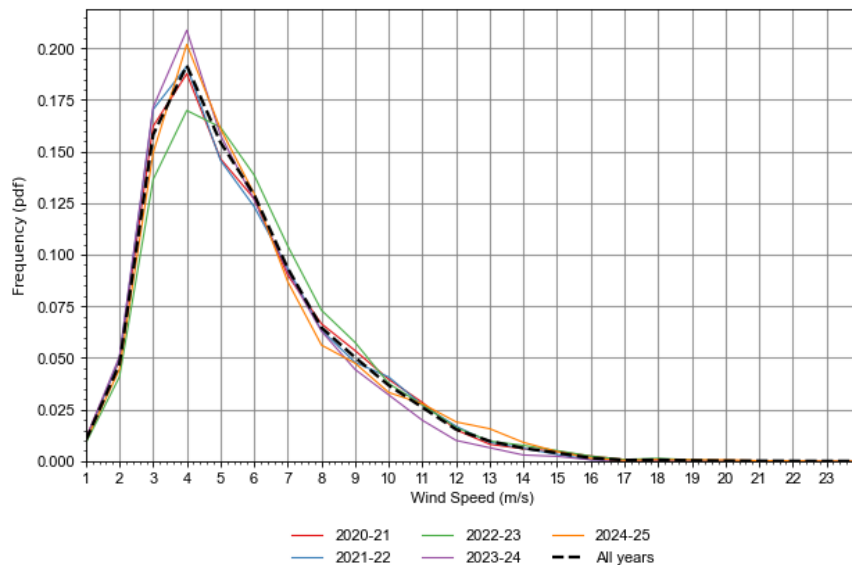


Figure 2-1 Comparison of annual observed wind speed frequency distributions to the mean
Figure Note: BoM Bellambi AWS site (Station number 068228)

The probability distribution for each year at Bellambi AWS closely follows that of the five-year mean, with the greatest noticeable deviation being a slight reduction in the frequency of 3 to 5 m/s winds occurring during the 2022-23 year.

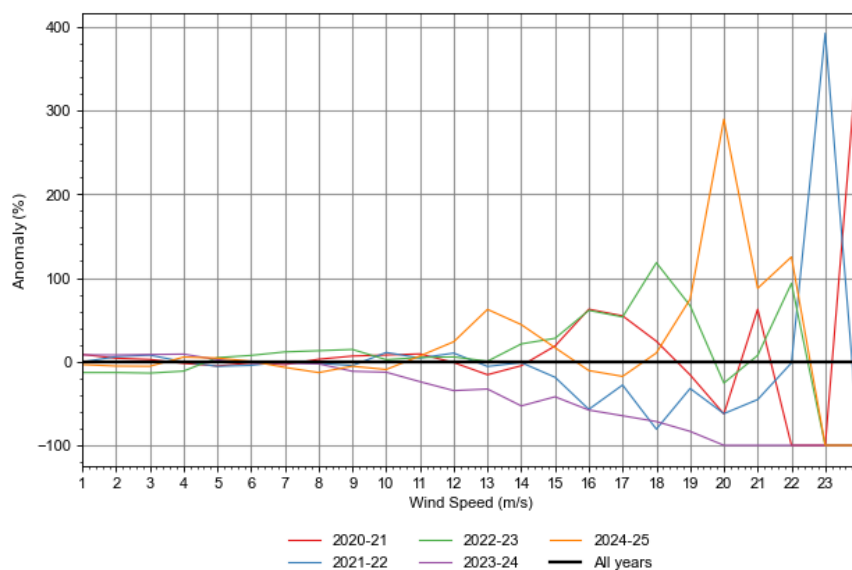


Figure 2-2 Annual observed wind speed frequency distribution anomaly from the mean
Figure Note: BoM Bellambi AWS site (Station number 068228)



The R^2 correlation statistics for each year-on-year, and each year versus the mean of all years, are summarised in Table 2-1.

Table 2-1 Correlation coefficients matrices of the distributions of wind speed at Bellambi AWS (BoM station number 068228)

Year	2020-21	2021-22	2022-23	2023-24	2024-25	All years
2020-21	1					
2021-22	0.999	1				
2022-23	0.989	0.985	1			
2023-24	0.997	0.998	0.983	1		
2024-25	0.995	0.994	0.988	0.996	1	
All years	0.999	0.998	0.992	0.998	0.997	1

2.2 Wind direction

The annual and five-year mean wind direction PDFs and the anomaly of each year to the mean of the five-year period (March 2020 to February 2025), are similarly presented in Figure 2-3 and Figure 2-4, respectively.

Each year's distribution is broadly similar to that of the five-year mean, with slightly greater variation than seen in the wind speed distribution. The variation between each year and the five-year mean shown in both the PDF and the anomaly plots indicates that whilst the general trend is consistent, there is noticeable variation between the years. This variation is most obvious between 160° (SSE) to 240° (WSW) and 310° (NW) to 360° (N), with the 2045-25 year showing the greatest departures from the mean.

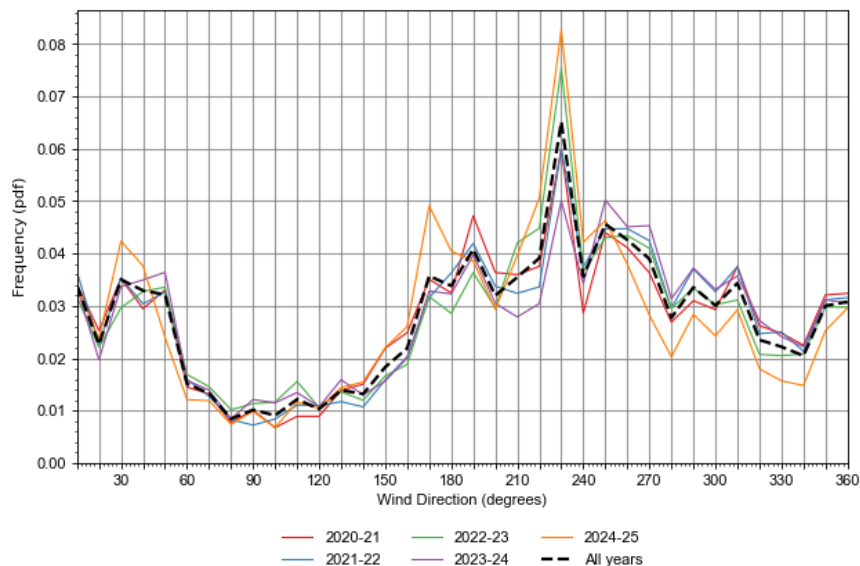


Figure 2-3 Comparison of annual observed wind direction frequency distributions to the mean

Figure Note: BoM Bellambi AWS site (Station number 068228)

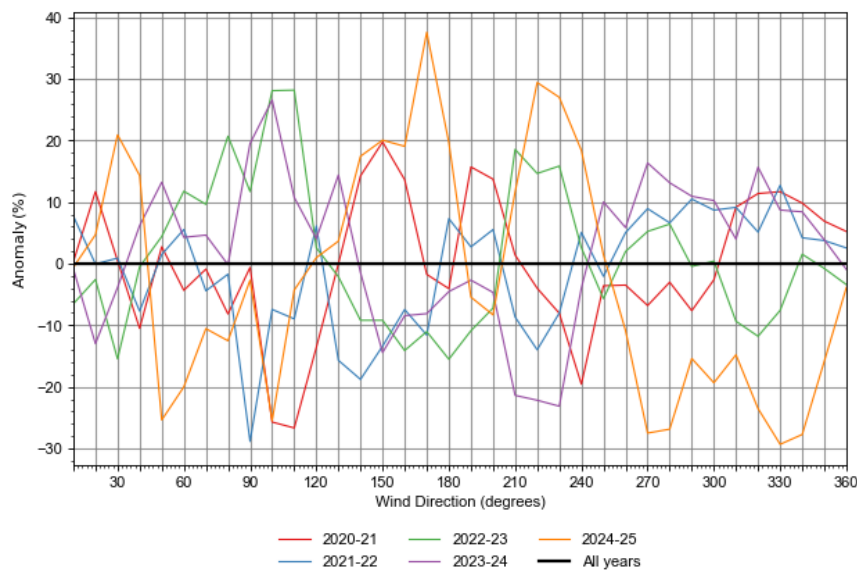


Figure 2-4 Annual observed wind direction frequency distribution anomaly from the mean
Figure Note: BoM Bellambi AWS site (Station number 068228)

The R^2 correlation statistics for each year on year, and each year versus the mean of all years, are summarised in Table 2-2.

Table 2-2 Correlation coefficients matrices of the distributions of wind direction at Bellambi AWS station (BoM station number 068228)

Year	2020-21	2021-22	2022-23	2023-24	2024-25	All years
2020-21	1					
2021-22	0.964	1				
2022-23	0.920	0.933	1			
2023-24	0.925	0.971	0.886	1		
2024-25	0.882	0.855	0.912	0.783	1	
All years	0.976	0.982	0.970	0.947	0.927	1

2.3 Wind U component

The annual and mean wind U-component (easterly component positive) PDF, and the anomaly of each year to the mean of the five-year period (March 2020 to February 2025), are presented in Figure 2-5 and Figure 2-6, respectively. All years analysed tend to follow the five-year average U-component wind distribution, with the greatest variability occurring in the 1 to 4 m/s range, most notably in the 2022-23 year.

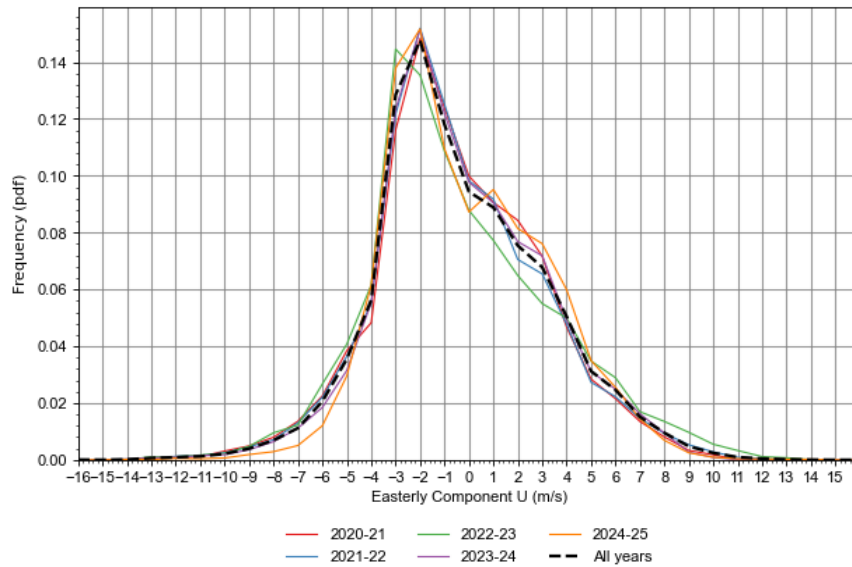


Figure 2-5 Comparison of annual observed wind U-component frequency distributions to the mean

Figure Note: BoM Bellambi AWS site (Station number 068228)

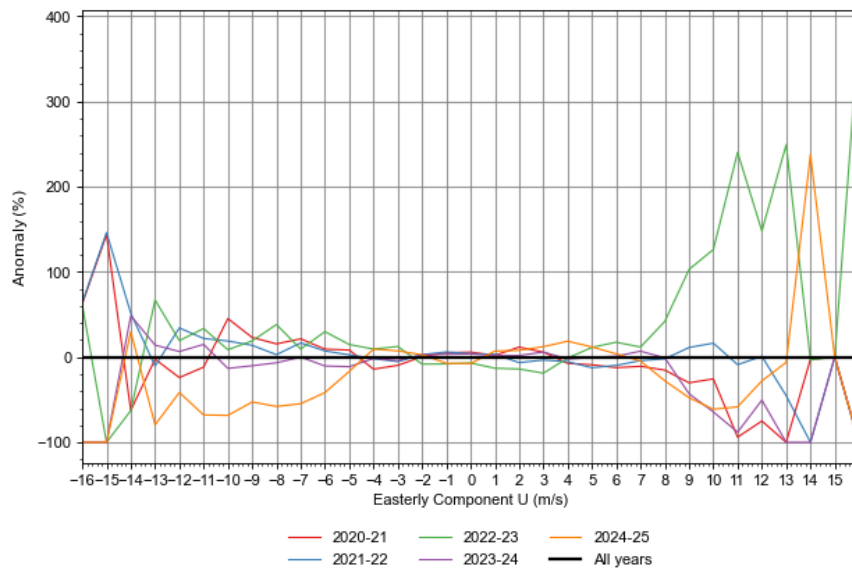


Figure 2-6 Annual observed wind U-component frequency distributions anomaly from the mean

Figure Note: BoM Bellambi AWS site (Station number 068228)

The R^2 correlation statistics for each year on year, and each year versus the mean of all years, are summarised in Table 2-3.



Table 2-3 Correlation coefficients matrices of the distributions of the wind U-component at Bellambi AWS (BoM station number 068228)

Year	2020-21	2021-22	2022-23	2023-24	2024-25	All years
2020-21	1					
2021-22	0.997	1				
2022-23	0.978	0.986	1			
2023-24	0.998	0.999	0.985	1		
2024-25	0.987	0.989	0.986	0.994	1	
All years	0.996	0.998	0.991	0.999	0.995	1

2.4 Wind V component

The annual and mean wind V-component (northerly component positive) PDF, and the anomaly of each year to the mean of the five-year period (March 2020 to February 2025), are presented in Figure 2-7 and Figure 2-8, respectively. All years analysed follow the five-year average V-component wind distribution, with the 2023-24 and 2024-25 years showing the greatest departures from the mean.

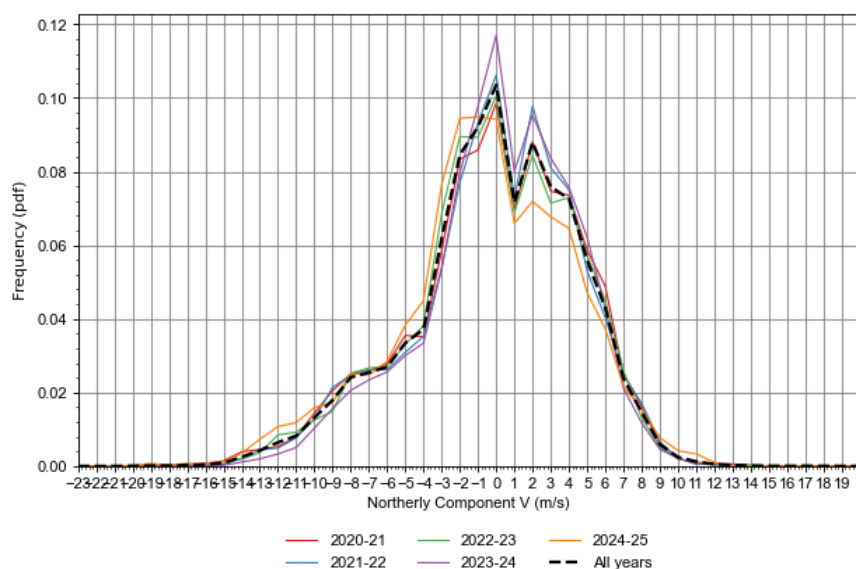


Figure 2-7 Comparison of annual observed wind V-component frequency distributions to the mean

Figure Note: BoM Bellambi AWS site (Station number 068228)

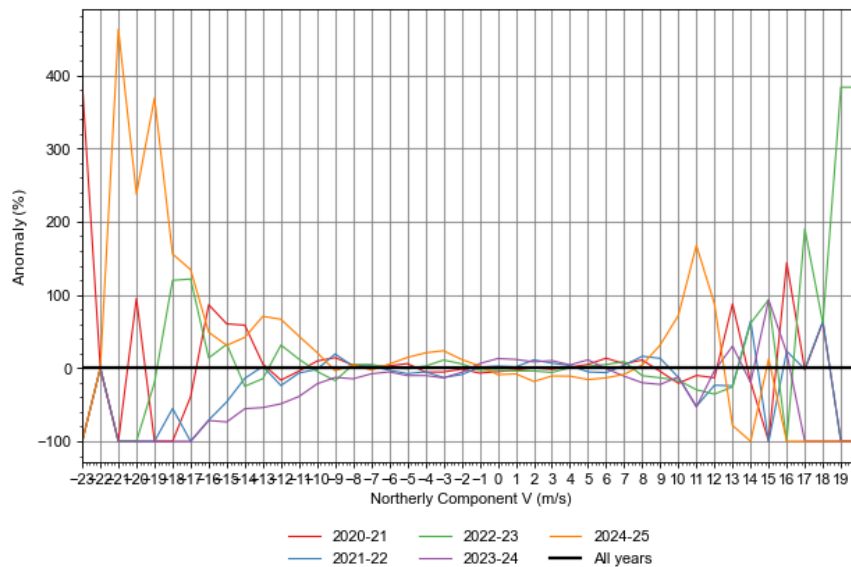


Figure 2-8 Annual observed wind V-component frequency distributions anomaly from the mean

Figure Note: BoM Bellambi AWS site (Station number 068228)

The R^2 correlation statistics for each year on year, and each year versus the mean of all years, are summarised in Table 2-4.

Table 2-4 Correlation coefficients matrices of the distributions of the wind V-component at Bellambi AWS (BoM station number 068228)

Year	2020-21	2021-22	2022-23	2023-24	2024-25	All years
2020-21	1					
2021-22	0.995	1				
2022-23	0.997	0.990	1			
2023-24	0.993	0.997	0.989	1		
2024-25	0.982	0.974	0.992	0.970	1	
All years	0.998	0.997	0.998	0.995	0.987	1

2.5 Temperature

The annual and mean temperature PDF and anomaly of each year to the mean of the five-year period, March 2020 to February 2025, are presented in Figure 2-9 and Figure 2-10 respectively. All years analysed broadly follow the five-year average temperature distribution, however the interannual variability is more pronounced than that seen in the wind distributions. The departures from the five-year mean are most noticeable for the 2023-24 year. The greatest interannual variations occur in the 16 to 22 °C range. The three years between 2020-21 and 2022-23 showed greater frequencies of temperatures within this range, with the following two years (2023-24 and 2024-25) showing lower frequencies. The year 2020-21 was the most representative of the five-year distribution.

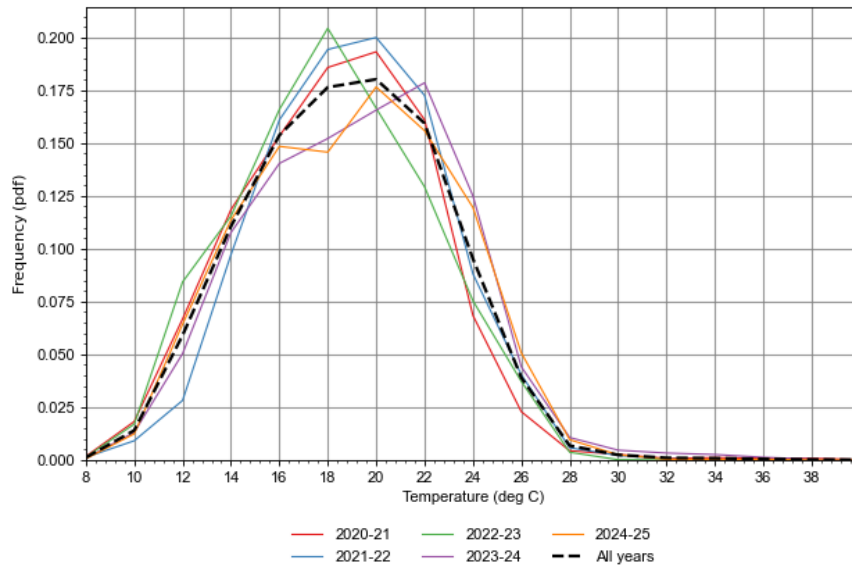


Figure 2-9 Comparison of annual observed temperature frequency distributions to the mean

Figure Note: BoM Bellambi AWS site (Station number 068228)

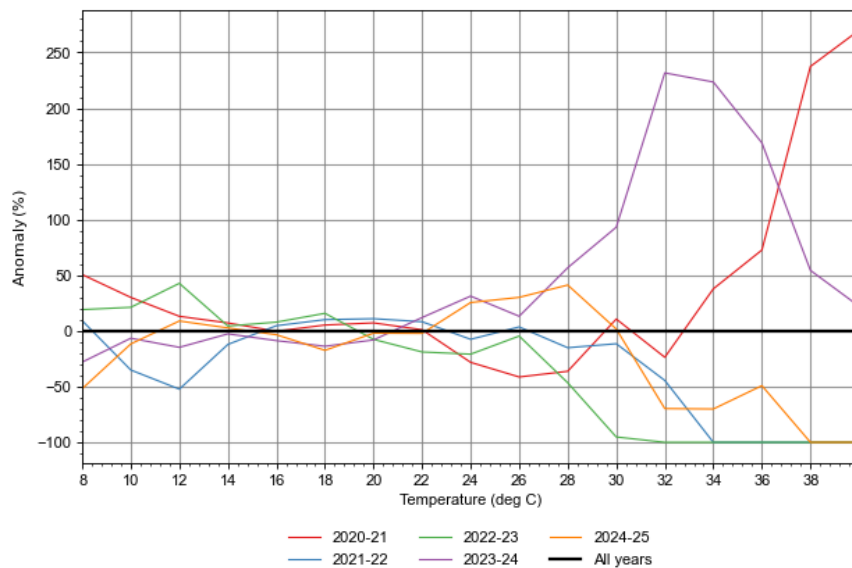


Figure 2-10 Annual observed temperature frequency distribution anomaly from the mean

Figure Note: BoM Bellambi AWS site (Station number 068228)

The R^2 correlation statistics for each year on year, and each year versus the mean of all years, are summarised in

Table 2-5.

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Appendix A - Meteorological Inter-annual Variability Analysis



Table 2-5 Correlation coefficients matrices of the distributions of temperature at Bellambi AWS (BoM station number 068228)

Year	2020-21	2021-22	2022-23	2023-24	2024-25	All years
2020-21	1					
2021-22	0.984	1				
2022-23	0.984	0.964	1			
2023-24	0.962	0.974	0.940	1		
2024-25	0.969	0.971	0.956	0.993	1	
All years	0.992	0.991	0.981	0.985	0.989	1

2.6 Dew point temperature

The annual and mean dew point temperature PDF and the anomaly of each year to the mean of the five-year period (March 2020 to February 2025), are presented in Figure 2-11 and Figure 2-12 respectively. The yearly distributions of dew point temperature broadly follow the five-year mean, similar to temperature, however the interannual variability is slightly greater. The greatest departure from the five-year mean occurred during the 2020-21 meteorological year, which experienced significantly higher-than-average frequencies of dew point temperatures between 11 °C and 16 °C (dry air) and corresponding lower frequencies of dew point temperatures above 16 °C (moist air). The most representative year was 2021-22.

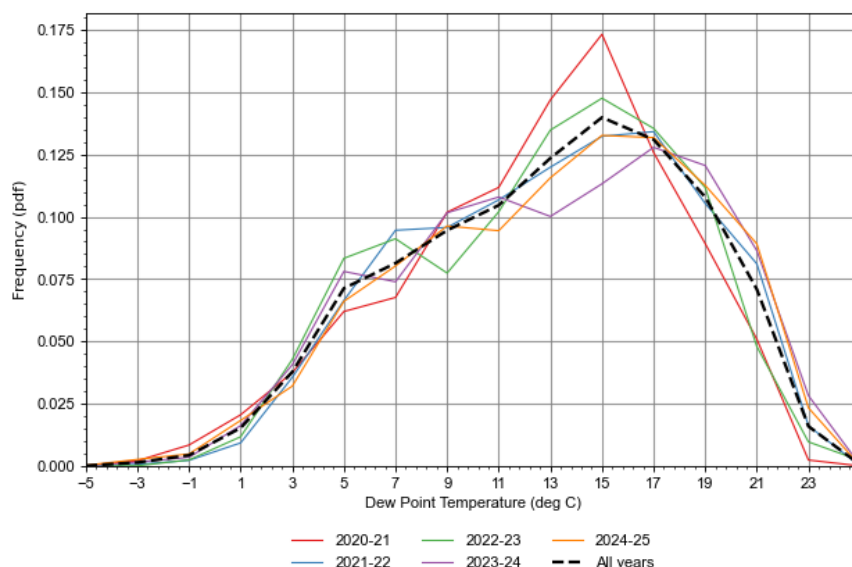


Figure 2-11 Comparison of annual observed dew point temperature frequency distributions to the mean at Bellambi AWS (BoM station number 068228)

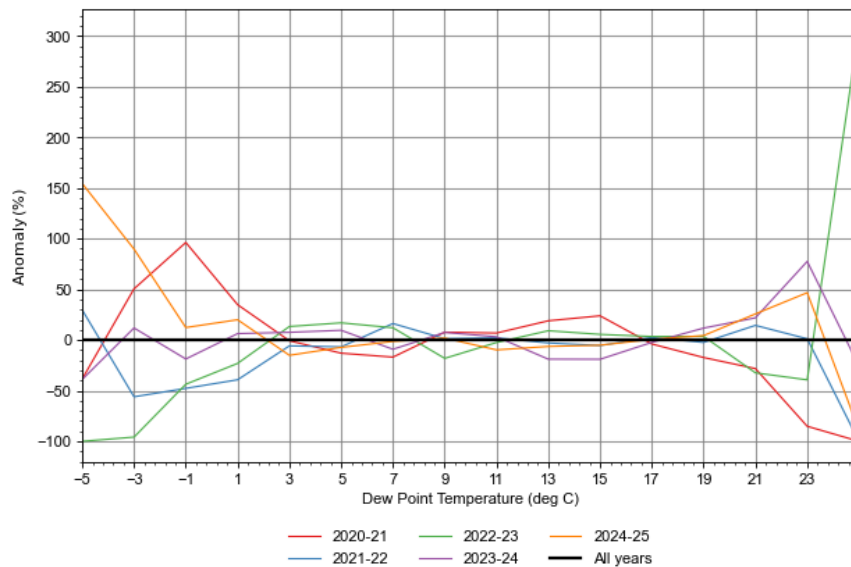


Figure 2-12 Annual observed dew point temperature frequency distribution anomaly from the mean

Figure Note: BoM Bellambi AWS site (Station number 068228)

The R^2 correlation statistics for each year on year, and each year versus the mean of all years, are summarised in Table 2-6 for the BoM Bellambi AWS site.

Table 2-6 Correlation coefficients matrices of the distributions of dew point temperature at Bellambi AWS (BoM station number 068228)

Year	2020-21	2021-22	2022-23	2023-24	2024-25	All years
2020-21	1					
2021-22	0.950	1				
2022-23	0.965	0.973	1			
2023-24	0.904	0.978	0.939	1		
2024-25	0.942	0.992	0.961	0.984	1	
All years	0.971	0.995	0.985	0.975	0.991	1

2.7 Rainfall

Monthly rainfall totals for the five-year period, March 2020 to February 2025, are presented in Figure 2-13 for the Bellambi BoM AWS site. The wettest year was 2022-23, which experienced greater than normal rains in March, April, July, and October. The 2021-22 meteorological year was drier than normal despite heavy rains in February. The 2020-21 year showed the closest to normal rainfall patterns.

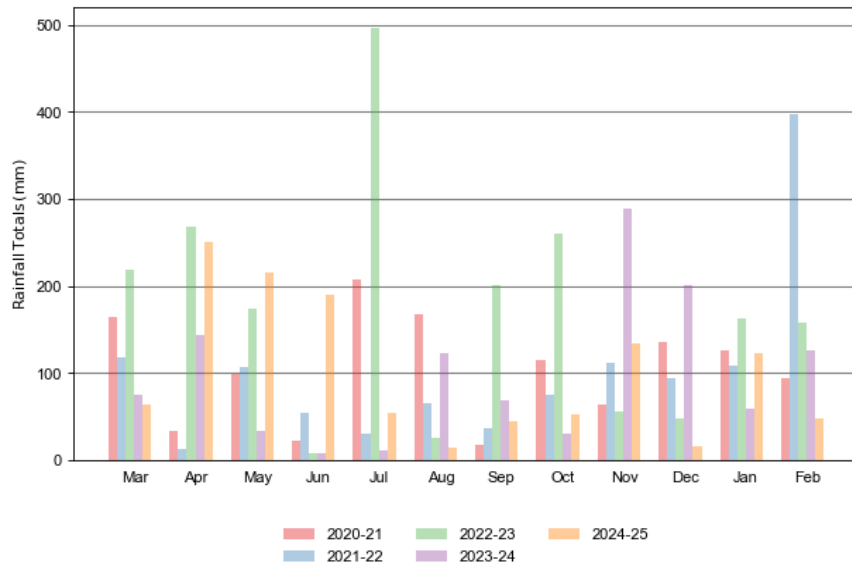


Figure 2-13 Monthly rainfall totals during the period March 2020 to February 2025
 Figure Note: BoM Bellambi AWS site (Station number 068228)

2.8 El Niño Southern Oscillation

The Southern Oscillation Index (SOI), as provided by the Bureau of Meteorology, indicates the development and intensity of El Niño or La Niña events in the Pacific Ocean. Sustained values of the SOI below -7 are indicative of El Niño events causing a reduction in winter and spring rainfall over eastern Australia. Likewise sustained positive values above +7 indicate La Niña events characterised by wetter than normal conditions.

The monthly SOI for the period March 2020 to February 2025 is provided in Figure 2-14.

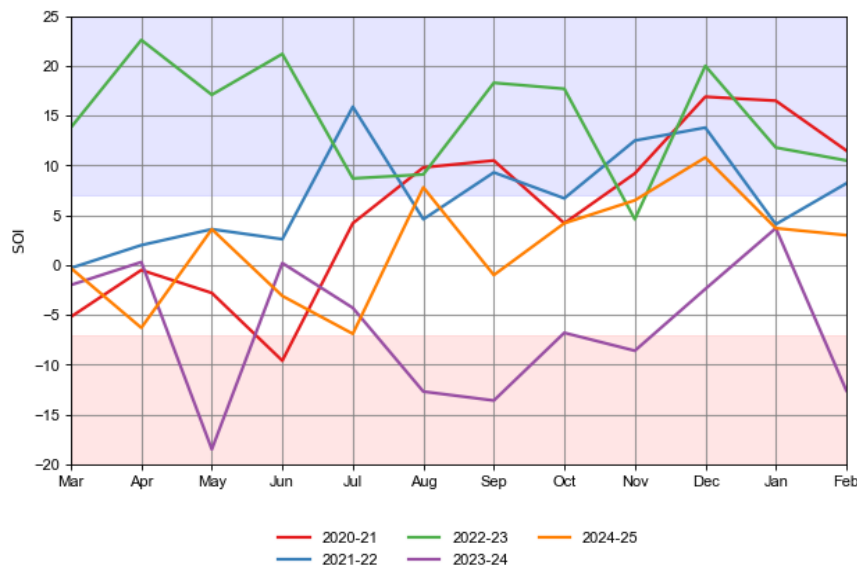


Figure 2-14 Monthly SOI for the period from March 2020 to February 2025



3 Analysis of annual variability

3.1 Correlation statistical analyses

The analysis of correlation statistics between individual years and the five-year mean found that:

- The wind speed for each individual modelling year was well correlated against the mean speed of all five years, with each year having an R^2 correlation of 0.99 or greater. Consequently, wind speed was not considered to vary significantly between years. The 2020-21 meteorological year had the highest wind speed correlation with an R^2 correlation coefficient of 0.999.
- There was slightly more variability in wind direction between years with correlations against the mean of all years varying between 0.927 (2024-25) and 0.982 (2021-22).
- Air temperature was well correlated against the mean temperature of all five years, with R^2 correlations ranging between 0.981 (2022-23) and 0.992 (2020-21).
- Dew point temperature, which is an indicator of humidity, correlated well against the long-term means, with R^2 correlations ranging between 0.971 (2020-21) and 0.995 (2021-22).
- The Southern Oscillation Index was found to vary most noticeably between the five years. Neutral, conditions most consistently occurred during the 2024-25 meteorological year. La Niña conditions occurred most often in the 2022-23 meteorological year, with El Niño conditions characterising the 2023-24 year.
- Annual rainfall totals were closest to the five-year mean during 2020-21.

3.2 Correlation statistic rankings

The correlation statistics for each meteorological parameter assessed were ranked and aggregated to determine the most typical year of the five-year period. Prior to aggregation the correlation statistics for each parameter were weighted according to the weightings provided in Table 3-1. Wind speed and direction each attracted a 30% weighting, whilst air temperature was weighted by 10%. All other parameters were left unweighted. These weightings were selected to reflect the relative importance of wind and temperature upon atmospheric dispersion.

Table 3-1 Weightings applied to the meteorological parameter aggregation

Meteorological parameter	Wind speed	Wind direction	Air temperature	Dew point temperature	SOI	Rain
Weighting	1.3	1.3	1.1	1	1	1

The statistical rankings for the Bellambi BoM site are presented in Table 3-1.



Table 3-1 Weighted rankings of correlation statistics for meteorological parameters

Year	Wind speed (m/s)	Wind direction (degrees)	Temp (°C)	Dew point temp (°C)	SOI	Annual rainfall	Aggregate ranking	Final rank
2020-21	1.3	2.6	1.1	5	2	1	13.0	1
2021-22	2.6	1.3	2.2	1	4	2	13.1	2
2022-23	6.5	3.9	5.5	3	5	5	28.9	5
2023-24	3.9	5.2	4.4	4	3	4	24.5	4
2024-25	5.2	6.5	3.3	2	1	3	21.0	3

Based on the assessment of meteorological inter-annual variability the one-year interval between 1 March 2020 to 28 February 2021 was identified as the most typical year of meteorology and was selected for use within the GrainCorp Port Kembla meteorological model.

Appendix B

TAPM Meteorological Model Configuration





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1 The GrainCorp Bulk Liquid Terminal TAPM Meteorological Model

1.1 Model description

The TAPM model requires synoptic meteorological information inputs for the region of interest that are generated by a global model similar to the large-scale models used to forecast the weather. TAPM incorporates re-analysed and validated synoptic weather forecast data at a resolution of approximately 75 km and at elevations of between 100 m and 5,000 m above the surface, with regionally specific terrain, land use, soil moisture content and soil type to simulate the meteorology of a region as well as at a specific location.

Landcover data for TAPM are sourced from the US Geological Survey, Earth Resources Observation Systems (EROS) Data Center Distributed Active Archive Center (EDC DAAC) at 30-second (approximately 1 km) grid spacing.

1.2 Geophysical databases

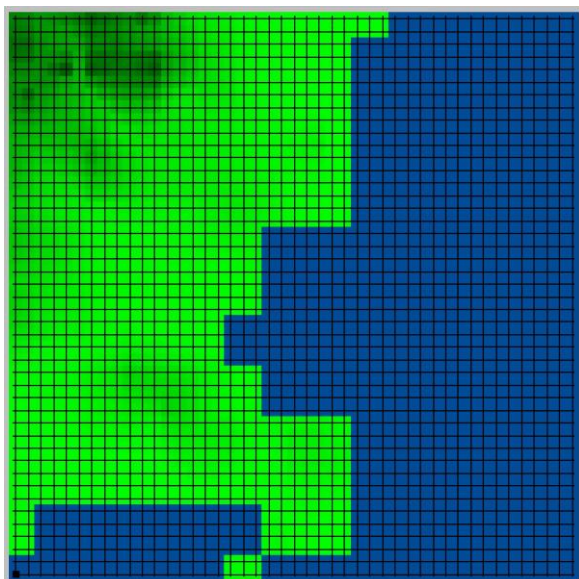
It is essential to accurately represent the geophysical features of the modelling domain. Geophysical parameters such as vegetation height, fraction of surface covered by vegetation and leaf area index are derived from land cover classification.

Where required, terrain and land-use data generated from the TAPM default database are improved. This could include a visual analysis of available imagery and may also include more complex methods using spatial analysis and techniques based on GIS (Geographic Information Systems).

Customised TAPM terrain and land use databases were created for the inner 300 m nest. Terrain heights were downloaded from the SRTM1 global 30 m (1 arc-second) dataset. Land use classes were extracted from the ACLUMP database (2017). The considerable improvement arising from use of the SRTM1 global 30 m dataset databases and the ACLUMP land use classifications are shown in Figure 1-1.



