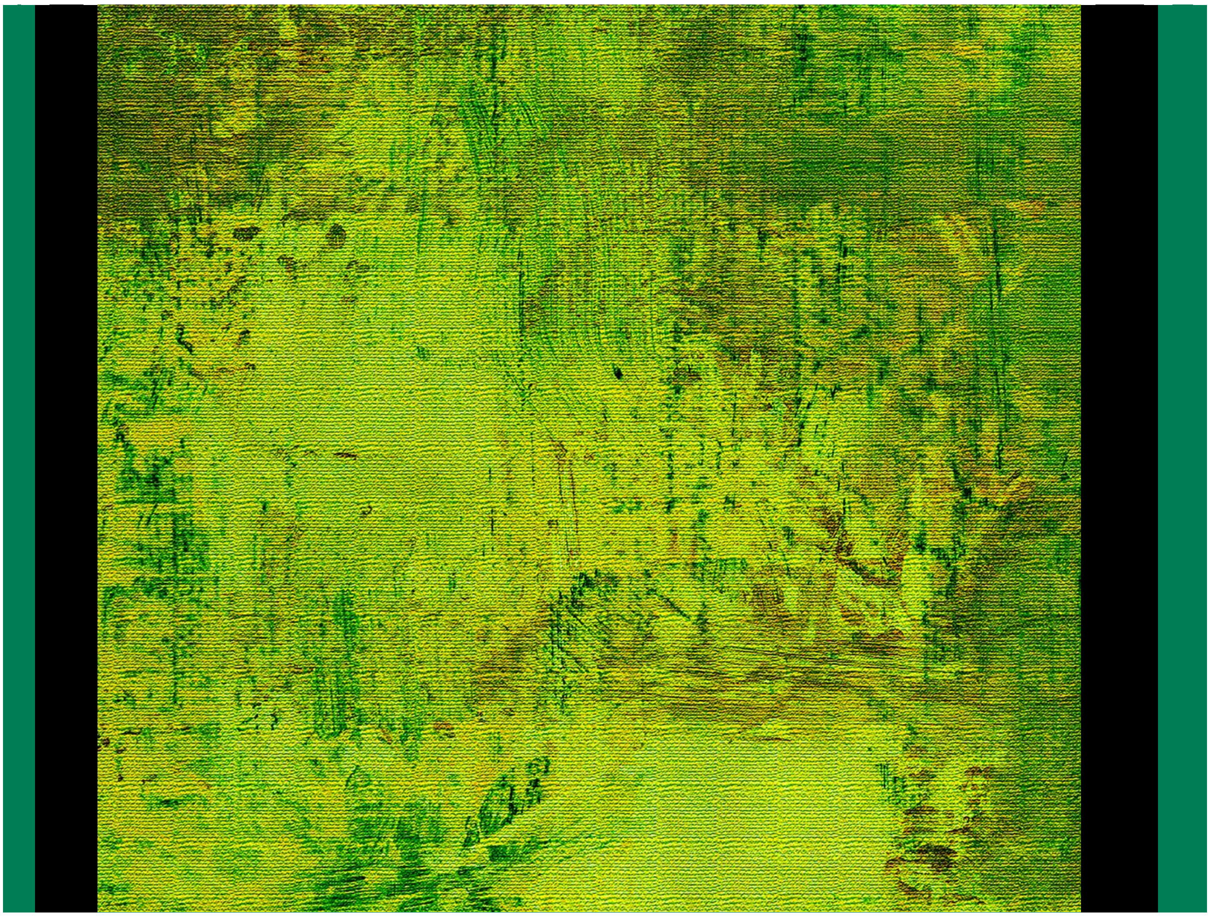
Lilydale Food Waste to Energy Facility Air Quality Impact Assessment Report

Yarra Valley Water

9 May 2023



Lilydale Food Waste to Energy Facility Air Quality Impact Assessment Report

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Executive summary

Yarra Valley Water (YVW) is proposing to construct a new Waste to Energy (WtE) facility within the Lilydale sewage treatment plant (STP) property boundary, approximately 36 km north-east of Melbourne CDB. The facility will be the second of its kind for YVW, the first being adjacent the Aurora STP plant at Wollert.

The proposed WtE facility will process waste in an anaerobic digester to produce biogas for the generation of electricity and process heat. The facility will consist of a waste receival building, liquid storage / mixing tank two digester vessels, an outlet digestate storage tank, and two 1.2 MW combined heat and power (CHP) units and a digestate treatment train. The CHP units will produce electricity and heat for the WtE facility and electrical power to the Lilydale STP and recycled water pumping station. Excess electrical energy will be exported to the grid.

The heat generated by the CHP units will be used to maintain the temperature within the anaerobic digesters. The waste receival shed is maintained under negative pressure with double layered doors to minimise emissions. Air from within the shed is drawn through a train of 8 trickling biofilters before discharge to atmosphere. There are no other venting systems from the shed.

Gas generated in the headspace of the digesters and tanks will be treated insitu to reduce hydrogen sulphides and discharged via a condenser to the CHPs. An emergency flare is also provided for use during maintenance or process upset events. The digestors are double lined domed structures, which include a clean layer of air in the interstitial space. This air is monitored (for methane, sulphides etc), to allow rapid identification of low level leaks. There are no permanent direct vents to atmosphere from any tank.

This report details an air quality assessment for the proposed facility. The air quality assessment was undertaken in accordance with the relevant EPA guidelines; Publication 1961 *Guideline for Assessment and Minimizing Air Pollution in Victoria* (EPA, 2022b), and Publication 1883 *Guidance for assessing odour* (EPA, 2022a). The assessment considers the potential for odour emissions from the feedstock receival activities, digestion process and digestate treatment activities plus combustion emissions from the two CHP units and the temporary use of a diesel-fired boiler during start-up.

Air emissions from the WtE are primarily from the combustion of biogas (and ancillary diesel) produced from the anaerobic digestion of wastes, rather than by direct combustion of the wastes themselves. This limits the scope of potential pollutants emitted.

The CALPUFF modelling system was adopted to complete the modelling assessment of odour and air quality impacts. Hourly meteorological data representative of the local Lilydale area for five years (2016 – 2020) was included in the dispersion model.

The assessment methodology included identification of relevant pollutants and associated emission rates, simulating the dispersion of those emissions using the CALPUFF dispersion model, processing of the model results for appropriate averaging periods and adding background concentrations where appropriate to calculate cumulative impacts, and comparing the resultant predicted concentrations against adopted air quality objectives.

Combustion Pollutants

Combustion gas emissions from the two CHP units and/or emergency were modelled, including oxides of nitrogen (NO_x) and sulfur dioxide (SO_2). Emissions from the diesel-fired boiler were also included in the model and included fine particles (PM_{10} and $PM_{2.5}$), poly aromatic hydrocarbons (PAHs), and total volatile organic compounds (TVOCs). The chemical species benzo(a)pyrene and benzene were adopted as indicator chemicals for the PAHs and TVOCs.

Dispersion modelling results predict incremental changes in ambient air quality due to project emissions. These incremental results were assessed relevant to the background air quality to predict the cumulative concentration for the Lilydale area, which is then compared to the adopted air quality objectives. For NO_2 and SO_2 the incremental concentrations were added to the maximum ambient background concentrations as a simple and conservative first estimate of cumulative concentrations. In the case of PM_{10} and $PM_{2.5}$, a cumulative assessment was not completed because background air quality already exceeds the air quality objectives on a few days each year. Instead, the incremental PM_{10} and $PM_{2.5}$ values were assessed by

following the method recommended in EPA Publication 1961 of comparing the incremental concentrations with a significance threshold of 4% of the air quality objectives.

Modelling of these air pollutants found that cumulative predicted concentrations of all pollutants complied with all adopted air quality objectives by a significant margin at all sensitive locations outside the WtE facility development footprint. For PM_{10} and $PM_{2.5}$, the predicted incremental concentrations were all well below the 4% threshold, and it was concluded that the contributions of PM_{10} and $PM_{2.5}$ due to operation of the Project will be so small that it is unlikely to result in measurable impacts in the population.

Odour

Dispersion modelling of odour emissions was carried out for two scenarios:

- **Scenario A:** WtE odour emissions only
- **Scenario B:** WtE plus background odour from the existing Lilydale STP.

Baseline odour monitoring was completed for the area around the STP and proposed WtE to support this assessment.

EPA Publication 1883 does not recommend using modelling alone to predict ground level odour concentrations in order to demonstrate compliance against odour objectives. However, the guideline acknowledges that modelling can be a useful tool provided the limitations of modelling are understood, particularly "relative" dispersion modelling. As such, an odour model was prepared with the primary intention of comparing relative ground level concentrations between scenarios, and not to demonstrate compliance with odour concentration criteria.

Relative dispersion modelling by itself is not useful to understand the potential for offensive odour impacts beyond the site boundary. To provide context for the model results predicted for the WtE facility, the conservative criteria of "*1 OU, to be met for at least 99.9 percent of the modelling hours, based on a 3-minute averaging time*" was used as a benchmark to compare against the model results for Scenario A.

The model results for odour for Scenario A led to the conclusion that in isolation, the predicted odour emissions from the WtE facility pose a very low risk of causing offensive odours beyond the site boundary. Further, for receptors close to the Lilydale STP, the STP is the dominant odour source relative to the WtE facility and there is no change to the risk of occurrence of offensive odours due to the cumulative emissions from both sources, compared to the current situation.

Summary

Overall, it is concluded that there is a very low risk of air emissions from the Project causing an exceedance of ambient air quality objectives defined by EPA in the ERS and Publication 1961.

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Acronyms and abbreviations

APAC	Air pollution assessment criterion
AQIA	Air quality impact assessment
AQMS	Air quality monitoring station
ASL	Above sea level
AWS	Automatic weather station
B(a)P	Benzo-a-pyrene
BNR	Biological nutrient reduction
BoM	Bureau of Meteorology
CO	Carbon monoxide
EETM	Emissions estimation technique manual
EPA	Environment Protection Authority (Victoria)
g/sec	grams per second
GLC	Ground Level Concentration
hPa	hectapascals
H_2S	Hydrogen sulphide
IAC	Impact assessment criteria
mg/m^3	milligrams per cubic meter
$\mu g/m^3$	micrograms per cubic meter
MBR	Membrane bioreactor
ML	mega litre (1×10^6 litres)
Nm^3	Normal cubic meters (referenced to 0 deg. C and 1 atmosphere)
NO	Nitric oxide
NO_x	Nitrogen oxides – nitric oxide and nitrogen dioxide
NO_2	Nitrogen dioxide
NPI	National pollution inventory
OCS	Odour control system
OER	Odour emission rate
OU	odour units
ppm and ppb	parts per million and parts per billion
Sm^3	Standard cubic meters (referenced to 15°C and 1 atmosphere)
PAHs	Polycyclic aromatic hydrocarbons
$PM_{2.5}$	Particulate matter, with diameter 2.5 µm and less
PST	Primary sedimentation tank
SBR	Sequencing batch reactor
SEPP(AQM)	State Environment Protection Policy (Air Quality Management)
SOER	Specific odour emission rate (per unit area of source)
SO_2	Sulphur dioxide
STP	Sewage Treatment Plant
TVOC	Total volatile organic compounds
USEPA	Unite States Environmental Protection Agency
WtE	Waste to Energy
YVW	Yarra Valley Water

1. Introduction

1.1 Project description

Yarra Valley Water (YVW) is investigating the development of a waste-to energy facility (WtE) on the site of the Lilydale Sewage Treatment Plant (STP) in Victoria.

The WtE facility will process organic wastes from food processing and agricultural activities, for example grease trap wastes, spoilt food, abattoir wastes, winery waste etc. The waste streams will be processed in two anaerobic digester(s) to produce biogas for the generation of electricity and heat. The WtE project supports YVW's environmental goals of increasing the use of renewable energy and increasing the diversion of waste from landfill.

The purpose of this report is to provide details of the air quality impact assessment (AQIA) carried out for the proposed WtE facility. This assessment forms part of the Development Licence Application submitted to the Victoria Environment Protection Authority (EPA) and the Planning Permit Application originally submitted to the Department of Environment, Land, Water and Planning (now the Department of Transport and Planning).

1.2 Site description

The WtE will be sited within the boundary of the existing Lilydale STP, at 83 – 85 Nelson Road, Lilydale, Victoria. The site is approximately 36 km east north-east of Melbourne central business district.

The STP property is owned and operated by YVW and is bounded by rural land to the north and residential and industrial areas to the south. There is a golf course adjacent the north-western boundary, and a quarry on the north-eastern boundary.

The YVW property and surrounding area is shown in Figure 1.

The YVW site, including the Lilydale STP, is relatively flat, with an elevation of approximately 85 – 90 m above sea level (ASL). There are some hills to the east of the property, where the elevation increases up to 190 m ASL. The topography of the site and the surrounding area is shown in Figure 2.

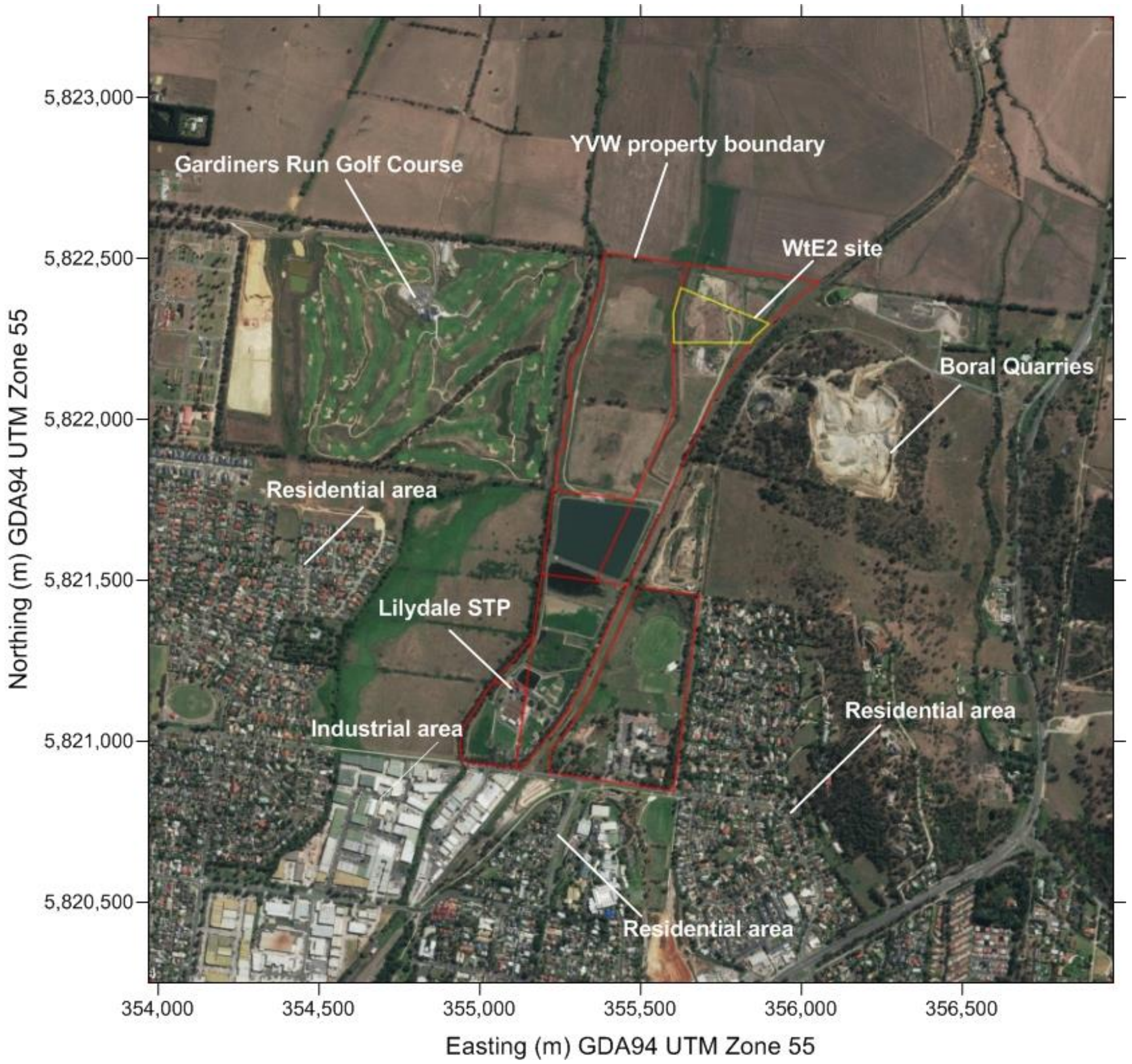

Figure 1 YVW property and surrounding area. Properties owned by YVW outlined in red.