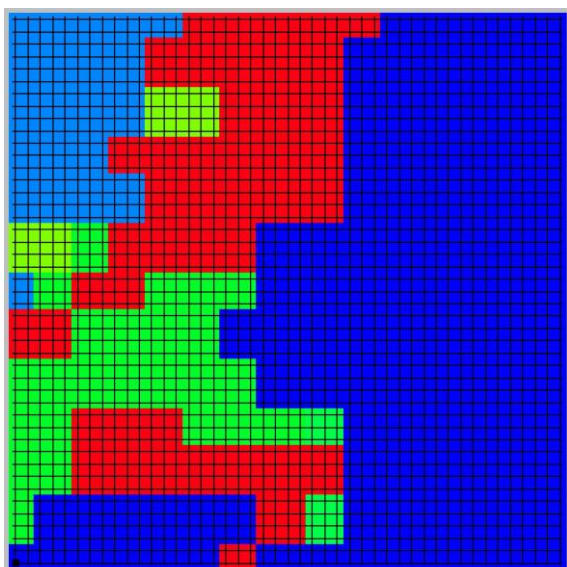
Default topography



Refined topography



Default land use classifications



Refined land use classifications

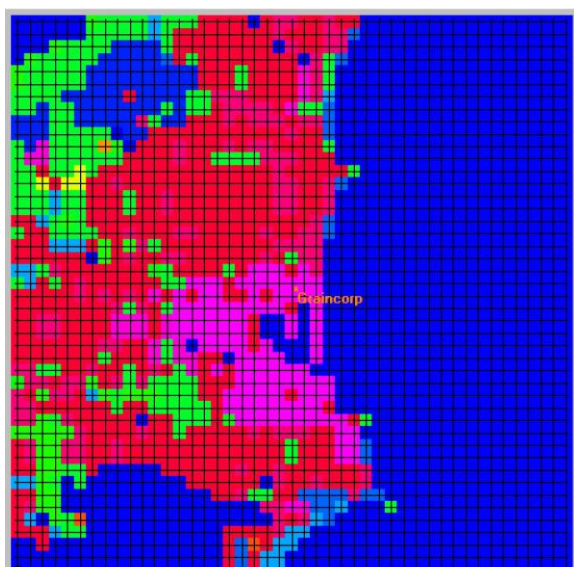


Figure 1-1 Corrections made to the inner (300 m) TAPM terrain and land use databases

1.3 TAPM configuration settings

TAPM (version 4.0.5) was configured as follows:

- Modelling period of one year from 1 March 2020 to 1 March 2021, with each month being modelled within a separate TAPM simulation,
- 45 x 45 grid point domain with an outer grid of 30 km and nesting grids of 10 km, 3 km, 1 km and 300 m,
- 30 vertical levels from the surface up to 8,000 m above the ground,

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Appendix B – TAPM Meteorological Model Configuration



- Grid centred over the GrainCorp Bulk Liquid Terminal (Latitude 34° 27.0' S, Longitude 150° 53.5' E; 306,317 mE, 6,185,931 mN MGA),
- Terrain and land use data Nests 1 to 4 based on Geoscience Australia 9 second (approximately 300 m) terrain and land use data (TAPM default terrain and land use),
- Terrain for the inner 300 m nest (Nest 5) downloaded from SRTM1 global 30 m (1 arc-second) dataset,
- Land cover data for the inner 300 m nest (Nest 5) was customised using the ACLUMP database (2017),
- Default options selected for advanced meteorological inputs, and
- No data assimilation.

The innermost domain covers an area of 13.5 km by 13.5 km. This area was selected to ensure that the main topographic features of the region were explicitly modelled at a high (300 m) grid resolution.

The data generated by TAPM was processed and formatted by the CALTAPM post-processor to produce a meteorological dataset (3D.DAT) suitable for direct use within CALMET.

Appendix C

CALMET Meteorological Model Configuration





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Figure 1-3	CALMET land-use classification of the modelling domain	6



1 The GrainCorp Bulk Liquid Terminal CALMET Meteorological Model

1.1 Model description

CALMET (version 6.5.0) was used to simulate meteorological conditions in the region. The TAPM prognostic grid data was used by the CALMET diagnostic model as an 'initial guess' before adjusting the local wind fields for the kinematic effects of terrain, slope flows, blocking effects and three-dimensional divergence minimisation. The TAPM-CALMET coupled approach improves the mesoscale prognostic simulation generated by TAPM with the refined local-scale land use and terrain capabilities of CALMET. The CALMET output provides a complete set of three-dimensional wind fields, temperature profiles and other important meteorological variables throughout the atmosphere for application in the simulation of plume dispersion.

1.2 CALMET configuration

CALMET (version 6.5.0) was configured as follows:

- Domain area of 91 by 91 grid points at 100 m spacing (9.1 km by 9.1 km), centered over the GrainCorp Bulk Liquid Terminal (Figure 1-1) with the southwest corner grid point located at 301.767 kmE, 6,181.381 kmN.
- Topographic data (Figure 1-2) based on the near-global 1-arc second (~30 m) Digital Elevation Model (DEM) produced by the Shuttle Radar Topography Mission (SRTM1 version 3), a project of the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL) program.
- Land use data (Figure 1-3) was derived from the ACLUMP database (2017), in order to calculate the dominant land use for each CALMET grid cell for inclusion within the geo.dat file.
- Modelling period for the selected representative year (1 March 2020 to 28 February 2021).
- Twelve vertical levels set at 20 m, 60 m, 100 m, 150 m, 200 m, 250 m, 350 m, 500 m, 800 m, 1,600 m, 2,600 m and 4,600 m.
- 'NO-OBS' (no observations) mode. Prognostic wind fields generated by TAPM input as 3D.DAT surface and upper air predictions as initial guess fields.
- Mixing height parameters all set as default.
- No extrapolation of surface winds observations.
- Step 1 wind field options include: divergence minimisation, Froude adjustment to a critical Froude number of 1, and slope flows.
- Coriolis parameter set to 8.228×10^{-5} rad/s, as calculated for the region.
- Terrain radius of influence set at 4 km following the method defined in the Generic Guidance and Optimum Model Settings for CALPUFF (TRC Environmental Group, 2011).
- CALMET parameters set based on recommendations from the Generic Guidance and Optimum Model Settings for CALPUFF.
- All other options set to default.

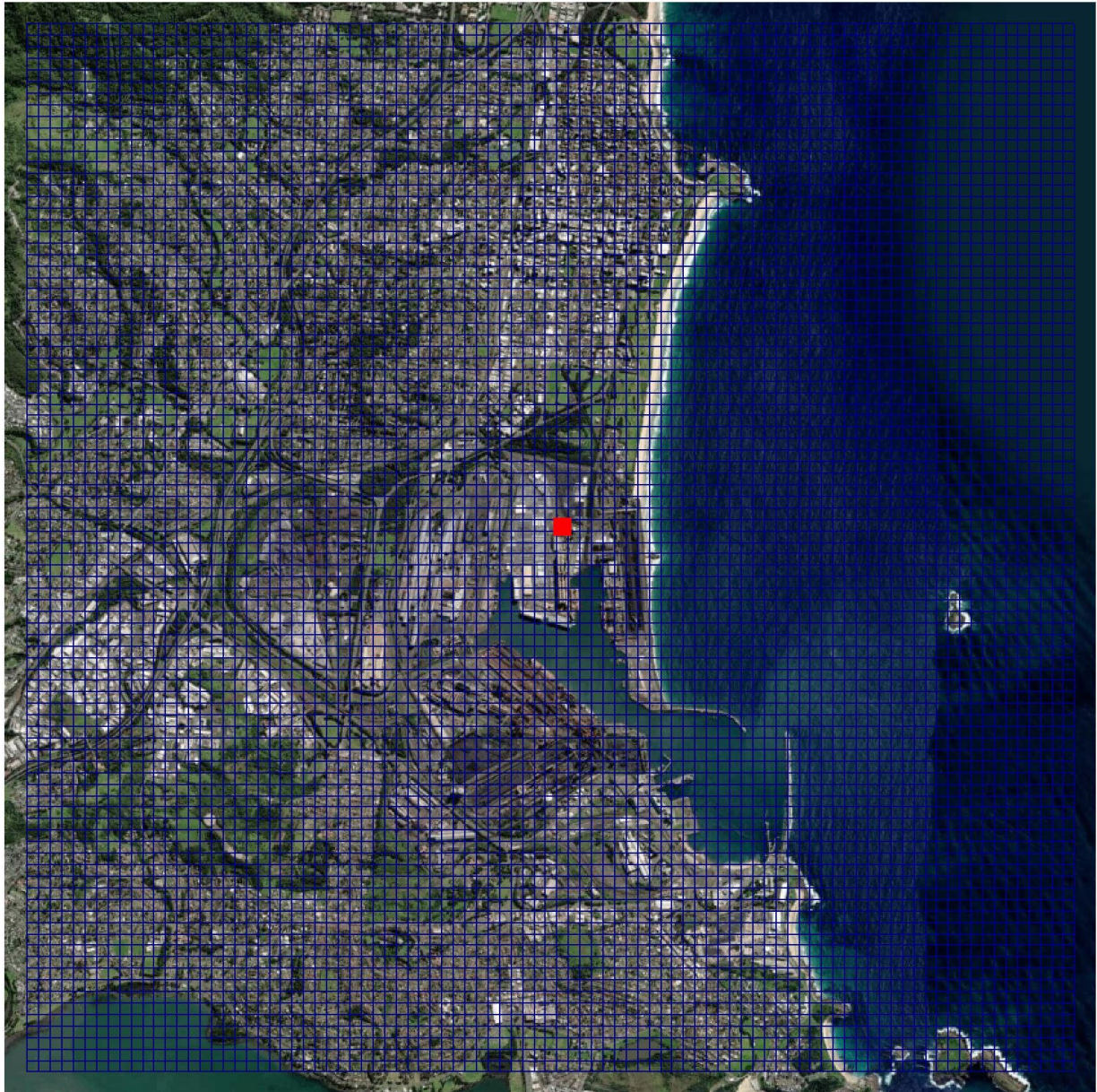


Figure 1-1 CALMET 100 m meteorological grid
Figure Note: The GrainCorp Bulk Liquid Terminal site is identified with a red square.

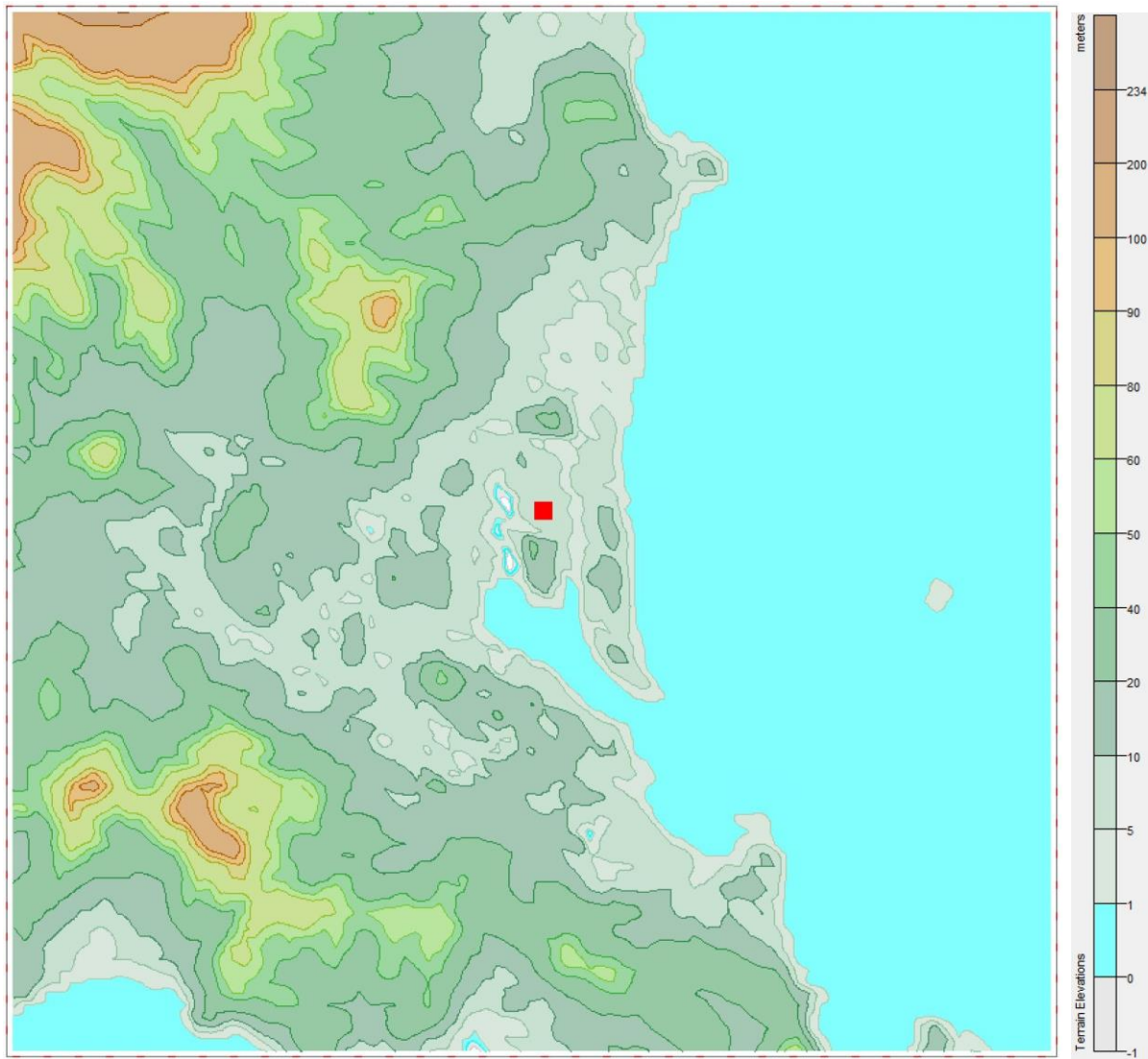
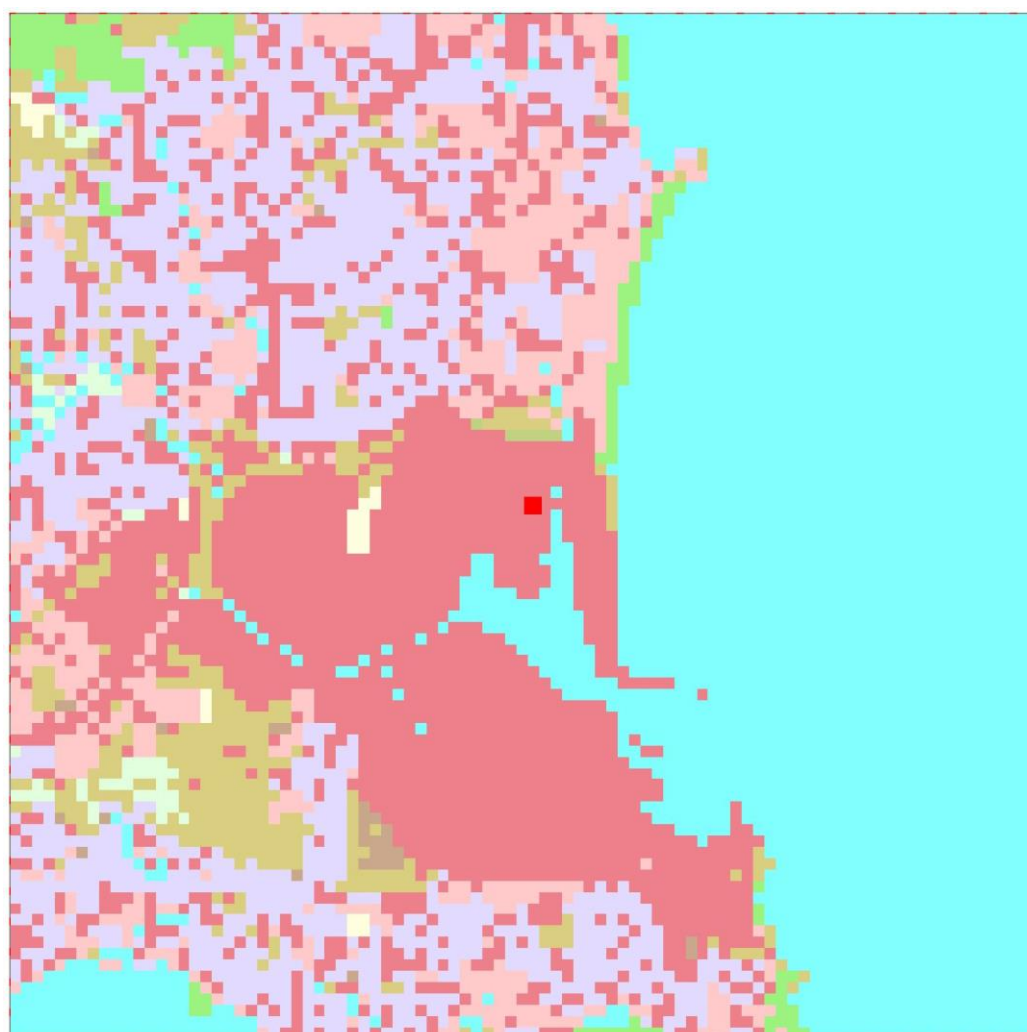


Figure 1-2 CALMET digital elevation model of the modelling domain
Figure Note: The GrainCorp Bulk Liquid Terminal site is identified with a red square.



Legend

- 77 Mixed Barren Land
- 76 Transitional Areas
- 62 Nonforested Wetlands
- 54 Bays and Estuaries
- 53 Reservoirs
- 52 Lakes
- 51 Streams and Canals
- 50 Water
- 43 Mixed Forest Land
- 33 Mixed Rangeland
- 32 Shrub and Brush Rangeland
- 31 Herbaceous Rangeland
- 23 Confined Feeding Operations
- 22 Orchards, Groves, Vineyards, Nurseries
- 21 Cropland and Pasture
- 15 Industrial and Commercial
- 14 Transportation, Communications
- 13 Industrial
- 12 Commercial Services
- 11 Residential

Figure 1-3 CALMET land-use classification of the modelling domain
 Figure Note: The GrainCorp Bulk Liquid Terminal site is identified with a red square.

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Appendix C – CALMET Meteorological Model Configuration



1.3 CALMET configuration settings

A comprehensive list of CALMET configuration settings is provided in the following pages.

CALMET Parameters

0180.2505 TfA GrainCorp AQIA

NoObs Mode

100 m met grid. Terrad = 4 km

INPUT GROUP: 0 -- Input and Output File Names		
Parameter	Description	Value
GEODAT	Input file of geophysical data (GEO.DAT)	GEO_LU.DAT
METLST	Output file name of CALMET list file (CALMET.LST)	CALMET.LST
METDAT	Output file name of generated gridded met files (CALMET.DAT)	CALMET.DAT
LCFILES	Lower case file names (T = lower case, F = upper case)	F
NUSTA	Number of upper air stations	0
NOWSTA	Number of overwater stations	0
NM3D	Number of prognostic meteorological data files (3D.DAT)	12
NIGF	Number of IGF-CALMET.DAT files used as initial guess	0

INPUT GROUP: 1 -- General Run Control Parameters		
Parameter	Description	Value
IBYR	Starting year	2020
IBMO	Starting month	3
IBDY	Starting day	1
IBHR	Starting hour	0
IBSEC	Starting second	0
IEYR	Ending year	2021
IEMO	Ending month	3
IEDY	Ending day	1
IEHR	Ending hour	0
IESEC	Ending second	0
ABTZ	Base time zone	UTC+1000
NSECDT	Length of modeling time-step (seconds)	3600
IRTYPE	Output run type (0 = wind fields only, 1 = CALPUFF/CALGRID)	1
LCALGRD	Compute CALGRID data fields (T = true, F = false)	T
ITEST	Flag to stop run after setup phase (1 = stop, 2 = run)	2
MREG	Regulatory checks (0 = no checks, 1 = US EPA LRT checks)	0

INPUT GROUP: 2 -- Map Projection and Grid Control Parameters		
Parameter	Description	Value
PMAP	Map projection system	UTM
FEAST	False easting at projection origin (km)	0.0
FNORTH	False northing at projection origin (km)	0.0

INPUT GROUP: 2 -- Map Projection and Grid Control Parameters		
Parameter	Description	Value
IUTMZN	UTM zone (1 to 60)	56
UTMHEM	Hemisphere of UTM projection (N = northern, S = southern)	S
XLAT1	1st standard parallel latitude (decimal degrees)	30S
XLAT2	2nd standard parallel latitude (decimal degrees)	60S
DATUM	Datum-Region for the coordinates	WGS-84
NX	Meteorological grid - number of X grid cells	91
NY	Meteorological grid - number of Y grid cells	91
DGRIDKM	Meteorological grid spacing (km)	0.1
XORIGKM	Meteorological grid - X coordinate for SW corner (km)	301.7670
YORIGKM	Meteorological grid - Y coordinate for SW corner (km)	6181.3810
NZ	Meteorological grid - number of vertical layers	12
ZFACE	Meteorological grid - vertical cell face heights (m)	0.00,20.00,60.00,100.00,150.00,200.00,250.00,350.00,500.00,800.00,1600.00,2600.00,4600.00

INPUT GROUP: 3 -- Output Options		
Parameter	Description	Value
LSAVE	Save met fields in unformatted output file (T = true, F = false)	T
IFORMO	Type of output file (1 = CALPUFF/CALGRID, 2 = MESOPUFF II)	1
LPRINT	Print met fields (F = false, T = true)	F
IPRINF	Print interval for output wind fields (hours)	1
STABILITY	Print gridded PGT stability classes? (0 = no, 1 = yes)	0
USTAR	Print gridded friction velocities? (0 = no, 1 = yes)	0
MONIN	Print gridded Monin-Obukhov lengths? (0 = no, 1 = yes)	0
MIXHT	Print gridded mixing heights? (0 = no, 1 = yes)	0
WSTAR	Print gridded convective velocity scales? (0 = no, 1 = yes)	0
PRECIP	Print gridded hourly precipitation rates? (0 = no, 1 = yes)	0
SENSHEAT	Print gridded sensible heat fluxes? (0 = no, 1 = yes)	0
CONVZI	Print gridded convective mixing heights? (0 = no, 1 = yes)	0
LDB	Test/debug option: print input met data and internal variables (F = false, T = true)	F
NN1	Test/debug option: first time step to print	1
NN2	Test/debug option: last time step to print	1
LDBCST	Test/debug option: print distance to land internal variables (F = false, T = true)	F
IOUTD	Test/debug option: print control variables for writing winds? (0 = no, 1 = yes)	0
NZPRN2	Test/debug option: number of levels to print starting at the surface	1
IPR0	Test/debug option: print interpolated winds? (0 = no, 1 = yes)	0

INPUT GROUP: 5 -- Wind Field Options and Parameters		
Parameter	Description	Value
I PROG	Use prognostic winds as input to diagnostic wind model (0 = no, 13 = use winds from 3D.DAT as Step 1 field, 14 = use winds from 3D.DAT as initial guess field, 15 = use winds from 3D.DAT file as observations)	14
ISTEPPGS	Prognostic data time step (seconds)	3600
IGFMET	Use coarse CALMET fields as initial guess? (0 = no, 1 = yes)	0
LVARY	Use varying radius of influence (F = false, T = true)	F
RMAX1	Maximum radius of influence in the surface layer (km)	0
RMAX2	Maximum radius of influence over land aloft (km)	0
RMAX3	Maximum radius of influence over water (km)	0
RMIN	Minimum radius of influence used in wind field interpolation (km)	0.1
TERRAD	Radius of influence of terrain features (km)	4
R1	Relative weight at surface of step 1 fields and observations (km)	0
R2	Relative weight aloft of step 1 field and observations (km)	0
RPROG	Weighting factors of prognostic wind field data (km)	0
DIVLIM	Maximum acceptable divergence	5E-006
NITER	Maximum number of iterations in the divergence minimization procedure	50
NSMTH	Number of passes in the smoothing procedure (NZ values)	2,11*4
NINTR2	Maximum number of stations used in each layer for interpolation (NZ values)	12*99
CRITFN	Critical Froude number	1
ALPHA	Empirical factor triggering kinematic effects	0.1
NBAR	Number of barriers to interpolation of the wind fields	0
KBAR	Barrier - level up to which barriers apply (1 to NZ)	12
IDIOPT1	Surface temperature (0 = compute from obs/prognostic, 1 = read from DIAG.DAT)	0
ISURFT	Surface station to use for surface temperature (between 1 and NSSTA)	-1
IDIOPT2	Temperature lapse rate used in the computation of terrain-induced circulations (0 = compute from obs/prognostic, 1 = read from DIAG.DAT)	0
IUPT	Upper air station to use for the domain-scale lapse rate (between 1 and NUSTA)	-1
ZUPT	Depth through which the domain-scale lapse rate is computed (m)	200
IDIOPT3	Initial guess field winds (0 = compute from obs/prognostic, 1 = read from DIAG.DAT)	0
IUPWND	Upper air station to use for domain-scale winds	-1
ZUPWND	Bottom and top of layer through which the domain-scale winds are computed (m)	1.0, 1.00
IDIOPT4	Read observed surface wind components (0 = from SURF.DAT, 1 = from DIAG.DAT)	0
IDIOPT5	Read observed upper wind components (0 = from UPn.DAT, 1 = from DIAG.DAT)	0
LLBREZE	Use Lake Breeze module (T = true, F = false)	F
NBOX	Lake Breeze - number of regions	0

INPUT GROUP: 6 -- Mixing Height, Temperature and Precipitation Parameters		
Parameter	Description	Value
CONSTB	Mixing height constant: neutral, mechanical equation	1.41
CONSTE	Mixing height constant: convective equation	0.15
CONSTN	Mixing height constant: stable equation	2400
CONSTW	Mixing height constant: overwater equation	0.16
FCORIOI	Absolute value of Coriolis parameter (1/s)	8.228E-005
IAVEZI	Spatial mixing height averaging? (0 = no, 1 = yes)	1
MNMDAV	Maximum search radius in averaging process (grid cells)	1
HAFANG	Half-angle of upwind looking cone for averaging (degrees)	30
ILEVZI	Layer of winds used in upwind averaging (between 1 and NZ)	1
IMIXH	Convective mixing height method (1 = Maul-Carson, 2 = Batchvarova-Gryning, - for land cells only, + for land and water cells)	1
THRESHL	Overland threshold boundary flux (W/m**3)	0
THRESHW	Overwater threshold boundary flux (W/m**3)	0.05
ITWPROG	Overwater lapse rate and deltaT options (0 = from SEA.DAT, 1 = use prognostic lapse rates and SEA.DAT deltaT, 2 = from prognostic)	0
ILUOC3D	Land use category in 3D.DAT	16
DPTMIN	Minimum potential temperature lapse rate (K/m)	0.001
DZZI	Depth of computing capping lapse rate (m)	200
ZIMIN	Minimum overland mixing height (m)	50
ZIMAX	Maximum overland mixing height (m)	3000
ZIMINW	Minimum overwater mixing height (m)	50
ZIMAXW	Maximum overwater mixing height (m)	3000
ICOARE	Overwater surface fluxes method	10
DSHELF	Coastal/shallow water length scale (km)	0
IWARM	COARE warm layer computation (0 = off, 1 = on)	0
ICOOL	COARE cool skin layer computation (0 = off, 1 = on)	0
IRHPROG	Relative humidity read option (0 = from SURF.DAT, 1 = from 3D.DAT)	1
ITPROG	3D temperature read option (0 = stations, 1 = surface from station and upper air from prognostic, 2 = prognostic)	2
IRAD	Temperature interpolation type (1 = 1/R, 2 = 1/R**2)	1
TRADKM	Temperature interpolation radius of influence (km)	500
NUMTS	Maximum number of stations to include in temperature interpolation	5
IAVET	Conduct spatial averaging of temperatures? (0 = no, 1 = yes)	1
TGDEFB	Default overwater mixed layer lapse rate (K/m)	-0.0098
TGDEFA	Default overwater capping lapse rate (K/m)	-0.0045
JWAT1	Beginning land use category for temperature interpolation over water	999
JWAT2	Ending land use category for temperature interpolation over water	999
NFLAGP	Precipitation interpolation method (1 = 1/R, 2 = 1/R**2, 3 = EXP/R**2)	2
SIGMAP	Precipitation interpolation radius of influence (km)	100.
CUTP	Minimum precipitation rate cutoff (mm/hr)	0.01

Appendix D

Evaluation of Meteorological Model Performance





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1 Available Observations

The closest Bureau of Meteorology (BoM) automatic weather station (AWS) collecting a suitable range of meteorological parameters for assessment of GrainCorp Bulk Liquid Terminal meteorological model is located at the Bellambi AWS (Station 068228), approximately 9.40 km to the north-northeast of the GrainCorp site. This AWS site lies beyond the CALMET 100 m meteorological grid, however it is within the TAPM inner (300 m) nest. The location of the Bellambi AWS site in relation to the GrainCorp site is provided in Table 1-1 and shown in Figure 1-1.

Table 1-1 Location of the Bellambi AWS in relation to the GrainCorp site

BoM Station Number	BoM Station Name	Latitude/ Northing (GDA 2020)	Longitude/ Easting (GDA 2020)	Distance from the GrainCorp Site	Bearing from the GrainCorp Site
068228	Bellambi AWS	-34.3692 °S (6,194,961 mN)	150.9292 °E (309,581 mE)	9.40 km	20.7 ° (NNE)

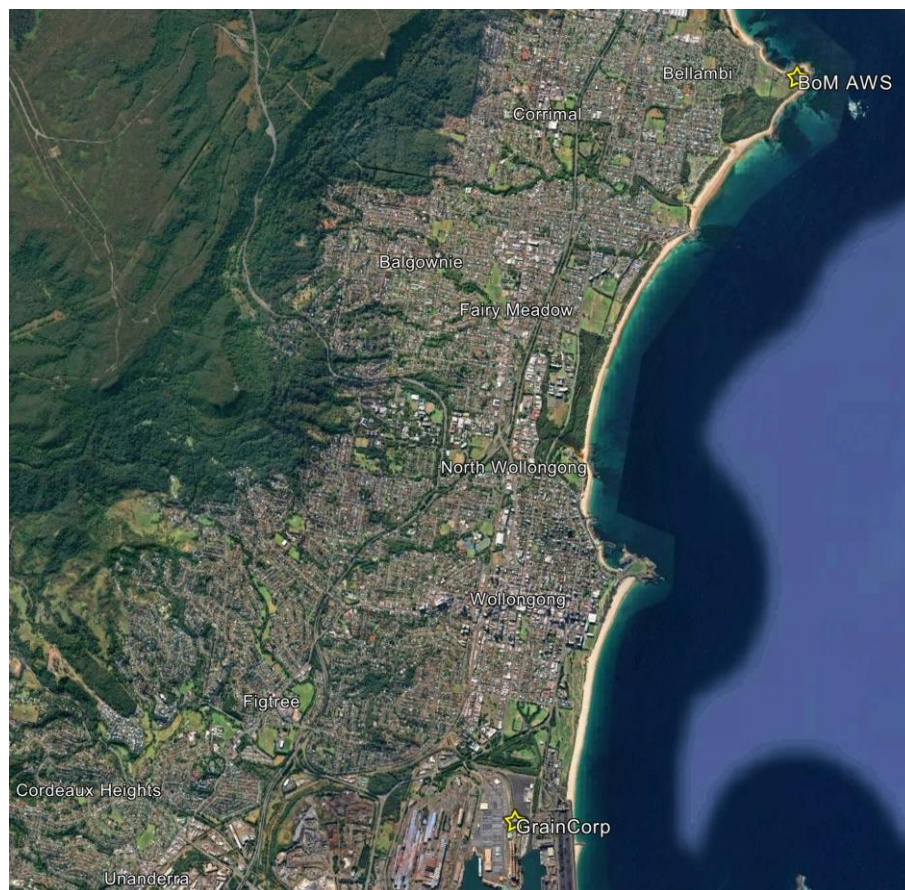


Figure 1-1 Location of the BoM Bellambi AWS site (Site 068228) in relation to the GrainCorp site



2 Model Performance Evaluation Method

Observations collected at the BoM Bellambi AWS, during the period selected for modelling (1 March 2020 to 28 February 2021), were compared with meteorological data generated by the TAPM and CALMET meteorological modelling systems for the same time period and approximate location. Model predictions were selected from the 300 m (Grid 5) TAPM grid at the closest respective model grid point to the BoM AWS site, for evaluation analysis.

The model predictions were validated against observations using the following statistical measures. Details about these measures are provided in Section 3.

- Root Mean Square Error (RMSE)
- Systematic Root Mean Square Error (RMSES)
- Unsystematic Root Mean Square Error (RMSEU)
- Mean Error (ME)
- Mean Absolute Error (MAE)
- Index of Agreement (IOA)
- Skill E
- Skill V
- Skill R.

In addition to these measures, basic descriptive statistics such as the minimum, mean, maximum, and standard deviation were also derived.



3 Statistical Evaluation Techniques

There are no defined standards for evaluating numerical weather prediction (NWP) model performance. Statistical scores simply provide a means to quantify the magnitude of the difference between predictions and observations. These provide a useful guide to performance benchmarks of what should be expected from a model and can be used to compare the performance of the TAPM and CALMET models. The performance benchmarks are guidelines and are not absolute values of pass or fail. Where possible, two criteria have been set for model performance statistics that are generally considered acceptable or good.

3.1 Root mean square error (RMSE)

$$\text{RMSE} = \sqrt{\frac{1}{N} \sum_{i=1}^N (P_i - O_i)^2}$$

Where:

N = number of observed and predicted hours in analysis (i.e. one year)

P_i = hourly prediction i

O_i = hourly observation i

The RMSE can be described as the standard deviation of the difference for hourly predicted and observed pairings at a specific point. The RMSE is a quadratic scoring rule, which measures the average magnitude of the error. The difference between predicted and corresponding observed values are each squared and then averaged over the sample. Finally, the square root of the average is taken. Since the errors are squared before they are averaged, the RMSE gives a relatively high weight to large errors. This means the RMSE is most useful when large errors are particularly undesirable. Overall, the RMSE is a good overall measure of model performance, but since large errors are weighted heavily (due to squaring), its value can be distorted. The units of RMSE are the same as those of the values being analysed.

An appropriate benchmark for acceptable model performance for wind speed predictions is an RMSE value of 2 m/s or lower.

3.2 Systematic root mean square error (RMSE_s)

$$\text{RMSE}_s = \sqrt{\frac{1}{N} \sum_{i=1}^N (\hat{P}_i - O_i)^2}$$

Where:

N = number of observed and predicted hours in analysis (i.e. one year)

$\hat{P}$ = mean of predictions

O_i = hourly observation i

The RMSE_s is calculated as the square root of the mean square difference of hourly predictions from the regression formula and observation pairings, at a specific point. The regressed predictions are taken from the least-squares formula. The RMSE_s estimates the model's linear (or systematic) error. The systematic error is a measure of the bias in the model due to user input or model deficiency, i.e., data input errors, assimilation variables, and choice of model options. The RMSE_s is a metric for the model's accuracy.



3.3 Unsystematic root mean square error (RMSE_u)

$$RMSE_u = \sqrt{\frac{1}{N} \sum_{i=1}^N (\hat{P}_i - P_i)^2}$$

Where:

N = number of observed and predicted hours in analysis (i.e. one year)

$\hat{P}$ = mean of predictions

P_i = hourly prediction i

The RMSE_u is calculated as the square root of the mean square difference of hourly predictions from the regression formula and model prediction value pairings, at a specific point. The RMSE_u is a measure of how much of the difference between predictions and observations result from random processes or influences outside the legitimate range of the model. This error may require model refinement, such as new algorithms or higher resolution grids, or that the phenomena being simulated cannot be fully resolved by the model. The RMSE_u is a metric for the model's precision.

Ultimately, for good model performance, the RMSE should be a low value, with most of the variation explained in the observations. Here, the systematic error RMSE_s should approach zero and the unsystematic error, RMSE_u, should approach the RMSE since:

$$RMSE^2 = RMSE_s^2 + RMSE_u^2$$

3.4 Mean error and mean absolute error

The Mean Error (ME), or Mean Bias, is simply the average of the hourly modelled values minus the hourly observed values. It contains both systematic and unsystematic errors and is heavily influenced by high and low errors.

Specific mean error benchmarks denoting acceptable model performance have been developed for simple and complex terrain scenarios, as shown in Table 3-1.

Table 3-1 Mean error (bias) benchmarks for assessing meteorological model performance

Meteorological parameter	Ideal value	Benchmark		Source
		Simple terrain	Complex terrain	
Wind speed	0 m/s	$\leq \pm 0.5$ m/s	$\leq \pm 1.5$ m/s	Monk et al., 2019, p.9, Table 3
Wind direction	0 °	$\leq \pm 5$ °	$\leq \pm 10$ °	Bowden et al., 2015, p.4-2, Table 4-1
Temperature	0 °C	$\leq \pm 0.5$ °C	$\leq \pm 2$ °C	Lake Michigan Air Directors Consortium, 2018, p.22, Table 5-1
Relative humidity	0 %	$< \pm 10$ %	$< \pm 10$ %	Arasa et al., 2015, Table 2

The Mean Absolute Error (MAE), or Mean Gross Error (MGE), measures the average magnitude of the errors in a set of predictions e.g. wind, without considering their direction. It measures accuracy for continuous variables. Expressed in words, the MAE is the average of the absolute values of the differences between predictions and the corresponding observation. The MAE is a linear score, which means that all the individual differences are weighted equally in the average. The MAE and the RMSE can be used together to diagnose the variation in the errors in a set of predictions. The RMSE will always



be larger or equal to the MAE; the greater difference between them, the greater the variance in the individual errors in the sample. If the RMSE = MAE, then all the errors are of the same magnitude. Both the MAE and RMSE can range from 0 to ∞ . They are negatively-oriented scores, i.e., lower values are better.

Specific mean absolute error benchmarks denoting acceptable model performance have been developed for simple and complex terrain scenarios, as shown in Table 3-2.

Table 3-2 Mean Absolute Error benchmarks for assessing meteorological model performance

Meteorological parameter	Ideal value	Benchmark		Source
		Simple terrain	Complex terrain	
Wind Speed	0 m/s	≤ 2 m/s	≤ 2.5 m/s	MDPI, 2019, p.2, Table S3
Wind Direction	0 °	≤ 30 °	≤ 55 °	Monk et al., 2019, p.9, Table 3
Temperature	0 °C	≤ 2 °C	≤ 3.5 °C	Lake Michigan Air Directors Consortium, 2018, p.22, Table 5-1
Relative Humidity	0 %	< 20 %	< 20 %	Arasa et al., 2015, Table 2

3.5 Index of agreement

The Index of Agreement (IOA) is defined as:

$$IOA = 1 - \frac{\sum_{i=1}^N (P_i - O_i)^2}{\sum_{i=1}^N (|P_i - O_{mean}| + |O_i - O_{mean}|)^2}$$

Where:

- N is the number of observations,
- P_i are the hourly model predictions,
- O_i are the hourly observations,
- O_{mean} is the observed observation mean, and

$\hat{P}_i = a + bO_i$ is the linear regression fitted with intercepts a and slope b .

The IOA is calculated using a method described in Willmott (1982). The IOA can take a value between 0 and 1, with 1 indicating perfect agreement. The IOA is the ratio of the total RMSE to the sum of two differences, i.e., the difference between each prediction and the observed mean, and the difference between each observation and observed mean. From another perspective, the IOA is a measure of the match between the departure of each prediction from the observed mean and the departure of each observation from the observed mean. In general, a value of 0.5 is considered acceptable and >0.6 is considered good performance for time and space predictions. Specific index of agreement benchmarks denoting acceptable model performance have been developed as shown in Table 3-3.



Table 3-3 Index of agreement benchmarks for assessing meteorological model performance

Meteorological parameter	Ideal score	Benchmark		Source
		Acceptable performance	Good performance	
Wind Speed	1	≥ 0.5	≥ 0.6	Monk et al., 2019, p.9, Table 3
Wind Direction	1	≥ 0.5	≥ 0.6	-
Temperature	1	≥ 0.5	≥ 0.8	Monk et al., 2019, p. 9, Table 3
Relative Humidity	1	≥ 0.5	≥ 0.6	Monk et al., 2019, p.9, Table 3

3.6 Skill measures

Skill measure statistics are given in terms of a score, rather than in absolute terms. A model's skill can be measured by the difference in the standard deviation of the modelled and observed values (Chang and Hanna, 2004).

The **Skill_E (se)** is indicative of how much of the standard deviation in the observations is predicted to be due to random/natural processes (unsystematic) in the atmospheric boundary layer. i.e., turbulence/chaos. For good model performance, the value for Skill_E should be less than one, i.e.: $SKILL_E = (RMSE_U / STDEV_OBS) < 1$ shows skill.

Skill_V (sv) is the ratio of the standard deviation of the model predictions to the standard deviation of the observations. For good model performance, the value for Skill_V should be close to one, i.e.: $SKILL_V = (STDEV_MOD / STDEV_OBS)$ close to 1 shows skill.

SKILL_R (sr) takes into account systematic and unsystematic errors in relation to the observed standard deviation. For good model performance, the value for Skill_R should be less than one, i.e.: $SKILL_R = (RMSE / STDEV_OBS) < 1$ shows skill.

Skill scores indicating good model performance are summarised in Table 3-4.

Table 3-4 Skill score criteria for assessing good meteorological model performance

Skill measure	Ideal score for good model performance
Skill_E	< 1
SKILL_V	Close to 1
SKILL_R	< 1



4 Model Performance Evaluation

4.1 Descriptive statistics

The basic descriptive statistics comparing observations against TAPM model predictions at the BoM Bellambi AWS site for the period modelled are compared in Table 4-1 (wind) and Table 4-2 (air temperature and relative humidity). The tables show that mean and maximum wind speed is underestimated. This is well-known behaviour for TAPM and adds a degree of conservatism when modelling dispersion from ground level sources. TAPM predicts the average and minimum air temperatures well, however it significantly overestimates the relative humidity across the distribution.

Table 4-1 Descriptive statistics comparing observed and predicted winds at the BoM Bellambi AWS, 1 March 2020 to 28 February 2021

Descriptive statistics	Wind speed, m/s		U Vector wind, m/s		V Vector wind, m/s	
	AWS	TAPM	AWS	TAPM	AWS	TAPM
Average	5.0	3.6	-0.9	0.3	-0.6	-0.7
Standard deviation	2.8	1.8	3.3	2.6	4.6	3.0
Minimum	0	0	-14.9	-8.5	-19.9	-10.4
Maximum	20.6	10.4	12.6	7.2	16.9	5.7
n	8698	8760	8638	8760	8638	8760

Table notes: AWS = observed observations collected from the BoM Bellambi automatic weather station.
TAPM = modelled TAPM predictions for the BoM Bellambi AWS site.
U component is the east-west component of the wind.
V component is the north-south component of the wind.

Table 4-2 Descriptive statistics comparing observed and predicted air temperature and relative humidity

Descriptive Statistics	Air Temperature, °C		Relative Humidity, %	
	AWS	TAPM	AWS	TAPM
Average	17.5	17.9	70.0	74.0
Standard deviation	3.8	3.4	15.4	13.8
Minimum	6.5	7.6	16.5	23.7
Maximum	38.8	34.9	97.5	100
n	8698	8760	8698	8760

Table notes: AWS = observed observations collected from the BoM Bellambi automatic weather station.
TAPM = modelled TAPM predictions for the BoM Bellambi AWS site.

The statistical measures and benchmarks used to evaluate model performance are provided in Table 4-3 for wind predictions and Table 4-4 for air temperature and relative humidity predictions. Table 4-3 shows that the TAPM wind speed and wind component predictions are slightly outside of their benchmark for root mean square error, with the systematic root mean square error for wind speed also slightly beyond its benchmark. The Skill_v scores for wind speed and v-component (north-south) winds were also slightly outside of their benchmarks. All other wind speed and wind component evaluation statistics were within their respective benchmarks. TAPM air temperature and relative humidity predictions were found to be well-predicted meet their respective benchmarks for all evaluation statistics. In particular, the index of



agreement score of 0.9 for relative humidity and temperature predictions show near-perfect agreement between model predictions and observed values.

Table 4-3 Evaluation statistics for TAPM wind speed predictions at the Bellambi AWS

Statistic	Ideal score	Wind speed benchmarks	Wind speed evaluation statistics	U-vector wind evaluation statistics	V-vector wind evaluation statistics
Root Mean Square Error	0 m/s	≤ 2 m/s	2.6	2.6	2.7
Systematic Root Mean Square Error	0 m/s	≤ 2 m/s	2.2	1.8	2.0
Unsystematic Root Mean Square Error	0 m/s	≤ 2 m/s	1.4	1.8	1.7
Mean Error (Bias)	0 m/s	$\leq \pm 1.5$ m/s	-1.4	1.2	0.8
Mean Absolute (Gross) Error	0 m/s	≤ 2.5 m/s	1.9	2.0	0.6
Index of Agreement	1	≥ 0.6	0.7	0.8	0.8
Skill _e	<1	< 1	0.5	0.6	0.4
Skill _v	1	~ 1	0.6	0.8	0.7
Skill _r	<1	< 1	0.9	0.8	0.6

Table note: U-component is the east-west component of the wind.
V-component is the north-south component of the wind.
Evaluation statistics meeting their respective benchmarks are highlighted in green, with those not meeting their benchmark being highlighted in red.

Table 4-4 Evaluation statistics for air temperature and relative humidity predictions at the Bellambi AWS

Statistic	Ideal score	Air temp. benchmarks	Air temp. evaluation statistics	Relative humidity evaluation statistics	Relative humidity evaluation statistics
Root Mean Square Error	0 °C or %	-	1.7	-	10.4
Systematic Root Mean Square Error	0 °C or %	-	0.9	-	6.0
Unsystematic Root Mean Square Error	0 °C or %	-	1.4	-	8.6
Mean Error (Bias)	0 °C or %	$\leq \pm 2$ °C	0.4	< +/-10 %	3.9
Mean Absolute (Gross) Error	0 °C or %	≤ 3.5 °C	1.3	< 20 %	8.4
Index of Agreement	1	≥ 0.8	0.9	≥ 0.6	0.9
Skill _e	<1	< 1	0.4	< 1	0.6
Skill _v	1	~ 1	0.9	~ 1	0.9
Skill _r	<1	< 1	0.4	< 1	0.7

Table note: Evaluation statistics meeting their respective benchmarks are highlighted in green, with those not meeting their benchmark being highlighted in red.



4.2 Wind

The wind speed probability density functions (PDFs) for the BoM observations and the TAPM predictions are presented in Figure 4-1. The corresponding PDFs for the easterly (U) and northerly (V) wind components are shown in Figure 4-2 and Figure 4-3. Quantile-Quantile (Q-Q) plots for wind speed are shown in Figure 4-4. Comparative wind roses for TAPM predictions and observed winds at the Bellambi AWS are presented in Figure 4-5.

Figure 4-1 to Figure 4-5 show that the TAPM meteorological model tended to underestimate the wind speed distribution at the Bellambi AWS with an observed mean speed of 5.0 m/s compared with a predicted value of 3.6 m/s. In particular the TAPM model overestimated the frequency of light winds up to approximately 5 m/s (a gentle breeze), critical for the dispersion and assessment of ground-level odour emissions. This is a known feature of TAPM, which adds a degree of conservatism to the model. The frequency of winds stronger than 5 m/s was correspondingly underestimated, however winds were predicted up to speeds of 10.0 m/s.

The distribution of U-component (east-west) winds (Figure 4-2) shows that the frequency of winds arriving from the west is underpredicted, with easterly-component winds below 5 m/s being correspondingly over-predicted. The distribution of V-component (north-south) winds is well-centred over the observed distribution, however the stronger wind components (beyond 7 to 11 m/s) are not predicted.

The wind roses for the TAPM predictions (Figure 4-5), show that the overall wind direction distribution was well predicted. The frequency of calm conditions was well-predicted, however the frequency of the occasionally-observed fresh to strong winds (those above 10 m/s) was underestimated.

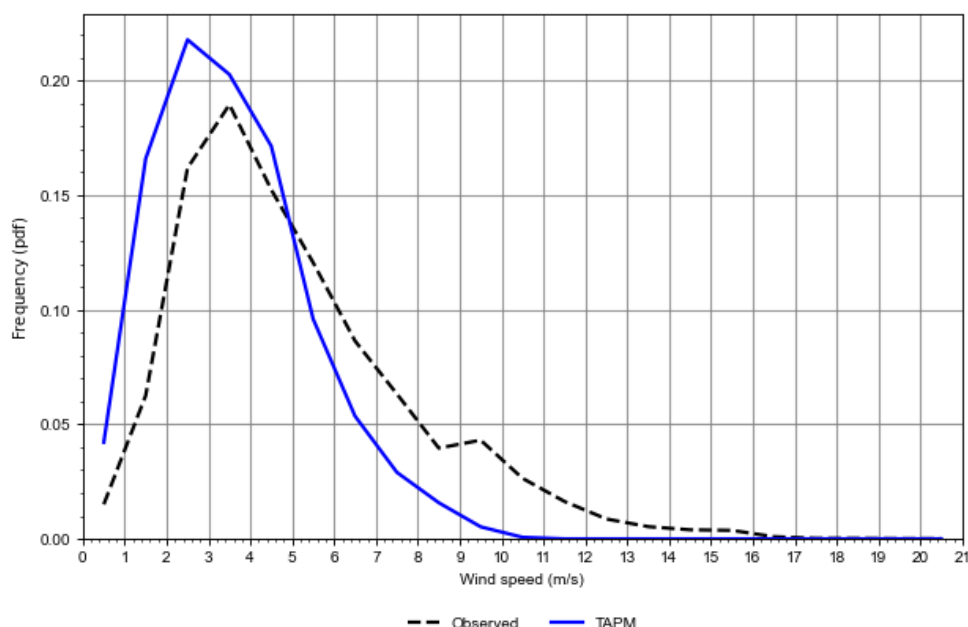


Figure 4-1 Distribution of observed and predicted wind speeds at the Bellambi AWS

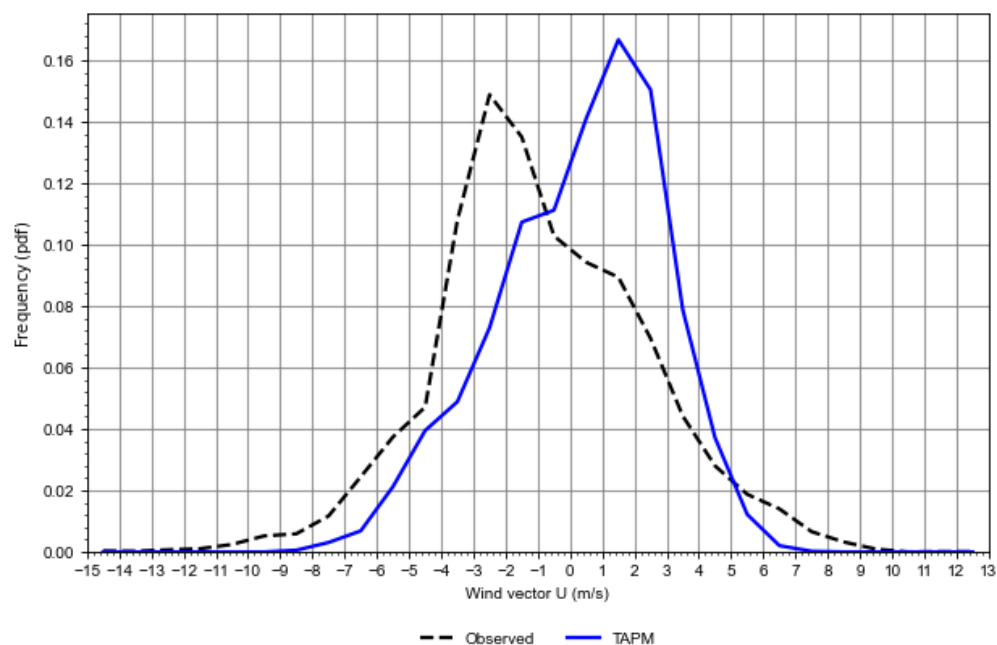


Figure 4-2 Distribution of observed and predicted easterly (U) wind components at the Bellambi AWS

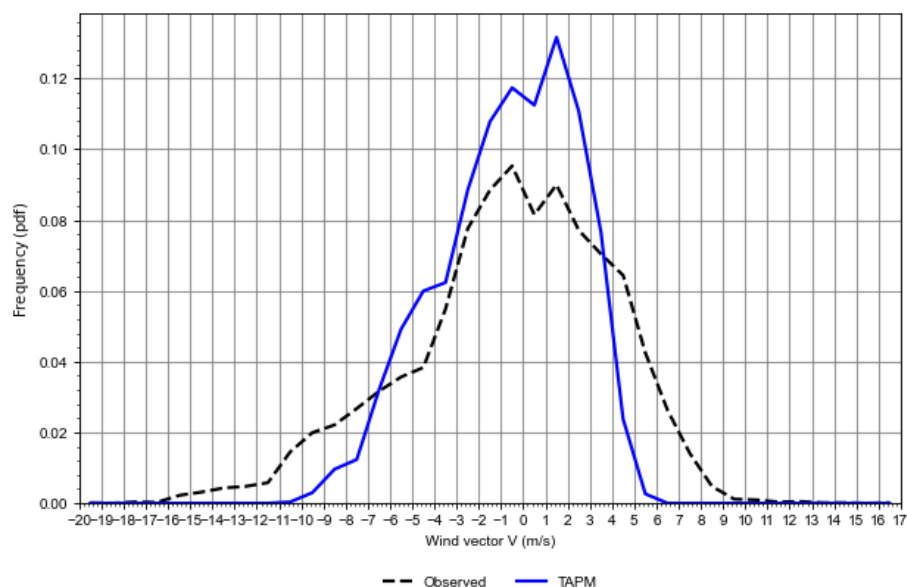


Figure 4-3 Distribution of observed and predicted northerly (V) wind components at the Bellambi AWS

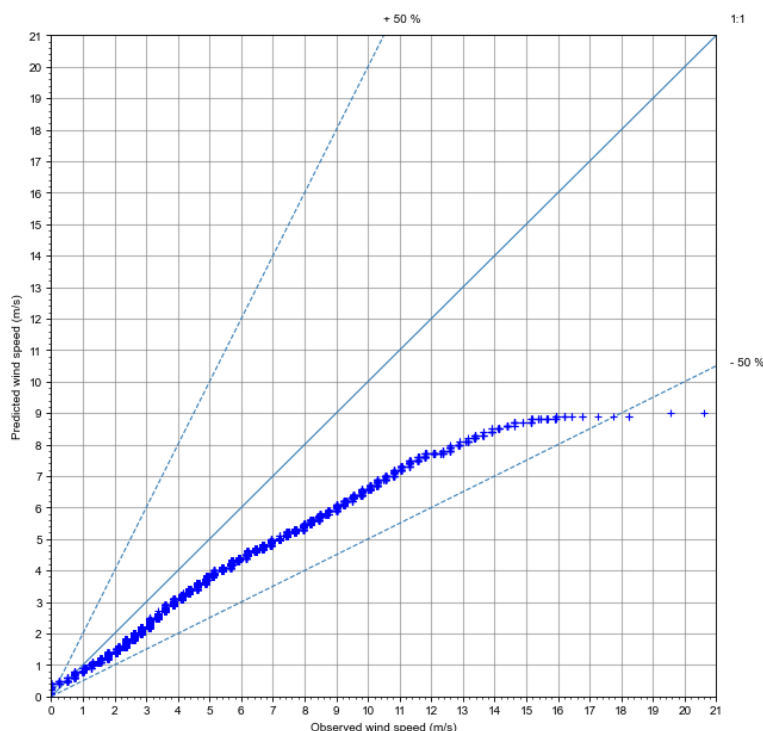


Figure 4-4 Quantile-quantile (Q-Q) plot of wind speeds at the Bellambi AWS

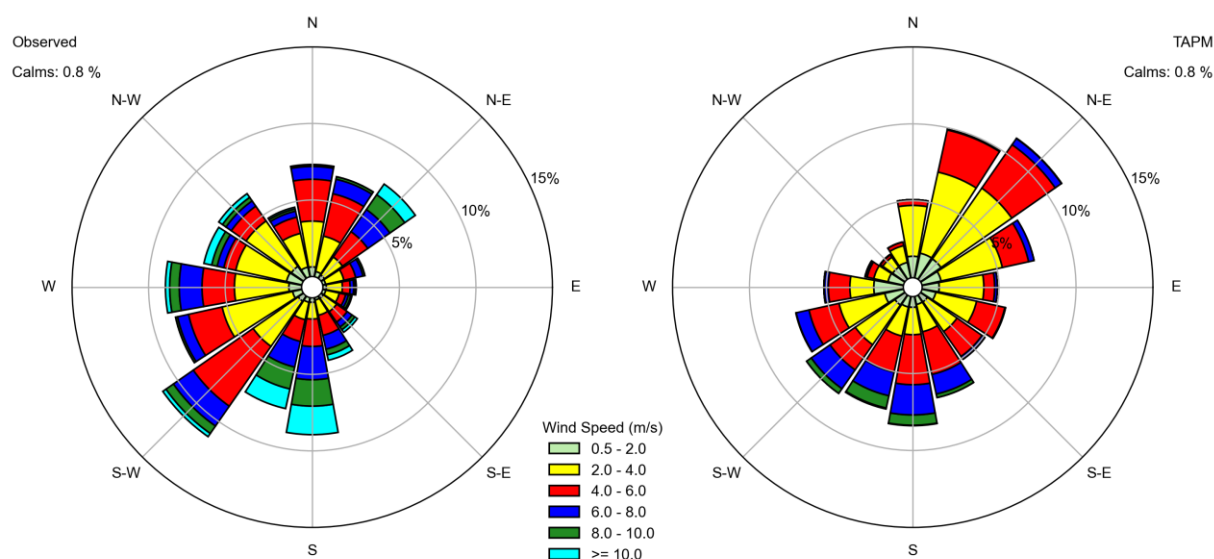


Figure 4-5 Distribution of observed and predicted winds at the Bellambi AWS

4.3 Air temperature

The PDF and Q-Q plots for air temperature are provided in Figure 4-6 and Figure 4-7 respectively, showing that the BOM-observed and TAPM-predicted temperature distributions for the period modelled were similar. The frequency of temperatures below approximately 13 °C was slightly under-predicted with those between 13 and 21 °C being slightly over-predicted. The Q-Q plot (Figure 4-7) shows that the temperature distribution was well predicted, staying within the $\pm 50\%$ range representing acceptable model performance for air temperature. The highest observed temperatures, those above approximately

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Appendix D – Meteorological Model Evaluation



24 °C were less well predicted, but still remained within the $\pm 50\%$ range representing acceptable model performance.

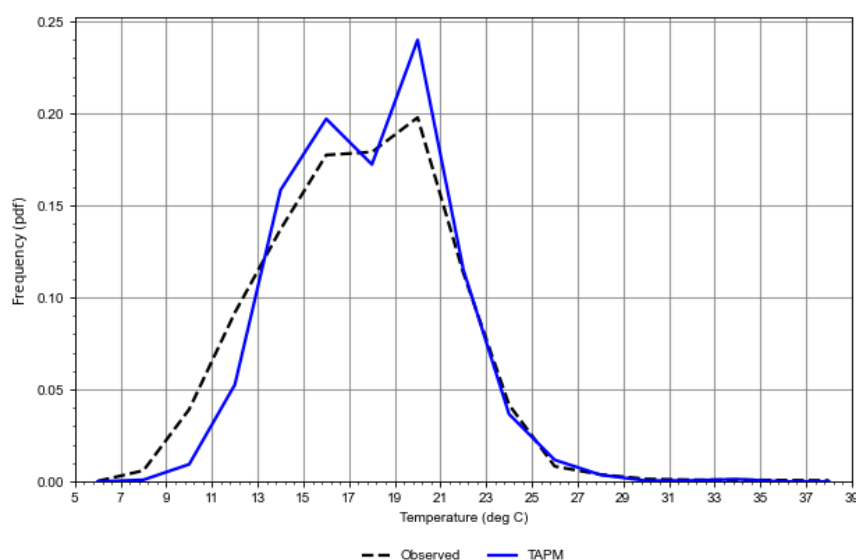


Figure 4-6 Distribution of ambient air temperature at the Bellambi AWS

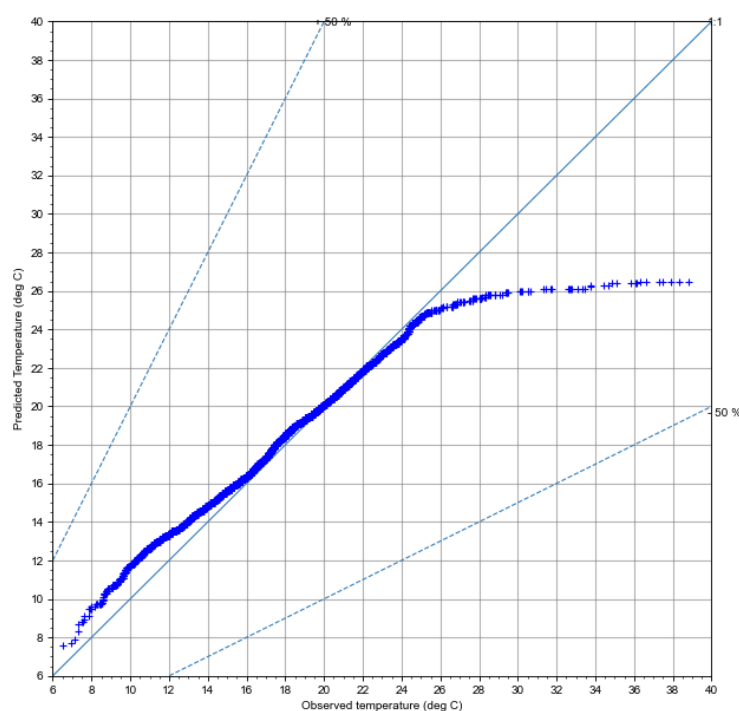


Figure 4-7 Quantile-quantile (Q-Q) plot of temperature at the Bellambi AWS

4.4 Relative humidity

The PDF and Q-Q plots for relative humidity are provided in Figure 4-8 and Figure 4-9, showing that TAPM predict the observed distribution well, predicting slightly higher frequencies of relative humidity above 75%, and lower frequencies below 75%.

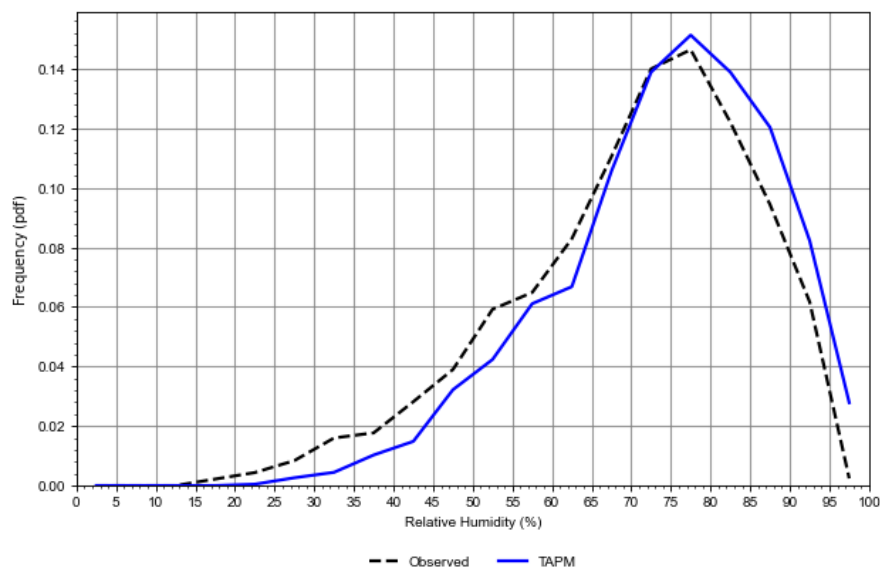


Figure 4-8 Distribution of observed and TAPM relative humidity at the Bellambi AWS

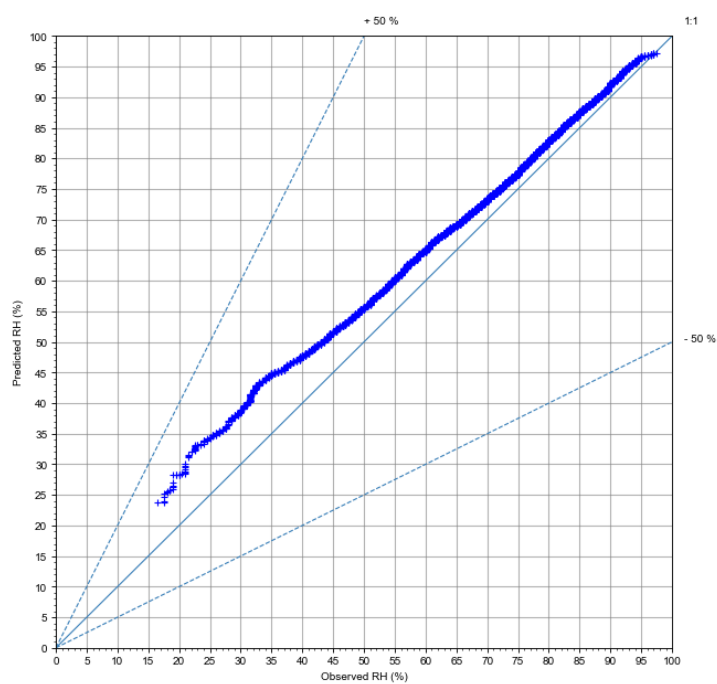


Figure 4-9 Quantile-quantile (Q-Q) plot of observed and TAPM relative humidity at the Bellambi AWS



5 Conclusions

The closest BoM AWS site to the GrainCorp site is located at the Bellambi AWS (Station 068228), approximately 9.4 km to the north-northeast of the GrainCorp site. This AWS site lies beyond the CALMET 100 m meteorological grid, falling within the TAPM inner (300 m) nest.

The model was evaluated at the Bellambi AWS site using predictions drawn from the TAPM 300 m nest. The results show that the TAPM predictions are generally representative of observed conditions at the Bellambi AWS site, meeting their respective statistical evaluation benchmarks. In particular, air temperature and relative humidity were well predicted.

TAPM was found to underestimate wind speed. The wind speed and wind component predictions were found to be slightly beyond their benchmark for root mean square error and systematic root mean square error. The Skill_v scores for wind speed and v-component (north-south) winds were also slightly outside of their benchmarks. All other wind speed and wind component evaluation statistics were within their respective benchmarks. This is a well known feature of TAPM.

The TAPM model was therefore considered to be suitable for use in providing initial-guess fields for the CALMET meteorological model used to drive the CALPUFF dispersion model.

Appendix E
Analysis of CALMET
Dispersion Meteorology at the
GrainCorp site





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1 Introduction

This appendix describes the meteorology generated by the CALMET model that is important to the dispersion of odour in the region surrounding the GrainCorp site.

Hourly CALMET meteorological predictions were extracted from the closest model grid point to the centre of the GrainCorp site as follows:

- Column 36 (306.317 km E),
- Row 36 (6,185.931 km N),
- 10 m grid level,
- Modelling period: 1 March 2020 to 28 February 2021.

Python scripts were used to analyse the extracted dataset and describe the dispersion meteorology of the Port Kembla region.



2 Wind speed and direction

Wind speed and wind direction are important meteorological parameters that influence the dispersion of air pollutants.

2.1 Wind rose analyses

The annual, diurnal and seasonal distributions of winds predicted by the TAPM/CALMET meteorological modelling system at the GrainCorp site for 1 March 2020 to 28 February 2021 are presented as wind rose diagrams in Figure 2-1 to Figure 2-3, respectively.

The most important features of the predicted annual wind rose (Figure 2-1) show that:

- The prevailing winds arrive from the north-northeast (10.9%) and northeast (10.2%), with the second-most frequent winds arriving from the west-southwest (9.0%) and west (8.3%) directions. Together these winds account for 38.3% of all winds.
- Most winds (97.4%) are below 4 m/s in speed, ranging from calm to gentle breeze conditions.
- Calm periods (winds < 0.5 m/s) occur on 2.8% of occasions.
- Light winds (0.5-2.0 m/s) arrive from all cardinal wind directions, and are most prominent from the north-northeast (9.5%).
- The highest predicted wind speeds were in the 4 to 6 m/s range (gentle to moderate breezes) and were largely confined to the southwest quadrant. The overall maximum predicted wind speed

In summary, the wind distribution is skewed towards light to gentle breezes arriving from the north-northeast and west-southwest sectors.

The diurnal wind distributions are presented in Figure 2-2, showing that:

- During the nighttime hours (0:00 to 06:00):
 - Calms (wind speeds < 0.5 m/s) and light winds (0.5-2.0 m/s) account for 81.3% of occurrences, with the highest diurnal calm frequency (4.6%) occurring during the nighttime hours.
 - Winds arrive mainly from the north-northeast (16.0%) and west-southwest (14.6%).
 - Winds are light, with only 1.1% winds above 4.0 m/s (a gentle breeze).
- During the morning hours (06:00 to 12:00):
 - There is a shift to slightly stronger winds, with 48.7% of winds in the 2.0-4.0 m/s range and a further 2.5% in the 4.0-6.0 m/s range.
 - Winds still predominantly arrive from the north-northeast to east-northeast sectors (27.6%) however they are more evenly distributed across all sectors.
- During the afternoon hours (12:00 to 18:00):
 - Wind speeds significantly increase, with 61.4% of winds in the 2.0-4.0 m/s range and a further 4.4% in the 4.0-6.0 m/s range. The strongest winds mainly arrive from the southwest quadrant.
 - The prevailing afternoon winds arrive from the northeast (22.0%) and east-northeast (12.6%).
 - The lowest diurnal calm frequency of 0.1% occurs during the afternoon hours.
- During the evening hours (18:00 to 24:00):
 - There is a return to lighter winds, with 80.2% of winds either calm or in the 0.5-2.0 m/s range. Only 1.6% of evening winds are above 4.0 m/s.



- Evening winds most frequently arrive from the north-northeast (15.0%) sector, however winds from the southwest quadrant are also common accounting for 36.6% of evening winds.
- In summary, the wind distribution shows a clear diurnal cycle with the lightest winds occurring during the nighttime hours and the strongest during the afternoon. Northeasterly and north-northeasterly winds prevail at all times of the day. West-southwesterly and westerly winds are also frequent during most hours apart from during the afternoon. This pattern likely reflects local thermotopographic effects and larger-scale atmospheric circulation changes throughout the day.

The seasonal wind distributions are provided in Figure 2-3, showing that:

- During the summer months (Dec, Jan, Feb):
 - Winds predominantly arrive from the eastern hemisphere (northerly, through easterly to southerly winds) accounting for 78% of all winds. The prevailing easterly-component summertime winds arrive from the northeast (14.7%) and north-northeast sectors (13.4%).
 - The mean wind speed remains remarkably uniform across the seasons, with average spring, summer and autumn wind speeds of 1.8 m/s in each season. The mean wintertime speed is marginally higher at 1.9 m/s.
- During the autumn months (Mar, Apr, May):
 - The distribution of wind directions becomes more uniform, with the prevailing autumn winds arriving from the west (10.6%).
 - The mean speed remains at 1.8 m/s.
 - The frequency of calm winds remains at 2.5%.
- During the winter months (Jun, Jul, Aug):
 - The prevailing winds shift to the southwest quadrant, with 58.2% of winds arriving from the south to west sectors.
 - There is an increase in the frequency of lighter winds, with 61.2% of observations either in the calm or 0.5-2.0 m/s ranges.
 - The mean speed is at the highest seasonal value of 1.9 m/s.
 - There is a slight decrease in the frequency of calm periods (from 2.5% to 2.4%).
- During the spring months (Sep, Oct, Nov):
 - Wind directions shift back towards the summertime distribution, with the prevailing winds from the north-northeast and northeast becoming re-established, and a reduction in winds from the southwest quadrant.
 - There is a slight increase in the frequency of calm periods during spring (from 2.4% to 3.7%).
- In summary, the summer wind rose is strongly skewed with winds arriving from the eastern hemisphere. During the winter period, winds are largely confined to the southwest quadrant. The autumn and spring distributions represent transition phases between the summer and winter patterns. Mean wind speed and the frequency of calm winds remain relatively constant across the seasons. This seasonal variation likely reflects changes in large-scale atmospheric circulation patterns, such as the movement of high and low-pressure systems, as well as local thermal effects that vary with the changing seasons.