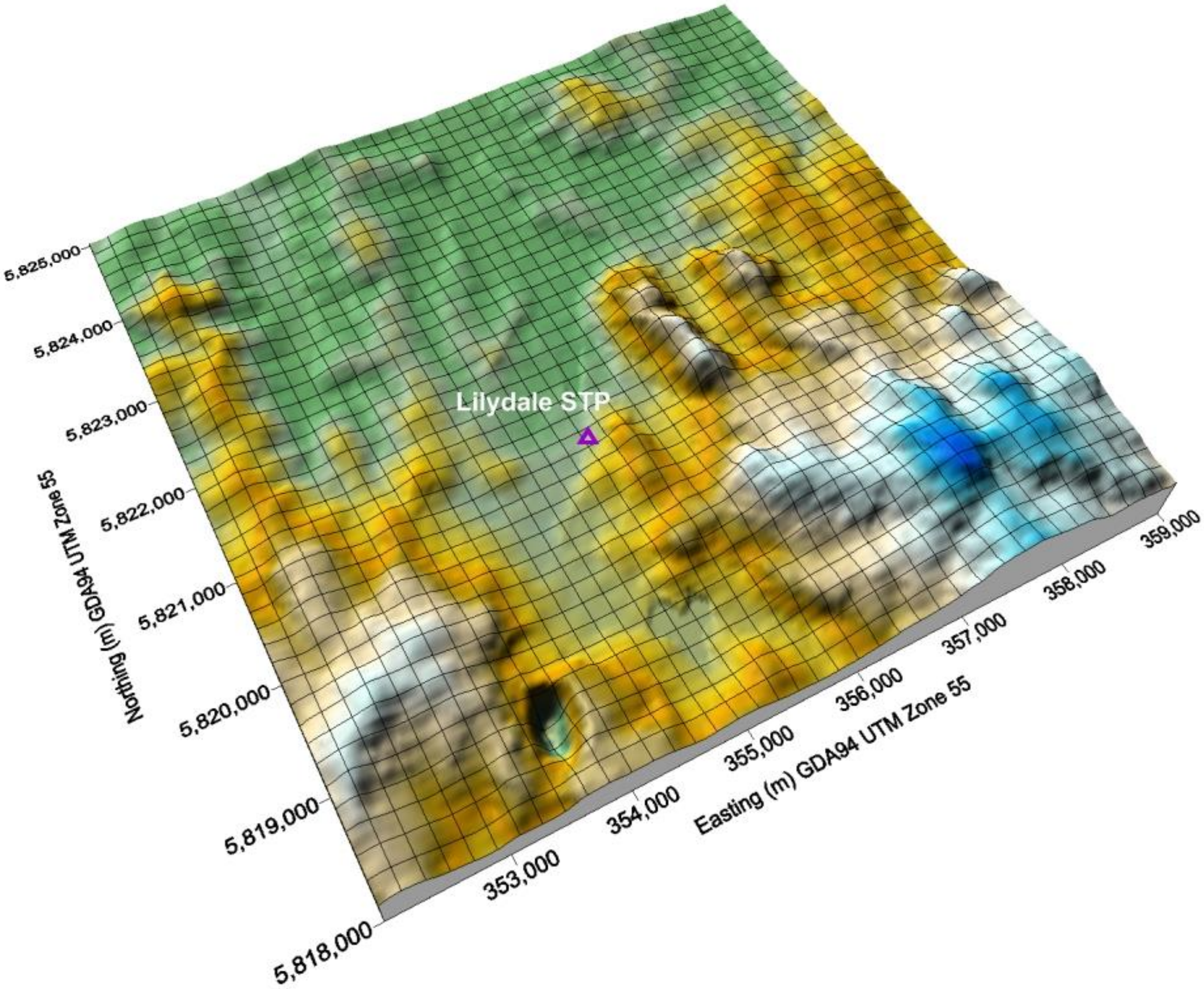

Figure 2 Topography of site and surrounding area.

1.3 Process description

The proposed WtE will be the largest of its kind in Victoria, comprising a feedstock receival and processing building, two digester vessels, two digestate storage tanks (inlet and outlet), an anoxic digester and aerobic reactor for treatment of separated liquid digestate, and two combined heat and power units (CHP). A layout of the site is presented in Appendix B.

The inlet tank will be used to receive and blend various liquid feedstock streams from external sources. The tank is located inside the fully bunded tank farm. Solid feedstock entering the plant will be sorted, shredded and mixed with liquid feedstock and/or water and directed to the digestors.

The anaerobic digesters will breakdown the organic feedstock to produce biogas for power generation. The digestate is separated into its solid and liquid components onsite, with the solid being transported to an appropriately licenced facility for reuse, mostly likely as an ingredient in a soil conditioner. The liquid component will be further treated onsite using a sequence of treatment steps including an anoxic reactor, aerobic digestion, as series of micro and ultra-filtration units and reverse osmosis. Various components from the liquid treatment process (permeates, condensates and concentrates) will be collected for offsite reuse, reused in onsite processes and/or transferred to the Lilydale STP via a dedicated sewer line.

Biogas will be pre-treated to remove siloxanes, hydrogen sulphide and water, before being combusted in 2 x 1.2 MW CHP units. The CHPs generate heat and power for use at the WtE and electrical power for direct use by the Lilydale STP and recycled water pumping station. Excess energy will be exported to the grid in accordance with the *Electricity Industry Act (2000) General Exemption Order (2017).*

During initial start-up, a dual gas/diesel boiler will be used to raise and maintain working temperatures within the digestion tanks until the CHP is fully commissioned, after which it will generate its own heat. It is expected that during commissioning the boiler may need to operate continuously for up to 12 weeks. The boiler may also be used following a shutdown event.

A diesel generator will also be required during start-up and shut-down operations and during emergencies. The generator would also be run for brief periods every six months for testing and maintenance purposes.

Odorous air extracted from the waste processing building, and the digesters, anoxic and aerobic treatment tanks and digestate storage tanks will be treated in a train of eight tricking biofilters, prior to discharge to atmosphere.

1.4 Relevant pollutants

1.4.1 Overview

Based on the identified emission sources and a review of equipment to be installed on site, it is expected that the key emissions to air from the Project would include the following:

- Biogas combustion emissions from the CHP units (or flare during an emergency):
    - These are likely to include oxides of nitrogen (NO_x), carbon monoxide (CO), and sulfur dioxide (SO_2).
    - Discharges of other volatile organic compounds and fine particulates from biogas combustion are negligible (NPI, 2008) and are not considered in the air quality assessment for the CHP units.
- Diesel combustion emissions from the start-up boiler:
    - These are likely to include NO_x, CO, SO_2, fine particles, polyaromatic hydrocarbons (PAHs), and volatile organic compounds.
    - The volatile organic compounds include a range of different chemical species collectively referred to as total volatile organic compounds (TVOCs).
    - The fine particles included in the diesel combustion emissions will include a range of particle sizes with the majority being in the size categories commonly known as PM_{10} and $PM_{2.5}$. Both

particle size categories are assessed in this report. These two size categories are recognised internationally as having the greatest potential to cause health problems due to their inhalation potential, and are regulated by EPA:

  - PM_{10} (particles with an aerodynamic diameter of 10 micrometres (µm) or less)
  - $PM_{2.5}$ (particles with an aerodynamic diameter of 2.5 µm or less). The PM_{10} category includes the $PM_{2.5}$ size range.

- Odour from the exhaust of the odour control biofilters.

1.4.2 Carbon monoxide

Carbon monoxide (CO) is present in small amounts in all discharges from fuel burning equipment due to inefficient or incomplete fuel combustion. CO discharges from industrial fuel burning in the presence of sufficient oxygen have very minor potential to cause adverse effects because CO is minimised through the high combustion efficiency of the fuel burning equipment. Furthermore, CO has a relatively high air impact criteria compared to other combustion gases such as nitrogen oxides or sulphur dioxide, making it harder for levels of concern to be reached. Therefore, CO emissions have not been considered in this air impact assessment

1.4.3 Oxides of nitrogen

NO_X is an expression of the total amount of both nitric oxide (NO) and nitrogen dioxide (NO_2) in a gas, with the mass of NO_x calculated by assuming that all of the NO has been oxidised to NO_2. Only the concentration of the NO_2 fraction of NO_X is regulated in ambient air.

NO_X is generated during combustion processes and is known to be a key emission from biogas-powered generators. In emissions from biogas-combustion processes, the NO_X is predominately made up of NO. As a general rule of thumb, NO_2 composition in the discharge from combustion processes will typically be about 5-10%. In this assessment, it was assumed that NO_2 comprised 10% of the NO_x discharge.

NO is slowly converted to NO_2 in the environment through complex atmospheric reactions. Therefore, it is necessary to estimate the oxidation of NO into NO_2 in the atmosphere after discharge from the stacks. The approach adopted in this AQIA is discussed in Section 5.3.

2. Relevant Legislation, Policy and Guidelines

The following sections detail the relevant legislation and guidelines that have been considered as part of the air quality impact assessment.

2.1 Overview of relevant legislation

The primary legislation underpinning the objectives for odour management at the Lilydale STP is the *Environment Protection Act 2017* (EP Act 2017) and the subordinate legislation established under this Act which came into effect on 1 July 2021, particularly the Environment Reference Standard (ERS).

The cornerstone of the new environmental protection legislation is the general environmental duty (GED). The GED requires anyone conducting an activity that poses risks to human health and the environment to understand those risks and put in place reasonably practicable measures to eliminate or reduce identified risks of harm from pollution or waste. Doing what is reasonably practicable means putting in proportionate controls to mitigate or minimise the risk of harm. Demonstrating that the person or business undertaking the activity has done what is reasonably practicable can be achieved if (EPA, 2020):

- Well-established effective practices or controls have been adopted to eliminate or manage risk; and/or
- Where well-established practices or controls do not exist, it can be shown that effective controls have been assessed and adopted.

New policies for air quality and odour assessment have also been published by EPA in 2021 and 2022.

Table 1 summarises the relevant regulations and policies/guidelines applicable to this AQIA.

Table 1 Victoria regulation and policy summary

Regulation or policy	Key policies and strategies	Implications for the Project
Regulations		
Environment Protection Act 2017 (EP Act 2017)	The EP Act 2017 is a risk-based approach to preventing environmental harm and includes a general environmental duty (GED). The GED requires people to take reasonably practicable steps to eliminate, or otherwise reduce risks of harm to human health or the environment from pollution and waste. Doing what is reasonably practicable means putting in proportionate controls to mitigate or minimise the risk of harm.	This legislation provides the framework for the policies, guidelines and objectives which are relevant to all air quality impact assessments in Victoria. The GED requires identification of all risks and implementation of effective control measures so far as reasonably practicable.
Environment Reference Standard (ERS)	The ERS is a new subordinate instrument made under the EP Act 2017. The ERS was gazetted on 26 May 2021 and was amended in February 2022. The ERS identifies environmental values for Victoria in the areas of air quality, noise, water and contaminated land; and defines indicators and objectives to measure those values. The ERS supports the protection of the environment from pollution and waste by providing a benchmark to assess and report on environmental conditions in the whole or any part of Victoria. The ERS does not set out enforceable compliance limits; rather, risks of harm to human health and the environment from pollution and waste must be minimised as far as reasonably practicable, in accordance with the GED.	The following environmental values (ambient air environment) are relevant to the Project: • Life, health and wellbeing of humans • Life, health and well-being of other forms of life including the protection of ecosystems and biodiversity • Local amenity and aesthetic enjoyment • Visibility • The useful life and aesthetic appearance of buildings structures property and materials • Climate systems that are consistent with human development, the life,

		health and well-being of humans and the protection of ecosystems and biodiversity The air quality objectives defined in the ERS informed the objectives for air quality for the Project.
Environment Protection Regulations	The Environment Protection Regulations are a subordinate instrument of the EP Act 2017 and cover a broad suite of topics including contaminated land, the new framework for permissions, waste management and environmental management (including air and noise) as well as administrative matters relating to offences, fees and transitional arrangements. Part 5 (Environmental Management) of the Regulations addresses matters including air. Part 5.2 – Air (Regulations 103 to 112) specifies obligations on manufacturers and suppliers in relation to air pollution, including in relation to the National Pollutant Inventory.	The Environment Protection Regulations are not directly relevant to the air quality impact assessment for the Project and are not considered in detail in this report.
Other Guidelines / policies		
EPA Victoria Publication 1961, Guideline for assessing and minimising air pollution in Victoria (February 2022)	This guideline provides a framework to assess and control risks associated with air pollution in the form of a technical guideline for air quality practitioners and specialists.	As the Project includes emissions of air pollutants Publication 1961 will be considered in this report.
EPA Victoria Publication 1883, Guideline for assessing odour (June 2022)	This guideline provides information on how to assess the risk posed by odour emission sources and to understand the receiving environment where effects might occur. The guidance is focused on the assessment of odour under the provisions of the EP Act 2017, including the GED.	The methodology used in this report is consistent with guidance in Publication 1883.
EPA Victoria Publication 1559.1, Guideline: Energy from waste (2017)	This guideline provides information on applicable assessment criteria based on the energy from waste facility type.	The methodology used in this report is consistent with guidance in Publication 1559.1. However, the air quality emissions from the Project are generated by the combustion of biogas (and ancillary diesel) produced from the anaerobic digestion of the wastes, rather than by direct combustion of the wastes themselves. This limits the scope of potential pollutants within the air emissions.

2.2 Environment Reference Standard

The ERS generally adopts the objectives in the National Environment Protection Measure (Ambient Air Quality) (NEPM AAQ) with some modifications. The ERS also contains other environmental values, indicators and/or objectives that are not in the NEPM AAQ, including a qualitative objective for odour in ambient air. The air quality objectives in the ERS are listed in Table 2.

Table 2 ERS air quality objectives

Environmental indicator (air pollutant)	Averaging period	ERS maximum concentration objective2
Particles as PM_{10}	1 day	50 µg/m^3
	1 year	20 µg/m^3
Particles as $PM_{2.5}$	1 day	25 µg/m^3
	1 year	8 µg/m^3
NO_2	1 hour	80 ppb
	1 year	15 ppb
CO	8 hours[1]	9.0 ppm (9000 ppb)
SO_2	1 hour	75 ppb
	1 day	20 ppb
Visibility reducing particles (minimum visual distance)	1 hour	20 km
Odour (qualitative objective)	Not applicable	An air environment that is free from offensive odours from commercial, industrial, trade and domestic activities

1 Rolling 8-hour average based on 1-hour averages.
2 Mass concentrations for particles in ERS are referenced to gas conditions of 0°C, 101.3 kPa

2.3 EPA Publication 1961

Publication 1961 (EPA, 2022b) outlines EPA's assessment framework and policy for air quality. The publication outlines a risk-based assessment of air pollution that is intended to help duty holders prioritise and manage their risks appropriately and proportionately. When evaluating risks from air pollution, there are three levels of assessment in order of increasing complexity.

1. Level 1 assessments - a screening level assessment that is qualitative or semiquantitative in nature. This is used to quickly describe risks from activities that either have:
   - Intrinsically low risks, or
   - Risks that are so common and well understood they can be effectively controlled without the need for extensive assessment work.
2. Level 2 assessments – the most common type of risk assessment for industry. They usually involve the use of dispersion modelling or monitoring. Predicted or measured pollutant concentrations can be benchmarked against a set of pre-defined air pollution assessment criteria (APACs) to understand the resulting risks.
3. Level 3 assessments – these detailed risk assessments are only used in exceptional circumstances when a simple comparison of a pollutant's concentration to an APAC cannot adequately describe the risk.

Routine activities that have controls that are known to be effective will generally require only a Level 1 qualitative assessment, e.g. natural gas boilers <20 MW, or small gas turbines or power plants <5 MW. However, Publication 1961 states that more complex projects such as waste incineration or waste to energy projects always require a full Level 2 or 3 assessment. Technically, the air emissions from this project are from combustion of either biogas or diesel and are not a waste combustion process. A Level 3 assessment was not required for the scale and nature of pollutants relevant to the Project. The air quality impact assessment of the Project has followed the methodology required for a Level 2 assessment.

APACs are risk-based levels. They apply to modelled or monitored air data, regardless of the type of source that generated the pollution. APACs are intended to serve a dual purpose:

- Help emitters understand the current inherent risks posed by their activities to inform the implementation of appropriate controls.

- Provide a benchmark against which current or future residual risks (risks remaining after proposed controls are implemented) can be compared to evaluate whether they are acceptable or not.

APACs are not intended to be concentrations one can 'pollute up to' and must not be interpreted as concentrations below which no action is required. This is because the duty holder is required under the GED to minimise risks so far as reasonably practicable.

The APACs relevant to this Project are identified in Section 2.5.

2.4 EPA Publication 1883

EPA Publication 1883 (EPA, 2022a) provides information on how to assess the risk posed by odour emission sources and to understand the receiving environment where effects might occur. The guidance is focused on the assessment of odour under the provisions of the EP Act 2017, including the GED.

There are three levels of assessment in the guide, and progression through each level of assessment depends on the scale or complexity of the scenario. These can be performed in sequence; if the lower levels of assessment show that the activity is low risk for odour, there is no need to proceed to the higher levels of assessment. The three levels of assessment are as follows:

1. The Level 1 assessment is a "gateway assessment" and includes tests for
   - Cumulative sources consideration
   - Duration of emissions
   - Wind direction
   - Minor odour emission sources
2. The Level 2 assessment consists of two tools, cumulative effects test and the source-pathway-receiving environment tool.
   - The cumulative effects test takes into consideration the effects of multiple odour sources where there is different dispersed industry, different clustered industries and clusters of similar industries.
   - The source-pathway-receiving environment tool gives guidance on determining the level of hazard posed by the odour source, the effectiveness of the exposure pathway and the sensitivity of the receiving environment. It enables the calculation of a risk score.
   - Depending on this score and the quality of the evidence used, further steps in the risk assessment can be identified.
3. The Level 3 assessment provides detailed risk assessment tools for issues that are complex or where the other levels of assessment have been exhausted because there is not enough evidence to establish what the odour risk is. Several different tools may be relevant depending on the site circumstances:
   - Comparisons with similar operations or case studies.
   - Risk assessment using field odour surveillance data.
   - Complaint assessment.
   - Odour complaint case study.
   - Community odour surveys/questionnaires and odour diaries.
   - The use of dispersion modelling.