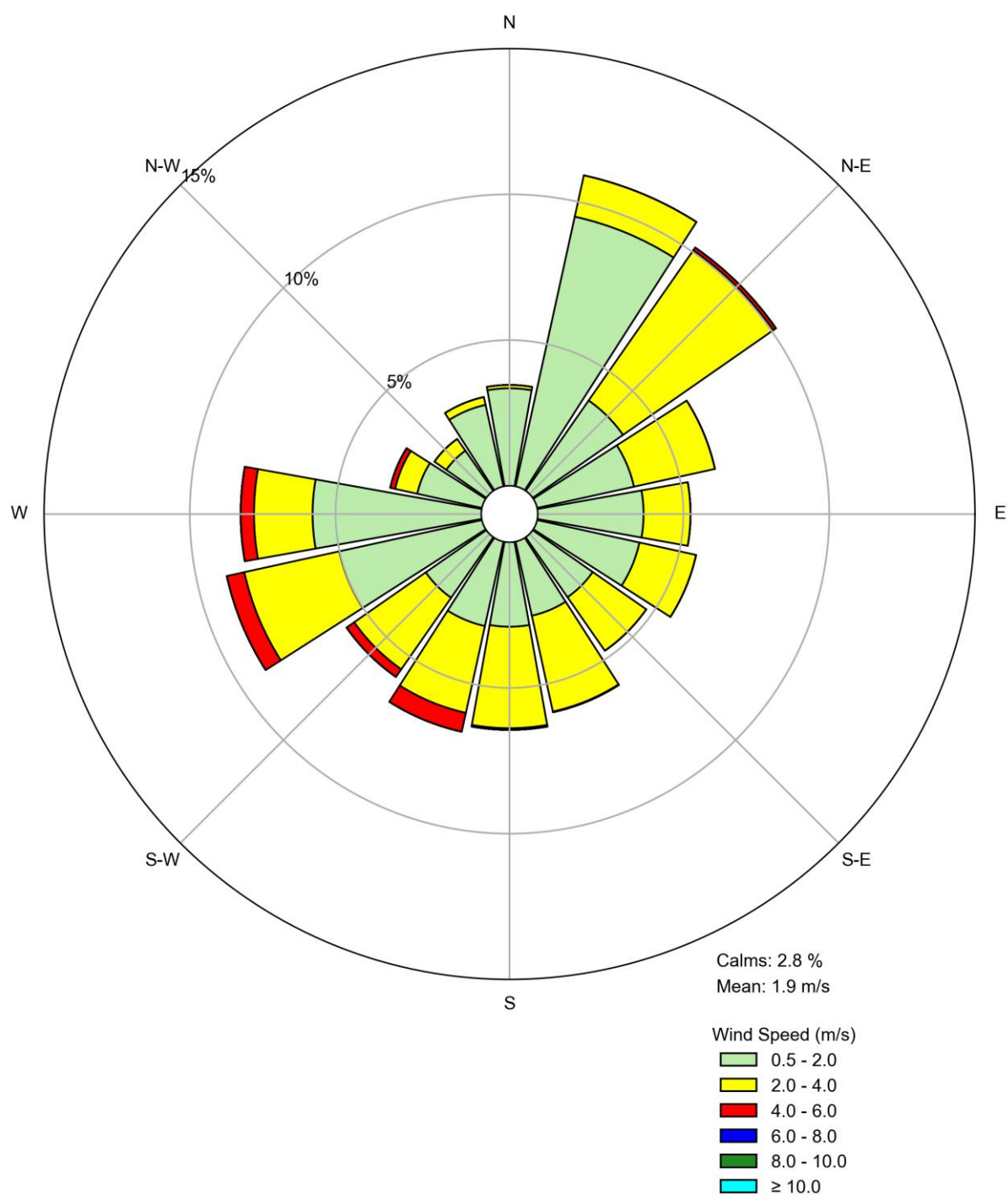


Figure 2-1 Annual distribution of winds at the GrainCorp site, 1 March 2020 to 28 February 2021

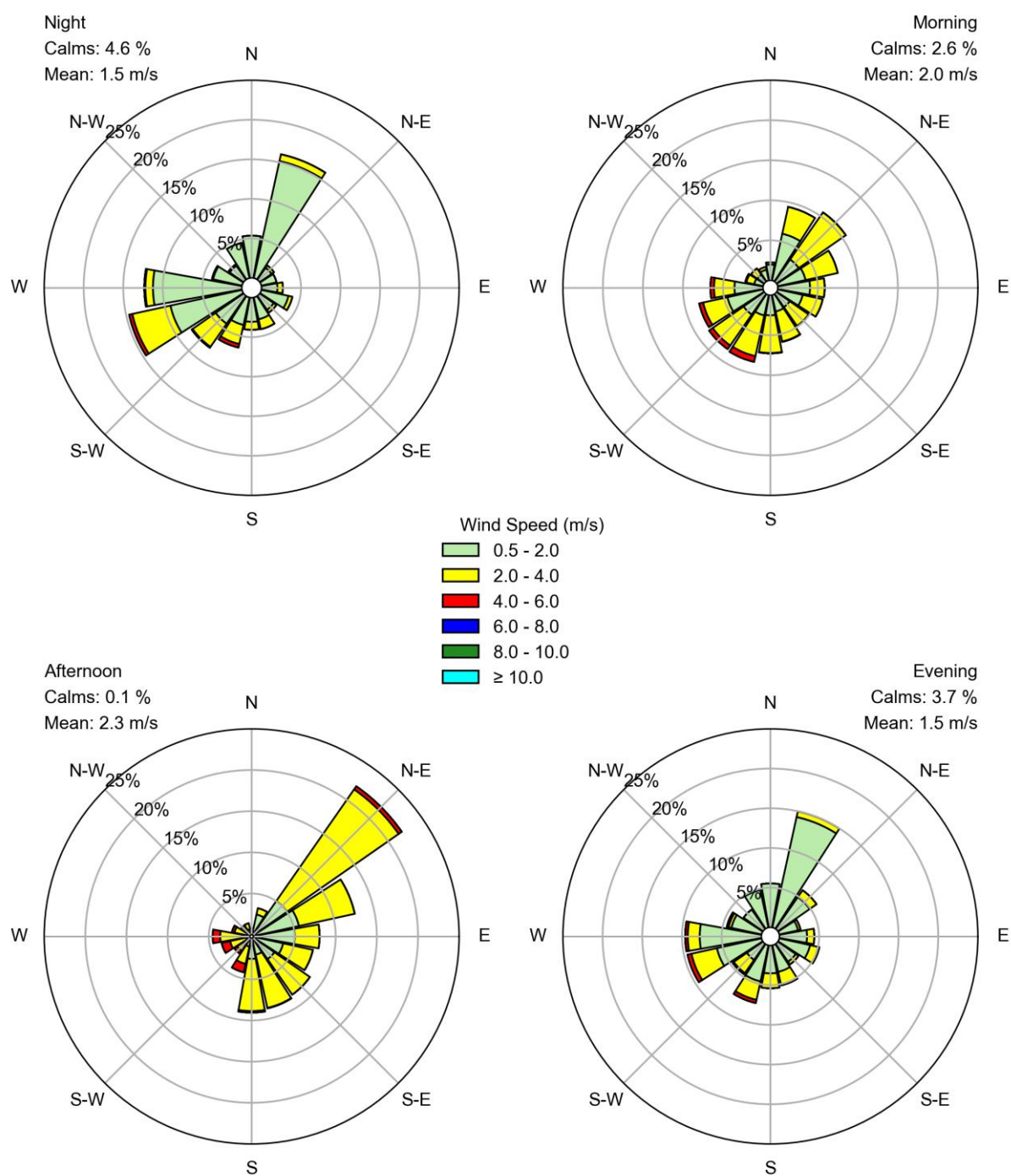


Figure 2-2 Diurnal distribution of winds at the GrainCorp site, 1 March 2020 to 28 February 2021

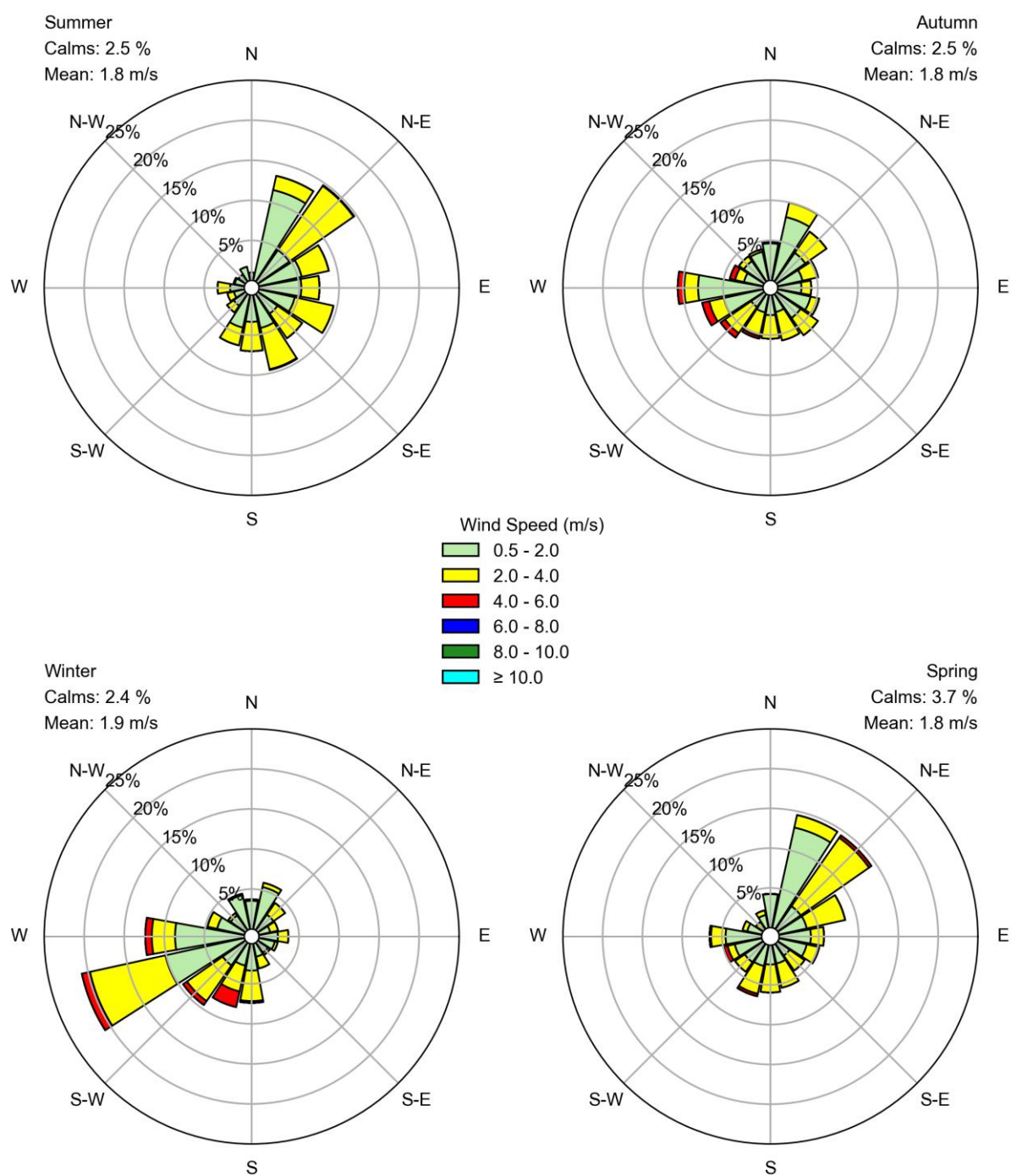


Figure 2-3 Seasonal distribution of winds at the GrainCorp site, 1 March 2020 to 28 February 2021

2.2 Mean wind speeds and calm winds

The mean annual, seasonal and diurnal wind speeds, and the frequency of calms at the GrainCorp site, are presented in Table 2-1.



Table 2-1 Annual, seasonal and diurnal mean wind speeds at the GrainCorp site, 1 March 2020 to 28 February 2021

Period	Mean Wind Speed (m/s)	Calms (%)
Annual	1.9	2.8
Summer	1.8	2.5
Autumn	1.8	2.5
Winter	1.9	2.4
Spring	1.8	3.7
Night: Midnight to 6am	1.5	4.6
Morning: 6am to Midday	2.0	2.6
Afternoon: Midday to 6pm	2.3	0.1
Evening: 6pm to midnight	1.5	3.7

2.3 Heat maps

The modelled profiles of wind speed and direction at the GrainCorp site have also been presented graphically as heat maps in Figure 2-4, to illustrate the monthly and hourly variations in wind conditions.

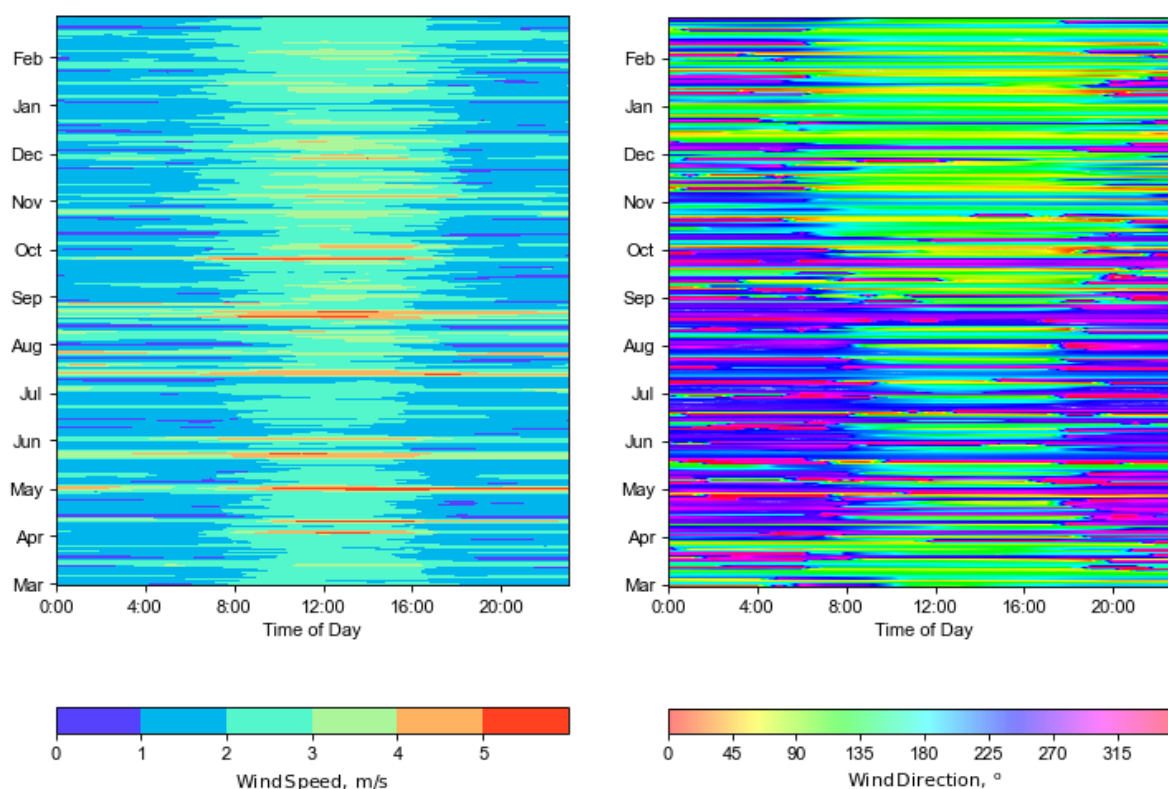


Figure 2-4 Predicted monthly and hourly profiles of wind speed and direction at the GrainCorp site, 1 March 2020 to 28 February 2021



3 Air Temperature

The diurnal and monthly variation in air temperature at the GrainCorp site is presented in Figure 3-1. The figure shows temperatures varying between 7 °C and 38 °C. The predicted mean and median temperatures are 17.8 °C and 17.9 °C respectively. High daytime temperatures, those above 31 °C, tend to occur between December and April. The coldest nights occur between June and October.

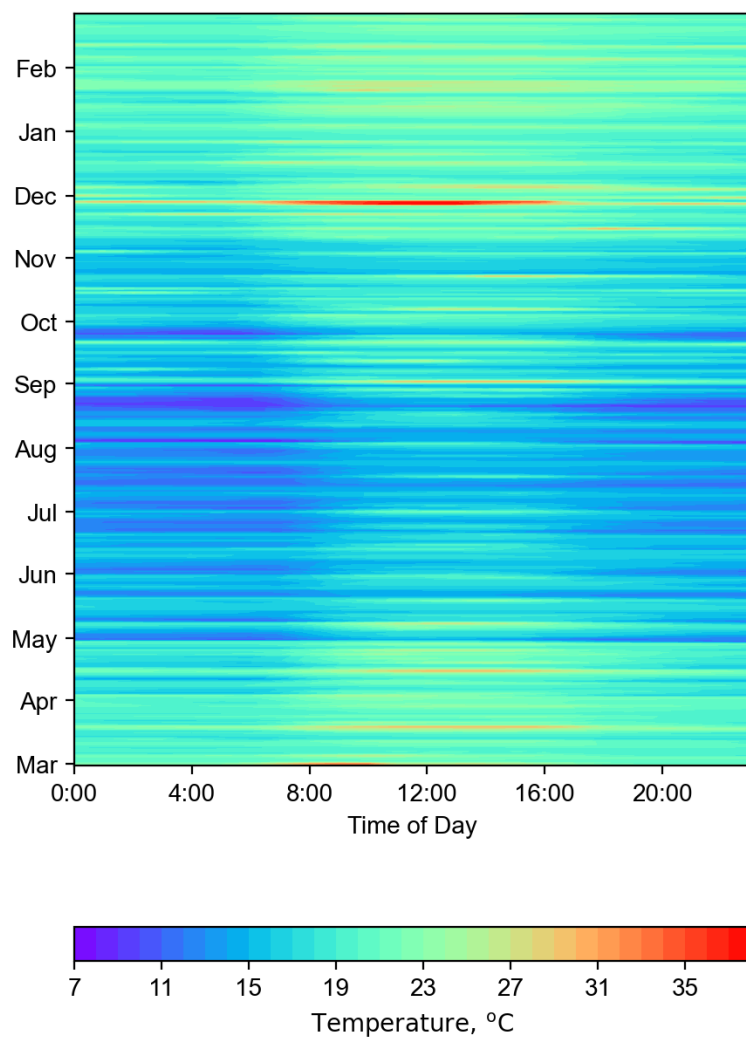


Figure 3-1 Diurnal and monthly variation in air temperature at the GrainCorp site, 1 March 2020 to 28 February 2021



4 Atmospheric stability

The flow of air in the planetary boundary layer (lowest one kilometer of the atmosphere) is an important factor in the dispersion of air pollutants and their effect on the population. This flow is affected by turbulence, which in turn affects the dispersion of the plume. Turbulence describes the vertical and horizontal motion of air and how a plume may be spread out and diffused. As turbulence increases, so does the rate of plume diffusion. As turbulence decreases, this diffusion is limited resulting in higher pollutant concentrations in the plume.

Turbulence is driven by thermal and mechanical influences as the atmosphere interacts with the land surface. Thermally driven turbulence is generated by convection as the sun heats the ground and the air above it is warmed, causing it to rise. Mechanically driven turbulence is generated by frictional effects as wind passes over the surface or by wind shear, produced at the boundary of two coinciding layers of wind or two different air masses.

A key indicator of thermally driven turbulence (or convection) in the atmosphere is stability, which is measured by the environmental lapse rate or vertical temperature profile of the atmosphere. Stability is a term applied to the properties of the atmosphere that govern the acceleration of the vertical motion of an air parcel. The acceleration is positive in an unstable atmosphere (turbulence increases), zero when the atmosphere is neutral, and negative (deceleration) when the atmosphere is stable (turbulence is suppressed). The vertical temperature gradient in the atmosphere governs whether a parcel of air, or plume, released into it will rise, fall, disperse or remain relatively still. If the plume is warmer than the surrounding air, it will tend to rise, while a plume that is cooler than the atmosphere will sink. Wind, or horizontal air movement, affects mechanical turbulence and therefore also affects atmospheric stability. As the wind speed increases, atmospheric stability will tend toward neutral conditions.

Atmospheric stability is commonly defined in terms of six main stability classifications designated as A (highly unstable or convective), B (moderately unstable), C (slightly unstable), D (neutral), E (slightly stable) and F (stable). This is known as the Pasquill-Gifford (P-G) stability classification and is widely used to describe the turbulent state of the atmosphere.

Unstable conditions (Classes A-C) are characterised by strong solar heating of the ground that induces turbulent mixing in the atmosphere close to the ground, and usually results in material from a plume reaching the ground closer to the source than for neutral or stable conditions. This turbulent mixing is the main driver of dispersion during unstable conditions. Dispersion processes for neutral conditions (Class D) are dominated by mechanical turbulence generated as the wind passes over irregularities in the local surface, such as terrain features and building structures. During the night, the atmospheric conditions are neutral or stable (Classes D, E and F). During stable conditions, plumes from short stacks or fugitive releases will be subject to minimal atmospheric turbulence. A plume released below an inversion layer during stable conditions, that has insufficient vertical momentum or thermal buoyancy to penetrate the inversion, will be trapped beneath it and result in elevated ground-level concentrations. Conversely, a plume that is hotter than its surroundings and is emitted above, or is able to penetrate the nocturnal inversion through momentum, will remain relatively undiluted, and will not reach the ground unless it encounters elevated terrain.

4.1 PG stability frequency distributions

The frequencies of Pasquill-Gifford stability classes based on the CALMET model predictions for the GrainCorp site are presented in Figure 4-1. Neutral (P-G Class D) conditions occur most frequently (46.8%), with stable (PG Classes E and F) being the second most frequent stability class (30.2%). Unstable (A, B & C classes) occur on 23.1% of occasions.



The distribution of Pasquill-Gifford stability classes by hour of day is illustrated in Figure 4-2, showing that the TAPM/CALMET models have correctly restricted stable conditions to the nighttime hours and unstable conditions to the daytime hours.

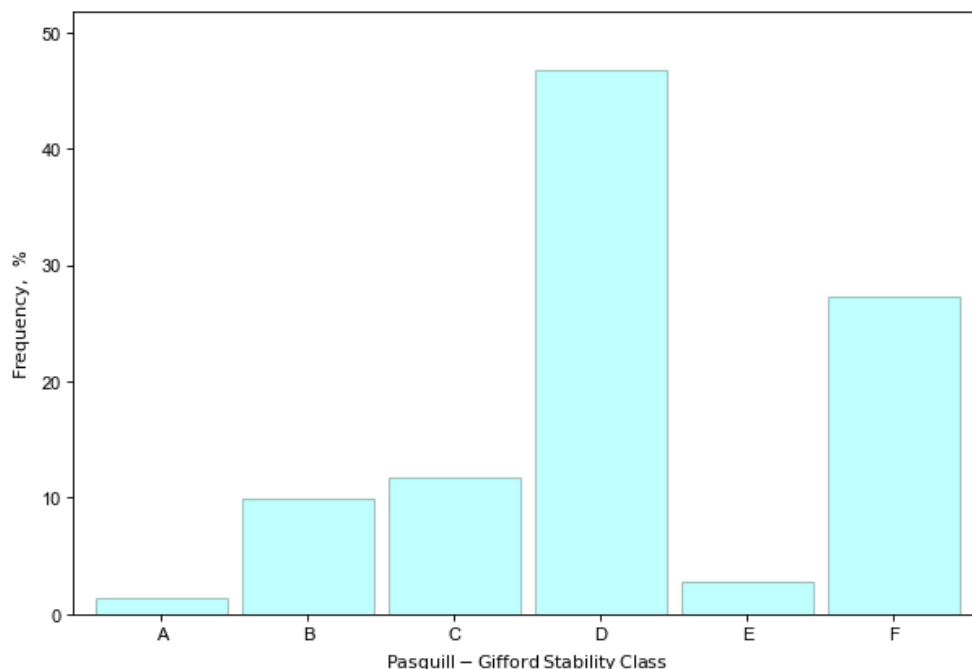


Figure 4-1 Frequency distribution of atmospheric stability classifications at the GrainCorp site, 1 March 2020 to 28 February 2021

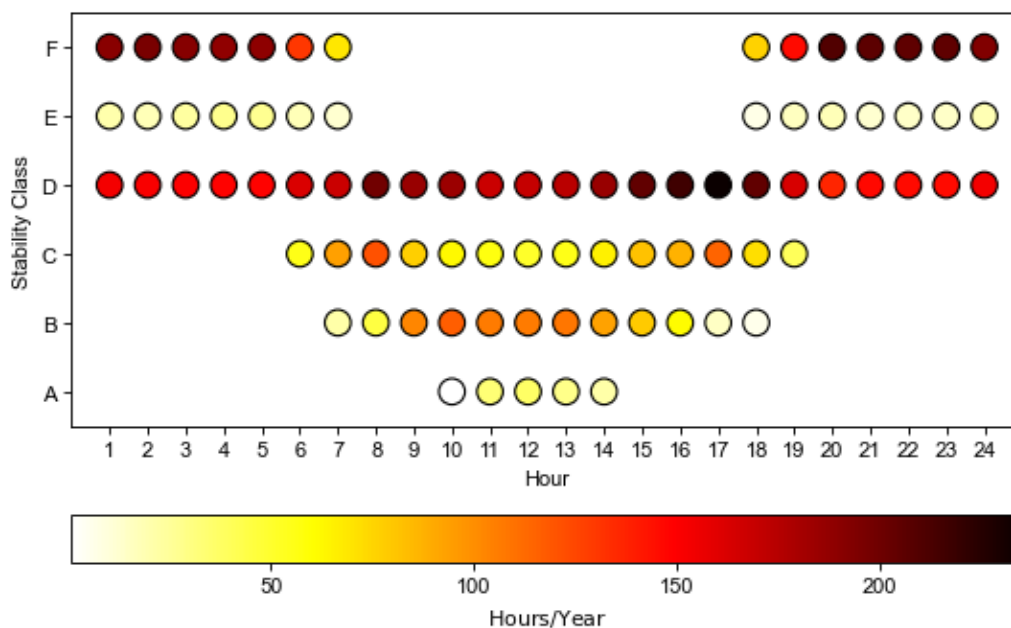


Figure 4-2 Hourly distribution of atmospheric stability classifications at the GrainCorp site, 1 March 2020 to 28 February 2021



4.2 Monin-Obukhov length

In more complex air dispersion models, such as CALPUFF, turbulence in the boundary layer is parameterised by Monin-Obukhov Similarity Theory. One measure, the Monin-Obukhov length (L), approximates the height at which thermally and mechanically driven turbulence is in equilibrium. In other words, it is a ratio of thermal and mechanical turbulence in the atmosphere.

Values of the Monin-Obukhov length can be difficult to conceptualise as they diverge to positive (+) and negative (-) infinity as stability approaches neutral from a stable or unstable atmosphere, respectively. Consequently, the inverse of the Monin-Obukhov length ($1/L$) is typically used to describe stability.

The hourly profiles of the inverse Monin-Obukhov length ($1/L$) at each site over the modelled year are presented in Figure 4-3 based on the CALMET model output. The plots show that the atmosphere ranges from neutral to unstable during the day (i.e. $1/L$ is between 0 (neutral) and increasingly negative), while at night the atmosphere is more stable (i.e. $1/L$ is positive).

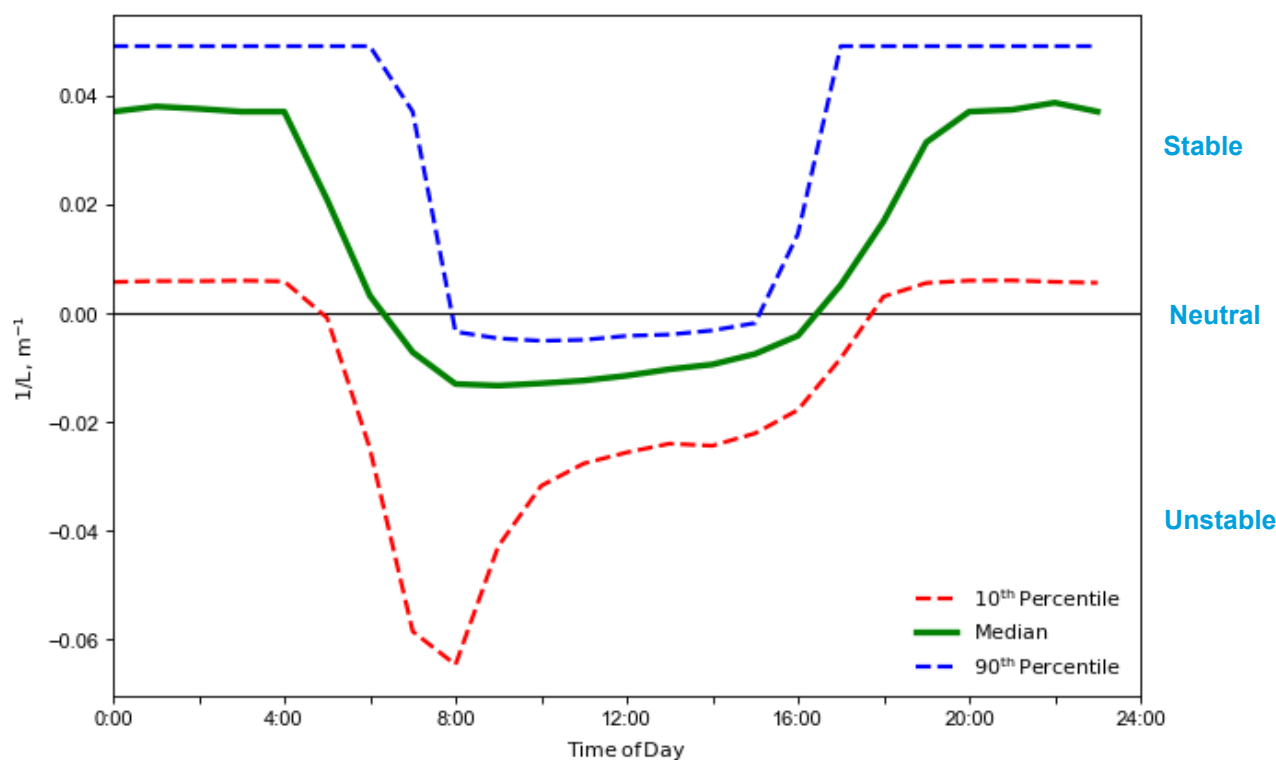


Figure 4-3 Hourly profile of the inverse Monin-Obukhov length ($1/L$) at the GrainCorp site, 1 March 2020 to 28 February 2021

4.3 Annual and diurnal atmospheric stability roses

The relationship between atmospheric stability and wind direction at each site is explored as the annual distribution in Figure 4-4 and diurnal distribution in Figure 4-5.

The annual stability rose shows that:

- Unstable flows (A, B, or C) most frequently arrive from the northeast and east-northeast (7.7%). A-class stability is rare across all sectors, most commonly arriving from the northeast and east-northeast.
- Neutral conditions (D-class) most frequently arrive from the north-northeast to the southwest sectors.



- Stable Conditions (E or F) are most frequently associated with flows arriving from the west-southwest to north-northeast sectors.

The diurnal stability roses show that:

- The nighttime rose is strongly skewed with stable flows most commonly arriving from the north-northeast (12.3%), and draining off elevated terrain to the west-southwest (12.0%) and west (11.8%). The nighttime hours are mostly stable with 55.8% of hours showing E or F-class stability.
- There is a significant shift towards unstable conditions during the morning hours, with A, B or C-class stability accounting for 47.3% of occasions. Neutral conditions (D-class, 49.0%) are also frequent during the morning. The morning stability rose is less skewed than the nighttime rose, with a more even distribution across wind sectors.
- During the afternoon unstable (A, B, and C) conditions are most frequent accounting for 40.6 % of hours. The frequency of neutral (D class) conditions rises to 55.6%.
- The evening hours show a rapid return to stable conditions (57.4%), with the dominant wind direction being the north-northeast (15.7%) and a more even distribution across the other sectors.

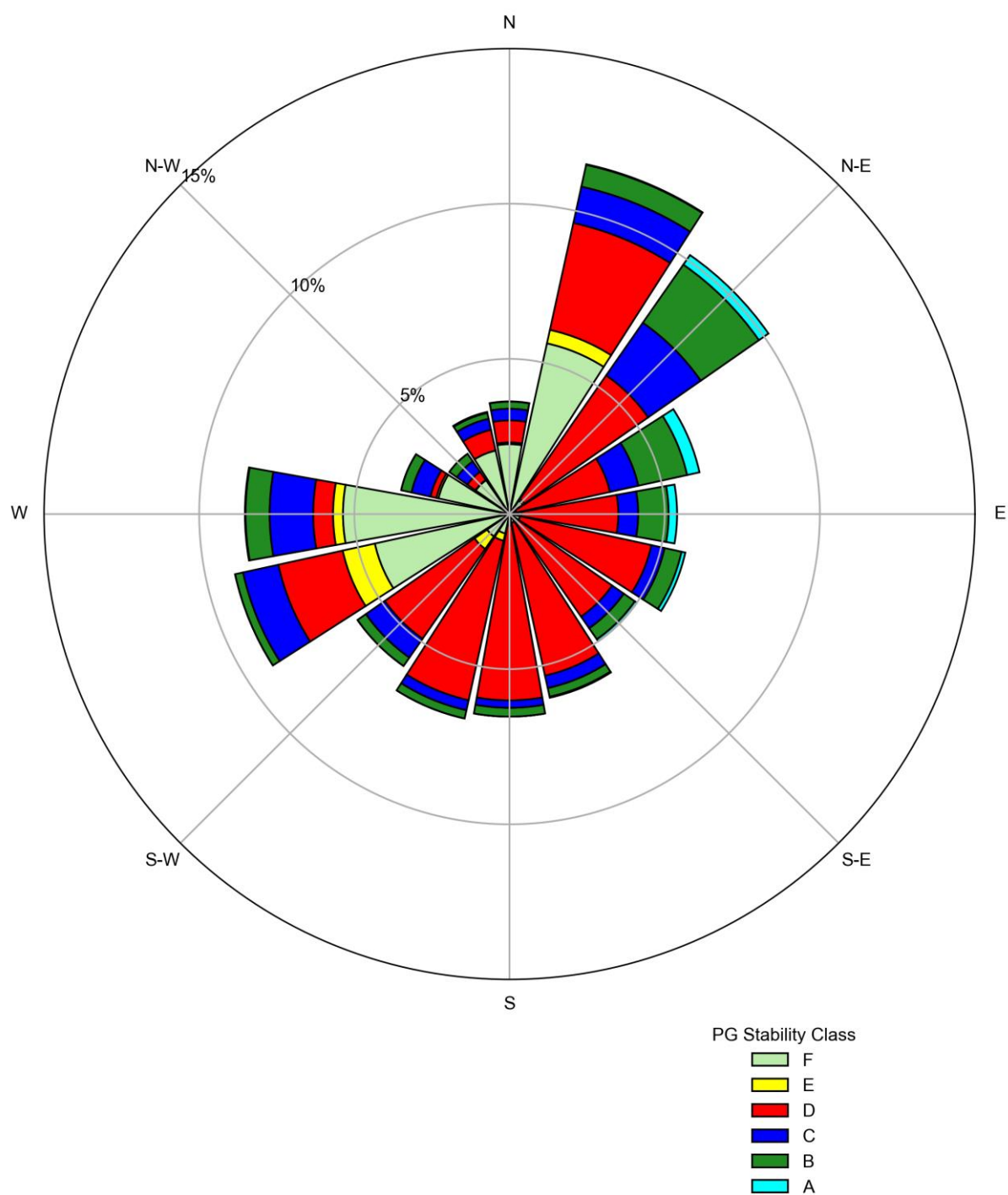


Figure 4-4 Stability roses illustrating the relationship between annual wind direction and Pasquill-Gifford stability class at the GrainCorp site, 1 March 2020 to 28 February 2021

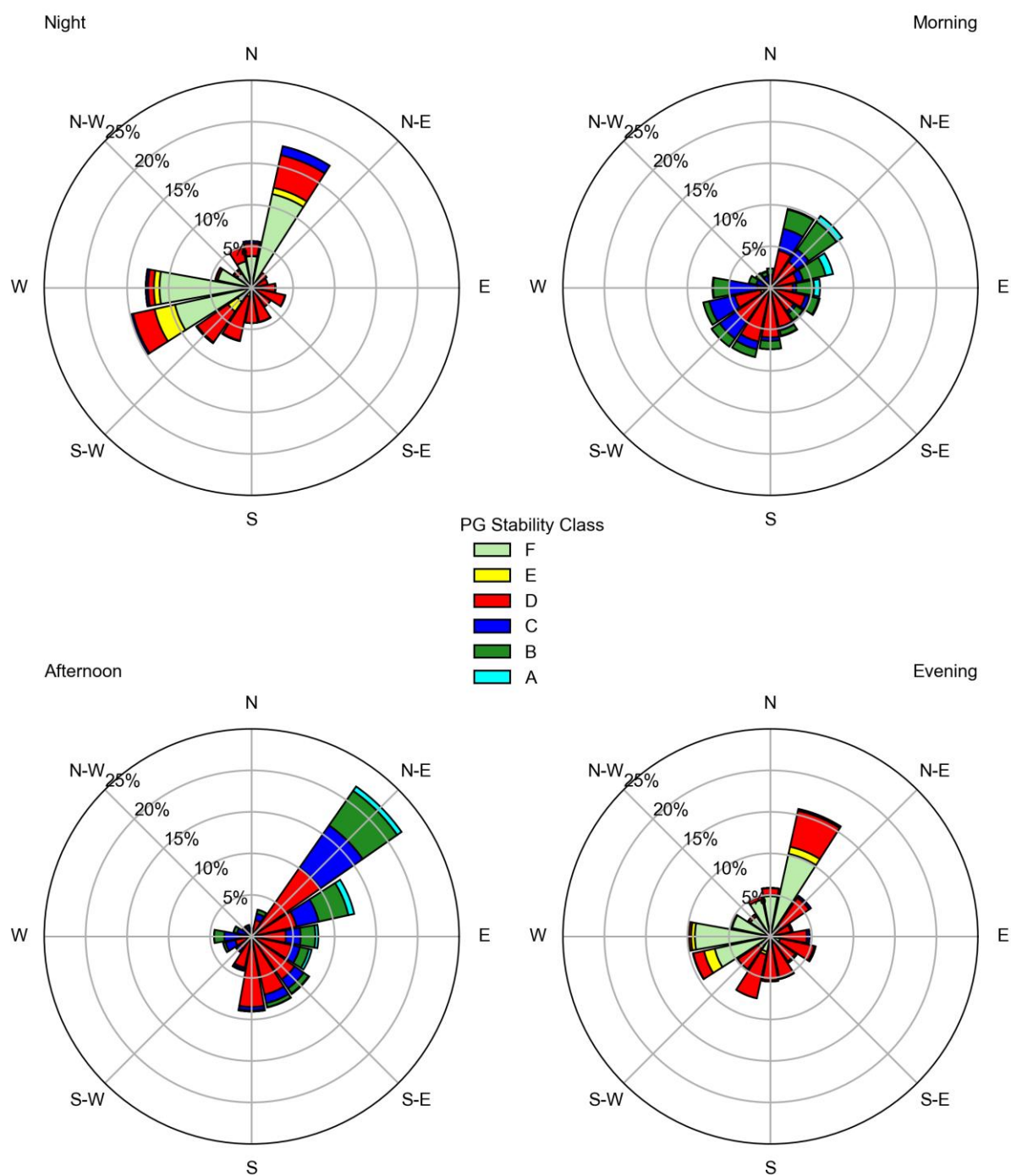


Figure 4-5 Diurnal stability rose diagram illustrating the relationship between hourly wind direction and Pasquill-Gifford stability class at the GrainCorp site, 1 March 2020 to 28 February 2021



5 Mixing height

The mixing height refers to the height above ground within which the plume can mix with ambient air. During stable atmospheric conditions at night, the mixing height is often quite low. During the day, incoming short-wave solar radiation from the sun heats the ground, which in turn re-radiates long wave radiation back into the atmosphere, heating the air above it. The heating of the air near the ground generates the growth of convection cells causing the air, and hence the mixing height, to rise. The air above the mixing height during the day is generally cooler. The growth of the mixing height is dependent on how well the air can mix with the cooler upper levels of air and therefore depends on turbulence, i.e. meteorological factors such as the intensity of solar radiation and wind speed. During strong wind speed conditions, the air will be well mixed resulting in a large mixing height.