The nature of odour emission sources at the Project site, the neighbouring Lilydale STP and the area's meteorological characteristics disqualify the site from being considered under a Level 1 assessment. The odour assessment detailed in this report follows the methodology required for both a Level 2 and Level 3 assessment.

2.5 Adopted air quality objectives

For each identified pollutant of concern, air quality objectives have been adopted from either the ERS or, if not listed in the ERS, the APACs listed in Publication 1961.

A summary of the adopted air quality objectives is provided in Table 3. Where there is more than one criterion for a pollutant, e.g. for both odour and toxicity, the most stringent (i.e. lowest) concentration has been applied.

For a screening assessment of volatile organic compounds, the compounds benzene, toluene, and xylene were identified as potential air quality indicators because these compounds are commonly emitted for diesel combustion. Of these, benzene has the lowest air quality objectives and therefore was selected as the assessment indicator for TVOCs. The TVOC concentrations predicted by the model were assumed to comprise 100% benzene for comparison with the air quality objectives. This is a highly conservative approach as the actual concentration of benzene (or any other single volatile organic compound) is likely to be significantly lower the predicted TVOC quantities.

Similarly for PAHs, the compound benzo(a)pyrene was adopted as the indicator for PAHs in line with common practice.

Table 3 Adopted air quality objectives for relevant pollutants

Pollutant	Averaging Time	Statistic	Assessment Criteria	Units	Source
NO_2	1 hour	99.9th percentile	164 (0.08)	µg/m^3 (ppm)	ERS
	1 year	Maximum	31 (0.015)	µg/m^3 (ppm)	ERS
SO_2	1 hour	99.9th percentile	214 (0.075)	µg/m^3 (ppm)	ERS
	24 hours	Maximum	57 (0.02)	µg/m^3 (ppm)	ERS
PM_{10}	24 hours	Maximum	50	µg/m^3	ERS
	1 year	Maximum	20	µg/m^3	ERS
$PM_{2.5}$	24 hours	Maximum	25	µg/m^3	ERS
	1 year	Maximum	8	µg/m^3	ERS
PAHs (as benzo(a)pyrene)	1 year	Maximum	0.0001	µg/m^3	APAC
Benzene (TVOC indicator)	1 hour	99.9th percentile	580	µg/m^3	APAC
	24 hours	Maximum	29	µg/m^3	APAC
	1 year	Maximum	9.6	µg/m^3	APAC

Table notes:
1. Criteria less than 24 hours apply at all locations, criteria 24 hours or greater apply at sensitive receptor locations.
2. Gas volumes are expressed at 0°C and at an absolute pressure of one atmosphere (1013.25 hPa).

3. Existing Environment

The following sections describe the existing environment surrounding the Project, including local meteorology, topography, land use, and sensitive receptor locations.

3.1 Background air environment and monitoring sites

Overall, the air pollution levels measured in the Yarra Ranges are low and the air quality of the region is mostly good. However, EPA's air quality data shows that Yarra Ranges sometimes experiences poor air quality. The worst air quality in recent years was mostly from bushfire smoke (EPA, 2021a).

EPA conducts long-term ambient air quality monitoring at several Air Quality Monitoring Stations (AQMS) to meet its obligations under the NEPM AAQ and ERS. The relevant EPA AQMS are listed in Table 4.

Table 4 Summary of EPA air quality monitoring stations relevant for Project (from EPA (2021b))

Station name	Location category	Site type*	Latitude	Longitude	Parameters measured
Mooroolbark	Residential	Pop	-37.78	145.33	PM_{10}, ozone (O_3)
Alphington	Residential / light industrial	G	-37.78	145.03	$PM_{2.5}$, PM_{10}, CO, SO_2, NO_2, O_3

* Site types are defined in NEPC (2001):

- G = "Generally representative upper bound for community exposure" site: performance monitoring station located to monitor the upper bound of the distribution of pollutant concentrations likely to be experienced by portions of the population, while avoiding the direct impacts of localised pollutant sources.
- Pop = "Population-average" site: station sited to ensure adequate monitoring of large portions of the populated area and of the total population within a region.

The nearest AQMS to the Project site is the Mooroolbark station, which is generally representative of the Yarra Valley area (EPA, 2021a). However, of the pollutants relevant to this Project, this monitoring station conducts long term monitoring only for PM_{10}. For other assessed pollutants, data from the Alphington AQMS have been analysed to characterise the background air environment. The following sections provide a summary of background air quality for the local area surrounding the Project site.

3.2 Specific pollutant data

3.2.1 NO_2

The main source of air pollution contributing to NO_2 concentrations measured at the Alphington AQMS station is expected to be road vehicle traffic. The Alphington AQMS is therefore a conservative representation of NO_2 at Lilydale (i.e. overstating NO_2 background concentrations) due to higher local traffic densities in the urban Melbourne area compared to the Project location.

Annual average and 1-hour average NO_2 concentrations from 2016 to 2020 for the Alphington AQMS are presented in Table 5. These statistics are taken from the EPA annual air quality monitoring reports (EPA 2017, 2018, 2019, 2020, and 2021b) and converted from parts per billion to micrograms per cubic metre (for consistent comparison with units used in dispersion modelling). The data indicates that no exceedances of the ERS criteria have been observed at the Alphington AQMS during the 2016 to 2020 monitoring period.

3.2.2 SO_2

There are no significant sources of SO_2 near the Mooroolbark and Alphington AQMS. As such, it is expected that measured SO_2 concentrations at Alphington are broadly representative of the Mooroolbark and Project locations.

Daily average and 1-hour average SO_2 concentrations from 2016 to 2020 for the Alphington AQMS are presented in Table 6. These statistics are taken from EPA (2021b) and converted from parts per billion to micrograms per cubic metre (for consistent comparison with units used in dispersion modelling). The data indicates that no exceedances of the ERS criteria have been observed at the Alphington AQMS during the 2016 to 2020 monitoring period, and that measured air quality is consistently well below the ERS criteria.

Table 5 NO_2 monitoring data summary for Alphington AQMS (2016 to 2020)

Year	1-hour average maximum	1-hour average 90^{th} percentile	Annual average	Units
2020	106	60	16.8	µg/m³
2019	87	61	18.5	
2018	103	64	18.5	
2017	117	64	20.5	
2016	88	59	20.5	
Average	100	61	18.9	
NO_2 criteria (ERS)	164		31	

Table 6 SO_2 monitoring data summary for Alphington AQMS (2016 to 2020)

Year	1-hour average maximum	1-hour average 90^{th} percentile	24-hour average maximum	24-hour average 90^{th} percentile	Units
2020	15	6.3	7.0	2.5	µg/m³
2019	29	9.2	6.0	2.8	
2018	37	8.6	10.7	2.9	
2017	31	11.4	7.4	2.9	
2016	26	11.4	6.5	2.7	
Average	28	9.4	7.5	2.7	
SO_2 criteria (ERS)	214		57		

3.2.3 PM_{10}

Annual average and 24-hour average PM_{10} concentrations from 2016 to 2020 for the Mooroolbark AQMS are presented below in Table 7. These statistics are taken from the EPA annual air quality monitoring reports (EPA 2017, 2018, 2019, 2020, and 2021b).

A number of exceedances of the ERS criteria were observed during the 2016 to 2020 monitoring period, which is consistent with other AQMS in Victoria (EPA 2017, 2018, 2019, 2020, and 2021b). Exceedances are generally attributed by EPA to bushfires, wind-blown raised dust, or urban sources accumulating during stable atmospheric conditions such as motor vehicles, domestic wood heaters and commercial/industrial emissions.

Table 7 PM_{10} monitoring data summary for Mooroolbark AQMS (2016 to 2020)

Year	24-hour average maximum	24-hour average 90^{th} percentile	Annual average	Units
2020	76	23	15.7	µg/m³
2019	75	30	16.3	
2018	111	25	15.7	
2017	55	22	16.4	
2016	45	22	12.5	
Average	73	25	15.3	
PM_{10} criteria (ERS)	50		20	

3.2.4 $PM_{2.5}$

Annual average and 24-hour $PM_{2.5}$ concentrations from 2016 to 2020 for the Alphington AQMS are presented below in Table 7. These statistics are taken from the EPA annual air quality monitoring reports (EPA 2017, 2018, 2019, 2020, and 2021b).

Table 8 $PM_{2.5}$ monitoring data summary for Alphington AQMS (2016 to 2020)

Year	24-hour average maximum	24-hour average 90th percentile	Annual average	Units
2016	35.7	13.5	7.8	µg/m³
2017	30.7	13.3	7.6	
2018	42.0	13.4	7.9	
2019	35.9	15.8	8.9	
2020	33.6	11.9	7.3	
Average	35.6	13.6	7.9	
$PM_{2.5}$ criteria (ERS)	25		8	

As with PM_{10}, exceedances of the ERS criteria were observed during the 2016 to 2020 monitoring period, which is consistent with other AQMS in Victoria (EPA 2017, 2018, 2019, 2020, and 2021b). Exceedances are generally attributed by EPA to bushfires, wind-blown raised dust, or urban sources accumulating during stable atmospheric conditions such as motor vehicles, domestic wood heaters and commercial/industrial emissions.

3.2.5 Volatile Organic Compounds and PAHs

The existing background concentrations for volatile organic compounds such as formaldehyde, benzene, toluene and xylenes and PAHs that are relevant to the Project are assumed to be zero, as there are no significant known sources of these volatile organic compounds in the modelling region based on a search of the National Pollutant Inventory[1] and the EPA licences database[2].

3.3 Odour

The main contributor to existing background odour at the WtE site is the Lilydale STP, located directly south of the proposed WtE site, within the YVW property boundary. The STP is described in Section 4.4.

To allow a cumulative impact assessment with the Project, odour sources from the STP have been explicitly included within the dispersion model.

3.4 Terrain

Topographical data is shown in Figure 3. On a regional scale, terrain is elevated to the northeast and katabatic wind flows will drain towards the west-southwest along the valley formed by the Yarra River.

The Project is located near the mouth of a valley draining northwards. Katabatic wind flows at the site location are likely to flow northwards but are also likely to be influenced somewhat by the broader scale katabatic drainage flows in the Yarra valley. As shown in Figure 3, an automatic weather station (AWS) operated by Bureau of Meteorology (BoM) at Coldstream (5 kilometres from the Project site) is also located on the southern edge of the Yarra Valley and is likely to experience similar south-to-north katabatic air drainage flows.

[1] https://www.dcceew.gov.au/environment/protection/npi/data accessed 10 October 2022.

[2] https://www.epa.vic.gov.au/for-business/permissions/search-for-licence accessed 10 October 2022.

The AQMS operated by EPA at Mooroolbark, also measures meteorological data and the location is shown on the topographical figures. Whilst ambient air quality monitoring data from this location is relevant to the assessment, this location is not applicable to the Project for meteorological data due to the nearby topography being very different.

3.5 Local meteorology

As identified in Section 3.4, the Coldstream AWS operated by BoM is likely to be relevant to the Lilydale WtE facility location. Historical wind data recorded at the Coldstream AWS for the last 10 years (2012-2021) was obtained from BoM at hourly intervals. The hourly-average data shows a relatively large proportion of light winds (typical of a sheltered inland location) with nearly a third of the hourly-average records (2012 – 2021, inclusive) less than 1 m/s and 46% less than 2 m/s – as shown in **Error! Not a valid bookmark self-reference.**. A similar overall wind speed distribution is expected at the Project location.

Table 9: Wind speed distributions, 1-hour average, by year, Coldstream AWS.

Wind speed	2012-2021	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
<0.5 m/s	24%	23%	22%	23%	23%	21%	26%	24%	25%	25%	26%
<1 m/s	32%	32%	30%	32%	32%	29%	35%	33%	33%	33%	34%
<2 m/s	46%	45%	43%	46%	45%	42%	50%	47%	47%	47%	48%
<3 m/s	61%	60%	57%	61%	60%	57%	65%	62%	63%	63%	65%
<5 m/s	87%	85%	83%	86%	85%	84%	88%	87%	87%	90%	91%

For the dispersion modelling (see Section 5.2), the meteorological dataset selected for modelling comprised five years of hourly data, for years 2016 – 2020, inclusive. These years were chosen on the basis of being most recent available for both meteorological and background air quality data, as well as encompassing a range of weather conditions. Annual wind roses from the Coldstream AWS for these five years of data are provided in Figure 4. On an annual basis, the dominant wind directions are north and southeast. The lowest average wind speeds occur during year 2017. The largest frequency of low wind speeds (<2.0 m/s) also occurs in 2017. The annual average wind speeds for the five-year Coldstream BoM (2016 – 2020) dataset range from 2.3 m/s to 2.7 m/s.

Figure 5 presents the overall average wind rose (for 2016 to 2020) and the daylight and night-time hours wind roses. A very high percentage of calms is observed during night-time hours (38.8%) in addition to a larger proportion of lower wind speeds when compared to winds observed during daylight hours.

Wind roses have been created from the dataset for each season (for 2016 to 2020) and are provided in Figure 6. These wind roses indicate the highest wind speeds occur in the summer (and spring), predominantly from a southerly direction. A high frequency of northerly winds occurs in the winter.

The 9 am and 3 pm annual wind roses downloaded from the BoM website[3] for long term observations (1994 to 2022) at the Coldstream AWS are provided in Figure 7, and can be compared with the 9 am and 3 pm data for the 2016-2020 period shown in Figure 8. Slight differences between the two datasets are expected, because the long term BoM windroses in Figure 7 are plotted from 10-minute average wind records whereas the windroses for 2016-2020 in Figure 8 are plotted from 1-hour average wind records. Nevertheless, the long-term wind pattern compares well with the period selected for dispersion modelling, indicating that the modelled period is representative of longer term meteorology in the area. Less frequent winds in the western sector and the near absence of winds in the eastern sector also show up clearly for both data sets.

[3] http://www.bom.gov.au/climate/averages/tables/cw_086383.shtml

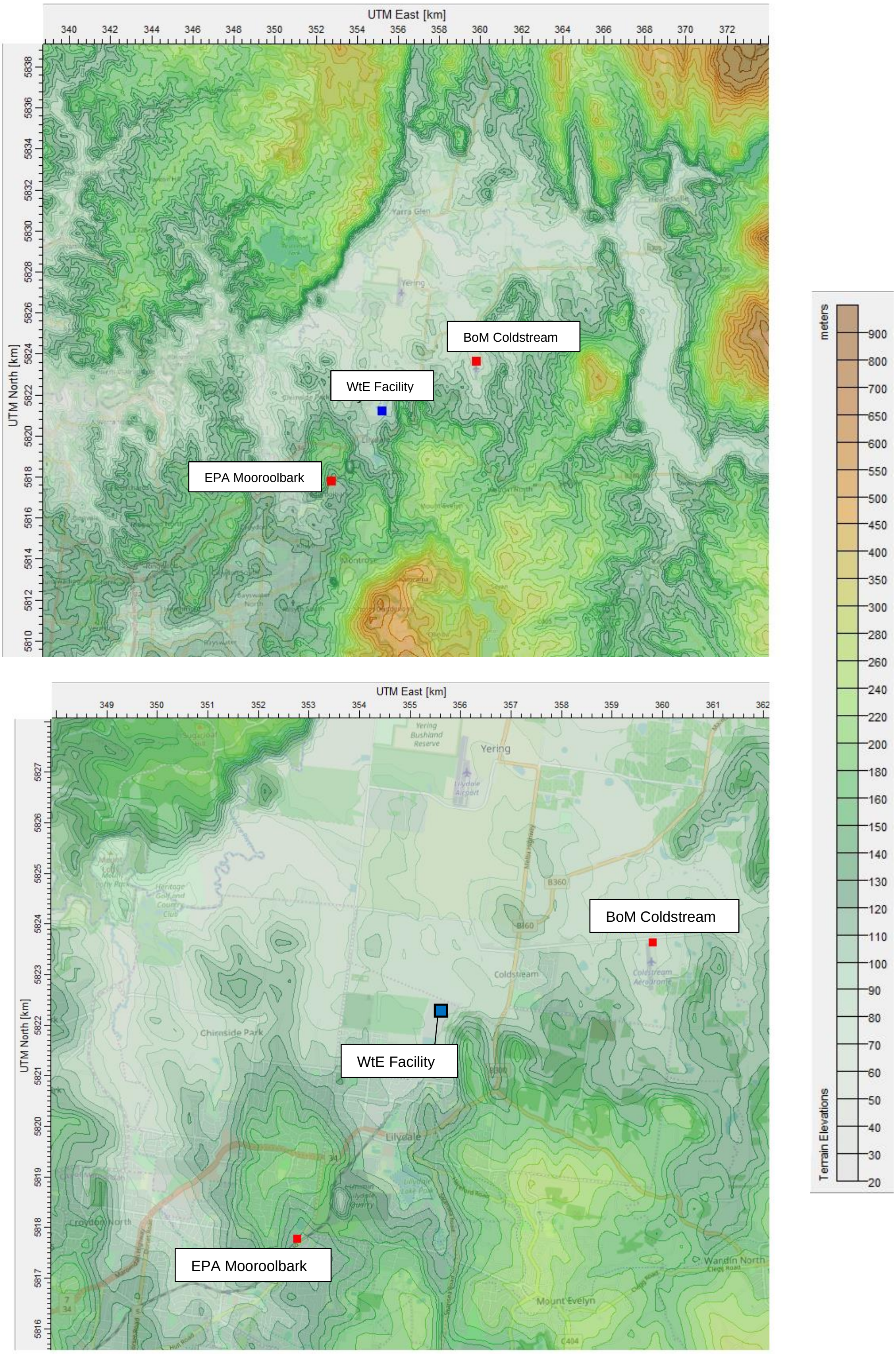

Figure 3 Topographical relief maps, showing location of the proposed Lilydale WtE facility and nearby meteorological monitoring stations operated by BoM and EPA. Above: wider Yarra Valley region. Below: Lilydale area.

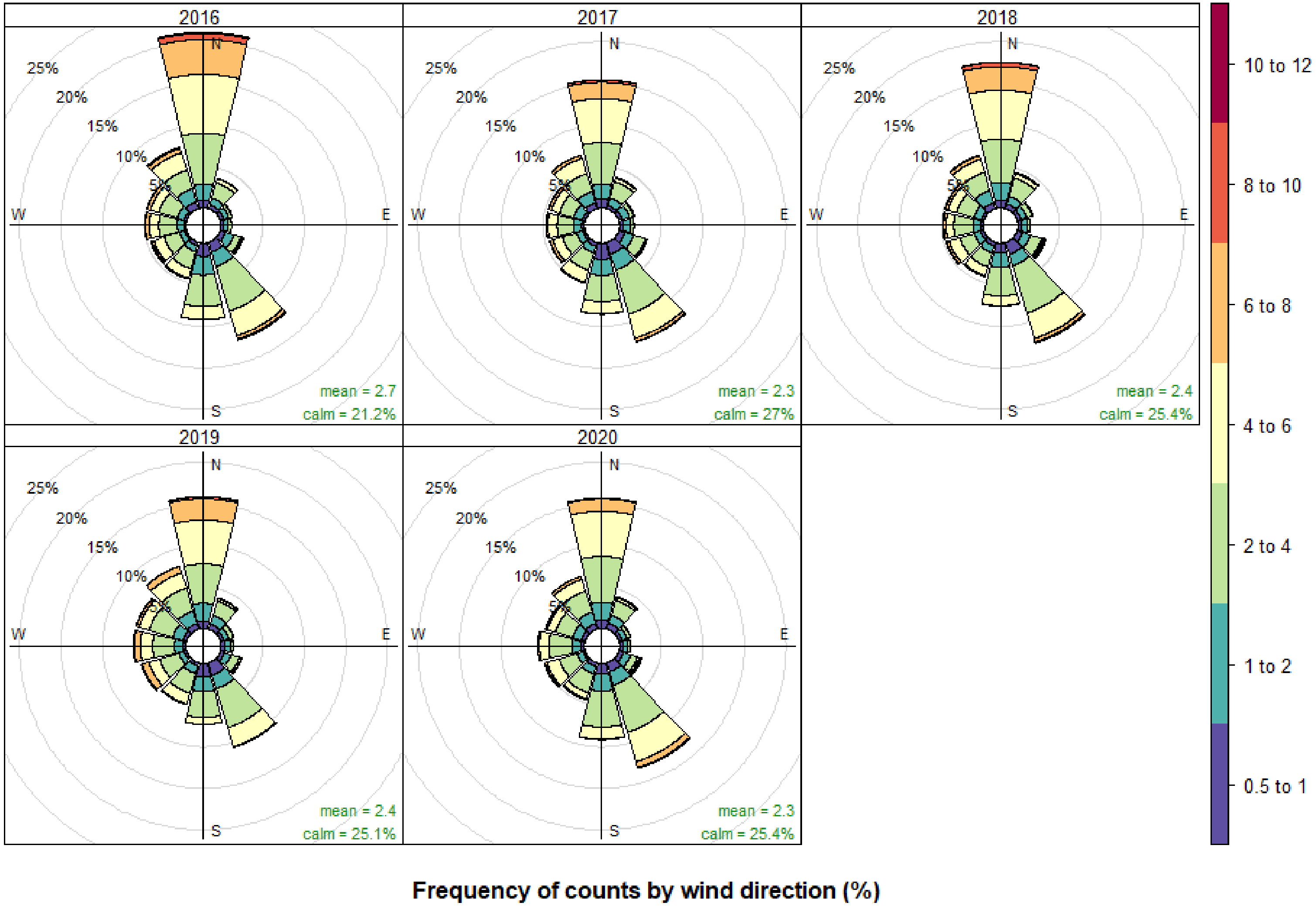

Figure notes:

1. Adopted calms threshold 0.5 m/s

Figure 4 Annual wind roses for Coldstream BoM AWS (2016 to 2020)

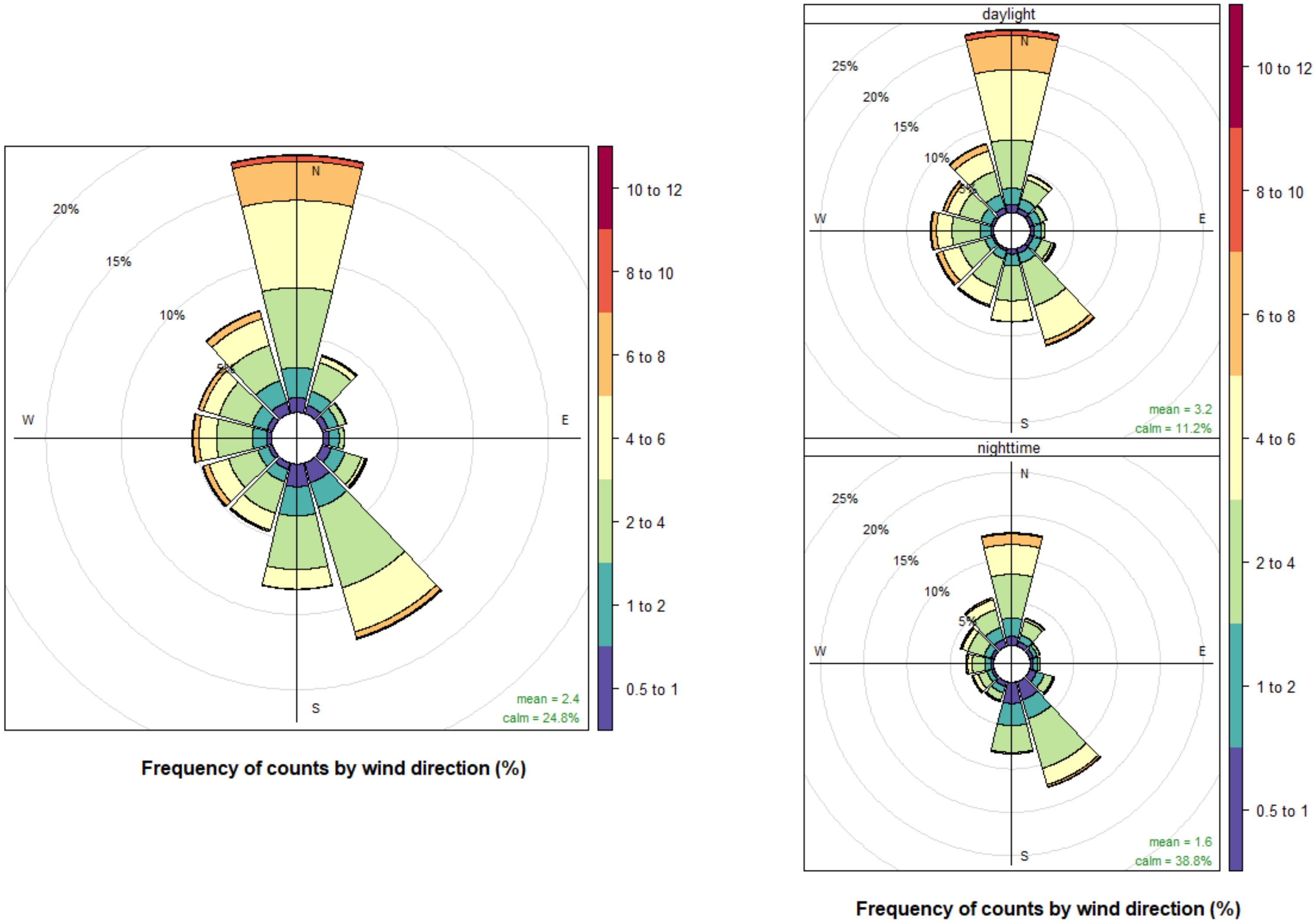

Figure notes:

1. Adopted calms threshold 0.5 m/s
2. Daylight and night-time hours are calculated as per the method by Meeus (1991)

Figure 5 Average (left) and daylight and night-time hours (right) wind roses for Coldstream BoM monitoring station (2016 to 2020)

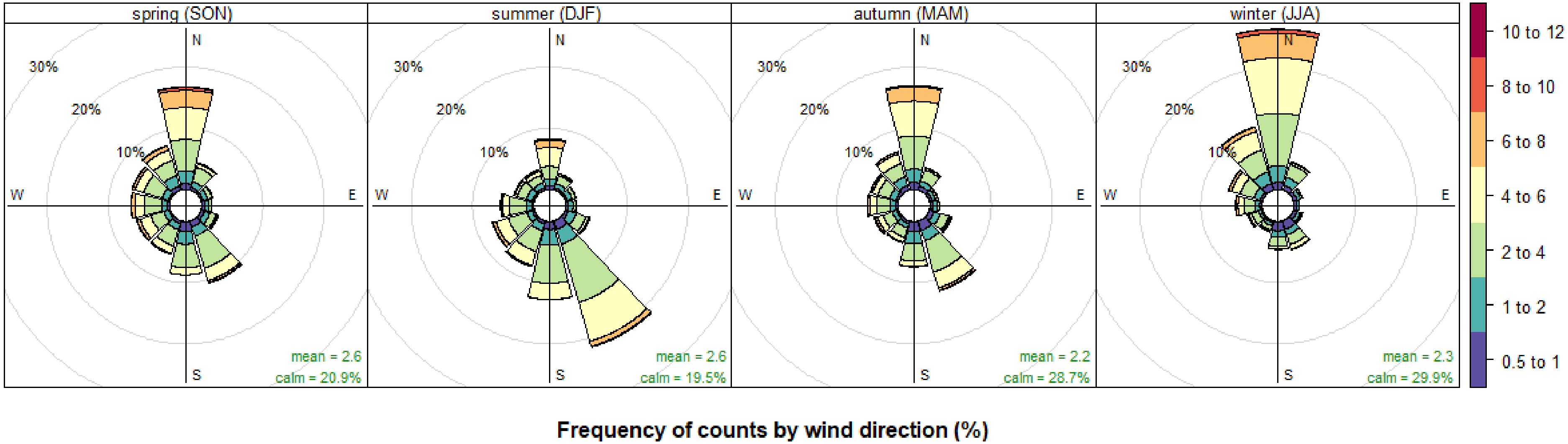

Figure notes:

1. Adopted calms threshold 0.5 m/s

Figure 6 Seasonal wind roses for Coldstream BoM monitoring station (2016 to 2020)

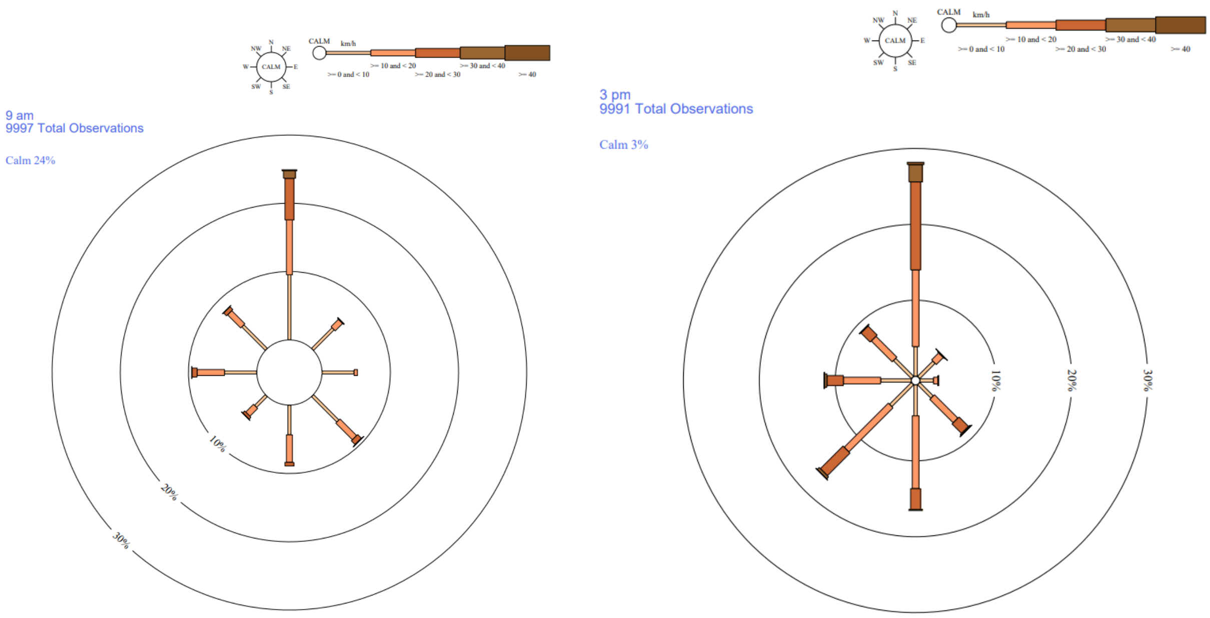

Figure 7 Coldstream BoM station (086383) long term wind roses (October 1994 – August 2022); 9 am (left) and 3 pm (right), 10-minute average winds; source – BoM http://www.bom.gov.au/climate/averages/tables/cw_086383.shtml.

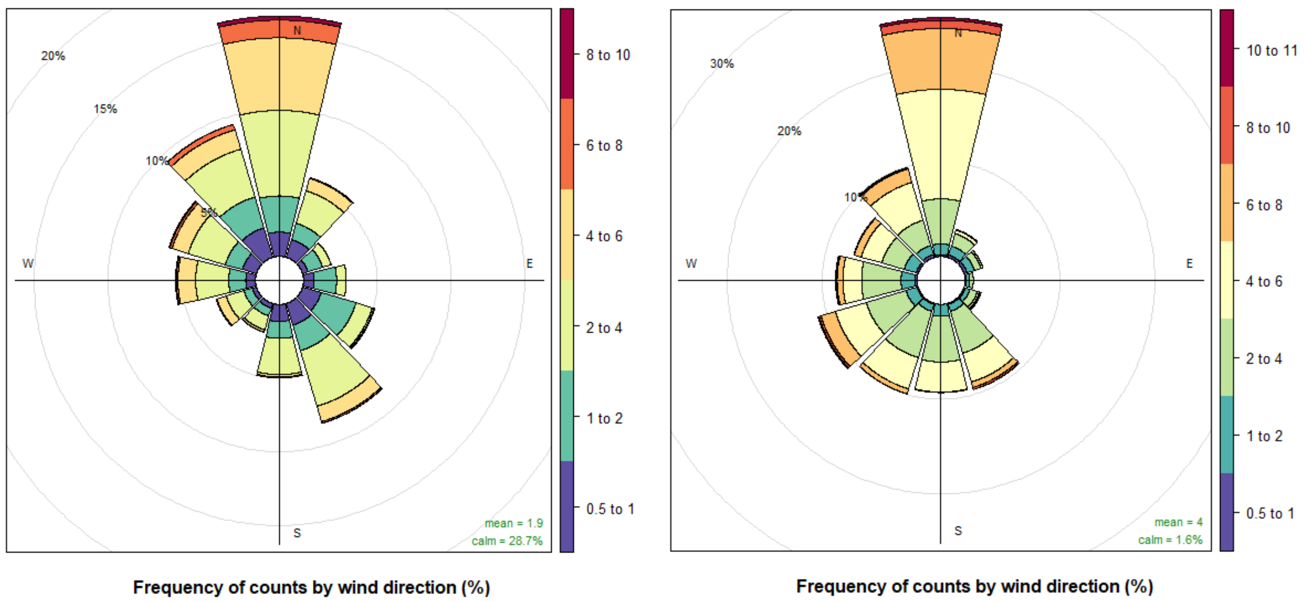

Figure 8 Coldstream BoM station wind roses (2016 – 2020); 9am (left) and 3pm (right); 1-hour average winds.

Figure notes:

1. Adopted calms threshold 0.5 m/s

3.6 Surrounding land use

The land use zonings and types of development around the Project site provide important information to understand the risk of adverse air quality and odour impacts occurring beyond the site boundary. Some types of land uses are usually regarded as more sensitive to air quality and odour than others. Land use zoning information can also indicate the potential for future encroachment of sensitive land uses closer to the Project boundary. Information about the locations of sensitive receptors can be used to inform community engagement programmes, and the development of an appropriate dispersion model.

Land use zones around the site are shown in Figure 9. The figure also shows the land parcels owned by YVW. The Lilydale locality around the Project site includes a mixture of land uses which are potentially sensitive to air emissions from the Project including residential, recreational and industrial/commercial.

Several other land parcels zoned as Green Wedge are also around the Project site, as the site is near the border of the Yarra Valley and Yarra and Dandenong Ranges Green Wedge, one of Victoria's twelve designated green wedges lying outside the Melbourne Urban Growth Boundary[4]. These land parcels are not currently considered to be sensitive land uses; however, this could change in future if subdivisions are proposed and granted development permits.

[4] https://www.planning.vic.gov.au/policy-and-strategy/green-wedges, accessed 26 November 2020.