The predicted hourly distributions of mixing height are presented as box and whiskers plots in Figure 5-1, which shows a pronounced diurnal variation, with the lowest mixing heights occurring during the evening to morning periods and the greatest mixing heights (up to 2,500 m) during the afternoon.

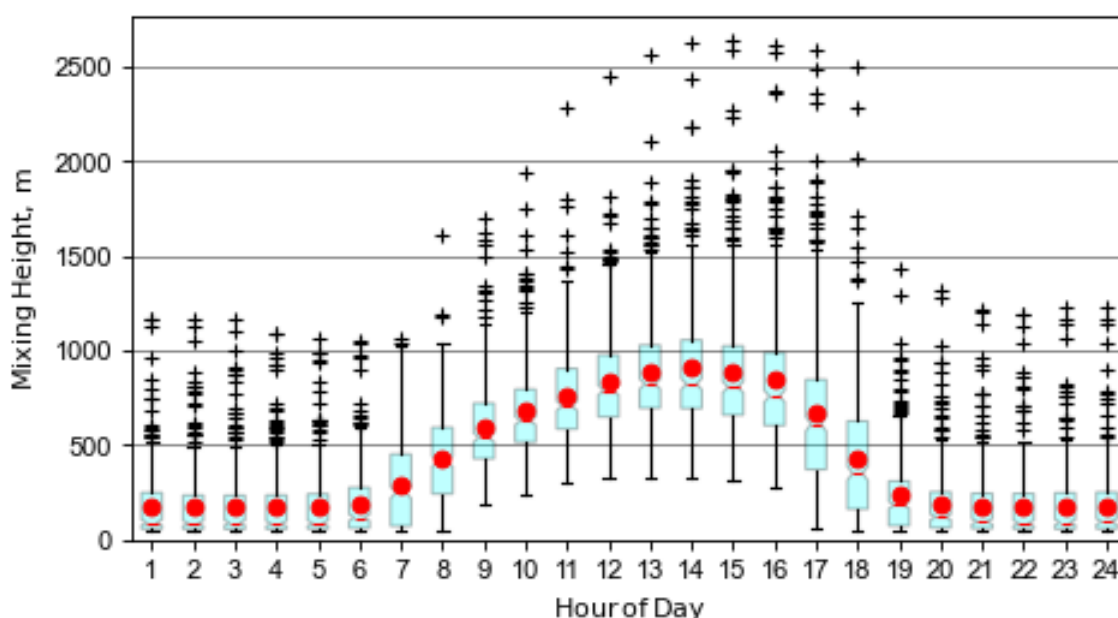


Figure 5-1 Distribution of hourly mixing heights at the GrainCorp site, 1 March 2020 to 28 February 2021

Appendix F

CALPUFF Dispersion Model Configuration





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1 The Port Kembla Bulk Liquid Terminal CALPUFF Gaussian Puff Dispersion Model

1.1 Model description

The CALPUFF model (version 7.2.1) is a standard regulatory model developed by Earth Tech in the United States.

CALPUFF is an advanced non-steady-state air quality modelling system. Twelve months of modelled meteorological data, generated from the TAPM/CALMET modelling system, was used as input for the dispersion model, in order to include all weather conditions likely to be experienced in the region throughout a typical year. The modelling has been used to predict ground-level odour concentrations across a Cartesian grid and at identified sensitive receptor locations.

CALPUFF simulates the dispersion of odour to predict ground-level concentrations across a network of receptors spaced on a Cartesian grid at regular intervals. Model predictions can also be explicitly produced at identified discrete locations between receptor grid points.

CALPUFF is a non-steady-state Gaussian puff model containing parameterisations for complex terrain effects, overwater transport, coastal interaction effects, building downwash, and wet and dry removal processes. CALPUFF employs the three-dimensional meteorological fields generated from the CALMET model by simulating the effects of time and space-varying meteorological conditions on plume transport, transformation and depletion. CALPUFF considers the geophysical features of the study area that affects dispersion of pollutants and ground-level concentrations of those pollutants in identified regions of interest. CALPUFF contains algorithms that can resolve near-source effects such as building downwash, transitional plume rise, partial plume penetration, sub-grid scale terrain interactions, as well as the long-range effects of removal, transformation, vertical wind shear, overwater transport and coastal interactions.

Emission sources can be characterised as arbitrarily varying point, area, volume and lines or any combination of those sources within the modelling domain.

1.2 CALPUFF configuration

CALPUFF (version 7.2.1) was configured following recommended settings defined in the NSW Modelling Guidance document (TRC, 2011). Key features of CALPUFF used to simulate dispersion include:

- Computational domain area of 91 by 91 grids at 100 m spacing corresponding to the CALMET domain,
- Sampling domain area of 91 by 91 grid cells covering a 9 km by 9 km extent at 100 m spacing (nesting factor of 1) centred over the GrainCorp Port Kembla Bulk Liquid Terminal site,
- 365 days modelled corresponding to the CALMET modelling period,
- Gridded 3D hourly-varying meteorological conditions generated by CALMET,
- Partial plume path adjustment for terrain modelled,
- Dispersion coefficients calculated internally from sigma-v and sigma-w using micrometeorological variables,
- CALPUFF parameters set based on recommendations from the Generic Guidance and Optimum Model Settings for CALPUFF, and
- All other options set to default.

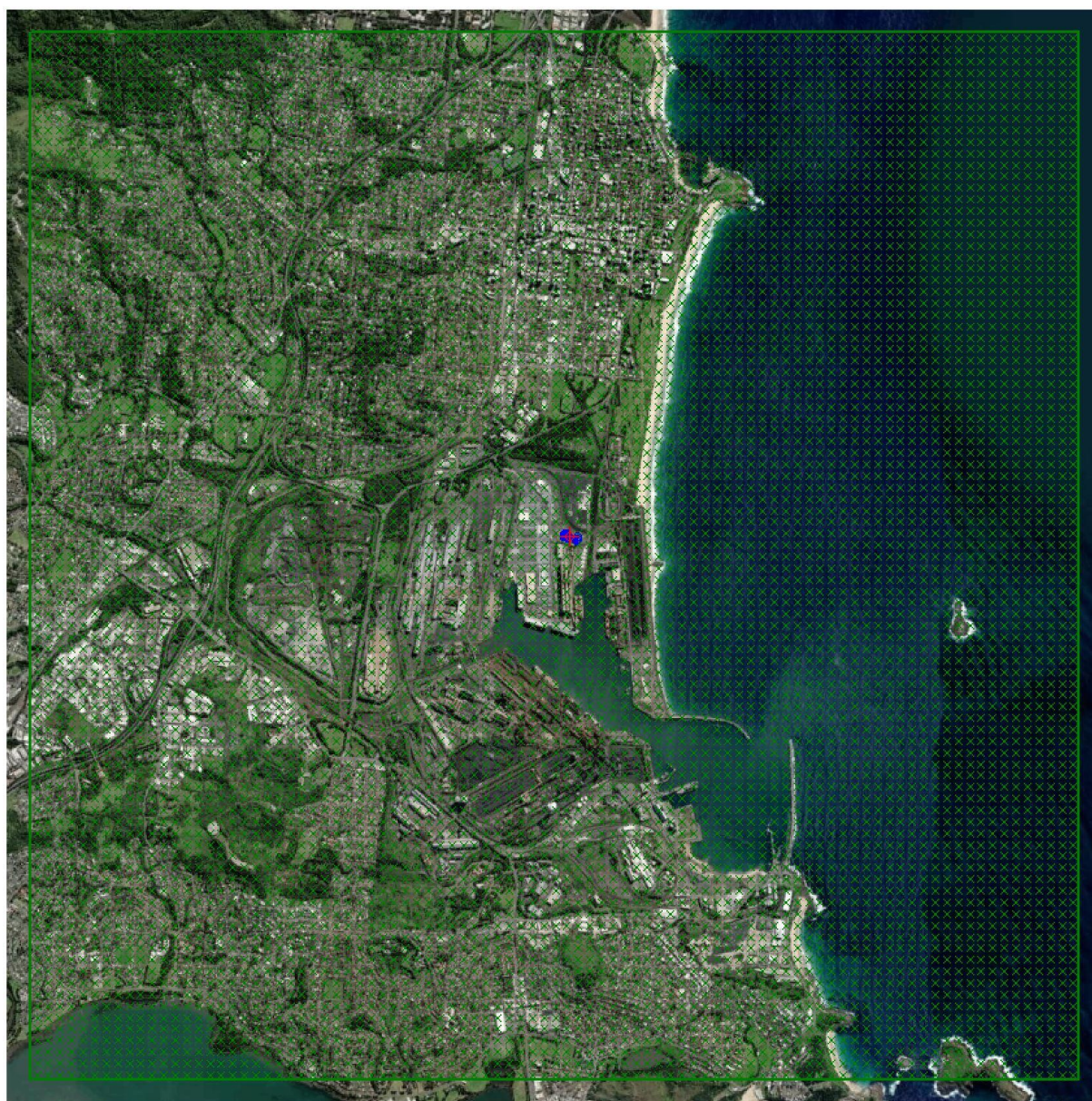


Figure 1-1 The CALPUFF sampling domain in relation to the computational domain and the CALMET meteorological grid

Figure Notes: The CALPUFF receptor grid is shown as a series of green X's. The Port Kembla Bulk Liquid Terminal site is shown in blue, with the Boiler 1 stack as a red + sign.

A comprehensive list of CALPUFF configuration settings for a sample simulation (Boiler 1) is provided in the following pages.

CALPUFF Parameters

0180.2505 TfA GrainCorp

Unit emissions Boiler 1 (2.5 MW)

Unit emissions (Peak emissions)

INPUT GROUP: 0 -- Input and Output File Names		
Parameter	Description	Value
PUFLST	CALPUFF output list file (CALPUFF.LST)	CALPUFF.LST
CONDAT	CALPUFF output concentration file (CONC.DAT)	CONC.DAT
DFDAT	CALPUFF output dry deposition flux file (DFLX.DAT)	DFLX.DAT
WFDAT	CALPUFF output wet deposition flux file (WFLX.DAT)	WFLX.DAT
LCFILES	Lower case file names (T = lower case, F = upper case)	F
NMETDOM	Number of CALMET.DAT domains	1
NMETDAT	Number of CALMET.DAT input files	12
NPTDAT	Number of PTEMARB.DAT input files	0
NARDAT	Number of BAEMARB.DAT input files	0
NVOLDAT	Number of VOLEMARB.DAT input files	0
NFLDAT	Number of FLEMARB.DAT input files	0
NRDDAT	Number of RDEMARB.DAT input files	0
NLNDAT	Number of LNEMARB.DAT input files	0
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2020-03-01-00-0000-2020-03-31-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2020-03-31-00-0000-2020-05-01-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2020-05-01-00-0000-2020-05-31-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2020-05-31-00-0000-2020-07-01-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2020-07-01-00-0000-2020-07-31-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2020-07-31-00-0000-2020-08-30-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2020-08-30-00-0000-2020-09-30-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2020-09-30-00-0000-2020-10-30-00-0000.DAT

INPUT GROUP: 0 -- Input and Output File Names		
Parameter	Description	Value
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2020-10-3 0-00-0000-2020-11-3 0-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2020-11-3 0-00-0000-2020-12-3 0-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2020-12-3 0-00-0000-2021-01-3 0-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2021-01-3 0-00-0000-2021-03-0 1-00-0000.DAT

INPUT GROUP: 1 -- General Run Control Parameters		
Parameter	Description	Value
METRUN	Run all periods in met data file? (0 = no, 1 = yes)	0
IBYR	Starting year	2020
IBMO	Starting month	3
IBDY	Starting day	1
IBHR	Starting hour	0
IBMIN	Starting minute	0
IBSEC	Starting second	0
IEYR	Ending year	2021
IEMO	Ending month	3
IEDY	Ending day	1
IEHR	Ending hour	0
IEMIN	Ending minute	0
IESEC	Ending second	0
ABTZ	Base time zone	UTC+1000
NSECDT	Length of modeling time-step (seconds)	3600
NSPEC	Number of chemical species modeled	1
NSE	Number of chemical species to be emitted	1
ITEST	Stop run after SETUP phase (1 = stop, 2 = run)	2
MRESTART	Control option to read and/or write model restart data	0
NRESPD	Number of periods in restart output cycle	0
METFM	Meteorological data format (1 = CALMET, 2 = ISC, 3 = AUSPLUME, 4 = CTDM, 5 = AERMET)	1
MPRFFM	Meteorological profile data format (1 = CTDM, 2 = AERMET)	1
AVET	Averaging time (minutes)	60
PGTIME	PG Averaging time (minutes)	60
IOUTU	Output units for binary output files (1 = mass, 2 = odour, 3 = radiation)	1

INPUT GROUP: 2 -- Technical Options		
Parameter	Description	Value
MGAUSS	Near field vertical distribution (0 = uniform, 1 = Gaussian)	1
MCTADJ	Terrain adjustment method (0 = none, 1 = ISC-type, 2 = CALPUFF-type, 3 = partial plume path)	3
MCTSG	Model subgrid-scale complex terrain? (0 = no, 1 = yes)	0
MSLUG	Near-field puffs modeled as elongated slugs? (0 = no, 1 = yes)	0
MTRANS	Model transitional plume rise? (0 = no, 1 = yes)	1
MTIP	Apply stack tip downwash to point sources? (0 = no, 1 = yes)	1
MRISE	Plume rise module for point sources (1 = Briggs, 2 = numerical)	1
MTIP_FL	Apply stack tip downwash to flare sources? (0 = no, 1 = yes)	0
MRISE_FL	Plume rise module for flare sources (1 = Briggs, 2 = numerical)	2
MBDW	Building downwash method (1 = ISC, 2 = PRIME)	2
MSHEAR	Treat vertical wind shear? (0 = no, 1 = yes)	0
MSPLIT	Puff splitting allowed? (0 = no, 1 = yes)	0
MCHEM	Chemical transformation method (0 = not modeled, 1 = MESOPUFF II, 2 = User-specified, 3 = RIVAD/ARM3, 4 = MESOPUFF II for OH, 5 = half-life, 6 = RIVAD w/ISORROPIA, 7 = RIVAD w/ISORROPIA CalTech SOA)	0
MAQCHEM	Model aqueous phase transformation? (0 = no, 1 = yes)	0
MLWC	Liquid water content flag	1
MWET	Model wet removal? (0 = no, 1 = yes)	0
MDRY	Model dry deposition? (0 = no, 1 = yes)	0
MTILT	Model gravitational settling (plume tilt)? (0 = no, 1 = yes)	0
MDISP	Dispersion coefficient calculation method (1= PROFILE.DAT, 2 = Internally, 3 = PG/MP, 4 = MESOPUFF II, 5 = CTDM)	2
MTURBVW	Turbulence characterization method (only if MDISP = 1 or 5)	3
MDISP2	Missing dispersion coefficients method (only if MDISP = 1 or 5)	3
MTAULY	Sigma-y Lagrangian timescale method	0
MTAUADV	Advective-decay timescale for turbulence (seconds)	0
MCTURB	Turbulence method (1 = CALPUFF, 2 = AERMOD)	1
MROUGH	PG sigma-y and sigma-z surface roughness adjustment? (0 = no, 1 = yes)	0
MPARTL	Model partial plume penetration for point sources? (0 = no, 1 = yes)	1
MPARTLBA	Model partial plume penetration for buoyant area sources? (0 = no, 1 = yes)	0
MTINV	Strength of temperature inversion provided in PROFILE.DAT? (0 = no - compute from default gradients, 1 = yes)	0
MPDF	PDF used for dispersion under convective conditions? (0 = no, 1 = yes)	1
MSGTIBL	Sub-grid TIBL module for shoreline? (0 = no, 1 = yes)	0
MBCON	Boundary conditions modeled? (0 = no, 1 = use BCON.DAT, 2 = use CONC.DAT)	0
MSOURCE	Save individual source contributions? (0 = no, 1 = yes)	0
MFOG	Enable FOG model output? (0 = no, 1 = yes - PLUME mode, 2 = yes - RECEPTOR mode)	0
MREG	Regulatory checks (0 = no checks, 1 = USE PA LRT checks)	0

INPUT GROUP: 3 -- Species List		
Parameter	Description	Value
CSPEC	Species included in model run	CO

INPUT GROUP: 4 -- Map Projection and Grid Control Parameters		
Parameter	Description	Value
PMAP	Map projection system	UTM
FEAST	False easting at projection origin (km)	0.0
FNORTH	False northing at projection origin (km)	0.0
IUTMZN	UTM zone (1 to 60)	56
UTMHEM	Hemisphere (N = northern, S = southern)	S
RLAT0	Latitude of projection origin (decimal degrees)	0.00N
RLON0	Longitude of projection origin (decimal degrees)	0.00E
XLAT1	1st standard parallel latitude (decimal degrees)	30S
XLAT2	2nd standard parallel latitude (decimal degrees)	60S
DATUM	Datum-region for the coordinates	WGS-84
NX	Meteorological grid - number of X grid cells	91
NY	Meteorological grid - number of Y grid cells	91
NZ	Meteorological grid - number of vertical layers	12
DGRIDKM	Meteorological grid spacing (km)	0.1
ZFACE	Meteorological grid - vertical cell face heights (m)	0.0, 20.0, 60.0, 100.0, 150.0, 200.0, 250.0, 350.0, 500.0, 800.0, 1600.0, 2600.0, 4600.0
XORIGKM	Meteorological grid - X coordinate for SW corner (km)	301.7670
YORIGKM	Meteorological grid - Y coordinate for SW corner (km)	6181.3810
IBCOMP	Computational grid - X index of lower left corner	1
JBCOMP	Computational grid - Y index of lower left corner	1
IECOMP	Computational grid - X index of upper right corner	91
JECOMP	Computational grid - Y index of upper right corner	91
LSAMP	Use sampling grid (gridded receptors) (T = true, F = false)	T
IBSAMP	Sampling grid - X index of lower left corner	1
JBSAMP	Sampling grid - Y index of lower left corner	1
IESAMP	Sampling grid - X index of upper right corner	91
JESAMP	Sampling grid - Y index of upper right corner	91
MESHDN	Sampling grid - nesting factor	1

INPUT GROUP: 5 -- Output Options		
Parameter	Description	Value
ICON	Output concentrations to CONC.DAT? (0 = no, 1 = yes)	1
IDRY	Output dry deposition fluxes to DFLX.DAT? (0 = no, 1 = yes)	0

INPUT GROUP: 5 -- Output Options		
Parameter	Description	Value
IWET	Output wet deposition fluxes to WFLX.DAT? (0 = no, 1 = yes)	0
IT2D	Output 2D temperature data? (0 = no, 1 = yes)	0
IRHO	Output 2D density data? (0 = no, 1 = yes)	0
IVIS	Output relative humidity data? (0 = no, 1 = yes)	0
LCOMPRS	Use data compression in output file (T = true, F = false)	T
IQAPLOT	Create QA output files suitable for plotting? (0 = no, 1 = yes)	1
IPFTRAK	Output puff tracking data? (0 = no, 1 = yes use timestep, 2 = yes use sampling step)	0
IMFLX	Output mass flux across specific boundaries? (0 = no, 1 = yes)	0
IMBAL	Output mass balance for each species? (0 = no, 1 = yes)	0
INRISE	Output plume rise data? (0 = no, 1 = yes)	0
ICPRT	Print concentrations? (0 = no, 1 = yes)	0
IDPRT	Print dry deposition fluxes? (0 = no, 1 = yes)	0
IWPRT	Print wet deposition fluxes? (0 = no, 1 = yes)	0
ICFRQ	Concentration print interval (timesteps)	1
IDFRQ	Dry deposition flux print interval (timesteps)	1
IWFRQ	Wet deposition flux print interval (timesteps)	1
IPRTU	Units for line printer output (e.g., 3 = ug/m**3 - ug/m**2/s, 5 = odor units)	1
IMESG	Message tracking run progress on screen (0 = no, 1 and 2 = yes)	2
LDEBUG	Enable debug output? (0 = no, 1 = yes)	F
IPFDEB	First puff to track in debug output	1
NPFDEB	Number of puffs to track in debug output	1000
NN1	Starting meteorological period in debug output	1
NN2	Ending meteorological period in debug output	10

INPUT GROUP: 6 -- Subgrid Scale Complex Terrain Inputs		
Parameter	Description	Value
NHILL	Number of terrain features	0
NCTREC	Number of special complex terrain receptors	0
MHILL	Terrain and CTSG receptor data format (1= CTDM, 2 = OPTHILL)	2
XHILL2M	Horizontal dimension conversion factor to meters	1.0
ZHILL2M	Vertical dimension conversion factor to meters	1.0
XCTDMKM	X origin of CTDM system relative to CALPUFF system (km)	0.0
YCTDMKM	Y origin of CTDM system relative to CALPUFF system (km)	0.0

INPUT GROUP: 9 -- Miscellaneous Dry Deposition Parameters		
Parameter	Description	Value
RCUTR	Reference cuticle resistance (s/cm)	30
RGR	Reference ground resistance (s/cm)	10

INPUT GROUP: 9 -- Miscellaneous Dry Deposition Parameters		
Parameter	Description	Value
REACTR	Reference pollutant reactivity	8
NINT	Number of particle size intervals for effective particle deposition velocity	9
IVEG	Vegetation state in unirrigated areas (1 = active and unstressed, 2 = active and stressed, 3 = inactive)	1

INPUT GROUP: 11 -- Chemistry Parameters		
Parameter	Description	Value
MOZ	Ozone background input option (0 = monthly, 1 = hourly from OZONE.DAT)	1
BCKO3	Monthly ozone concentrations (ppb)	80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00
MNH3	Ammonia background input option (0 = monthly, 1 = from NH3Z.DAT)	0
MAVGNH3	Ammonia vertical averaging option (0 = no average, 1 = average over vertical extent of puff)	1
BCKNH3	Monthly ammonia concentrations (ppb)	10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00
RNITE1	Nighttime SO2 loss rate (%/hr)	0.2
RNITE2	Nighttime NOx loss rate (%/hr)	2
RNITE3	Nighttime HNO3 loss rate (%/hr)	2
MH2O2	H2O2 background input option (0 = monthly, 1 = hourly from H2O2.DAT)	1
BCKH2O2	Monthly H2O2 concentrations (ppb)	1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00
RH_ISRP	Minimum relative humidity for ISORROPIA	50.0
SO4_ISRP	Minimum SO4 for ISORROPIA	0.4
BCKPMF	SOA background fine particulate (ug/m**3)	1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00
OFRAC	SOA organic fine particulate fraction	0.15, 0.15, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.15
VCNX	SOA VOC/NOX ratio	50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00
NDECAY	Half-life decay blocks	0

INPUT GROUP: 12 -- Misc. Dispersion and Computational Parameters		
Parameter	Description	Value
SYTDEP	Horizontal puff size for time-dependent sigma equations (m)	550
MHFTSZ	Use Heffter equation for sigma-z? (0 = no, 1 = yes)	0
JSUP	PG stability class above mixed layer	5

INPUT GROUP: 12 -- Misc. Dispersion and Computational Parameters		
Parameter	Description	Value
CONK1	Vertical dispersion constant - stable conditions	0.01
CONK2	Vertical dispersion constant - neutral/unstable conditions	0.1
TBD	Downwash scheme transition point option (<0 = Huber-Snyder, 1.5 = Schulman-Scire, 0.5 = ISC)	0.5
IURB1	Beginning land use category for which urban dispersion is assumed	10
IURB2	Ending land use category for which urban dispersion is assumed	19
ILANDUIN	Land use category for modeling domain	20
Z0IN	Roughness length for modeling domain (m)	.25
XLAIIN	Leaf area index for modeling domain	3.0
ELEVIN	Elevation above sea level (m)	.0
XLATIN	Meteorological station latitude (deg)	-999.0
XLONIN	Meteorological station longitude (deg)	-999.0
ANEMHT	Anemometer height (m)	10.0
ISIGMAV	Lateral turbulence format (0 = read sigma-theta, 1 = read sigma-v)	1
IMIXCTDM	Mixing heights read option (0 = predicted, 1 = observed)	0
XMULEN	Slug length (met grid units)	1
XSAMLEN	Maximum travel distance of a puff/slug (met grid units)	1
MXNEW	Maximum number of slugs/puffs release from one source during one time step	99
MXSAM	Maximum number of sampling steps for one puff/slug during one time step	99
NCOUNT	Number of iterations used when computing the transport wind for a sampling step that includes gradual rise	2
SYMIN	Minimum sigma-y for a new puff/slug (m)	1
SZMIN	Minimum sigma-z for a new puff/slug (m)	1
SZCAP_M	Maximum sigma-z allowed to avoid numerical problem in calculating virtual time or distance (m)	5000000
SVMIN	Minimum turbulence velocities sigma-v (m/s)	0.2, 0.2, 0.2, 0.2, 0.2, 0.2, 0.2, 0.2, 0.2, 0.2, 0.2, 0.2
SWMIN	Minimum turbulence velocities sigma-w (m/s)	0.2, 0.12, 0.08, 0.06, 0.03, 0.016, 0.2, 0.12, 0.08, 0.06, 0.03, 0.016
CDIV	Divergence criterion for dw/dz across puff (1/s)	0, 0
NLUTIBL	TIBL module search radius (met grid cells)	4
WSCALM	Minimum wind speed allowed for non-calm conditions (m/s)	0.5
XMAXZI	Maximum mixing height (m)	3000
XMINZI	Minimum mixing height (m)	50
TKCAT	Emissions scale-factors temperature categories (K)	265., 270., 275., 280., 285., 290., 295., 300., 305., 310., 315.
PLX0	Wind speed profile exponent for stability classes 1 to 6	0.07, 0.07, 0.1, 0.15, 0.35, 0.55

INPUT GROUP: 15 -- Line Source Parameters		
Parameter	Description	Value
NLINES	Number of buoyant line sources	0
ILNU	Units used for line source emissions (e.g., 1 = g/s)	1
NSLN1	Number of source-species combinations with variable emission scaling factors	0
NLRSE	Number of distances at which transitional rise is computed	6

INPUT GROUP: 16 -- Volume Source Parameters		
Parameter	Description	Value
NVL1	Number of volume sources	0
IVLU	Units used for volume source emissions (e.g., 1 = g/s)	1
NSVL1	Number of source-species combinations with variable emission scaling factors	0
NVL2	Number of volume sources in VOLEMARB.DAT file(s)	0

INPUT GROUP: 17 -- FLARE Source Control Parameters (variable emissions file)		
Parameter	Description	Value
NFL2	Number of flare sources defined in FLEMARB.DAT file(s)	0

INPUT GROUP: 18 -- Road Emissions Parameters		
Parameter	Description	Value
NRD1	Number of road-links sources	0
NRD2	Number of road-links in RDEMARB.DAT file	0
NSFRDS	Number of road-links and species combinations with variable emission-rate scale-factors	0

INPUT GROUP: 19 -- Emission Rate Scale-Factor Tables		
Parameter	Description	Value
NSFTAB	Number of emission scale-factor tables	0

INPUT GROUP: 20 -- Non-gridded (Discrete) Receptor Information		
Parameter	Description	Value
NREC	Number of discrete receptors (non-gridded receptors)	0
NRGRP	Number of receptor group names	0

Appendix G

Boiler stack sizing memorandum



MEMORANDUM



To:	Jacob McRae & Tim Guyatt	From:	Shyno Susan John
Email:	jacob.mcrae@tfa.com.au tim.guyatt@graincorp.com.au	Email:	susan@airenvironment.com.au
Company:	TfA Project Group GrainCorp	Company:	Air Environment
		Date:	28 July 2025

GrainCorp Bulk Liquid Terminal: Boiler Stack Sizing Study

1 Introduction

Our preliminary modelling for the two proposed boilers operating at their maximum power rating (2.5 MW) was based on typical boiler stack architecture and release conditions. The following assumptions were made, given the lack of currently available specifications on the precise boiler make and model to be commissioned:

- Two 21 m stacks (stack height assumed to be bulk storage tank height plus 3 m)
- Stack diameter = 0.3 m assumed for 1 to 5 MW boilers (NIWA, 2012, p. 7)
- Exit temperature of 200 °C (NIWA, 2012, p. 7)
- Exit velocity of 20 m/s based on typical velocities of 15 to 25 m/s as provided by the Engineering Toolbox (https://www.engineeringtoolbox.com/boiler-exhaust-velocity-d_389.html)

The resultant model showed a significant exceedance of the 1-hour NO₂ impact assessment criterion beyond the GrainCorp site boundary as shown in Figure 1-1.

A stack sizing study was therefore conducted to determine the most appropriate stack height to adopt, allowing boiler emissions to comply with the NSW EPA 1-hour NO₂ impact assessment criterion of 164 µg/m³.

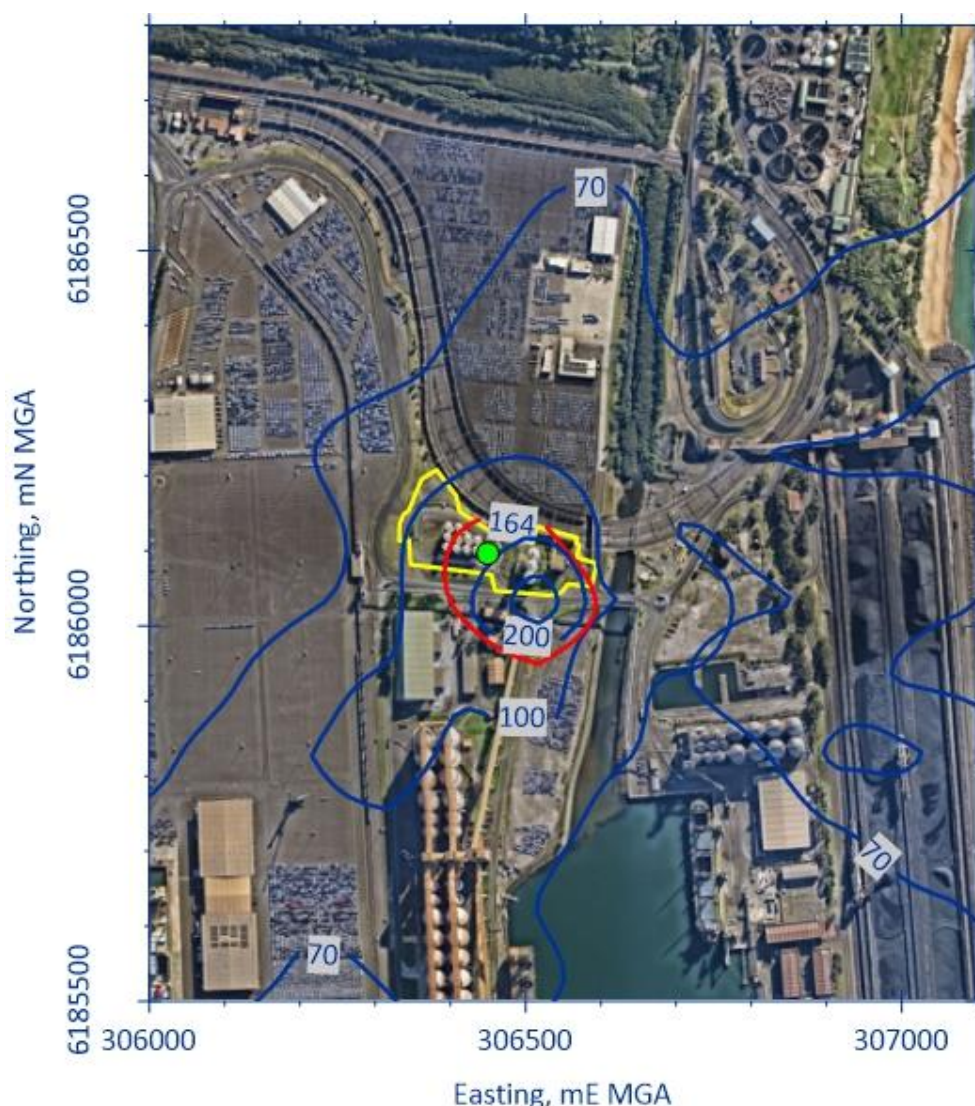


Figure 1-1 Maximum 1-hour cumulative NO_2 concentrations arising from boiler stack emissions from a pair of 21-metre high stacks.

Figure Notes: The GrainCorp site boundary is shown in yellow. The boiler house is shown as a green dot. The red isopleth shows the 1-hour NO_2 impact assessment criterion of $164 \mu\text{g}/\text{m}^3$.

2 Stack Sizing Methodology

The revised stack-sizing model assumes that GrainCorp will commission a single stack protruding from the Boiler House at a location mid-way between the two proposed boilers, with emissions from each boiler being ducted into the stack. The stack diameter was selected to provide the total cross-sectional area of the two originally modelled stacks. The volumetric flows, and hence exit velocity, and in-stack temperatures were similarly summed across the two originally modelled boiler stacks.

Given the lack of available information on proposed boiler specifications it was assumed that the in-stack NO_2 concentration was $350 \text{ mg}/\text{m}^3$ (i.e. at the regulatory in-stack NO_2 concentration limit). This means that any boilers meeting this limit are assessed within this investigation. The modelled boiler stack location, dimensions, and release conditions are provided in Table 2-1. The Ozone Limiting Method was used to determine the conversion of NO_x emissions to NO_2 .



Table 2-1 Boiler stack location, dimensions and release conditions

Modelling Parameter	Dimensions
Stack location (MGA coordinates)	306,450.5 mE 6,186,098.5 mN
Stack diameter (m)	0.424
Exit velocity (m/s)	20
In-stack temperature (K)	473.2
In-stack NO ₂ concentration (mg/m ³)	350
Mass emission rate (g/s)	0.571

Good engineering practice (GEP) assumes that a stack height of 2.5 times that of the closest buildings/structures will release emissions into the free air above the building and will not be impacted by building wake effects. The GEP stack height for a boiler stack adjacent to the 18 m high bulk storage tanks is therefore 45 m.

Three different stack heights were initially assessed as follows:

- 25 m
- 35 m
- 45 m (wake free).

Model predictions were reviewed at this stage, and an additional intermediate stack height was selected for modelling. A final stack height was then modelled, on the basis of these results, to further refine the stack height predictions.

3 Stack Sizing Predictions

The model predictions are summarised in Table 3-1, with cumulative 1-hour maximum NO₂ isopleth plots being provided in Figure 3-1 to Figure 3-5.