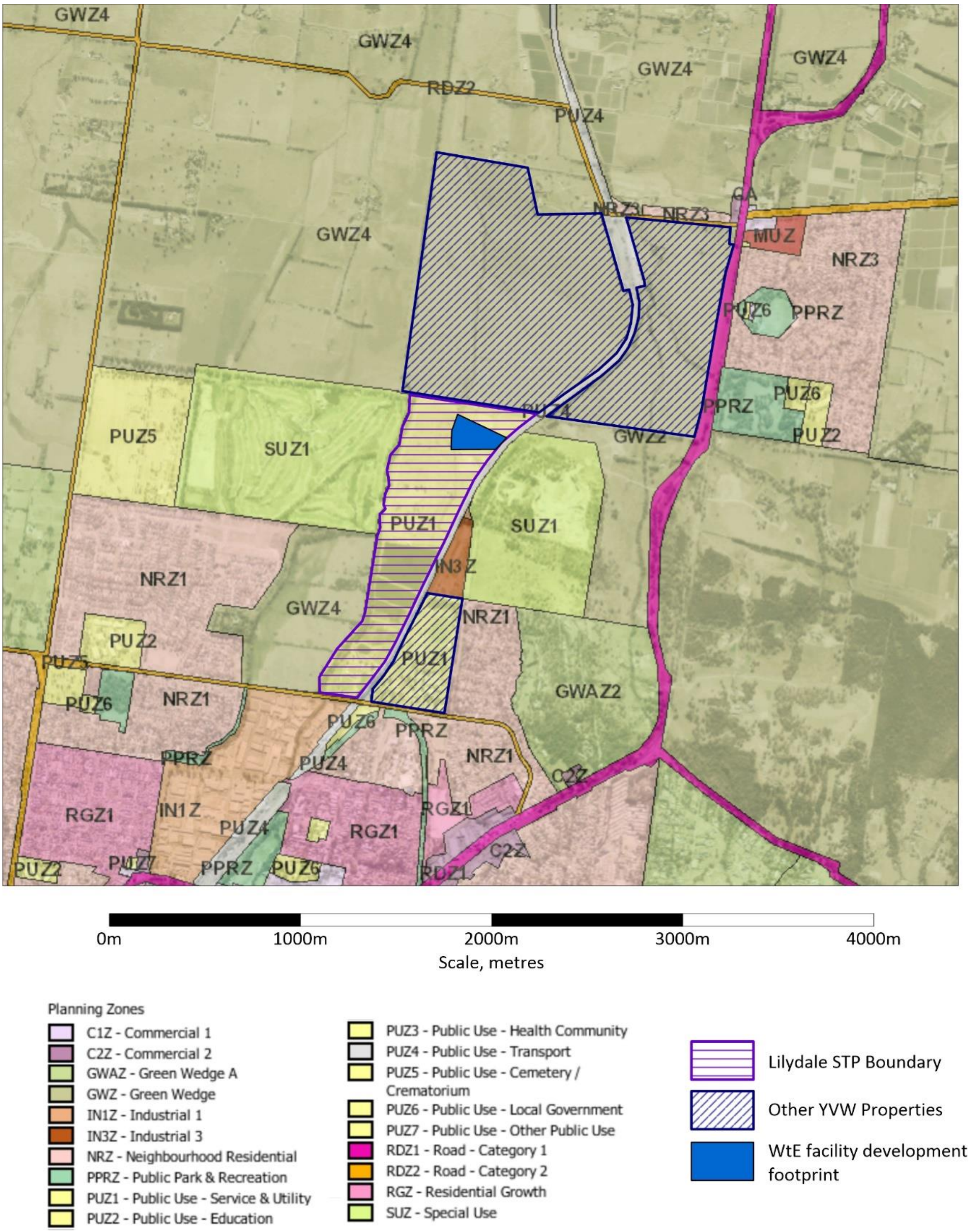

Figure 9 Land use zones – regional scale. Map from VicPlan https://mapshare.vic.gov.au/vicplan/, accessed 19 November 2020 and checked 31 August 2022.

3.7 Sensitive receptors

Several potentially sensitive receptor sites were identified and included in the model. The sites were selected to represent key land use areas, i.e. residential, recreational and industrial, as depicted in Figure 10.

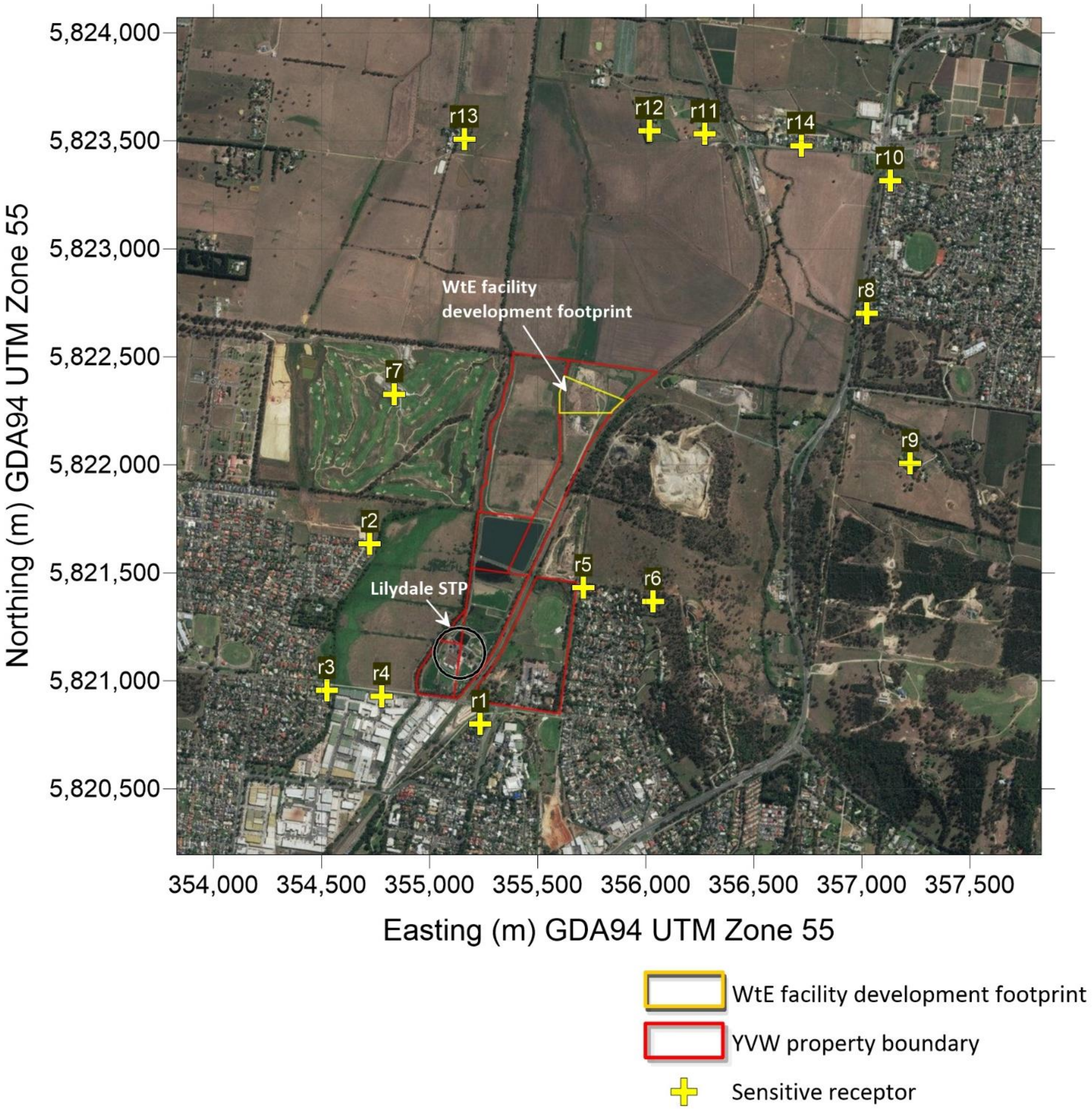

Figure 10 Base map showing modelled sensitive receptors

4. Emissions Inventory

4.1 Air Emission Sources

The design of the Lilydale WtE adopts best practice design measure described in the *EU BAT Reference for Waste Treatment* (EUR 29362) and incorporates improvements learnt from the operation of the Wollert WtE facility. This includes the use of more advanced technology for the elimination and management of air emissions and odour.

The air emission / odour sources identified of relevance for the risk assessment are summarised in the following Table.

Table Sources of Air Emissions

Source	Emission Type	Potential Contaminants	Existing Controls
Two Digestors 3,684 m^3 each	Emergency pressure relief valve	Biogas CH_4 (60-65%), CO_2 (30-35%), H_2O (5%), NH_3, H_2S	There are no permanent open vents on the digestors. Biogas is continuously monitored and treated in the head space of each tank. The tanks are double lined and are maintained with a slight pressure (using natural air) between the roofing layers. The digestors have weighted pressure release valves set at: • overpressure 10 mBar • vacuum relief pressure -2 mbar The valve automatically resets (in seconds) and release events can be monitored on the SCADA system.
Two CHPs 1.2 MW each	Continuous flow Point source	Products of complete / partial combustion Particulates, CO, CO_2, NOx, SOx, VOCs	Iron oxide dosing in the digesters to reduce hydrogen sulphide. Air sparging in the biogas to further reduce hydrogen sulphide. Condensation to remove moisture. In-line monitoring of select biogas quality. Compliance with German air quality standard TA Luft will be included in the contract.
Inlet & Outlet Tanks 1,637 m^3 each	Emergency pressure relief valve	Biogas (as above)	There are no permanent open vents. Biogas is continuously monitored and treated in the head space of each tank. The tanks are double lined and are maintained with a slight pressure (using natural air) between the roofing layers. The digestors have weighted pressure release valves set at: • overpressure 10 mBar • vacuum relief pressure -2 mbar The valve automatically resets (in seconds) and release events can be monitored on the SCADA system.
Anoxic treatment tank 800 m^3	Emergency pressure relief valve	Biogas	The tank is maintained under anoxic (i.e. oxygen free) conditions. It is fully contained and there are no permanent open vents. Air in the headspace will be withdrawn via a liquid condenser and discharged through the biofilters
Aerobic digester tank 1,500 m^3	Fugitive emissions	Biogas	The tank is enclosed and will be provided with air blowers to aerate the liquid digestate There are no permanent open vents Air in the headspace will be withdrawn via a liquid condenser and discharged through the biofilters
RO Permeate Tank 800 m^3	Fugitive emissions	None expected	Standard design under atmospheric pressure No specific air extraction or treatment required
Feedstock reception shed	Fugitive emissions	Odour, particulates	Enclosed building with automatic external roller doors and fast acting inner doors. Shed is maintained under slight negative pressure. All entrained air is discharged via the biofilter train.

Source	Emission Type	Potential Contaminants	Existing Controls
			The extraction fans ramp up when the doors open to allow vehicles to enter / exit (30 trucks per day).
Transport vehicles	Fugitive emissions	Odour, particulates	Vehicles must comply to relevant Vic Roads, EPA and industry standards for waste transport. Highly odours loads can be rejected or given priority access to unload in the feedstock receival shed. Inspection and unloading is only permitted inside the shed, with the doors closed. Estimate 30 trucks per day.
Digestate transport vehicles	Fugitive emissions	Odour, particulates	Material has been treated and odours are Negligible. Strict requirement for vehicles to be enclosed or covered.
Eight Biofilters 54 m^3 each	Point source	Odour, particulates	Design specifications Using proven technology Monitoring of control parameters (flow rate, pressure drop etc)
Emergency flare	Emergency only Point source	Products of complete / partial combustion Particulates, CO, CO_2, NOx, SOx, VOCs	Rigorous preventative maintenance regime Design specifications Using proven technology
Surface water catchment pond	Emergency only Disperse source	Odour	Pond may be impacted in the event of a large spill from a delivery vehicle. The spill would immediately be addressed and contaminated water recycled through the process.
Back-up generator	Emergency only Point source	Products of complete / partial combustion Particulates, CO, CO_2, NOx, SOx, VOCs	Only functions during an emergency and for short tests at 6 monthly intervals.
Cooling towers	Fugitive emissions	None expected	Designed and maintained in accordance with Australian Standard AS/NZS 3666 - Management of Cooling Towers

4.2 Input information

Table 10 presents the key design parameters that have been adopted to estimate emissions expected from the Project. The parameters are derived from technical drawings, CHP engine specifications, and design parameters advised by the WtE facility design team.

The diesel boiler manufacturer specifications do not provide emission factors for all key emitted pollutants. Missing emission factors (for PM_{10}, $PM_{2.5}$, SO_2 and PAHs) have instead been adopted from the National Pollutant Inventory emission factor database (NPI, 2011) and are listed in Table 11.

Table 10 Key design inputs supplied

Parameter	Value
Odour Treatment Biofilters	
Biofilter design odour concentration	<500 OU
Biofilter flow rate	1,200 m^3/hour (per biofilter, 8 biofilters in total)
Biofilter vertical height	3.3 m
Biofilter tank diameter	4.6 m
CHP Units	
Maximum biogas total sulfur content	140 mg/Nm^3 (used to calculate SO_2 emission rate by mass balance)
Exhaust gas concentration, NOx	<500 mg/Nm^3 (dry, 5% O_2)
Diesel Boiler	
Boiler model	Reillo RL100/M (diesel)
Output, max	1,482 kW

Parameter	Value
Boiler CO emissions	<40 mg/kWh
Boiler TVOC emissions	<10 mg/kWh
Boiler NOx emissions	<200 mg/kWh

Table 11 Adopted emission factors from NPI (2011) for diesel boiler

Pollutant	Emission factor (per volume of diesel consumed)
PM_{10}	0.117 kg/kL
$PM_{2.5}$	0.0251 kg/kL
PAHs	0.000188 kg/kL
TVOCs	0.0228 kg/kL

4.3 WtE Facility

4.3.1 Air pollutant emissions

Table 12 presents the air pollutant emission rates and key emission parameters modelled for the two 1.2 MW CHP units. Table 13 presents similar information for the diesel boiler.

Table 12: Modelled air pollutant emission rates and parameters, CHP Units

Parameter	Units	Value (per CHP)	Reference*
Rated capacity	MWe	1.2	
Energy input	kW	3,616	1
Exhaust temperature	°C	445	1
Assumed oxygen content of exhaust gas	%	11	Assumed based on testing at other similar installations
Assumed biogas heat content	MJ/Nm^3	20	Assumed based on other similar installations
Exhaust gas flow rate (actual at operating exhaust temperature and oxygen content, wet)	m^3/hr	12,514	1
Stack exit velocity	m/s	35	Assumed based on other similar installations
Stack diameter	m	0.356	Calculated from assumed stack exit velocity
Stack height	m	7	2
Discharge angle		Horizontal	2
NO_x emission rate	g/s	0.375	3
SO_2 emission rate	g/s	0.0386	4

*** Reference sources:**

1. Technical Data Sheet MTU 12V4000 GS.
2. Drawings showing building and stack elevations provided by project designers, March 2023.
3. Calculated assuming upper limit of manufacturer's stated emission factor range of 500 mg/Nm^3 (dry, 5% O_2)
4. Calculated assuming all sulfur in biogas (140 mg/Nm^3) is converted to SO_2 during combustion process

Table 13: Modelled air pollutant emission rates and parameters, diesel boiler

Parameter	Units	Value	Reference*
Rated capacity	kW	1,482	
Boiler efficiency	%	90	Assumed based on typical values

Parameter	Units	Value	Reference*
Energy input	kW	1,647	Calculated
Diesel calorific value	MJ/kg	44.5	Assumed based on typical values
Diesel density	kg/L	0.85	Assumed based on typical values
Stack diameter	m	0.2	Assumed
Stack exit velocity	m/s	10	Assumed
Stack height	m	6	Assumed based on typical values
Exhaust temperature	°C	200	Assumed based on typical values
NO_x	g/s	0.092	1
SO_2	g/s	0.00070	2
PM_{10}	g/s	0.0051	2
$PM_{2.5}$	g/s	0.0011	2
PAHs	g/s	0.0000082	2
TVOC	g/s	0.00099	1

*** Reference sources:**

1. Calculated assuming upper limit of manufacturer's stated emission factor range (summarised in Table 10)
2. Calculated using NPI (2011) emission factors (summarised in Table 11)

4.3.2 Odour emissions

4.3.2.1 Sources of odour at the WfE facility

The odour will be generated within the following activities at the WfE facility:

- Fugitive emissions from the waste receival shed during feedstock delivery
- Fugitive emissions from the delivery vehicles
- Treated emissions from the biofilters

4.3.2.2 Odour Control for Waste Receival Shed

The following activities will be conducted inside the waste receival shed:

- Vehicle movements
- Solids unloading
- Inspection and sorting of feedstock
- Depackaging of containerised food waste
- Macerating / mixing of feedstock and pumping to the inlet storage tank
- Washdown of vehicles and storage bays
- MCC (motor control centre)
- Liquid digestate storage tank

Tankered liquid feedstock can also be unloaded in a bunded area outside of the shed, from where it is pumped to the inlet tank.

The primary objectives of the odour control strategy for the waste receival shed are to ensure:

- air quality inside the building is suitable for personnel working in the building
- there is no adverse odour impact to the area beyond the site boundary.

The following controls have been adopted:

- No waste material is stored outside of the receival shed
- The shed will be maintained under slight negative pressure to minimise the escape fugitive emissions
- Double layered doors (automatic outer roller doors and inner fast acting doors) which minimise the time that the doors will be open during feedstock delivery
- Vehicles will only be permitted to unload once the doors are sealed
- Extraction fans draw air within the shed through a train of 8 biotrickling filters

- The fan speeds are linked to the doors, and increase speed (and therefor extraction) when the doors open
- All materials are processed during the business day. No depackaged feedstock will be permitted to be held overnight

Appendix A shows a preliminary configuration drawing for the biofilter design.