Table 3-1 Cumulative 1-hour maximum NO₂ concentration by stack height

Boiler stack height	Cumulative 1-hour maximum NO ₂ concentration, µg/m ³	
	At and within site boundary	At and beyond site boundary
21 m ¹	347	369
25 m	208	229
35 m	189	202
40 m	170	182
42.5 m	161	171
45 m	151	161

Table Note: The 1-hour NO₂ impact assessment criterion is 164 µg/m³.
¹Original model

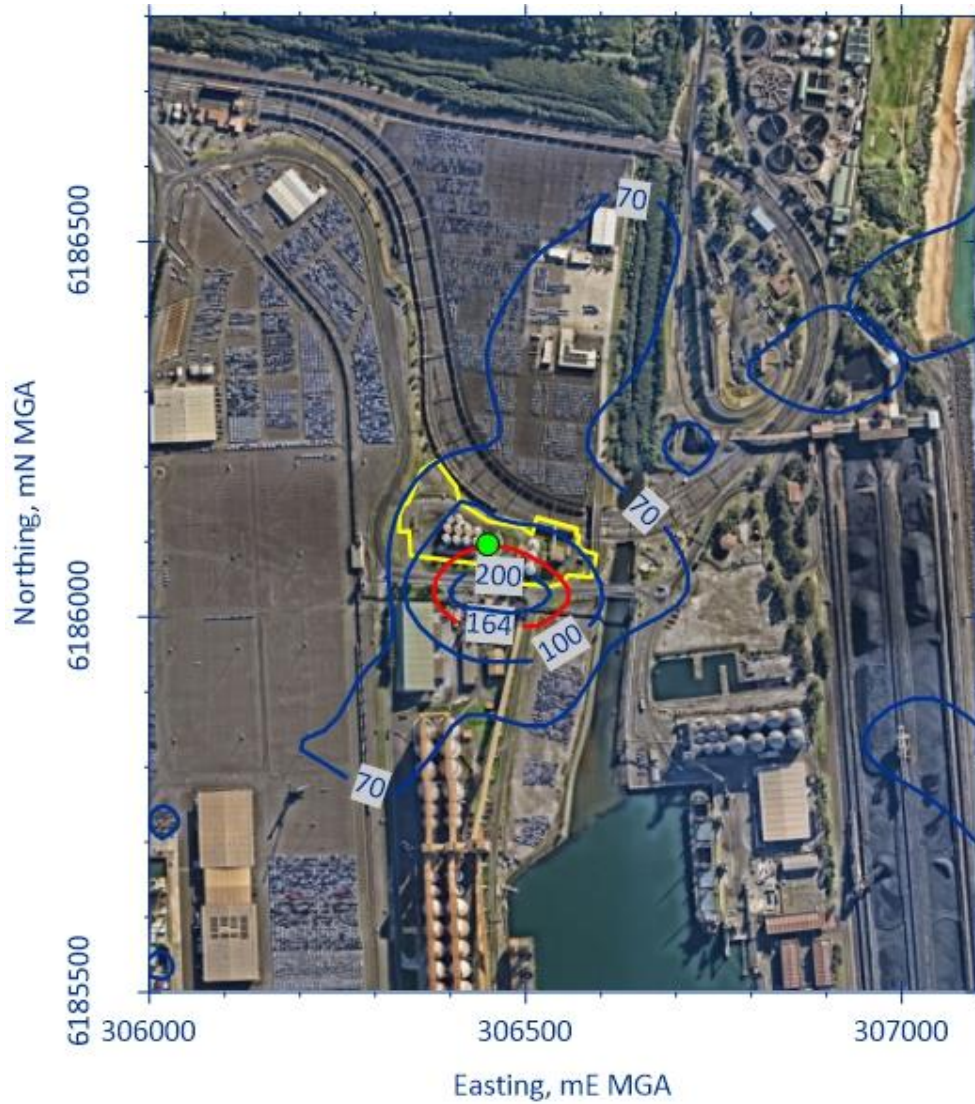


Figure 3-1 Maximum 1-hour cumulative NO_2 concentrations arising from a single 25 m boiler stack serving both boilers

Figure Notes: The GrainCorp site boundary is shown in yellow. The boiler stack is shown as a green dot. The red isopleth shows the 1-hour NO_2 impact assessment criterion of $164 \mu\text{g}/\text{m}^3$.

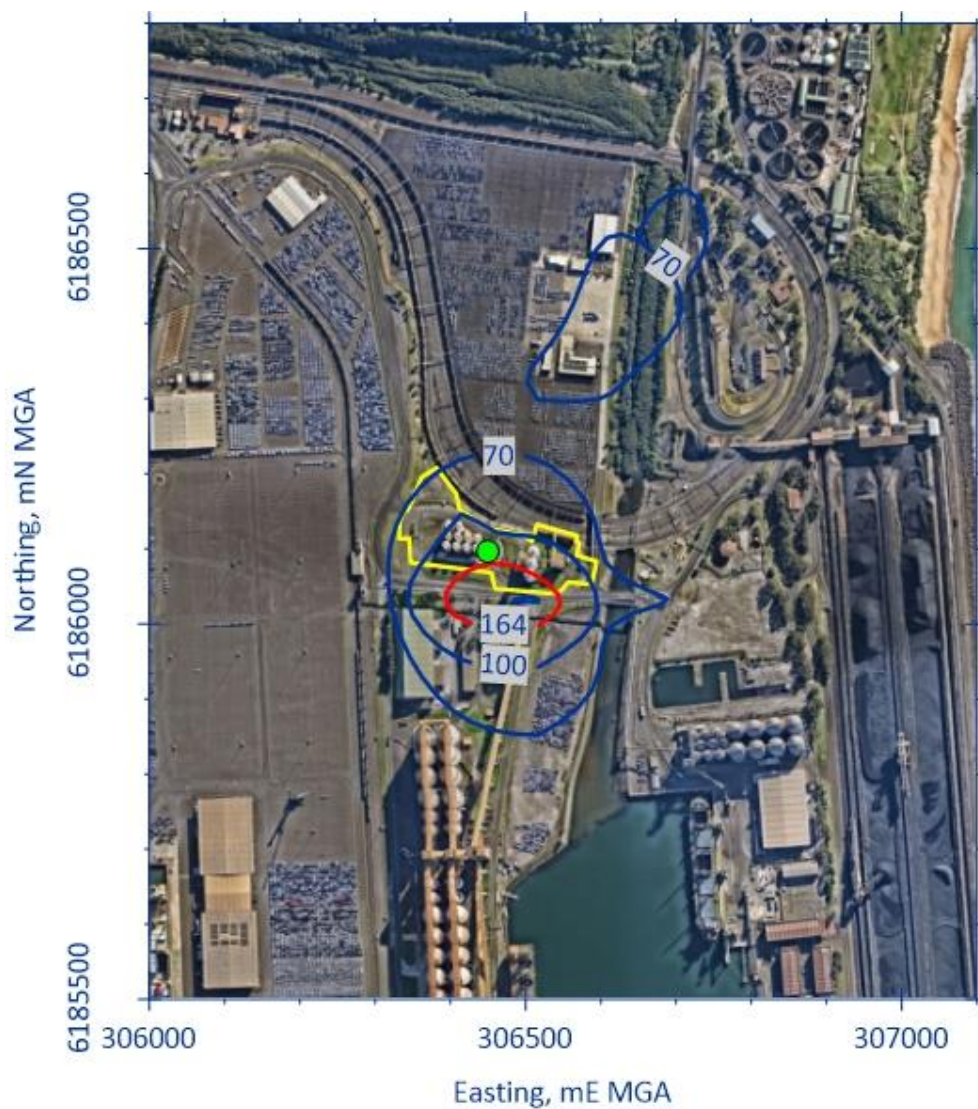


Figure 3-2 Maximum 1-hour cumulative NO₂ concentrations arising from a single 35 m boiler stack serving both boilers

Figure Notes: The GrainCorp site boundary is shown in yellow. The boiler stack is shown as a green dot. The red isopleth shows the 1-hour NO₂ impact assessment criterion of 164 µg/m³.

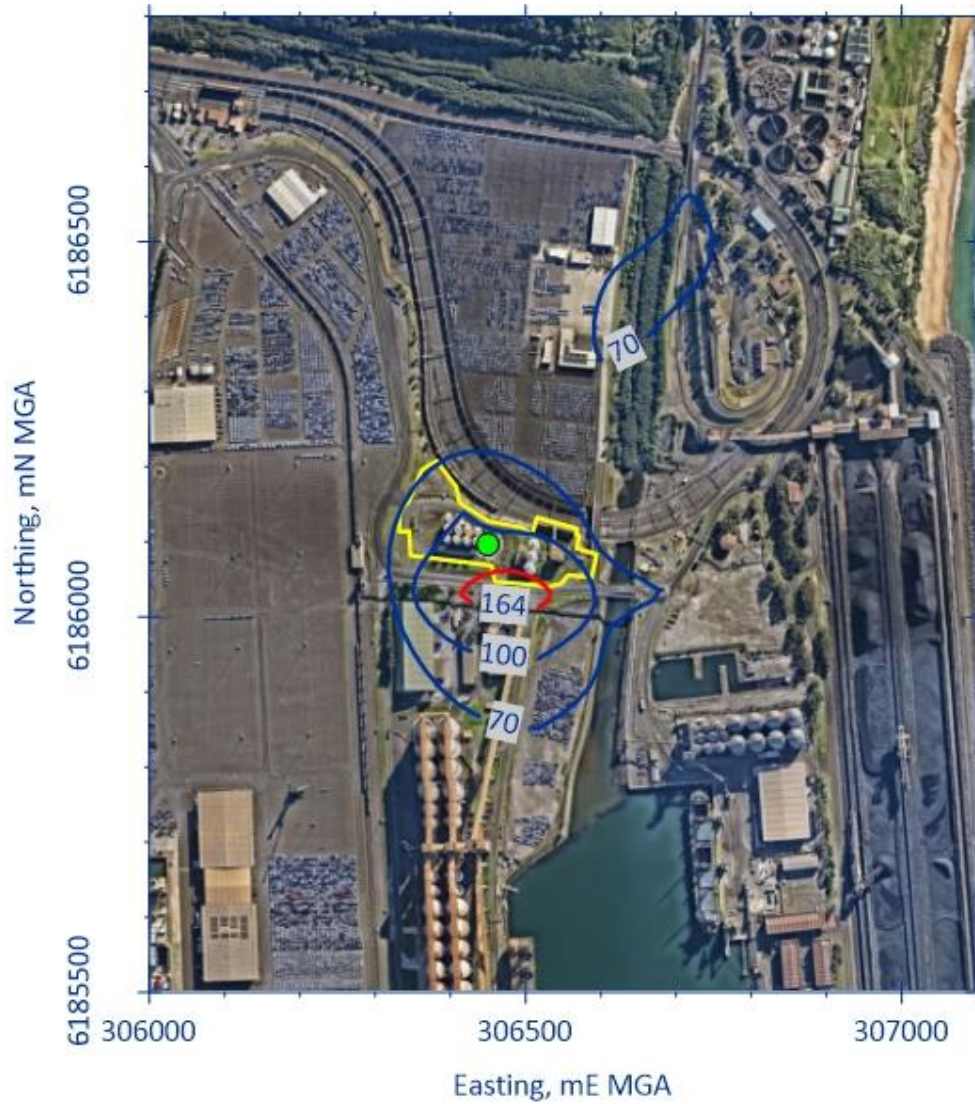


Figure 3-3 Maximum 1-hour cumulative NO₂ concentrations arising from a single 40 m boiler stack serving both boilers

Figure Notes: The GrainCorp site boundary is shown in yellow. The boiler stack is shown as a green dot. The red isopleth shows the 1-hour NO₂ impact assessment criterion of 164 µg/m³.

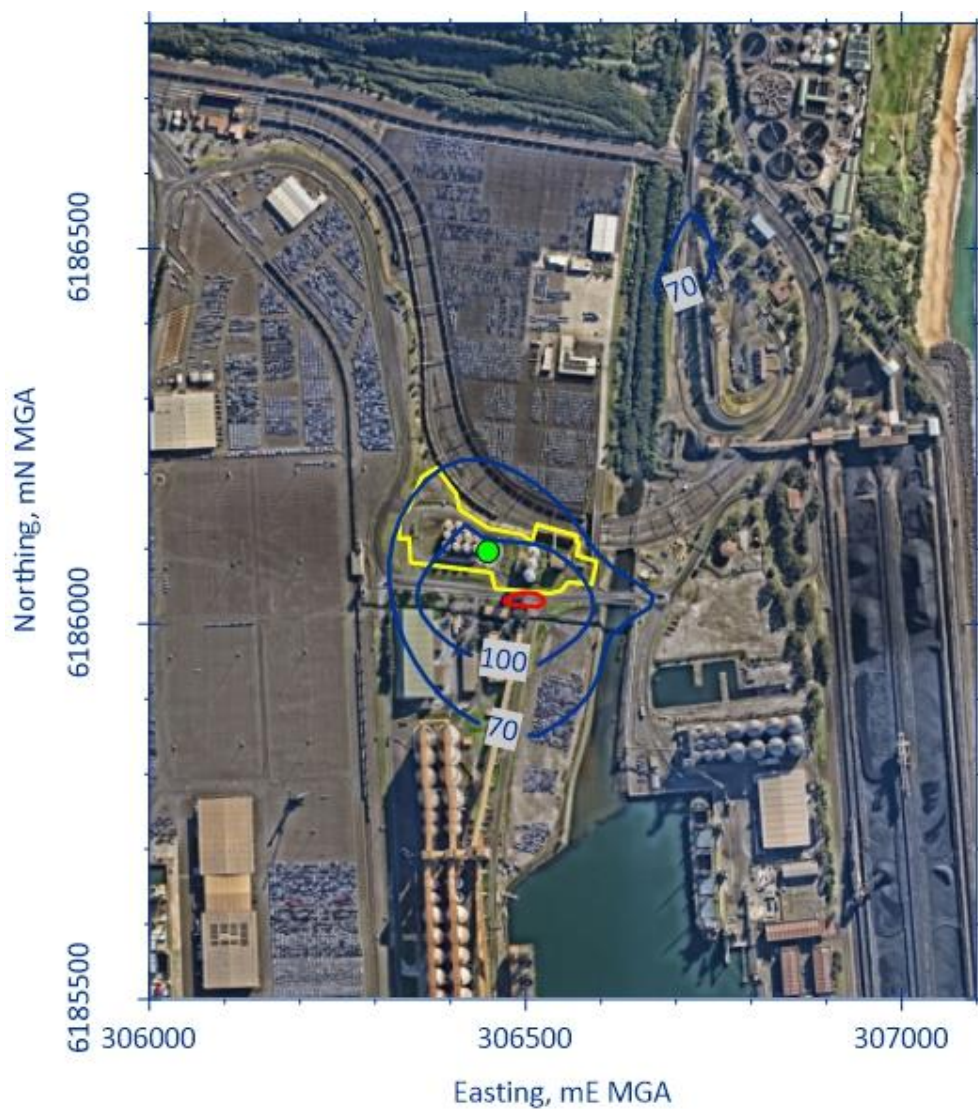


Figure 3-4 Maximum 1-hour cumulative NO₂ concentrations arising from a single 42.5 m boiler stack serving both boilers

Figure Notes: The GrainCorp site boundary is shown in yellow. The boiler stack is shown as a green dot. The red isopleth shows the 1-hour NO₂ impact assessment criterion of 164 µg/m³.

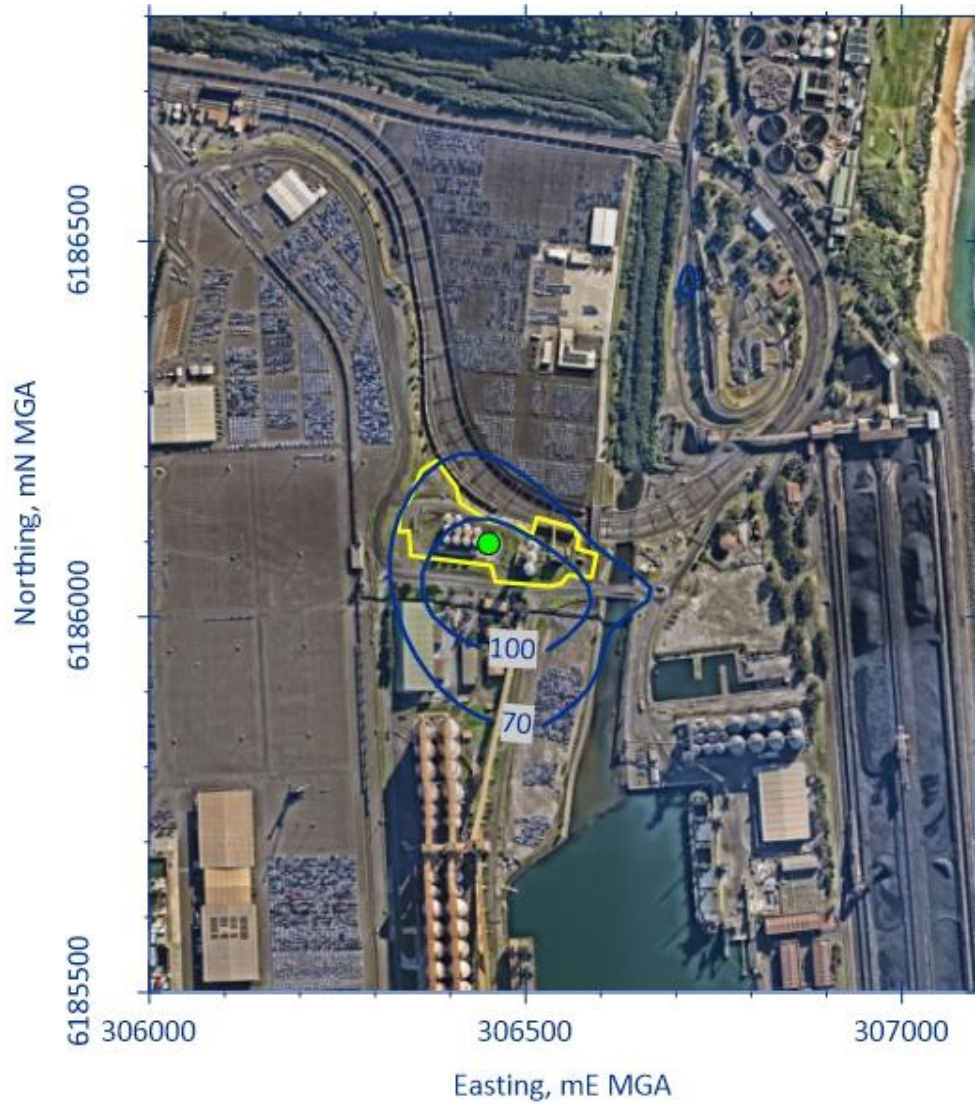


Figure 3-5 Maximum 1-hour cumulative NO₂ concentrations arising from a single 45 m boiler stack serving both boilers

Figure Notes: The GrainCorp site boundary is shown in yellow. The boiler stack is shown as a green dot. The red isopleth shows the 1-hour NO₂ impact assessment criterion of 164 µg/m³.



4 Conclusions and Recommendations

The model results for all stack height scenarios show that the highest predicted ground level concentrations occur in a region beyond the southern site boundary. This is caused by a combination of building wake effects from the bulk storage tanks, the stack release conditions (exit temperature and velocity), and the prevailing meteorology of the region at effective stack height.

The 1-hour NO₂ impact assessment criterion of 164 µg/m³ is exceeded beyond the site boundary for all assessed stack heights apart from 45 m indicating that a 45 m stack height is appropriate.

These are preliminary results based on conservative modelling estimates. They would be significantly improved if actual boiler stack diameters, volume flow rate, exit velocity, and exit temperature were known. It is therefore recommended that the boiler stack dispersion model be refined once the precise boiler make, model and specifications are known.

Please let us know if we can proceed with our final impact assessment report assuming a single 45 m high boiler stack at this location or whether you would like us to wait until more accurate information becomes available?

5 References

NIWA, 2012. Definition of Activity Classes for Industrial Boilers, Part 2: Setting Limits, NIWA Project: ELF12229, December 2012, 22 pp.

Appendix H

Compliance with Clause 48 of the Environmental Planning and Assessment Regulation 2021



MEMORANDUM



To:	Tim Guyatt	From:	Michael Power
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Company:	GrainCorp	Company:	Air Environment
		Date:	3 October 2025

GrainCorp Bulk Liquid Terminal: Compliance with Clause 48 of the Environmental Planning and Assessment Regulation 2021

1 Introduction

Air Environment was previously commissioned by GrainCorp Bulk Liquid Terminal at Port Kembla (GrainCorp) to prepare an air quality impact assessment (AQIA) of the operation of their Bulk Liquid Terminal at Tom Thumb Rd, Port Kembla NSW (Air Environment, 2025). The assessment pathway for the proposal relies on Part 3, Clause 48 of the *Environmental Planning and Assessment Regulation 2021* (NSW). To successfully navigate this pathway GrainCorp must demonstrate that “... *the alterations or additions do not significantly increase the environmental impacts of the existing or approved development*”.

Clause 48 states:

48 Alterations or additions to existing or approved development

- (1) Development involving alterations or additions to development, whether existing or approved, is not designated development if, in the consent authority’s opinion, the alterations or additions do not significantly increase the environmental impacts of the existing or approved development.
- (2) In forming its opinion, a consent authority must consider the following—
- (a) the impact of the existing development, including the following—
 - (i) previous environmental management performance, including compliance with the conditions of any consents, licences, leases or authorisations by a public authority and compliance with any relevant codes of practice,
 - (ii) rehabilitation or restoration of any disturbed land,
 - (iii) the number and nature of all past changes and their cumulative effects,
 - (b) the likely impact of the proposed alterations or additions, including the following—
 - (i) the scale, character or nature of the proposal in relation to the development,
 - (ii) the existing vegetation, air, noise and water quality, scenic character and special features of the land on which the development is, or will be, carried out and the surrounding locality,
 - (iii) the degree to which the potential environmental impacts can be predicted with adequate certainty,
 - (iv) the capacity of the receiving environment to accommodate changes in environmental impacts,
 - (c) proposals to mitigate the environmental impacts and manage residual risk,
 - (d) proposals to facilitate compliance with relevant standards, codes of practice or guidelines published by the Department or other public authorities.

(Environmental Planning and Assessment Regulation 2021. Part 3 Exceptions, Clause 48)



Air Environment has therefore been commissioned by GrainCorp to prepare a comparison of current allowable emissions (the “existing consent scenario”) against the proposed upgraded emissions, with the aim of demonstrating that the requirements of Clause 48 are met.

2 Emissions Inventory for the Existing Consent Scenario

2.1 Modelling scenarios

The Existing Consent and Upgrade Scenarios are described in Table 2-1. The upgrade emissions were characterised in Section 5 of the AQIA (Air Environment 2025). This section provides the estimated emission rates for the existing consent scenario.

Table 2-1 The Existing Consent and Upgrade Scenarios

Existing Consent Scenario	Upgrade Scenario
1 x existing heated 1250 t bulk storage tank (TK-01) storing “Brightstock” product comprising residual petroleum oils	15 x heated 1250 t bulk storage tanks (TK-01 to TK10) storing either tallow or used cooking oil (UCO). Not considered to be a pollutant source and therefore unassessed.
9 x existing unheated 1250 t bulk storage tanks (TK-02 to TK-10) storing Class C1 and C2 combustible liquids	4 x 100 kL tanks storing either tallow or UCO. Not considered to be a pollutant source and therefore unassessed.
6 x yet to be developed unheated 1250 t bulk storage tanks (TK-11 to TK-16) storing Class C1 and C2 combustible liquids	-
ECS Model 25VWT 250 kW hot water boiler	Bosch 3.8 MW heating plant comprising: UT-M 18 (2.5 MW) & UT-M 10 (1.3 MW) hot water boilers
Diesel fuel storage tank (60 kL)	Repurposed diesel fuel storage tank (60 kL)

2.2 ECS 250 kW boiler

Emissions from the existing ECS 25VWT 250 kW boiler were characterised using manufacturer’s specifications, information provided by GrainCorp, and mass emission rates contained within the National Pollutant Inventory (NPI) Emissions Estimation Technique (EET) Manual for Combustion in Boilers Version 3.6 (NPI, 2011). Only the major boiler pollutants identified in the AQIA (Air Environment 2025) were assessed.

The boiler characteristics used in the existing consent scenario CALPUFF model are provided in Table 2-2.



Table 2-2 ECS 250 kW boiler characteristics

Parameter	Value	Comments
Make	ECS	Manufacturer's specifications
Model	25VWT	Manufacturer's specifications
Nominal capacity, kW	250	Manufacturer's specifications
Stack location	306,450 mE 6,186,098 mN	Provided by GrainCorp
Stack diameter, m	0.2	Provided by GrainCorp
Stack height, m	8.5	Provided by GrainCorp
Exit velocity, m/s	10	8 to 12 m/s provided by manufacturer
In-stack temperature, °C	220	Manufacturer's specifications
In-stack moisture content, %	12	Assumed
Peak fuel usage rate, t/h	0.025	Calculated from manufacturer-supplied peak fuel usage rate of 1,125 MJ/h and a gross calorific value for diesel fuel of 45.6 MJ/kg.
Oxides of nitrogen mass emission rate, g/s	0.012	Calculated from boiler size (250 kW) and emission factor of 170 mg/kWh provided by manufacturer
Sulfur dioxide mass emission rate ¹ , g/s	0.023	Calculated from boiler size (250 kW) and emission factor of 336 mg/kWh provided by manufacturer
Particles as PM _{2.5} , g/s	2.056E-04	Calculated from boiler size (250 kW) and NPI emission factor ² of 0.003 kg/t of diesel fuel burnt
Particles as PM ₁₀ , g/s	9.594E-04	Calculated from boiler size (250 kW) and NPI emission factor ² of 0.14 kg/t of diesel fuel burnt
Beryllium, g/s	3.968E-07	Calculated from boiler size (250 kW) and NPI emission factor ² of 5.790E-05 kg/t of diesel fuel burnt
Cadmium, g/s	3.968E-07	Calculated from boiler size (250 kW) and NPI emission factor ² of 5.790E-05 kg/t of diesel fuel burnt

Table notes: ¹Estimated sulfur dioxide emissions for the proposed 1.3 MW and 2.5 MW boiler (6.326E-04 and 1.233E-03 g/s respectively) are lower than those estimated for the 250 kW boiler, which were estimated using the NPI EET Manual for Combustion in Boilers (version 3.6, NPI, 2011).
²NPI EET Manual for Combustion in Boilers (version 3.6, NPI, 2011).



2.3 Diesel storage tank

Standing and working losses from the diesel storage tank will differ between the two modelling scenarios, despite both scenarios featuring a 60 kL diesel storage tank. An existing slops tank, which is adjacent to the current diesel storage tank, will be re-purposed for diesel fuel storage as part of the upgrade. In addition to the location change, the working losses will be different between each scenario due to the increased fuel usage rates by the 3.8 MW heating plant.

The AQIA (Air Environment 2025) determined that impacts from the proposed re-purposed diesel storage tank were minor. The pollutant of most concern was cumene, which only accounted for 1.5% of its 1-hour average impact assessment criterion at and beyond the GrainCorp site boundary. On this basis only cumene emissions from the existing diesel storage tank are assessed here.

The cumene emission factor for the storage of diesel fuel in vertical fixed roof tanks in NSW (Zone 10) was selected from the NPI EET Manual for Fuel and Organic Liquid Storage (NPI, 2012). The cumene emission rate was determined using the NPI emission factor and a maximum total diesel fuel usage rate of 0.025 t/h as shown in Table 2-3.

Table 2-3 Cumene emission factor and emission rate from a fixed vertical diesel storage tank in NSW under a fuel usage rate of 0.025 t/h

Pollutant	Emission Factor, kg/t ¹	Emission Rate, kg/h	Emission Rate, g/s
Cumene	6.400E-04	1.579E-05	4.386E-06

Table Note: ¹Source NPI, 2012, Appendix F.1: Fuel storage- vertical fixed roof tank, p. 41, Zone 10 NSW.

2.4 Bulk storage tanks

Emissions from the storage of tallow and UCO were not assessed in the AQIA (Air Environment, 2025) as these substances are not considered to be pollutants. The tanks are currently used for the storage of the following Class C1 and C2 combustible liquids:

- Brightstock: Residual oils (petroleum). Solvent-refined.
- Group II 150N: Distillates. Hydrotreated heavy paraffinic.
- Group II 500N: Distillates, Hydrotreated heavy paraffinic
- Yubase 3: Distillates, Hydrotreated light paraffines.
- Yubase 4: Distillates, Hydrotreated heavy paraffinic.
- Yubase 6: Distillates, Hydrotreated heavy paraffines.

The US EPA Tanks software version 5.1, available at <https://tanks.app.cloud.gov/>, was used to estimate hazardous air pollutant emissions from the ten existing and six additional consented 1250 t bulk storage tanks. The existing consent scenario assumes that tank TK-01 is configured for heating and is used for the storage of the Brightstock product, and the remaining nine existing and six consented tanks are used for the storage of the Group II and Yubase products. The Tanks software was configured using detailed information supplied by GrainCorp. The adopted configuration settings are provided in Table 2-4.



Table 2-4 Configuration settings for the US EPA Tanks v 5.1 tank emissions estimation software

Configuration Parameter	Configuration Setting
Tank Identification	
Tank ID	TK-01 to TK-16
Tank Type	Vertical Fixed Roof Tank
Meteorological Data	
Meteorological Location	Custom data developed for Sydney Airport (NPI, 2012)
Tank Characteristics	
Tank Shape	Cylinder
Shell Height	16,680 mm = 54.72 ft
Shell Diameter	10,000 mm = 32.81 ft
Maximum liquid height measured from the bottom of the tank shell	16,680 mm = 54.72 ft
Average liquid height measured from the bottom of the tank shell	8,340 mm = 27.36 ft
Tank Bottom Type	Flat or Nominally Flat Bottom
Liquid heel type at tank minimum	No liquid heel
Vapor space pressure at normal operating conditions (psig)	0 psig (ambient atmospheric pressure)
Is Tank Insulated?	TK-01 partially insulated TK=02 to TK-16 not insulated
Liquid Bulk Temperature (TK-01 only)	65 °C = 608 °R
Liquid bulk temperature calculation method	AP-42 calculation
Shell Characteristics	
Shell colour/shade	White
Shell condition	Good
Roof Characteristics	
Roof colour/shade	White
Roof condition	Good
Roof type	Cone
Tank cone roof shape	0.167
Breather Vent Settings	
Vacuum setting	0 psig (ambient atmospheric pressure)
Pressure setting	0 psig (ambient atmospheric pressure)
Control Device Settings	
Is Tank Equipped with a Control Device?	No control device
Tank Contents	
Input type	Enter Annual Values
Chemical Category of Liquid	AP-42 Petroleum Liquids (Table 7.1-2)
Sum of Increases in Liquid Level Method	AP-42 calculation



Configuration Parameter	Configuration Setting
Working Loss Turnover Factor Method	AP-42 calculation
Chemical Name	Vacuum Residual Oil

The mass emission rates of vacuum residual oil estimated by the US EPA Tanks software for tanks TK-01 to TK-16 are provided in Table 2-5.

Table 2-5 Vacuum residual oil mass emission rates for bulk storage tanks TK-01 to TK-16 under the existing consent scenario

Tank	Emission Rate, kg/yr	Emission Rate, g/s
TK-01	2.115	6.71E-05
TK-02 to TK-16	0.356	1.13E-05

3 CALPUFF Configuration

The CALPUFF model described in Section 7 of the AQIA (Air Environment, 2025), was adopted for the Existing Consent scenario, with the only changes being related to the emission sources and their emissions.

The CALPUFF configuration settings for the existing 250 kW boiler stack, the only point source, are provided in Table 3-1. The diesel storage tank and bulk storage tanks TK-01 to TK-16 were configured as shown in Table 3-2, Table 3-3, and Table 3-4.

Table 3-1 Point source configuration settings

Parameter	Existing 250 kW boiler
Source ID	BOIL250K
Stack height (m)	8.5
Stack Diameter (m)	0.2
Exit Velocity (m/s)	10
Exit Temperature (K)	493
Easting (mE, WGS-84)	306,450
Northing (mN, WGS-84)	6,186,098
Base elevation (m)	6.59



Table 3-2 Volume source configuration parameters: Diesel storage tank & TK-01 to TK-05

Parameter	Diesel storage tank	TK-01	TK-02	TK-03	TK-04	TK-05
Source ID	DIESELEX	TK-01	TK-02	TK-03	TK-04	TK-05
Effective height (m)	3.63	9.0	9.0	9.0	9.0	9.0
Sigma Y ₀ (m)	0.8	2.33	2.33	2.33	2.33	2.33
Sigma Z ₀ (m)	8.37	8.37	8.37	8.37	8.37	8.37
Easting (mE, WGS-84)	306,426	306,437	306,439	306,424	306,425	306,410
Northing (mN, WGS-84)	6,186,120	6,186,096	6,186,109	6,186,098	6,186,111	6,186,099
Base elevation (m)	6.05	6.65	6.44	6.54	6.21	6.43

Table 3-3 Volume source configuration parameters: TK-06 to TK-11

Parameter	TK-06	TK-07	TK-08	TK-09	TK-10	TK-11
Source ID	TK-06	TK-07	TK-08	TK-09	TK-10	TK-11
Effective height (m)	3.63	9.0	9.0	9.0	9.0	9.0
Sigma Y ₀ (m)	0.8	2.33	2.33	2.33	2.33	2.33
Sigma Z ₀ (m)	8.37	8.37	8.37	8.37	8.37	8.37
Easting (mE, WGS-84)	306,412	306,414	306,397	306,399	306,400	306,384
Northing (mN, WGS-84)	6,186,112	6,186,126	6,186,101	6,186,114	6,186,127	6,186,102
Base elevation (m)	6.18	6.02	6.54	6.28	6.16	6.71

Table 3-4 Volume source configuration parameters: TK-12 to TK-16

Parameter	TK-12	TK-13	TK-14	TK-15	TK-16
Source ID	TK-12	TK-13	TK-14	TK-15	TK-16
Effective height (m)	3.63	9.0	9.0	9.0	9.0
Sigma Y ₀ (m)	0.8	2.33	2.33	2.33	2.33
Sigma Z ₀ (m)	8.37	8.37	8.37	8.37	8.37
Easting (mE, WGS-84)	306,385	306,387	306,370	306,372	306,373
Northing (mN, WGS-84)	6,186,115	6,186,128	6,186,103	6,186,117	6,186,130
Base elevation (m)	6.57	6.46	7.04	7.02	6.96



Figure 3-1 **Modelled emission sources**

Figure Notes: The 250 kW boiler stack location is indicated with a green circle. The 60 kL diesel storage tank location is shown with an orange triangle. The existing bulk storage tank locations (TK-01 to TK-10) are shown as red squares. The consented, but not yet built, bulk storage tank (TK-11 to TK-16) locations are shown as blue squares. The GrainCorp site boundary is outlined in yellow.

4 Air Quality Impact Assessment

4.1 250 kW boiler to 3.8 MW heating plant

4.1.1 Nitrogen dioxide

A comparison of the maximum 1-hour incremental NO_2 predictions for the existing 250 kW boiler and the proposed 3.8 MW heating plant is provided in Figure 4-1. Model predictions at the identified sensitive receptor locations are plotted in Figure 4-2. The plots show an increase in ambient ground level NO_2 concentrations with the greatest increases occurring within either the northern or southern GrainCorp boundaries. The most exposed sensitive receptor (R3) shows an increase from $6 \mu\text{g}/\text{m}^3$ to $37 \mu\text{g}/\text{m}^3$ with the move from the existing 250 kW boiler to the proposed 3.8 MW heating plant. The difference between the two scenarios ($31 \mu\text{g}/\text{m}^3$) is small, representing only 19% of the $164 \mu\text{g}/\text{m}^3$ impact assessment criterion.

Further investigation of the predicted NO_2 percentile levels at R3 (Figure 4-3) revealed that 1-hour average NO_2 concentrations for both scenarios are zero up until the 70th percentile is reached, indicating the relative rarity of boiler impacts at this receptor location.

The annual average predictions are compared in Figure 4-4 and Figure 4-5, once again showing that any increase in predicted ground level concentrations associated with the proposed heating plant is small compared to the $31 \mu\text{g}/\text{m}^3$ impact assessment criterion.

A summary of the comparative hourly and annual average NO_2 predictions at sensitive receptor locations is provided in Table 4-1.

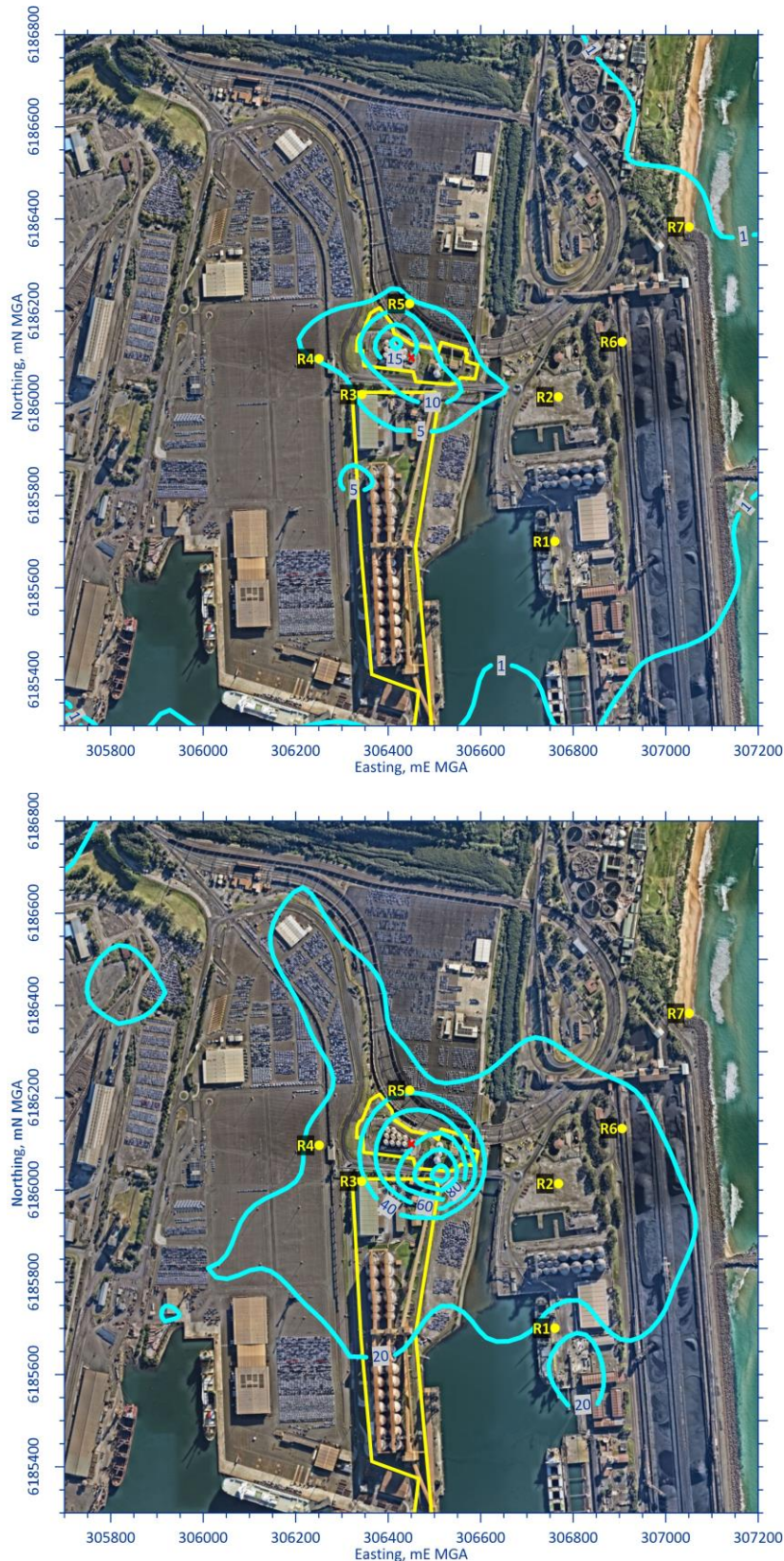


Figure 4-1 Comparison of maximum 1-hour incremental NO₂ concentrations arising from the existing 250 kW boiler (top) and the proposed 3.8 MW heating plant (bottom).