4.3.2.3 Biofilters

A train of 8 tank-style biofilters will treat odorous air from the receival shed, dryer enclosure, and the anoxic and aerobic tanks in the MBR.

The biofilters will operate concurrently, with flows controlled by pressure instrumentation installed at the inlet of each of the tank. Each biofilter has a design input air flow of 1,200 m^3/hr. The same volumetric air flow rate is assumed in the discharge from the biofilter.

Using the design specification of 500 OU, odour emission rates were calculated for each biofilter tank. Table 14 provides a summary of the emissions modelled as part of the impact assessment.

The biofilters are not fitted with stacks for the exhaust discharge; instead, treated air is released from around the roof of each tank. Therefore, the tank emissions were modelled as volume sources in the dispersion model. As such, the temperature and buoyancy of the discharge was not factored into the dispersion calculations which results in a conservative prediction of downwind odour concentrations.

Table 14: Biofilter odour emissions parameters

Parameter	Units	Value	Reference
Air flow	m^3/hr	1,200	Design specification
Odour concentration in discharge air	OU	500	Design assumption
Odour emission rate per biofilter	OU.m^3/s	165	Calculated

4.4 Lilydale STP

The Lilydale STP is a secondary treatment plant using the activated sludge treatment process. The STP includes the following main treatment elements:

- Inlet pump station with odour treatment filter.
- Preliminary treatment – flow measurement, screens and grit removal, with screenings and grit stored in bins.
- One primary sedimentation tank (PST), 20 m diameter.
- Secondary treatment through a biological nutrient reduction (BNR) reactor followed by secondary clarification (two clarifiers, 22 m diameter each)
- Open conveyance channels between primary and secondary treatment sources, and for return activated sludge.
- Tertiary treatment (sand filters, ultra-violet disinfection).
- Class B effluent storage in a lagoon
- Sludge dewatering, with dewatered sludge removed from site and delivered to Brushy Creek STP.
- Sludge lagoon for storage and drying of excess waste activated sludge (WAS).
- Storage lagoons for temporary wet weather overflows.

YVW has conducted an odour monitoring programme in 2022 to baseline odour emissions around the Lilydale STP and WtE areas. This data has been included in the dispersion model for the Project. A summary of modelled odour emission rates is presented below in Table 15.

Table 15 Summary of modelled odour emissions for Lilydale STP (data supplied by YVW)

Source	Odour Emission Rate	Units
Secondary Clarifier #1	1.6	OU.m^3/m^2/min
Secondary Clarifier #2	1.6	OU.m^3/m^2/min
Inlet Pump Station	6,000	OU.m^3/min
Primary Sedimentation Tank	650	OU.m^3/m^2/min

Source	Odour Emission Rate	Units
Sludge Lagoon	10.35	$OU.m^3/m^2/min$
Aerobic Tanks	40	$OU.m^3/m^2/min$
Anoxic Tanks	43	$OU.m^3/m^2/min$

5. Assessment Methodology

5.1 Model selection

The modelling for the Project was conducted with the CALPUFF model. CALPUFF is an advanced "puff" dispersion model that can simulate dispersion in complex situations with very low wind speeds and non-uniform topography. In a "puff" model, pollutant releases are represented by a series of puffs of material which are transported by the winds across the modelling domain. CALPUFF is approved for regulatory use by the United States Environmental Protection Agency and is widely used in Australia and New Zealand in complex modelling situations.

EPA Publication 1961 states that the preferred dispersion model is AERMOD, although alternative models that are fit for purpose are acceptable in highly complex scenarios. The topography of the Yarra Valley, and the high frequency of calm wind speeds and stable atmospheric conditions presents a complex geographical and meteorological situation where AERMOD is less fit for purpose than the CALPUFF model.

A consequence of the use of advanced dispersion models like CALPUFF is that these models require detailed meteorological input data to accurately simulate the complex dispersion effects. Therefore, the CALPUFF model is accompanied by the separate meteorological processor model CALMET which must be run first to prepare wind data for use by the CALPUFF model. The CALMET model itself requires detailed input data concerning land use, terrain heights, cloud layers, and surface and upper air meteorological data across the domain which is to be modelled.

Guidance on running CALMET and CALPUFF for modelling applications in New South Wales was prepared for the NSW EPA by TRC Environmental Corporation (OEH, 2011). Since its publication, the guidance in OEH (2011) become widely adopted by consultants in Australia and New Zealand as a best practice guideline for CALMET and CALPUFF modelling. The guidance in that document was followed in the preparation of CALMET and CALPUFF models for the Project.

5.2 CALPUFF modelling system

5.2.1 CALMET

CALMET is a meteorological model which includes a diagnostic wind field generator containing objective analysis and parameterised treatments of slow flows, kinematic terrain effects, terrain blocking effects, and a divergence minimization procedure, and a micrometeorology model for overland and overwater boundary layers. The CALMET model is used to develop meteorological data in the format required in the CALPUFF air dispersion model.

The CALMET model was run in "observations only" mode. Wind speed, wind direction, ambient temperature, sigma theta data, and supplementary data (such as surface pressure, cloud observations, relative humidity and rainfall) were provided by BoM for the Coldstream AWS. Upper air (radiosonde) data from Melbourne Airport was also used for construction of an upper air meteorological data file for use in CALPUFF.

Land use categories were assigned for a 10 km x 10 km region, centred on the Lilydale WtE site. These land categories were used to assign Albedo and Bowen ratios. Surface roughness was assigned for each of seven wind direction sectors, and for four segments within each sector.

5.2.2 CALPUFF

CALPUFF is a regulatory model and is recommended for a wide variety of applications including long range transport and on a case-by-case basis, for near-field applications such as in coastal applications, complex flows and non-steady state situations, such as coastal applications, calm wind dispersion, stagnation, fumigation, complex terrain, and chemical transformation. It is suitable for source receptor distances from fence–line applications (tens of metres) to several hundred kilometres.

CALPUFF is a three-dimensional non-steady state Gaussian puff model which is particularly suited for near-field impact assessments in complex geographical locations where there are spatially varying flows.

Of significance for this Project, the dispersion model can characterise:

- Emission plume history, where the positions of the airborne emissions (puffs) are stored from one hour to the next.

- Enabling the simulation of curved, recirculating, or stagnating transport of the emissions.
- Emission plume transport during near calm winds events, including build-up and fumigation.
- Dispersion over a range of land surfaces or water bodies.

Cumulative impacts for many sources within a spatially varying flow field, and a range of emission source types including point, area, volume, and buoyant line plume sources with time-varying emission conditions.

5.2.3 Model settings

Table 16 presents a summary of the key input model settings for the CALMET meteorology model and the CALPUFF dispersion model. Figure 11 presents the modelled CALMET and CALPUFF domains.

Table 16 Summary of model input parameters

Parameter	Input
CALMET (v6.42)	
Meteorological grid domain	15 km x 15 km (120 x 120 cells)
Meteorological grid resolution	125 m
Reference grid coordinates (centre)	355,517m E; 5,822,132m S (UTM, zone 55)
Cell face heights in vertical grid	0, 20, 40, 80, 160, 320, 640, 1200, 2000, 3000 and 4000 m
Simulation length	5 years
Modelling mode (NOOBS)	Obs only (0)
Surface meteorology stations	BoM Coldstream
Upper air meteorology stations	Melbourne Airport
Terrain data	SRTM Version 3.0 (~30m)
Land use data	ACLUMP (Land Use South Australia 2008-2017)
TERRAD (terrain radius of influence)	10.0 km
RMAX1	5.0 km
RMAX2	5.0 km
R1	2.0 km
R2	2.0 km
CALPUFF (v7.2.1)	
Computational grid	62 x 60 cells (8 km x 8 km)
Number of sensitive receptors	27
Dispersion modelling period	Jan 2016 to Dec 2020
Dry deposition modelled (MDRY)	1 - Yes
Wet deposition modelled (MWET)	0 - No
Chemical transformation method (MCHEM)	0 - Not modelled
Dispersion coefficients (MDISP)	2 - Dispersion coefficient, use turbulence computed from micrometeorology
Minimum turbulence velocities (SVMIN)	0.2 m/s

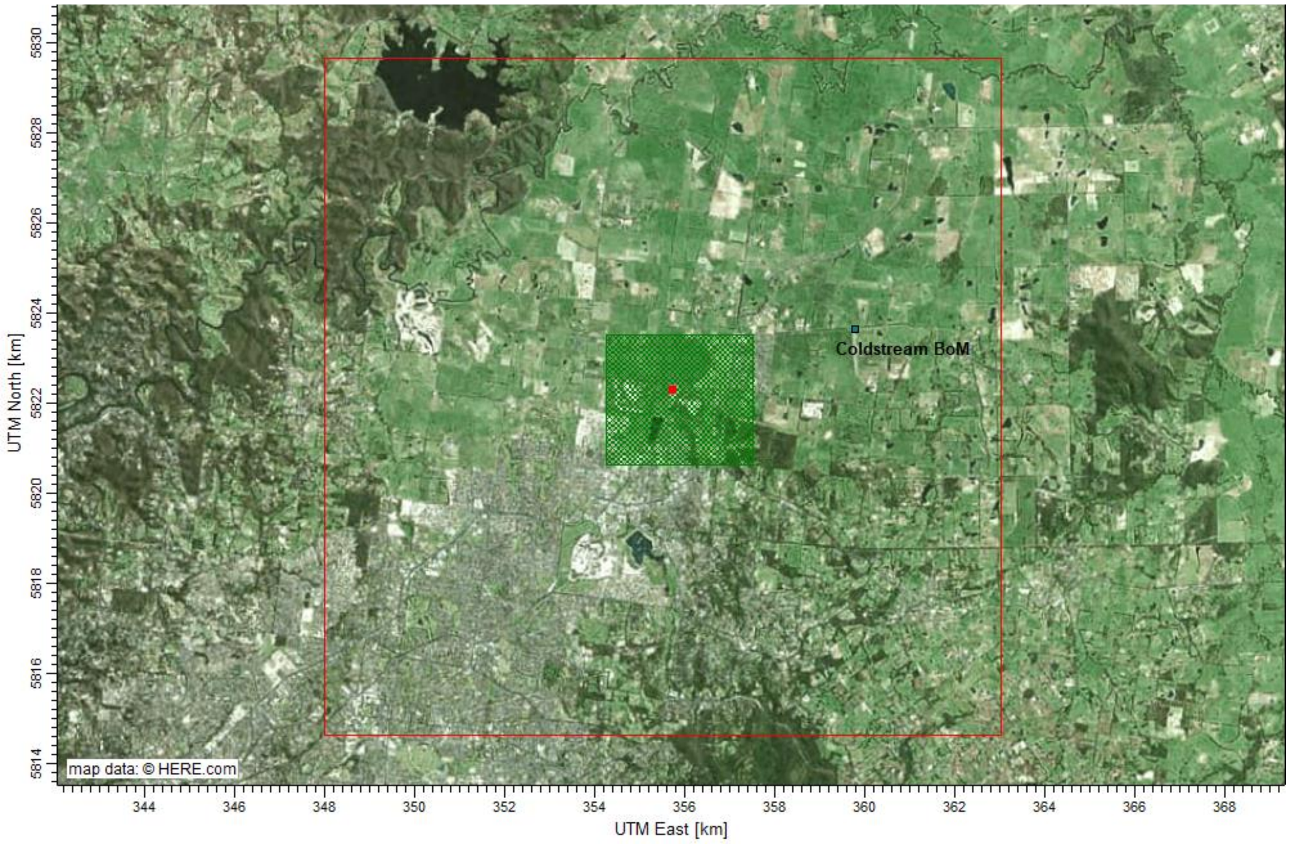

Figure 11 Modelled domains – red boundary indicates CALMET and CALPUFF modelled domain. Green boundary indicates the modelled sampling grid receptors.

5.3 NO_x to NO_2 conversion method

Oxides of nitrogen (NO and NO_2) will be formed at high temperatures during the combustion of fuel in the CHP units. The majority of the NO_x formed will be NO. After combustion, as the plume exits the stack and disperses, the NO is oxidised to NO_2 by ozone in the atmosphere. To estimate the NO_2 concentrations in the ambient atmosphere, it is necessary to estimate the extent of conversion of NO to NO_2 in the gas plume exiting the CHP units.

For this assessment, the NO_2 emissions in the exhaust were estimated using a 30% conversion rate of NO to NO_2, plus 10% for the assumed proportion of NO_x present as NO_2 in the discharge (i.e. total conversion rate 40%). The 30% conversion rate for NO to NO_2 was determined from a review of ambient NO_x levels and calculated ratios for the Mooroolbark monitoring station for 2014 which were provided to Jacobs by EPA in 2017. The assessment indicated that typically, NO_2 to NO_x ratios trended towards 20%-30% for higher measured NO_x concentrations, as shown in Figure 12.

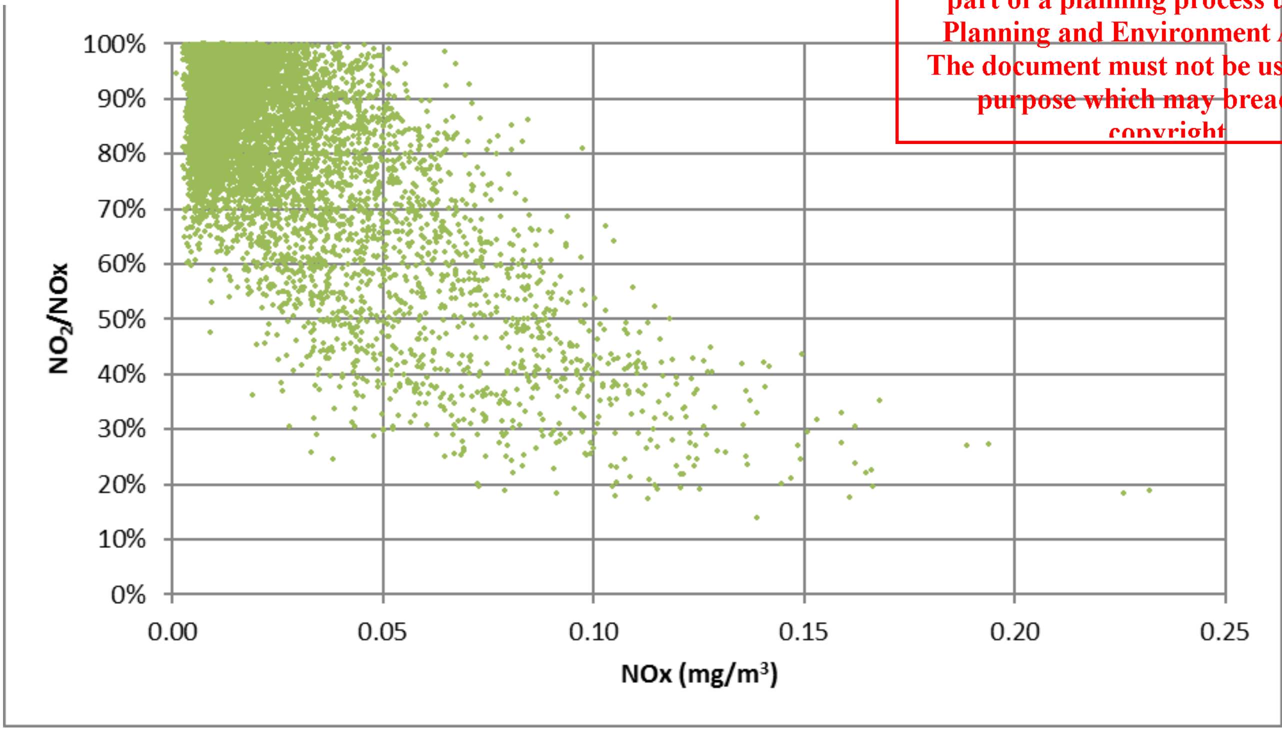

Figure 12 NO_2 to NO_x ratio trend, 1-hour average concentrations from Mooroolbark AQMS for 2014.

5.4 Cumulative assessment approach

Dispersion modelling results predict incremental changes in ambient air quality due to Project emissions. These incremental results must be added to relevant background air quality concentrations to predict the cumulative concentration which is compared to the adopted air quality objectives.

In this AQIA for NO_2 and SO_2 the incremental concentrations are added to maximum ambient background concentrations as a simple and conservative first estimate of cumulative concentrations. This approach was sufficient to complete the assessment for those pollutants. The adopted background concentrations for which this cumulative assessment method was applied are listed in Table 17.

Table 17 Summary of Adopted Background Concentrations

Pollutant	Background concentration (µg/m³)	Averaging Period	Rationale
NO_2	100	1 hour	Mean of 1-hour average yearly maximum for years 2016-2020 from Table 5
	20.5	1 year	Maximum of annual average for years 2016-2020 from Table 5
SO_2	28	1 hour	Mean of 1-hour average yearly maximum for years 2016-2020 from Table 6
	10.7	24 hours	Maximum of 24-hour average yearly maximums for years 2016-2020 from Table 6

However, for PM_{10} and $PM_{2.5}$ the background air quality concentrations already exceed the air quality objectives on a few days per year, and therefore a cumulative assessment for the Project is more complex. In Publication 1961, EPA recommends that when background air quality concentrations are high, it is useful to consider whether the incremental contribution of the source is a significant addition to what naturally occurs in the environment. The guideline recommends that as a general rule an increment of 4 % of the relevant APACs can be applied at the most impacted sensitive location and explains that this figure indicates a contribution so small that it is unlikely to result in measurable impacts in the population. This approach was adopted for this AQIA and was sufficient to complete the cumulative assessment for fine particles.