Figure Notes: The boiler stack locations are indicated with a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots. The 1-hour NO₂ impact assessment criterion is 164 µg/m³.

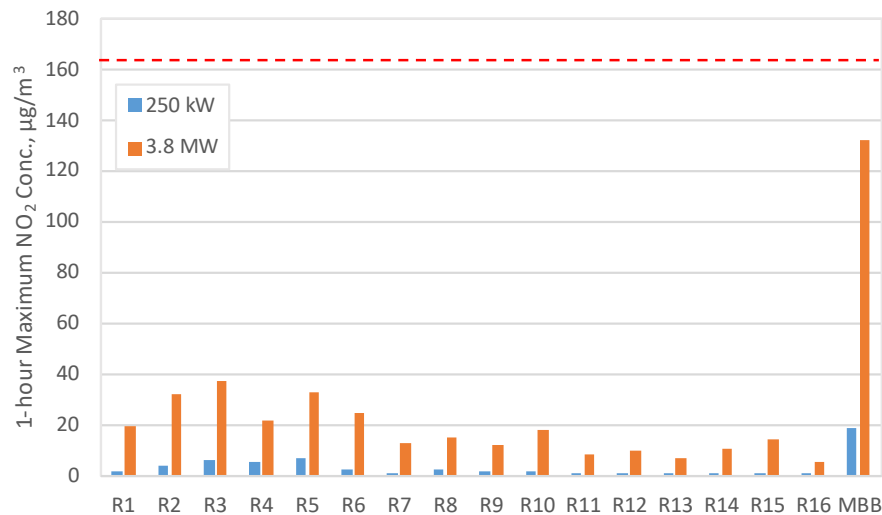


Figure 4-2 Comparison of maximum 1-hour incremental NO₂ concentrations at sensitive receptor locations arising from the existing 250 kW boiler and the proposed 3.8 MW heating plant

Figure Note: The 1-hour NO₂ impact assessment criterion is 164 µg/m³.
MBB = Maximum model prediction at and beyond the GrainCorp northern site boundary.

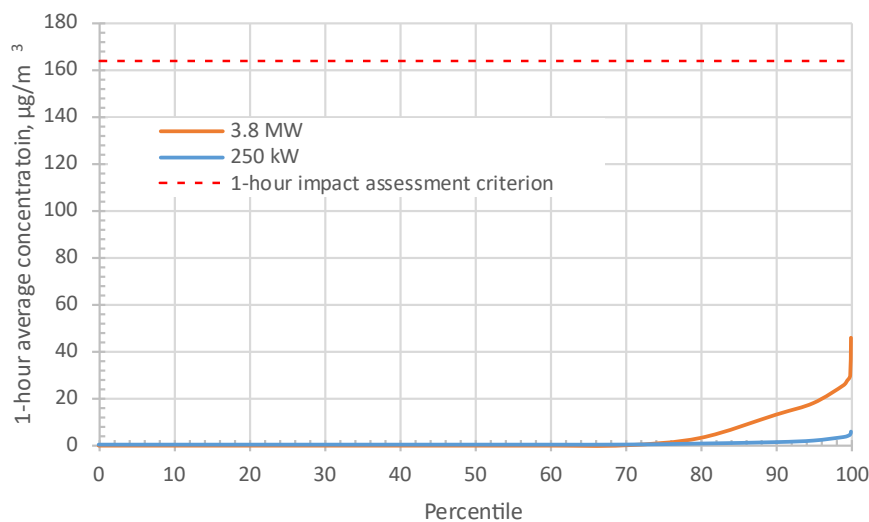


Figure 4-3 Comparison of the 1-hour incremental NO₂ concentration distributions at the most exposed sensitive receptor location (R3)

Figure Note: The 1-hour NO₂ impact assessment criterion is 164 µg/m³.

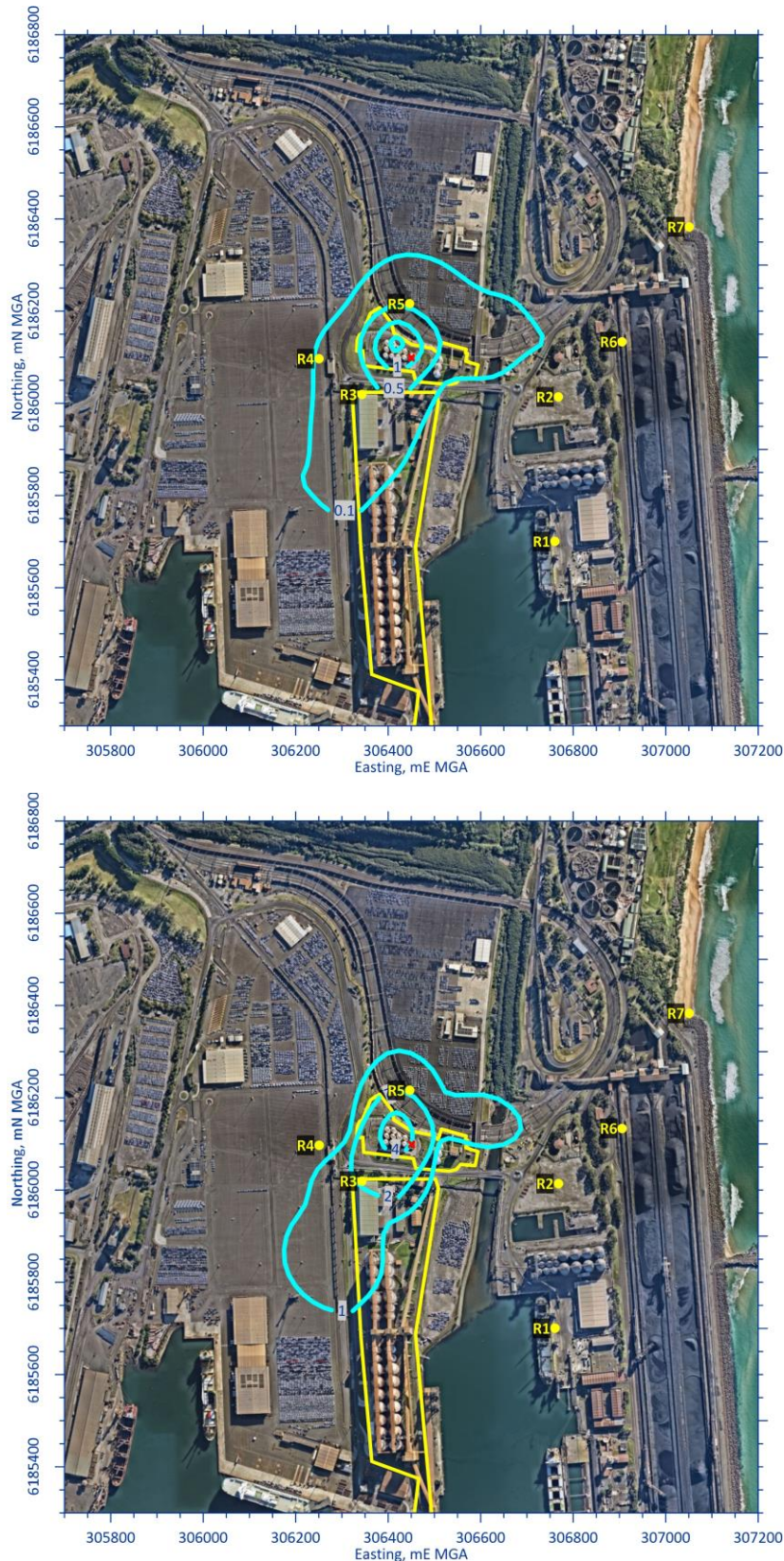


Figure 4-4 Comparison of annual average incremental NO₂ concentrations arising from the existing 250 kW boiler (top) and the proposed 3.8 MW heating plant (bottom).

Figure Notes: The boiler stack locations are indicated with a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots. The annual average NO₂ impact assessment criterion is 31 µg/m³.

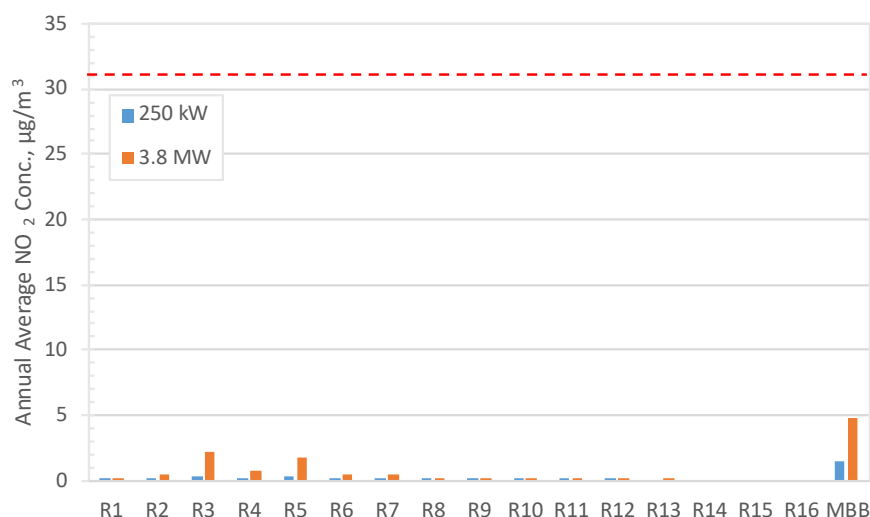


Figure 4-5 Comparison of annual average incremental NO₂ concentrations at sensitive receptor locations arising from the existing 250 kW boiler and the proposed 3.8 MW heating plant.

Figure Note: The annual average NO₂ impact assessment criterion is 31 µg/m³.

Table 4-1 Comparison of incremental NO₂ concentrations at sensitive receptor locations arising from the existing 250 kW boiler and the proposed 3.8 MW heating plant

Sensitive Receptor	1-hour maximum, µg/m ³		Annual average, µg/m ³	
	250 kW Boiler	3.8 MW Plant	250 kW Boiler	3.8 MW Plant
IAC ¹	164 µg/m ³		31 µg/m ³	
R1	1.8	19.7	0.01	0.10
R2	3.5	31.7	0.04	0.40
R3	5.9	37.3	0.31	2.20
R4	5.2	21.3	0.11	0.80
R5	6.8	32.9	0.36	1.80
R6	2.6	24.8	0.05	0.50
R7	1.1	12.8	0.03	0.40
R8	2.1	15.2	0.01	0.20
R9	1.8	12.0	0.01	0.10
R10	1.6	18.2	0.01	0.10
R11	0.8	8.2	0.01	0.10
R12	0.8	9.8	0.01	0.10
R13	0.8	7.0	0.00	0.10
R14	0.7	10.6	0.00	0.00
R15	0.8	13.9	0.00	0.00
R16	0.4	5.0	0.00	0.00
MBB ²	18.6	132.4	1.41	4.80

Table Notes: ¹IAC = Impact Assessment Criterion.

²MBB = Maximum model prediction at and beyond the GrainCorp northern site boundary.



4.1.2 Sulfur dioxide

A comparison of the maximum 1-hour incremental SO₂ predictions for the existing 250 kW boiler and the proposed 3.8 MW heating plant is provided in Figure 4-6. The plots show a decrease in ambient ground level SO₂ concentrations caused by the larger SO₂ emission factor provided by ECS, the manufacturer of the existing 250 kW boiler. The most exposed sensitive receptor (R3) shows a decrease from 11.4 µg/m³ to 0.4 µg/m³ with the move from the existing 250 kW boiler to the 3.8 MW heating plant. The difference between the two scenarios (a reduction of 11 µg/m³) is small, representing only 5% of the 214 µg/m³ impact assessment criterion.

A comparison of 24-hour average predictions is presented in Figure 4-7, once again showing a small decrease in predicted ground level concentrations associated with the proposed heating plant in comparison to the 57 µg/m³ impact assessment criterion. Predicted hourly and daily average SO₂ impacts at sensitive receptor locations are summarised in Table 4-2.

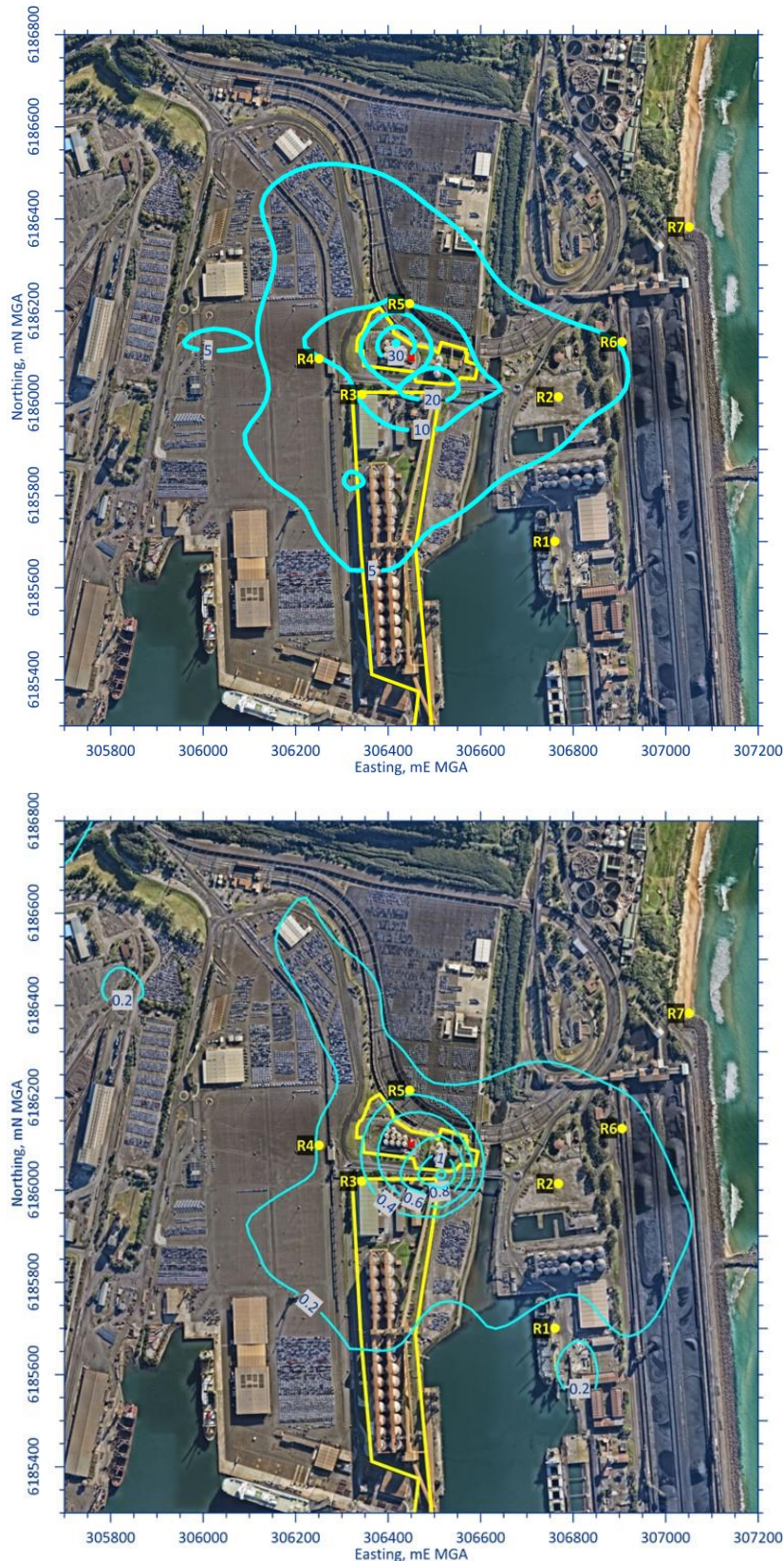


Figure 4-6 Comparison of maximum 1-hour incremental SO₂ concentrations arising from the existing 250 kW boiler (top) and the proposed 3.8 MW heating plant (bottom).

Figure Notes: The boiler stack locations are indicated with a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots. The 1-hour SO₂ impact assessment criterion is 214 µg/m³.

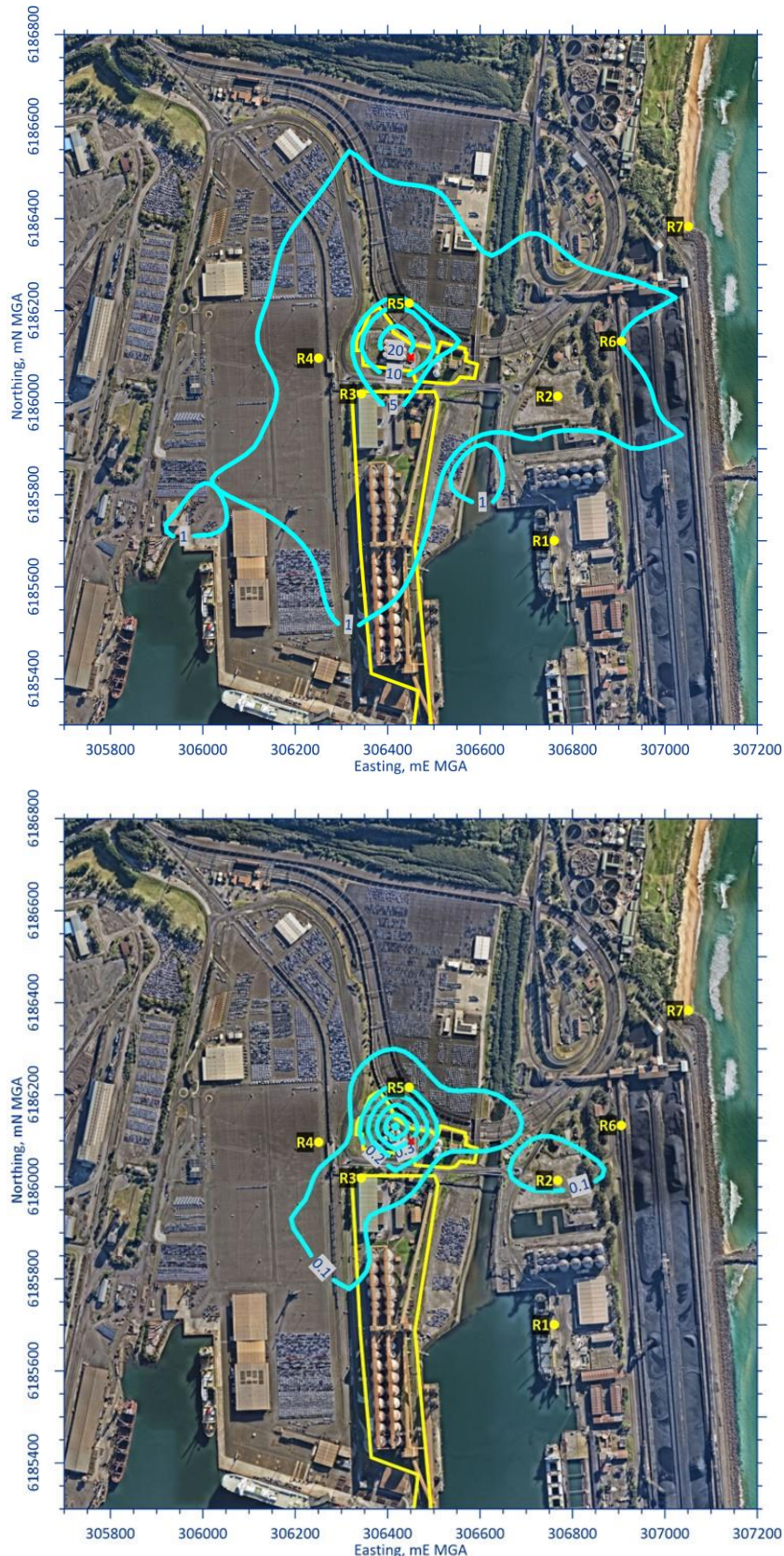


Figure 4-7 Comparison of 24-hour average incremental SO₂ concentrations arising from the existing 250 kW boiler (top) and the proposed 3.8 MW heating plant (bottom).

Figure Notes: The boiler stack locations are indicated with a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots. The 24-hour average SO₂ impact assessment criterion is 57 µg/m³.



Table 4-2 Comparison of incremental SO₂ concentrations at sensitive receptor locations arising from the existing 250 kW boiler and the proposed 3.8 MW heating plant

Sensitive Receptor	1-hour maximum, µg/m ³		24-hour maximum, µg/m ³	
	250 kW Boiler	3.8 MW Plant	250 kW Boiler	3.8 MW Plant
IAC ¹	214 µg/m ³		57 µg/m ³	
R1	3.4	0.2	0.6	0.0
R2	6.7	0.3	2.7	0.1
R3	11.4	0.4	4.2	0.2
R4	10.0	0.2	2.3	0.1
R5	13.0	0.3	6.7	0.2
R6	4.9	0.2	1.0	0.1
R7	2.2	0.1	0.5	0.0
R8	4.0	0.1	0.6	0.0
R9	3.4	0.1	0.5	0.0
R10	3.1	0.2	0.3	0.0
R11	1.6	0.1	0.2	0.0
R12	1.5	0.1	0.2	0.0
R13	1.5	0.1	0.2	0.0
R14	1.3	0.1	0.1	0.0
R15	1.4	0.1	0.2	0.0
R16	0.7	0.0	0.1	0.0
MBB ²	35.6	1.3	24.3	0.5

Table Notes: ¹IAC = Impact Assessment Criterion.

²MBB = Maximum model prediction at and beyond the GrainCorp northern site boundary.

4.1.3 Particles as PM_{2.5}

A comparison of the maximum 24-hour incremental PM_{2.5} predictions for the existing 250 kW boiler and the proposed 3.8 MW heating plant is provided in Figure 4-8. The plots show an increase in ambient ground level PM_{2.5} concentrations, however the magnitude is small. The most exposed sensitive receptor (R3) shows an increase from 0.04 µg/m³ to 0.25 µg/m³ with the move from the existing 250 kW boiler to the 3.8 MW heating plant. The difference between the two scenarios (an increase of 0.21 µg/m³) is small, representing only 1% of the 20 µg/m³ impact assessment criterion.

A comparison of the annual average predictions is presented in Figure 4-9, once again showing a very small increase in predicted ground level concentrations associated with the proposed heating plant in comparison to the 7 µg/m³ impact assessment criterion. Predicted hourly and daily average PM_{2.5} impacts at sensitive receptor locations are summarised in Table 4-3.

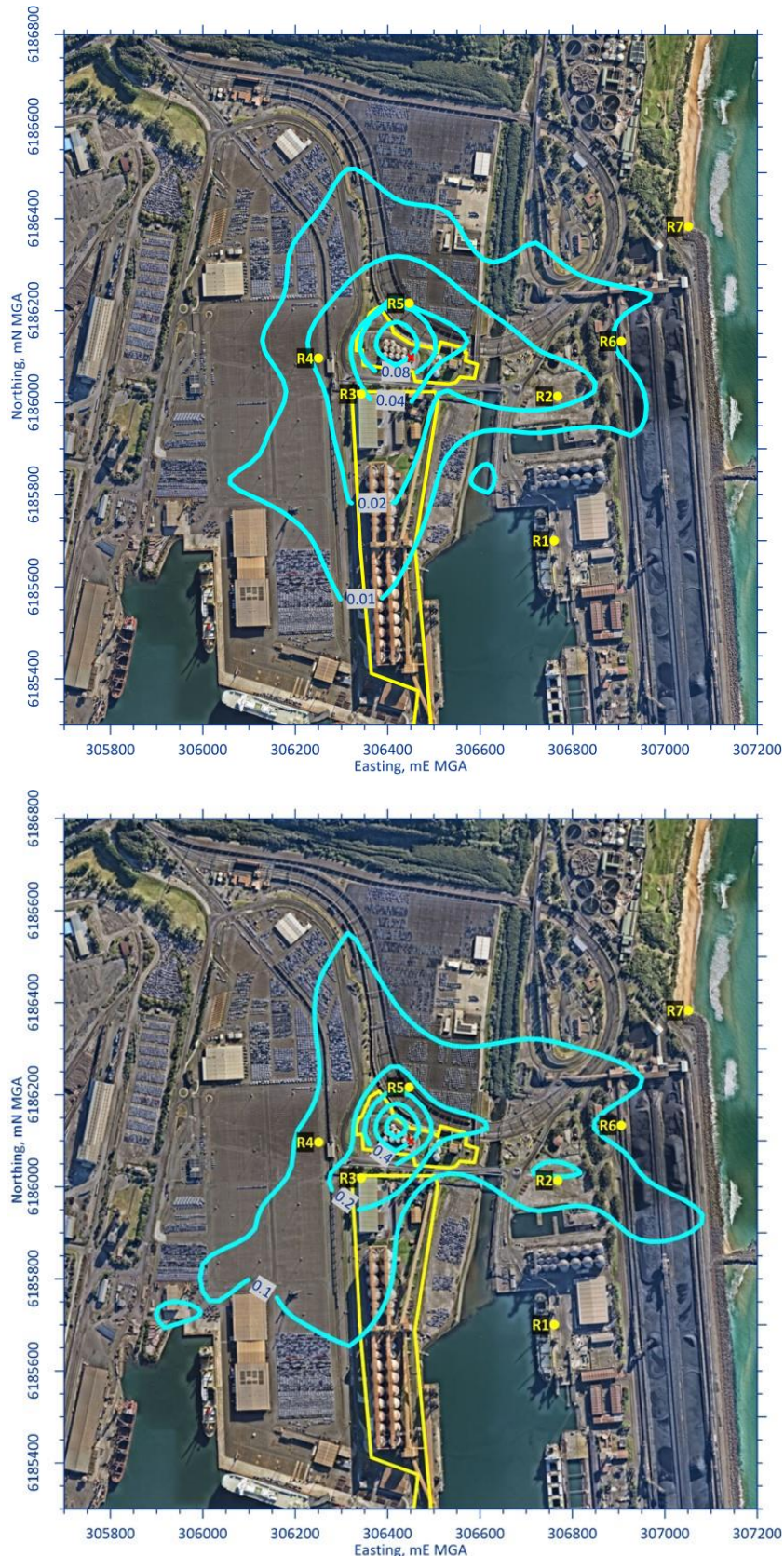


Figure 4-8 Comparison of maximum 24-hour incremental $PM_{2.5}$ concentrations arising from the existing 250 kW boiler (top) and the proposed 3.8 MW heating plant (bottom).

Figure Notes: The boiler stack locations are indicated with a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots. The 24-hour $PM_{2.5}$ impact assessment criterion is $20 \mu g/m^3$.

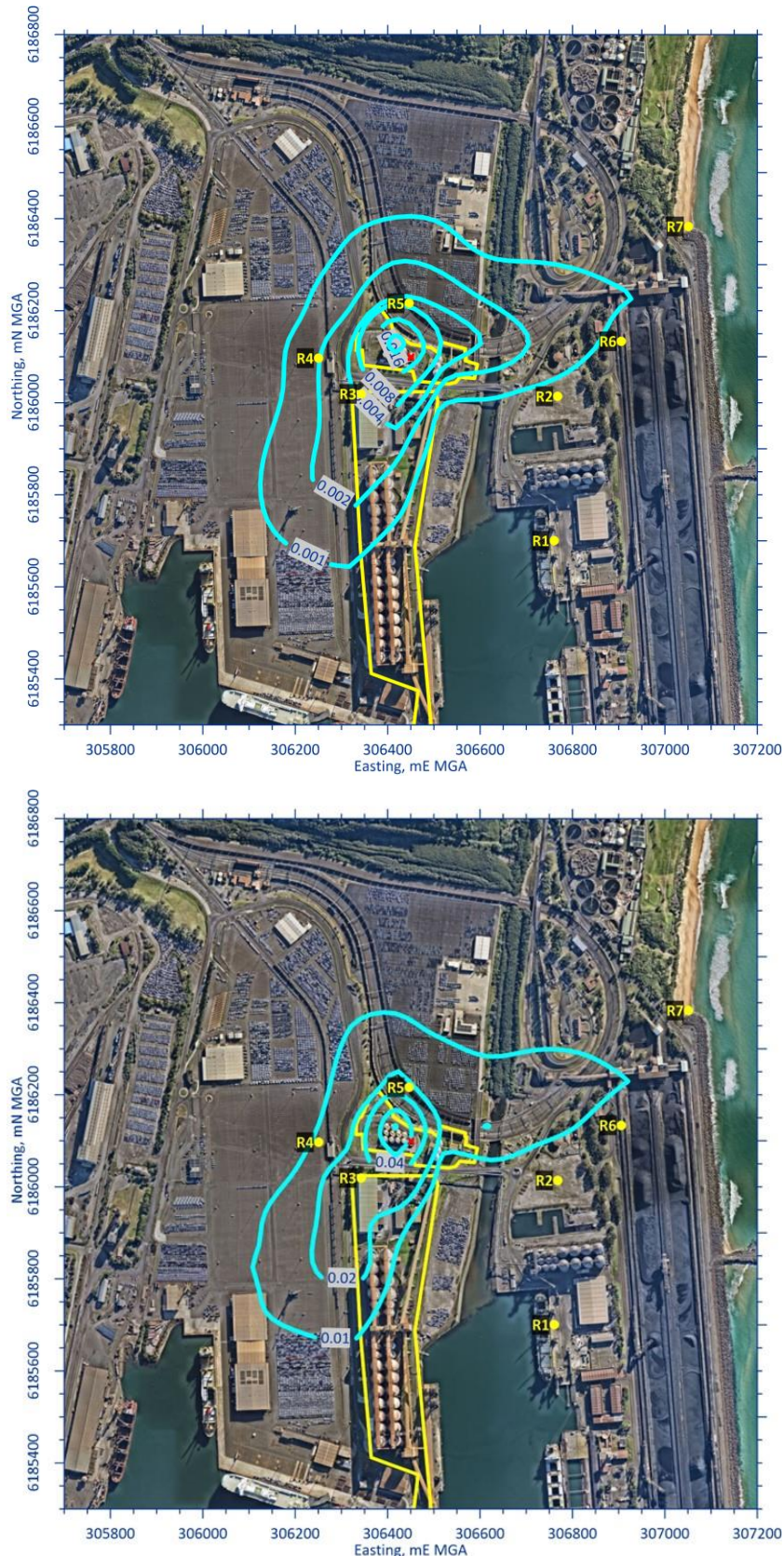


Figure 4-9 Comparison of annual average incremental $PM_{2.5}$ concentrations arising from the existing 250 kW boiler (top) and the proposed 3.8 MW heating plant (bottom)

Figure Notes: The boiler stack locations are indicated with a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots. The annual average $PM_{2.5}$ impact assessment criterion is $7 \mu g/m^3$.



Table 4-3 Comparison of incremental PM_{2.5} concentrations at sensitive receptor locations arising from the existing 250 kW boiler and the proposed 3.8 MW heating plant

Sensitive Receptor	24-hour maximum, µg/m ³		Annual average, µg/m ³	
	250 kW Boiler	3.8 MW Plant	250 kW Boiler	3.8 MW Plant
IAC ¹	20 µg/m ³		7 µg/m ³	
R1	0.01	0.05	0.00	0.00
R2	0.02	0.18	0.00	0.01
R3	0.04	0.25	0.01	0.03
R4	0.02	0.13	0.00	0.01
R5	0.06	0.29	0.01	0.03
R6	0.01	0.08	0.00	0.01
R7	0.00	0.05	0.00	0.01
R8	0.01	0.04	0.00	0.00
R9	0.00	0.03	0.00	0.00
R10	0.00	0.03	0.00	0.00
R11	0.00	0.02	0.00	0.00
R12	0.00	0.01	0.00	0.00
R13	0.00	0.01	0.00	0.00
R14	0.00	0.01	0.00	0.00
R15	0.00	0.02	0.00	0.00
R16	0.00	0.01	0.00	0.00
MBB ²	0.22	0.83	0.02	0.07

Table Notes: ¹IAC = Impact Assessment Criterion.

²MBB = Maximum model prediction at and beyond the GrainCorp northern site boundary.

4.1.4 Particles as PM₁₀

A comparison of the maximum 24-hour incremental PM₁₀ predictions for the existing 250 kW boiler and the proposed 3.8 MW heating plant is provided in Figure 4-10. The plots show a small increase in ambient ground level PM₁₀ concentrations. The most exposed sensitive receptor (R3) shows an increase from 0.17 µg/m³ to 0.39 µg/m³ with the move from the existing 250 kW boiler to the 3.8 MW heating plant. The difference between the two scenarios (an increase of 0.22 µg/m³) is small, representing only 0.4 % of the 50 µg/m³ impact assessment criterion.

A comparison of the annual average predictions is presented in Figure 4-11, once again showing a very small increase in predicted ground level concentrations associated with the proposed heating plant in comparison to the 25 µg/m³ impact assessment criterion. Predicted hourly and daily average PM₁₀ impacts at sensitive receptor locations are summarised in Table 4-4.

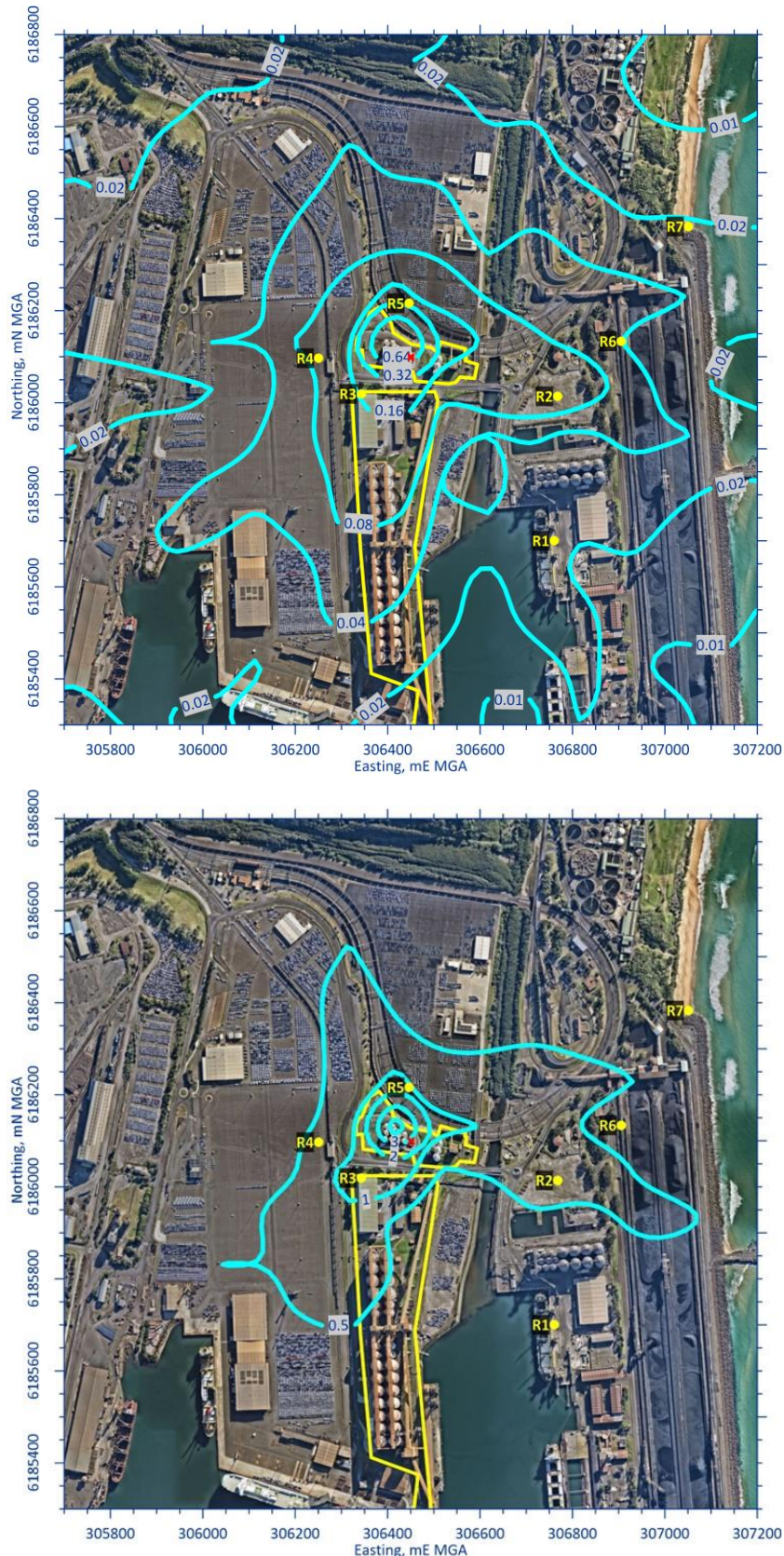


Figure 4-10 Comparison of maximum 24-hour incremental PM₁₀ concentrations arising from the existing 250 kW boiler (top) and the proposed 3.8 MW heating plant (bottom).