For TVOCs and PAHs, background concentrations were assumed to be zero and therefore the incremental Project concentration was compared to the relevant air quality objectives to complete the assessment.

5.5 Limitations of modelling assessment

The modelling assessment of the Project was based on the following assumptions and limitations:

- Uncertainties in published emission factors used to estimate Project emissions. The air pollutant emission factors may be influenced by site specific and temporal factors such as equipment selection, and local meteorological conditions. The published factors currently represent the best available estimates of emissions in Australia and may or may not provide an accurate estimate of Project emissions. The modelling assessment assumes referenced published values are applicable for the Project site.
- Computational dispersion modelling uses current knowledge of meteorological and atmospheric processes approximated by mathematical equations to represent these complex processes, which can then be predicted with minimal computational resources. This simplification comes at the expense of the accuracy of model predictions. To address these shortcomings, dispersion models tend to provide conservative estimates of pollutant concentrations.
- Emissions are assumed to occur at the maximum rates identified, 24 hours per day, every day of the year.

Based on these limitations of the modelling assessment methodology, results from this assessment are considered conservative in nature.

6. Modelled Meteorology

The following sections provides a summary of the modelled meteorology and a comparison to measured data from the BoM Coldstream monitoring station.

6.1 Winds

The period between 2016 and 2020 was selected as the assessment period to represent long-term climatic trends. Table 18 compares the modelled wind speeds generated by CALMET with historical monitoring data from the BoM Coldstream monitoring station. Wind roses and statistical plots from the observed and modelled meteorological data are presented in Appendix C.

Table 18 Summary of winds data analysis

Year	Wind parameter	Project Site		BoM Coldstream	
		CALMET prediction	Observation	CALMET prediction	Observation
2016-2020	Minimum (m/s)	<0.5	-	<0.5	<0.5
	Average (m/s)	2.3	-	2.4	2.4
	Maximum (m/s)	12.5	-	12.4	12.4
	Calms (%)	26	-	25	25

Table notes:

1. Calm conditions are assumed to occur where wind speed is less than 0.5 m/s

From review of the wind roses from both monitoring data and CALMET generated data, the following observations are made:

- Due to the adopted methodology of using observations to inform the wind simulations, CALMET predicted winds and calms percentages for the BoM Coldstream location are almost identical. For the Project site, wind speeds were slightly lower with an average wind speed of 2.3 m/s although the percentage of calm winds was equivalent at 25-26%. This is due to the methodology adopted to model winds in CALMET, where winds from the BoM Coldstream monitoring station were used to drive the predicted meteorology for the area.
- Wind directions measured at the Coldstream BoM station generally reflected the CALMET winds at both the Project site and Coldstream BoM station.

Overall, the winds simulated by CALMET generally represent measured meteorology at the Coldstream BoM monitoring site.

6.2 Mixing height

Mixing height or mixed layer height is an important meteorological parameter for air quality as it determines the height of vertical diffusion of atmospheric pollutants in the boundary layer (Aron, 1983; Stull, 1988; Tang *et al.*, 2016). Mixing height is estimated within CALMET for stable and convective conditions, with a minimum mixing height of 50 m and maximum height of 3,000 m.

Figure 22 and Figure 23 in Appendix C show the mixing height statistics by hour of the day at the Project site and Coldstream BoM from the CALMET predictions.

The model predictions are consistent with general atmospheric processes that show increased vertical mixing with the progression of the day through, as well as lower mixing heights during the night-time. The mixing height predictions show a typical diurnal pattern of mixing height gradual growth from morning continuing through the day, and subsequent steep decline in the evening. There is minimal observable difference in mixing heights between the Coldstream BoM and the Project site due to the short distance between the two locations and the similar topography influencing meteorology at each site.

6.3 Atmospheric stability

Stability class is used as an indicator of atmospheric turbulence in meteorological models. The class of atmospheric stability generally used in these types of assessments is based on the Pasquill-Gifford-Turner (PG) scheme, which uses six categories (A to F) to describe atmospheric stability based mainly on static stability (vertical temperature profile/structure), convective turbulence (caused by radiative heating of the ground) and mechanical turbulence (caused by surface roughness). In general, stable conditions result in less atmospheric mixing and poorer dispersion, and unstable conditions are more turbulent and result in greater mixing in the boundary layer. The PG stability classes are as follows:

- A: Very unstable
- B: Moderately unstable
- C: Slightly unstable
- D: Neutral
- E: Slightly stable, and
- F: Stable.

The stability class frequency distribution from the CALMET model for the Coldstream AWS location and Project site is shown in Figure 24 and Figure 25 (Appendix C), and stability class by hour of day is shown in Figure 26 and Figure 27 (Appendix C).

The frequency distributions indicate a high proportion of stable conditions, with fewer highly and moderately unstable conditions. Stable conditions occur only during night-time hours and very unstable conditions are limited to the daylight hours in the middle of the day. The predominant stability classes are consistent with typical distributions for inland areas around Australia.

6.4 Suitability of developed meteorology

A five-year meteorological dataset for the period of 2016 to 2020 has been prepared for the Project location centred in Lilydale. The method involved incorporating observation measurements from the Coldstream BoM and Melbourne Airport BoM monitoring stations into the CALMET meteorological pre-processor and diagnostic model. The findings show that the CALMET model predicts wind flows at the Project site to be similar to the Coldstream BoM station when incorporating terrain and land use data for the area.

A key assumption of the CALMET meteorology is that the observations from the Coldstream AWS are representative of the site and allow the CALMET model to correctly estimate winds experienced at the Project site after adjustment for terrain and land use influences.

From the analysis of wind speed, mixing height and atmospheric stability detailed in Sections 6.1-6.3, the predicted meteorology is considered fit for purpose and acceptable for use in modelling of odour and air emissions for the Project.

7. Air Quality Impact Assessment

7.1 Odour

7.1.1 Level 2 Odour Assessment

As introduced in Section 2.4, the Level 2 odour assessment in Publication 1883 consists of two tools: the cumulative effects test and the source-pathway receiving environment tool.

The cumulative effects test takes into consideration the effects of multiple odour sources. This test is applicable to the Project because of the neighbouring Lilydale STP, and the two sites together would be classified as a “clustered industry” according to Publication 1883, for which a Level 2 assessment is appropriate.

The Level 2 qualitative source-pathway-receiving environment tool was scored for the Project following the procedure outlined in Publication 1883 Chapter 5.

Scoring is based on three attributes:

1. Hazard potential of the source (odour source score – OSS)
2. Exposure pathway between the source and sensitive locations (odour pathway score – OPS)
3. Sensitivity of the receiving environment (odour receiving environment score – ORS)

Each attribute is broken up into categories, a score of 1-3 is then applied to each category, except for certain high-risk odour activities where the default is 4. The overall score for each attribute is the highest score for each attribute.

Weightings are also applied to

- the OSS based on the odour controls in place
- the ORS based on any relevant compliance or community history

All the attribute scores are added together to get an overall risk score which will normally range between 1 and 12.

Based on the score, the following recommendations for odour risk and further assessment are indicated in Publication 1883:

1 to 7 – low risk: The risk of odour is low.

8 or 9 – medium risk: Borderline cases – there may be one element that can influence the score and tip it into a low or high score. In these cases, this should be explored further.

10 to 11 – high risk: A level 3 assessment is recommended to fully understand risk.

12 – very high-risk: A level 3 assessment is not likely to demonstrate risk is acceptable but may provide further illustration on the nature of the risks and/or inform on odour mitigation measures.

The scoring for the Project is provided in Table 19, using the formatting recommended in Appendix C of Publication 1883. A score of 9 is calculated, implying a medium risk potential.

A Level 3 assessment is considered appropriate for the Project because the source is adjacent to the Lilydale STP and in a receiving environment with high proportion of calm/light winds as well as some historical heightened sensitivity to odour due to a previous composting operation. The remainder of this section details the Level 3 odour assessment.

Table 19: Level 2 Odour Risk Assessment – following Appendix C template, Publication 1883

Category	Criteria	Comment	Score - Least Conservative Estimate	Score - Most Conservative Estimate
Hazard potential of the source	Activity type	Organics, industrial waste treatment	3	3
	Size of odour hazard	55,000 tonnes per year processed	2	3
	Character of odour emission	Untreated Project odours are rated "Unsafe" in Appendix B of Publication 1883, but residual odour after treatment would be "Unwelcome" or "Innocuous" character	2	3
	Level of control (weighting of -1, 0 or +1)	High weighting - tangible mitigation measures in place and fully enclosed operations	-1	-1
(Odour source score, OSS)			3	3
Exposure pathway between the source and sensitive locations	Distance	Tens to hundreds of metres from sensitive receptors	2	2
	Meteorology	Neutral - even distribution of winds (10-20%) from source to receiving environment, particularly for the closest sensitive receptors	2	2
	Terrain and built form	Source is upslope of receiving environment, relatively flat cleared land.	3	3
	Hours of operation	Emissions occur 24/7	3	3
(Odour pathway score, OPS)			3	3
Sensitivity of the receiving environment	Historical context weighting	Some historical heightened sensitivity	1	1
	Receiving environment	Residential, schools, recreational.	3	3
(Odour receiving environment score, ORS)			4	4
Total score			9	9
Recommendation	A score of 9 implies medium risk potential - borderline case where there may be one element that can influence the score and tip it into a low or high score. In this case, a Level 3 assessment is recommended due to the neighbouring STP, the receiving environment having a high proportion of calm/light winds, and some local historical heightened sensitivity to odour			

7.1.2 Scenarios modelled

Dispersion modelling of odour emissions was carried out for two scenarios:

- **Scenario A:** WtE odour emissions only
- **Scenario B:** WtE plus background odour from the existing Lilydale STP

7.1.3 Odour modelling impact assessment criteria

EPA Publication 1883 does not support using modelling alone to predict odour concentrations at ground level as a tool to demonstrate compliance against odour objectives. However, the guideline acknowledges that modelling can be a useful tool provided the limitations of modelling are understood, particularly "relative" dispersion modelling. Relative dispersion modelling is used to compare different emission scenarios through the analysis of the relative variations in predicted ground level concentrations (GLCs) of odour.

As such, the odour modelling in this AQIA was conducted with the intention of comparing relative GLCs between scenarios, and not to demonstrate compliance with odour concentration criteria.

However, relative dispersion modelling by itself is not useful to understand the potential for offensive odour impacts beyond the site boundary for a new activity. The former EPA State Environment Protection Policy for Air Quality Management (SEPP(AQM), 2001) (replaced by the ERS in 2021) specified an impact assessment criteria (IAC) for odour which was "*1 OU, to be met for at least 99.9 percent of the modelling hours, based on a 3-minute averaging time*". This was a very stringent criteria compared with other States in Australia. The percentile term refers to the percentage of time per annum at each downwind receptor that a specified odour concentration is not exceeded. For example, a single year contains 8,760 hours of meteorological data records. The 99.9th percentile at each receptor would be the 9th highest prediction at the location from the year of meteorological data records that were simulated. Percentile terms are commonly used in IAC for odour but vary between jurisdictions typically from 99.0 to 99.9 %.

To provide context for the model results predicted for the WtE facility odour emissions, the IAC from the SEPP(AQM) is used as a conservative benchmark to compare against the model results for Scenario A (i.e. the model for WtE facility odour emissions alone). It is noted that this IAC is not relevant to the model results for Scenario B and the model results from that scenario is provided only for relative modelling purposes.

7.1.4 Model results

Modelling of odour emissions from the proposed WtE facility was conducted for each of five years of hourly meteorological data sets (2016 – 2020), to show the extents of potential impact and change in impacts for each scenario. Contour plots of modelled results for each scenario are presented in Figure 13 and Figure 14.

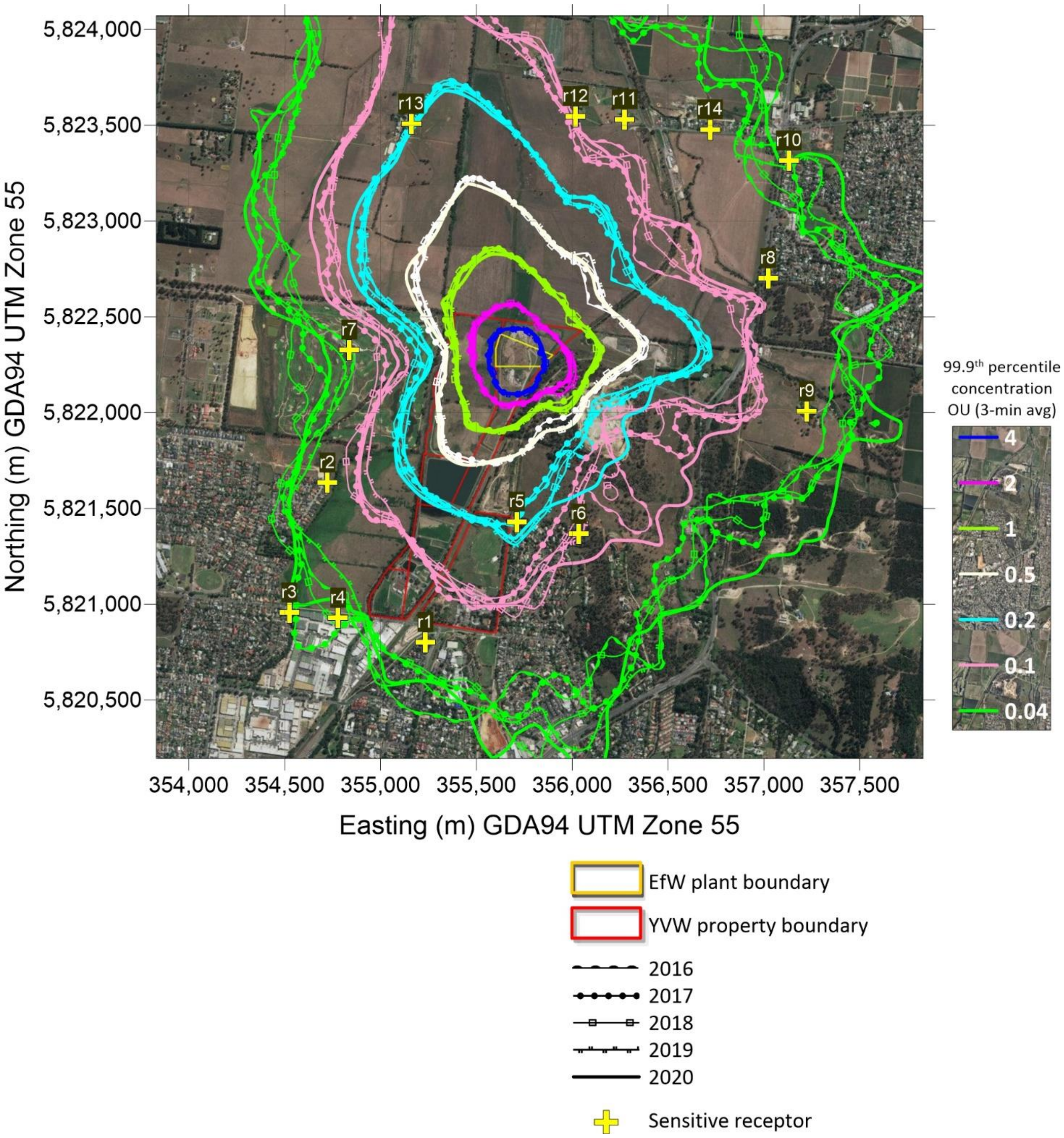

Figure 13 Odour model results for Scenario A – Project-only predicted odour concentration (OU), 3-minute average, 99.9th percentile.