Figure Notes: The boiler stack locations are indicated with a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots. The 24-hour PM₁₀ impact assessment criterion is 50 µg/m³.

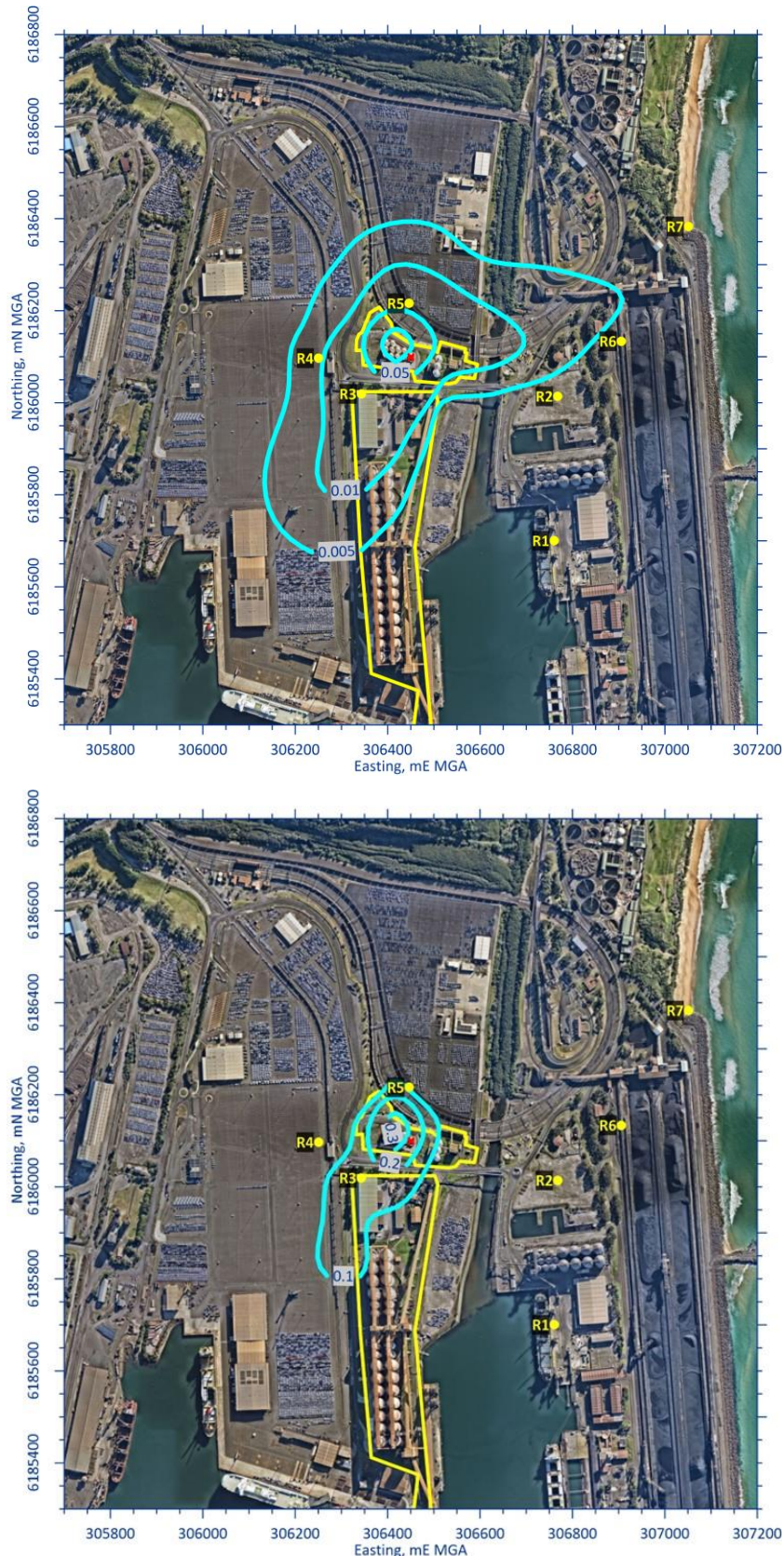


Figure 4-11 Comparison of annual average incremental PM_{10} concentrations arising from the existing 250 kW boiler (top) and the proposed 3.8 MW heating plant (bottom).

Figure Notes: The boiler stack locations are indicated with a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots. The annual average PM_{10} impact assessment criterion is $25 \mu g/m^3$.



Table 4-4 Comparison of incremental PM₁₀ concentrations at sensitive receptor locations arising from the existing 250 kW boiler and the proposed 3.8 MW heating plant

Sensitive Receptor	24-hour maximum, µg/m ³		Annual average, µg/m ³	
	250 kW Boiler	3.8 MW Plant	250 kW Boiler	3.8 MW Plant
IAC ¹	50 µg/m ³		25 µg/m ³	
R1	0.02	0.60	0.00	0.01
R2	0.11	1.35	0.00	0.03
R3	0.17	0.39	0.02	0.15
R4	0.10	0.24	0.01	0.06
R5	0.28	0.20	0.03	0.12
R6	0.04	0.16	0.00	0.04
R7	0.02	0.15	0.00	0.02
R8	0.02	0.11	0.00	0.01
R9	0.02	0.07	0.00	0.00
R10	0.01	0.05	0.00	0.01
R11	0.01	0.04	0.00	0.01
R12	0.01	0.10	0.00	0.00
R13	0.01	0.04	0.00	0.00
R14	0.00	3.89	0.00	0.00
R15	0.01	0.60	0.00	0.00
R16	0.00	1.35	0.00	0.00
MBB ²	1.01	0.39	0.11	0.33

Table Notes: ¹IAC = Impact Assessment Criterion.

²MBB = Maximum model prediction at and beyond the GrainCorp northern site boundary.

4.1.5 Beryllium

A comparison of the maximum 1-hour incremental beryllium predictions for the existing 250 kW boiler and the proposed 3.8 MW heating plant is provided in Figure 4-12. The plots show a small increase in ambient ground level beryllium concentrations. The most exposed sensitive receptor (R3) shows an increase from 0.0002 µg/m³ to 0.0011 µg/m³ with the move from the existing 250 kW boiler to the 3.8 MW heating plant. The difference between the two scenarios (an increase of 0.0009 µg/m³) is small, representing 22.5% of the 0.004 µg/m³ impact assessment criterion. Predicted hourly impacts at sensitive receptor locations are summarised in Table 4-5.

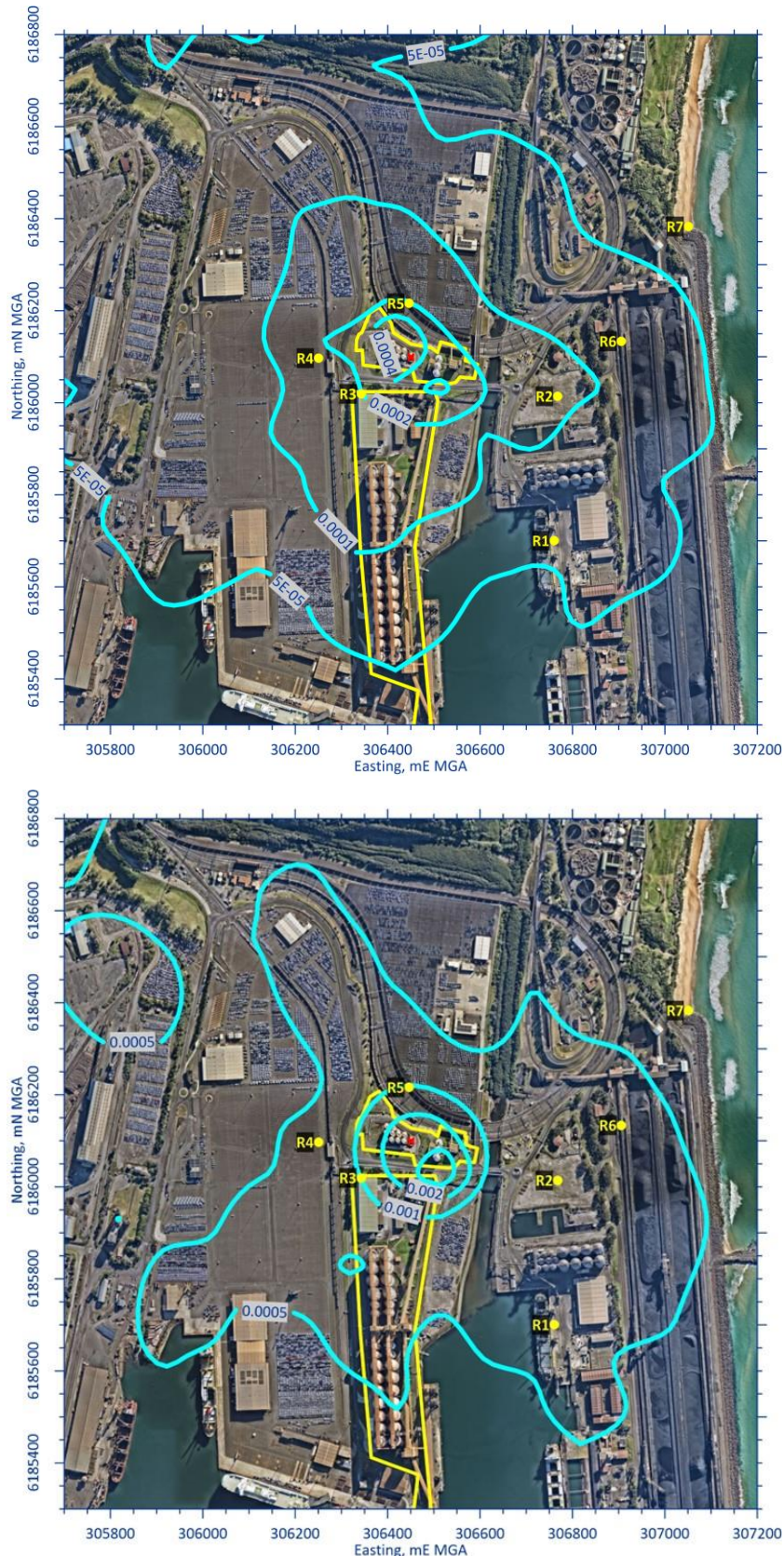


Figure 4-12 Comparison of max 1-hour incremental beryllium concentrations arising from the existing 250 kW boiler (top) and the proposed 3.8 MW heating plant (bottom).

Figure Notes: The boiler stack locations are indicated with a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots. The 1-hour beryllium impact assessment criterion is 0.004 $\mu\text{g}/\text{m}^3$.



Table 4-5 Comparison of incremental beryllium concentrations at sensitive receptor locations arising from the existing 250 kW boiler and the proposed 3.8 MW heating plant

Sensitive Receptor	1-hour maximum, $\mu\text{g}/\text{m}^3$	
	250 kW Boiler	3.8 MW Plant
IAC ¹	0.004 $\mu\text{g}/\text{m}^3$	
R1	0.0001	0.0006
R2	0.0001	0.0009
R3	0.0002	0.0011
R4	0.0002	0.0006
R5	0.0002	0.0009
R6	0.0001	0.0007
R7	0.0000	0.0004
R8	0.0001	0.0004
R9	0.0001	0.0003
R10	0.0001	0.0005
R11	0.0000	0.0002
R12	0.0000	0.0003
R13	0.0000	0.0002
R14	0.0000	0.0003
R15	0.0000	0.0004
R16	0.0000	0.0001
MBB ²	0.0006	0.0038

Table Notes: ¹IAC = Impact Assessment Criterion.

²MBB = Maximum model prediction at and beyond the GrainCorp northern site boundary.

4.1.6 Cadmium

A comparison of the maximum 1-hour incremental cadmium predictions for the existing 250 kW boiler and the proposed 3.8 MW heating plant is provided in Figure 4-13. The plots show a small increase in ambient ground level cadmium concentrations. The most exposed sensitive receptor (R3) shows an increase from 0.0002 $\mu\text{g}/\text{m}^3$ to 0.0011 $\mu\text{g}/\text{m}^3$ with the move from the existing 250 kW boiler to the 3.8 MW heating plant. The difference between the two scenarios (an increase of 0.0009 $\mu\text{g}/\text{m}^3$) is small, representing 5% of the 0.018 $\mu\text{g}/\text{m}^3$ impact assessment criterion. Predicted hourly impacts at sensitive receptor locations are summarised in Table 4-6.

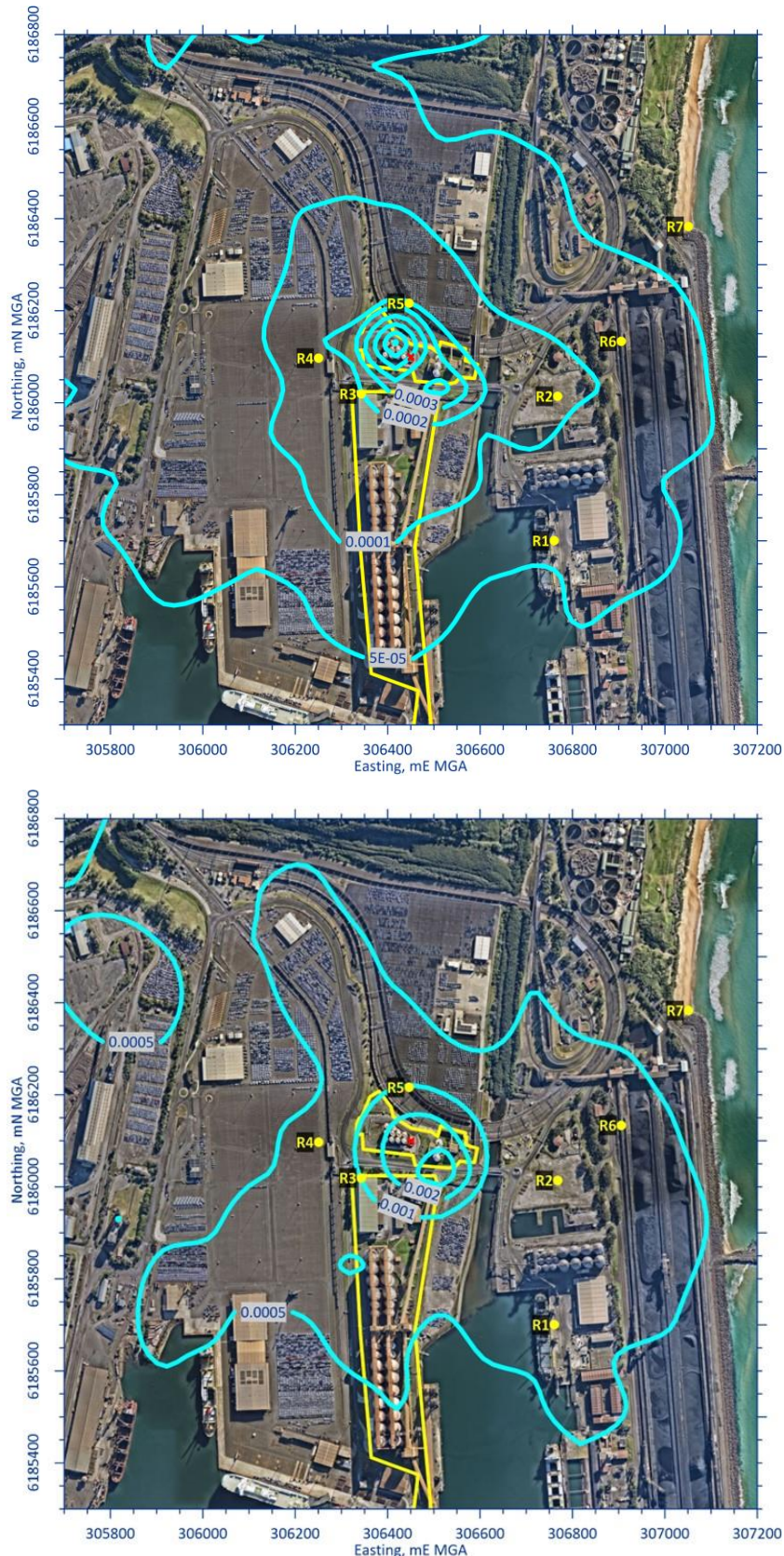


Figure 4-13 Comparison of max 1-hour incremental cadmium concentrations arising from the existing 250 kW boiler (top) and the proposed 3.8 MW heating plant (bottom).

Figure Notes: The boiler stack locations are indicated with a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots. The 1-hour cadmium impact assessment criterion is $0.018 \mu\text{g}/\text{m}^3$.



Table 4-6 Comparison of incremental cadmium concentrations at sensitive receptor locations arising from the existing 250 kW boiler and the proposed 3.8 MW heating plant

Sensitive Receptor	1-hour maximum, $\mu\text{g}/\text{m}^3$	
	250 kW Boiler	3.8 MW Plant
IAC ¹	0.018 $\mu\text{g}/\text{m}^3$	
R1	0.0001	0.0006
R2	0.0001	0.0009
R3	0.0002	0.0011
R4	0.0002	0.0006
R5	0.0002	0.0009
R6	0.0001	0.0007
R7	0.0000	0.0004
R8	0.0001	0.0004
R9	0.0001	0.0003
R10	0.0001	0.0005
R11	0.0000	0.0002
R12	0.0000	0.0003
R13	0.0000	0.0002
R14	0.0000	0.0003
R15	0.0000	0.0004
R16	0.0000	0.0001
MBB ²	0.0006	0.0038

Table Notes: ¹IAC = Impact Assessment Criterion.

²MBB = Maximum model prediction at and beyond the GrainCorp northern site boundary.

4.2 Diesel storage tank (cumene)

The Upgrade Scenario modelling for the proposed repurposed 60 kL diesel storage tank found that all assessed pollutants were well below their respective impact assessment criteria. Cumene was found to have the greatest impacts with respect to its impact assessment criterion.

A comparison of the maximum 1-hour incremental cumene predictions for the existing 250 kW boiler and the proposed 3.8 MW heating plant is provided in Figure 4-14. The plots show a very small increase in ambient ground level cumene concentrations. The most exposed sensitive receptor (R3) shows an increase from 0.008 $\mu\text{g}/\text{m}^3$ to 0.092 $\mu\text{g}/\text{m}^3$ with the move from the existing 250 kW boiler to the 3.8 MW heating plant. The difference between the two scenarios (an increase of 0.084 $\mu\text{g}/\text{m}^3$) is very small, representing 0.4% of the 21 $\mu\text{g}/\text{m}^3$ impact assessment criterion. Predicted hourly impacts at sensitive receptor locations are summarised in Table 4-7.

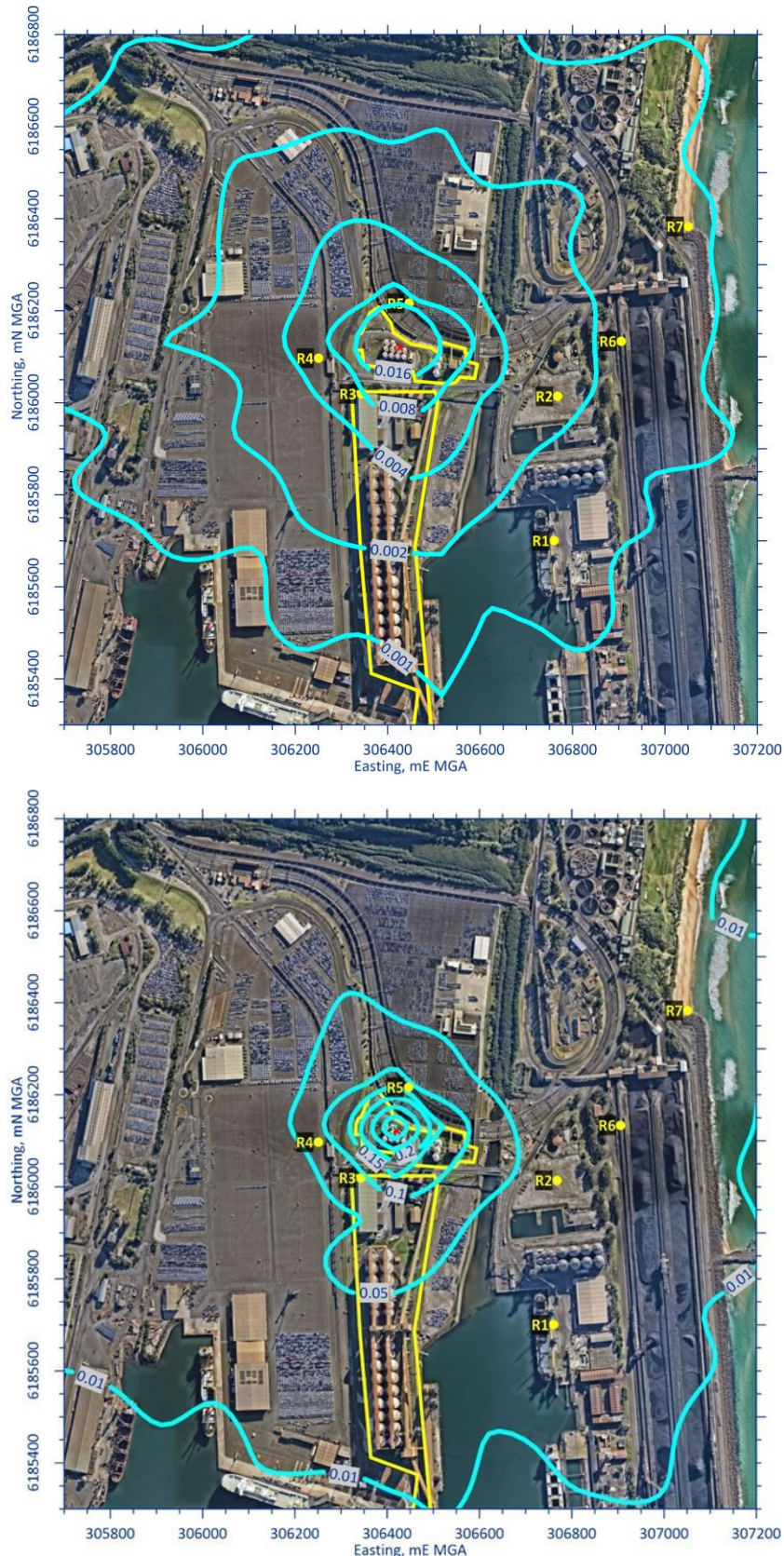


Figure 4-14 Comparison of maximum 1-hour incremental cumene concentrations arising from the existing (top) and proposed (bottom) diesel storage tanks.

Figure Notes: The diesel storage tank locations are indicated with a red X. The two GrainCorp site boundaries are outlined in yellow. The closest sensitive receptor locations are shown as yellow dots. The 1-hour cumene impact assessment criterion is $21 \mu\text{g}/\text{m}^3$.



Table 4-7 Comparison of incremental cumene concentrations at sensitive receptor locations arising from the existing and proposed diesel storage tanks

Sensitive Receptor	1-hour maximum, $\mu\text{g}/\text{m}^3$	
	Existing diesel storage tank	Proposed diesel storage tank
IAC ¹	21 $\mu\text{g}/\text{m}^3$	
R1	0.001	0.017
R2	0.003	0.035
R3	0.008	0.092
R4	0.006	0.076
R5	0.013	0.128
R6	0.002	0.025
R7	0.001	0.015
R8	0.001	0.017
R9	0.001	0.008
R10	0.001	0.008
R11	0.001	0.009
R12	0.000	0.006
R13	0.000	0.006
R14	0.000	0.004
R15	0.000	0.004
R16	0.000	0.002
MBB ²	0.044	0.307

Table Notes: ¹IAC = Impact Assessment Criterion.

²MBB = Maximum model prediction at and beyond the GrainCorp northern site boundary.

4.3 Bulk storage tanks

Emissions from the bulk storage tanks were only assessed for the existing consent scenario, as the storage of UCO and tallow under the upgrade scenario was not considered to be a source of pollutant emissions. The model predictions for dispersion of petroleum products (vacuum residual oil) from the bulk storage tanks therefore represent an improvement in ambient pollutant concentrations.

Emissions arising from the storage of vacuum residual oil were assessed against the TWA (8-hour) National Occupational Health and Safety Commission (NOHSC) exposure standards for oil mist of $5 \text{ mg}/\text{m}^3$ ($5,000 \mu\text{g}/\text{m}^3$). A 24-hour exposure level was estimated from the TWA exposure standard using a standard approach¹ ($5,000 / 30 = 167 \mu\text{g}/\text{m}^3$).

The maximum 8-hour incremental predictions arising from standing and working losses from a single heated bulk storage tank (TK-01) and fifteen unheated storage tanks (TK-02 to TK-16), all containing various vacuum residual oil products, are shown in Figure 4-15. The most exposed sensitive receptor (R3) shows a maximum 8-hour average concentration of $0.144 \mu\text{g}/\text{m}^3$ representing 0.0029% of the $5,000 \mu\text{g}/\text{m}^3$ NOHSC exposure standard for oil mist. The equivalent R3 24-hour average prediction of

¹ When substance-specific ambient air quality criteria are unavailable, established practice applies a factor of 1/30 to occupational TWA standards to derive protective screening criteria for general population exposure. This methodology accounts for continuous exposure potential, sensitive population groups (children, elderly), and the difference between controlled workplace and involuntary ambient exposure scenarios.



0.068 $\mu\text{g}/\text{m}^3$ (see Figure 4-16) represents 0.04% of the estimated 167 $\mu\text{g}/\text{m}^3$ 24-hour exposure level. Predicted hourly impacts at sensitive receptor locations are summarised in Table 4-8.

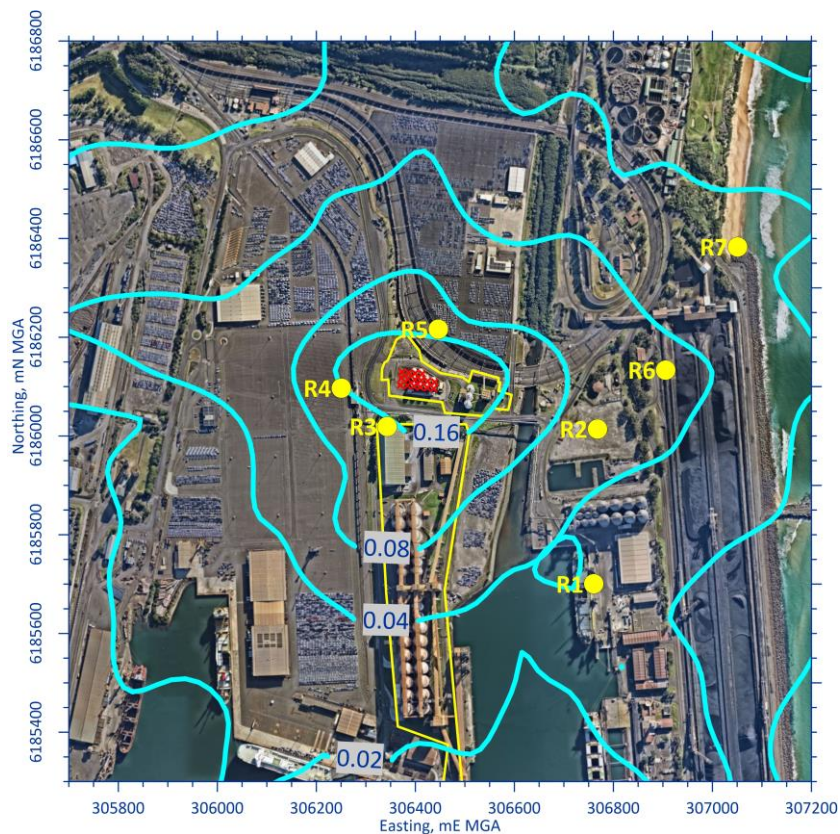


Figure 4-15 Maximum 8-hour incremental concentrations arising from standing and working losses from a heated bulk storage tank (TK-01) and fifteen unheated storage tanks, all containing various vacuum residual oil products

Figure Notes: The GrainCorp site boundary is shown in yellow. The sixteen bulk storage tank locations are shown as red X's. The TWA (8-hour) National Occupational Health and Safety Commission (NOHSC) exposure standards for oil mist is 5 mg/m^3 (5,000 $\mu\text{g}/\text{m}^3$).

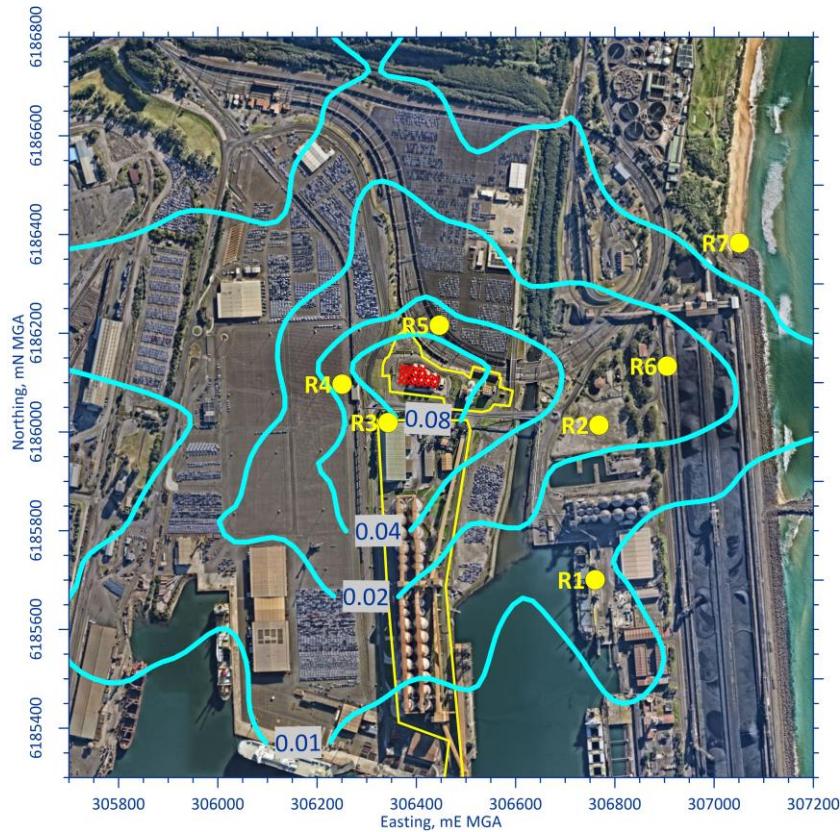


Figure 4-16 Maximum 24-hour incremental concentrations arising from standing and working losses from a heated bulk storage tank (TK-01) and fifteen unheated storage tanks, all containing various vacuum residual oil products

Figure Notes: The GrainCorp site boundary is shown in yellow. The sixteen bulk storage tank locations are shown as red X's. The TWA (8-hour) National Occupational Health and Safety Commission (NOHSC) exposure standards for oil mist is 5 mg/m^3 ($5,000 \text{ }\mu\text{g/m}^3$). The estimated 24-hour exposure level is $5,000 / 30 = 167 \text{ }\mu\text{g/m}^3$.



Table 4-8 Maximum 8-hour and 24-hour concentrations arising from standing and working losses from a heated bulk storage tank (TK-01) and fifteen unheated storage tanks, all containing various vacuum residual oil products

Sensitive Receptor	Maximum 8-hour average, $\mu\text{g}/\text{m}^3$	Maximum 24-hour average, $\mu\text{g}/\text{m}^3$
IAC ¹	5,000	167
R1	0.036	0.012
R2	0.060	0.029
R3	0.144	0.068
R4	0.153	0.057
R5	0.131	0.057
R6	0.050	0.028
R7	0.025	0.009
R8	0.025	0.009
R9	0.012	0.004
R10	0.008	0.003
R11	0.013	0.004
R12	0.007	0.002
R13	0.006	0.002
R14	0.003	0.001
R15	0.004	0.002
R16	0.002	0.001
MBB ²	0.292	0.126

Table Notes: ¹IAC = Impact Assessment Criterion.
²MBB = Maximum model prediction at and beyond the GrainCorp northern site boundary.

5 Conclusions

This comparative air quality impact assessment has evaluated the environmental impacts of GrainCorp's proposed plant upgrade against the existing consent scenario at the Port Kembla Bulk Liquid Terminal. The assessment demonstrates that the proposed alterations and additions satisfy the requirements of Clause 48 of the Environmental Planning and Assessment Regulation 2021.

The replacement of the existing 250 kW ECS boiler with a 3.8 MW Bosch heating plant results in varying changes to ground level pollutant concentrations with minor increases in most pollutants and decreases or the complete elimination of others. The assessment determined that:

- **Nitrogen dioxide** concentrations increase modestly at sensitive receptors (an increase in the maximum 1-hour average NO_2 concentration of $31 \mu\text{g}/\text{m}^3$ at the most exposed receptor R3, representing only 19% of the $164 \mu\text{g}/\text{m}^3$ criterion). An investigation of the predicted NO_2 percentile levels at receptor R3 shows that 1-hour average NO_2 concentrations for both scenarios are zero until the 70th percentile is reached, indicating the rarity of boiler impacts at this receptor location.
- **Sulfur dioxide** concentrations were determined to decrease significantly due to lower emission factors in the proposed equipment (a reduction of $11 \mu\text{g}/\text{m}^3$ at R3, representing 5% of the 1-hour $214 \mu\text{g}/\text{m}^3$ assessment criterion).



- **PM_{2.5} and PM₁₀** particle concentrations were predicted to increase a small amount, with the predicted maximum 24-hour concentration at the most exposed receptor (R3) rising by 0.21 µg/m³ and 0.22 µg/m³ respectively. These represent less than 1% of their respective impact assessment criteria.
- **Beryllium** and **cadmium** concentrations show small increases but remain well below impact assessment criteria, representing 22.5% and 5% of their respective criteria at the maximum impact location respectively.
- Diesel fuel storage impacts remain negligible under both the existing consent and upgrade scenarios, with **cumene** representing the pollutant of greatest concern at only 0.4% of its impact assessment criterion.

The transition from petroleum product storage to tallow and used cooking oil represents an environmental improvement, eliminating vacuum residual oil emissions entirely.

It is therefore concluded that the plant upgrade does not significantly increase the environmental impacts of the existing or approved development. This view is informed by the following:

- The existing consent scenario easily meets all impact assessment criteria in accordance with Clause 48(2)(a)(i).
- The proposed plant upgrade represents a change in operational character from petroleum product storage to food-grade material handling (tallow and UCO), coupled with upgraded heating infrastructure to support the modified operations (Clause 48(2)(b)(i)).
- The assessment demonstrates that the existing airshed can easily accommodate the proposed changes, with all predicted concentrations at sensitive receptor locations remaining well below their respective impact assessment criteria (Clause 48(2)(b)(ii)).
- The atmospheric dispersion modelling for both the existing consent and upgrade scenarios utilises the well-established CALPUFF atmospheric dispersion modelling suite with validated emission factors from manufacturer specifications and National Pollutant Inventory guidelines, providing high confidence in impact predictions (Clause 48(2)(b)(iii)).
- The Port Kembla industrial environment demonstrates adequate capacity to accommodate the proposed changes, with predicted ground-level concentrations showing minimal increases for most pollutants and decreases for sulfur dioxide and bulk storage tank emissions (Clause 48(2)(b)(iv)).
- The proposed development incorporates inherent mitigation through the elimination of petroleum product storage emissions and the utilisation of modern, efficient heating equipment with low emission rates meeting European standards for key pollutants. A boiler stack sizing study was prepared to inform the AQIA (Appendix G, Air Environment, 2025) and determine the most suitable boiler stack height to mitigate emissions (Clause 48(2)(c)).
- All modelling methods and emission estimation techniques comply with current EPA guidelines and impact assessment criteria, ensuring regulatory compliance in the assessment approach (Clause 48(2)(d)).



6 References

Air Environment, 2025. Report prepared by Air Environment Consulting Pty Limited for GrainCorp – *Air Quality Impact Assessment for the GrainCorp Bulk Liquid Terminal Port Kembla Upgrade*, 18 September 2025, Brisbane, Australia.

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