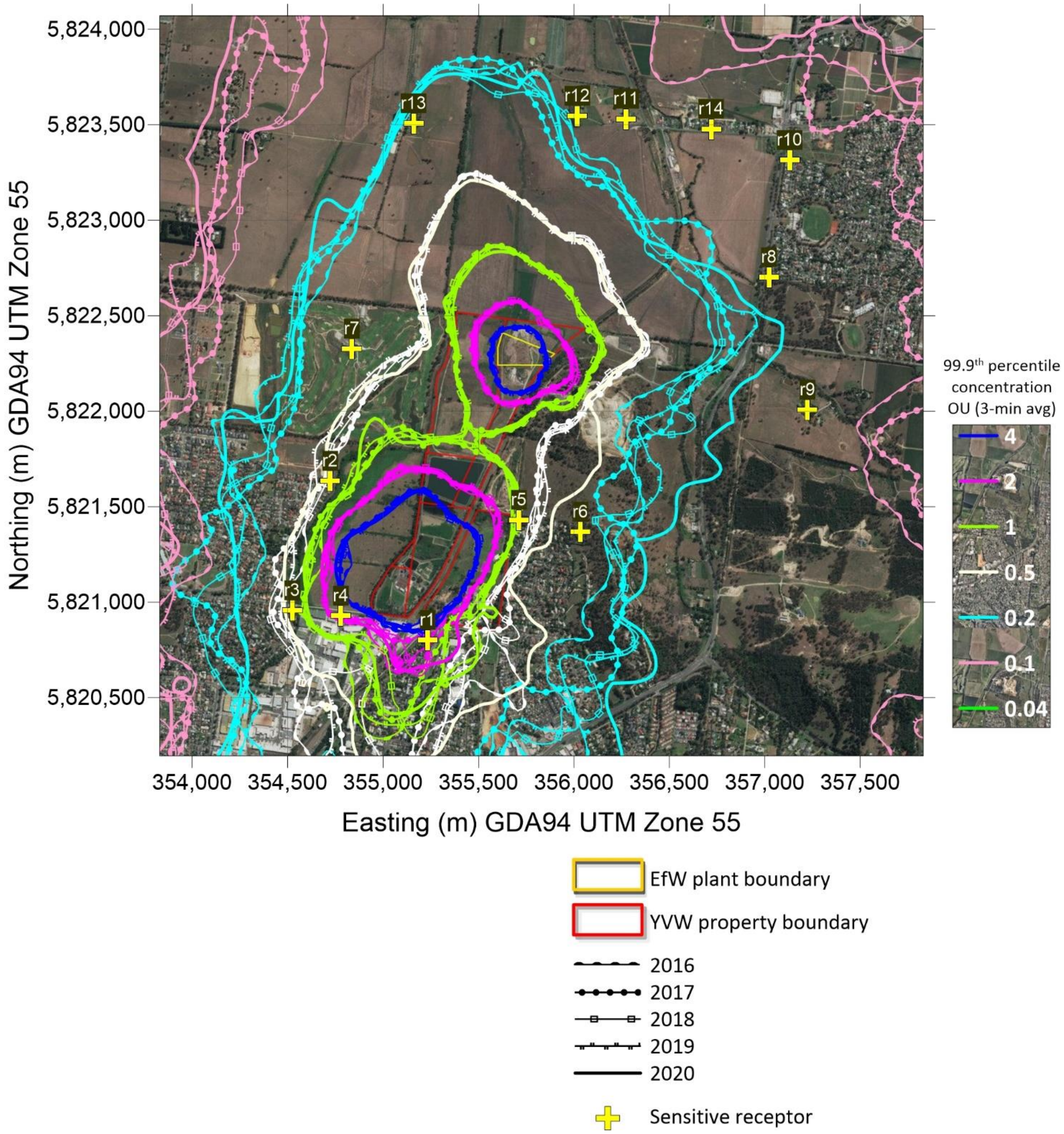

Figure 14 Odour model results for Scenario B – Cumulative Project and Lilydale STP predicted odour concentration (OU), 3-minute average, 99.9th percentile

Table 20 summarises the odour model results at each nominated sensitive receptor for the two scenarios. In preparing this table, the predicted 99.9th percentile odour concentration at each receptor for each of the five years of meteorological data was extracted from the model, and the maximum of those five results for each receptor is reported in the table.

Table 20 Predicted odour concentrations for identified sensitive receptor locations, highest results from five calendar years of meteorological simulations (OU, 99.9th percentile, 3-minute average)

Sensitive Receptor	Project only	Project and STP	Sensitive Receptor	Project only	Project and STP
R1	0.06	3.7	R8	0.08	0.17
R2	0.08	0.64	R9	0.06	0.14
R3	0.04	0.83	R10	0.04	0.13
R4	0.04	2.4	R11	0.08	0.16
R5	0.24	0.95	R12	0.10	0.19
R6	0.15	0.36	R13	0.20	0.23
R7	0.07	0.39	R14	0.06	0.14

Scenario A – WtE odour emissions only (no background)

The 1 OU contour extends beyond the boundary of the Lilydale STP site (marked by the red lines on the figures) to the north and to the east, but not in the vicinity of any sensitive receptors. The maximum predicted odour concentration at the Lilydale STP site boundary is 5.0 OU, occurring at the eastern boundary, southeast of the WtE facility development. The maximum predicted odour concentration at any of the sensitive receptor sites is 0.24 OU, occurring at R5 which represents the closest residential zone boundary south of the Project site.

Scenario B – WtE and existing STP odour emissions

The maximum predicted odour concentration at any of the sensitive receptor locations is 3.7 OU, occurring at R1 in the residential zone near the southeast corner of the Lilydale STP boundary. At this receptor, the Project contributes a very small incremental odour concentration of 0.06 OU.

The model results for odour for Scenario A led to the conclusion that in isolation, the predicted odour emissions from the WtE facility pose a very low risk of causing offensive odours beyond the site boundary. Further, for receptors close to the Lilydale STP (such as R1-R5), the STP is the dominant odour source relative to the WtE facility and there is no change to the risk of occurrence of offensive odours due to the cumulative emissions from both sources, compared to the current situation.

7.2 Combustion pollutants

7.2.1 NO_2

Figure 28 and Figure 29 in Appendix D show the 1-hour average and annual average incremental concentration predictions for NO_2, using the 40% NO_x-to-NO_2 conversion assumption explained in Section 5.3. Table 21 presents a summary of the predicted NO_2 concentrations. The results are presented for the following categories:

- "Project only": incremental concentrations due to emissions from the Project without any background concentrations added.
- "Cumulative": total of Project plus background concentrations (as per Section 5.4) that are to be compared against the adopted air quality objectives. For the 1-hour average in particular, this cumulative concentration is very conservative because of the high assumed background concentration.

In preparing this table, the predicted 99.9th percentile 1-hour average or annual average at each receptor for each of the five years of meteorological data was extracted from the model, and the maximum of those five results for each receptor and each averaging period is reported in the table.

Table 21 Summary of maximum predicted NO_2 concentrations, highest results from five calendar years of meteorological simulations

Receptor	Predicted pollutant concentration			
	99.9th % 1-hour average (µg/m^3)		Annual average (µg/m^3)	
	Incremental (Project only)	Cumulative [1]	Incremental (Project only)	Cumulative [1]
Highest predicted concentration outside the boundary of the WtE facility development footprint	66	166	5.0	25.5
Discrete receptors				
R1	3.2	103.2	0.03	20.5
R2	7.5	107.5	0.04	20.5
R3	3.9	103.9	0.05	20.5
R4	5.2	105.2	0.08	20.6
R5	9.3	109.3	0.26	20.8
R6	17.0	117.0	0.24	20.7
R7	2.4	102.4	0.03	20.5
R8	7.0	107.0	0.08	20.6
R9	9.9	109.9	0.10	20.6
R10	3.6	103.6	0.04	20.5
R11	3.9	103.9	0.04	20.5
R12	5.3	105.3	0.05	20.6
R13	11.5	111.5	0.21	20.7
R14	4.0	104.0	0.04	20.5
Background only (without Project)		100		20.5
Adopted Air Quality Objective (µg/m^3)		164		31

1. Project emissions plus assumed background concentration of 100 µg/m^3.

2. Project emissions plus assumed background concentration of 20.5 µg/m^3.

Incremental concentrations are minor compared to the assumed background. The cumulative predicted NO_2 concentrations at sensitive receptors are lower than the air quality objectives for both averaging periods, despite the conservative approach of adding the incremental concentrations to the highest background concentrations.

The cumulative predicted NO_2 concentration at the WfE facility development boundary (the area outlined in yellow on Figure 28) slightly exceeds the air quality objective on the north boundary of the facility, however this location is rural land owned by YVW and is not a potentially sensitive receptor.

7.2.2 SO_2

Figure 30 and Figure 31 in Appendix D show the 1-hour and 24-hour average incremental concentration predictions for SO_2. Table 22 presents a summary of the predicted incremental and cumulative SO_2 concentrations at each receptor. In preparing this table, the predicted 99.9th percentile 1-hour average or maximum 24-hour average at each receptor for each of the five years of meteorological data was extracted from the model, and the maximum of those five results for each receptor and each averaging period is reported in the table.

Incremental concentrations are minor compared to the assumed background. The cumulative predicted SO_2 concentrations beyond the WtE Facility development footprint are much lower than the air quality objectives for both averaging periods, despite the conservative approach of adding the incremental concentrations to the highest background concentrations.

Table 22 Summary of maximum predicted SO_2 concentrations, highest results from five calendar years of meteorological simulations

Receptor	Predicted pollutant concentration			
	99.9th percentile 1-hour average ($\mu g/m^3$)		Maximum 24-hour average ($\mu g/m^3$)	
	Incremental (Project only)	Cumulative [1]	Incremental (Project only)	Cumulative [2]
Highest predicted concentration outside the boundary of the WtE facility development footprint	11.5	39.5	5.0	15.7
Discrete receptors				
R1	0.76	28.8	0.11	10.8
R2	1.74	29.7	0.15	10.9
R3	0.95	28.9	0.20	10.9
R4	1.08	29.1	0.23	10.9
R5	2.33	30.3	0.44	11.1
R6	4.38	32.4	0.78	11.5
R7	0.41	28.4	0.27	11.0
R8	1.66	29.7	0.29	11.0
R9	2.18	30.2	0.47	11.2
R10	0.86	28.9	0.19	10.9
R11	0.91	28.9	0.12	10.8
R12	1.22	29.2	0.18	10.9
R13	2.62	30.6	0.34	11.0
R14	0.92	28.9	0.12	10.8
Background only (without Project)		28		10.7
Adopted Air Quality Objective ($\mu g/m^3$)		214		57

1. Project emissions plus assumed background concentration of 28 $\mu g/m^3$.

2. Project emissions plus assumed background concentration of 10.7 $\mu g/m^3$.

7.2.3 PM_{10} and $PM_{2.5}$

Figure 32 to Figure 35 in Appendix D show the 24-hour and annual average incremental concentration predictions for PM_{10} and $PM_{2.5}$. Table 23 presents a summary of the predicted incremental PM_{10} and $PM_{2.5}$ concentrations at each receptor.

In preparing this table, the predicted maximum 24-hour average or annual average at each receptor for each of the five years of meteorological data was extracted from the model, and the maximum of those five results for each receptor and each averaging period is reported in the table.

The predicted incremental concentrations at discrete receptors are all much lower than the "4% of the air quality objective" threshold, indicating as recommended by EPA in Publication 1961 that the incremental contributions of PM_{10} and $PM_{2.5}$ will be so small that it is unlikely to result in measurable impacts in the population.

Table 23 Summary of maximum predicted PM_{10} and $PM_{2.5}$ concentrations

Receptor	Incremental predicted concentration			
	PM_{10}		$PM_{2.5}$	
	24-hour average (µg/m³)	Annual average (µg/m³)	24-hour average (µg/m³)	Annual average (µg/m³)
Highest predicted concentration outside the boundary of the WtE facility development footprint	2.0	0.36	0.47	0.079
Discrete receptors				
R1	0.03	0.0012	0.006	0.0003
R2	0.04	0.0017	0.009	0.0004
R3	0.06	0.0021	0.013	0.0005
R4	0.11	0.0044	0.024	0.0010
R5	0.07	0.0079	0.016	0.0017
R6	0.10	0.0043	0.022	0.0009
R7	0.03	0.0012	0.007	0.0003
R8	0.07	0.0031	0.016	0.0007
R9	0.08	0.0042	0.018	0.0009
R10	0.03	0.0012	0.007	0.0003
R11	0.02	0.0013	0.004	0.0003
R12	0.02	0.0018	0.005	0.0004
R13	0.05	0.0061	0.012	0.0013
R14	0.03	0.0011	0.006	0.0010
Adopted air quality objective	50	20	25	8
4% of air quality objective	2	0.8	1	0.32

7.2.4 TVOCs and PAHs

Predicted contour plots for maximum predicted incremental concentrations for the indicator compounds for TVOCs and PAHs (benzene and B(a)P) are presented in Figure 36 to Figure 39 in Appendix D. Table 23 presents a summary of the predicted maximum incremental concentrations of benzene and B(a)P at each receptor.

In preparing this table, the predicted 99.9th percentile 1-hour average, maximum 24-hour average or annual average at each receptor for each of the five years of meteorological data was extracted from the model, and the maximum of those five results for each receptor and each averaging period is reported in the table.

It is noted that even though model results for annual average concentrations are provided, the boiler is the only source of benzene and B(a)P emissions and will only be used for periods of up to about 12 weeks. Therefore the annual average for benzene and B(a)P is not strictly relevant to this assessment.

There are no background concentrations of benzene and B(a)P to add to the incremental concentrations. Compliance with adopted air quality objectives for these indicator pollutants is achieved by a significant margin.

Table 24 Summary of maximum predicted concentrations of benzene and B(a)P (indicators for TVOCs and PAHs)

Receptor	Incremental predicted concentration			
	Benzene			B(a)P
	1-hour average (µg/m³)	24-hour average (µg/m³)	Annual average (µg/m³)	Annual average (µg/m³)
Highest predicted concentration outside the boundary of the WtE facility development footprint	1.0	0.40	0.067	0.0006
Discrete receptors				
R1	0.025	0.0052	0.00024	0.0000020
R2	0.041	0.0078	0.00034	0.0000028
R3	0.036	0.0114	0.00041	0.0000034
R4	0.048	0.0213	0.00086	0.0000071
R5	0.071	0.0143	0.00153	0.0000127
R6	0.083	0.0201	0.00084	0.0000070
R7	0.019	0.0067	0.00024	0.0000020
R8	0.059	0.0142	0.00059	0.0000049
R9	0.071	0.0158	0.00081	0.0000067
R10	0.030	0.0063	0.00024	0.0000020
R11	0.023	0.0032	0.00025	0.0000021
R12	0.032	0.0047	0.00035	0.0000029
R13	0.046	0.0104	0.00118	0.0000097
R14	0.019	0.0050	0.00021	0.0000018
Adopted air quality objective	580	29	9.6	0.0001

7.3 Unplanned emissions

The emission estimates used in the model reflect the worst-case scenario under normal operation. It is anticipated that at times, there will be upsets to the operation of the WtE facility which will result in changes to air emissions. Some of the potential plant upset scenarios are discussed below.

Equipment failure of one or both of the CHP units

In the event of failure of the CHP unit, the biogas from the anaerobic digesters will be directed to the flare. In this case, the ground level concentrations of the combustion gases (NO_2, SO_2) may be different from the 'normal operation' concentrations predicted by the model. This would be due to the different combustion process and emission point (height, velocity, temperature, etc.) of the flare. However, such situations would be infrequent and temporary. Normal operation would resume once repairs were completed. Operational procedures are to be in place for the flare system to ensure it is operated correctly and in accordance with design parameters.

Commissioning of the WtE facility

During commissioning of the WtE facility, it is anticipated that the air emissions from the site will vary from those included in the model. For example, there is potential for higher odour emissions from the biofilters while the biological activity of the filter bed reaches optimum performance.

Other examples include variable pollutant emission rates from the CHP units during commissioning and variable odour emissions from the building as the ventilation system is optimised. It is expected that comprehensive commissioning and plant start-up procedures will be followed which will include requirements to minimise air emissions wherever practical. This will include starting and optimising individual equipment items prior to the introduction of odorous waste material where possible.

Failure of the odour control systems

During normal operation, it is possible that there will be failure of one or more components of the two odour control systems. It is expected that the detailed design of the WtE plant will identify the key scenarios which have a risk of causing environmental and/or safety hazards and that these will be adequately assessed and addressed. This process will enable appropriate decisions to be made such as redundancy of equipment, spare equipment inventory, etc. so that potential unplanned air emissions can be minimised.

In addition to the scenarios provided above, there are other examples of potential failure events, as is the case for almost any plant. It is expected the management strategies implemented will ensure that suitable operating and maintenance procedures are in place. As such, any unplanned air emission events are anticipated to be short-lived and the release of potentially harmful pollutants will be minimised.

8. Conclusions

The air quality assessment for the proposed Lilydale WtE facility has been undertaken in accordance with EPA *Guideline for Assessment and Minimizing Air Pollution in Victoria* (EPA, 2022). The CALPUFF modelling system was adopted to complete the modelling assessment of odour and air quality impacts. Hourly meteorological data representative of the local Lilydale area for five years (2016 – 2020) was included in the dispersion model.

The assessment included combustion emissions from the CHP units and diesel-fired start-up boiler, and odour emissions from the exhaust of the odour control biofilters. The odour assessment included background odour from the existing Lilydale STP.

Modelling of air pollutants from the combustion processes found that cumulative predicted concentrations at sensitive receptor locations complied with all adopted air quality objectives by a significant margin.

The analysis of odour modelling results concluded that the predicted odour emissions from the WtE facility pose a very low risk of causing offensive odours beyond the site boundary. Further, for receptors close to the Lilydale STP, the STP is the dominant odour source relative to the WtE facility and there is no change to the risk of occurrence of offensive odours due to the cumulative emissions from both sources, compared to the current situation

Overall, it is concluded that there is a very low risk of air emissions from the Project causing an exceedance of ambient air quality objectives defined by EPA in the ERS and Publication 1961.

9. References

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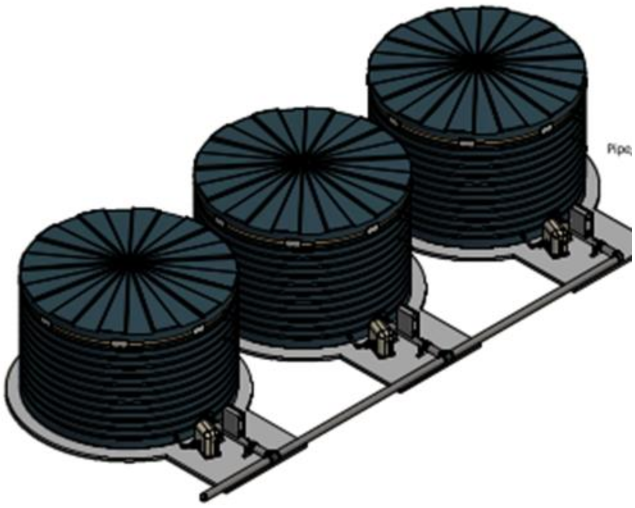
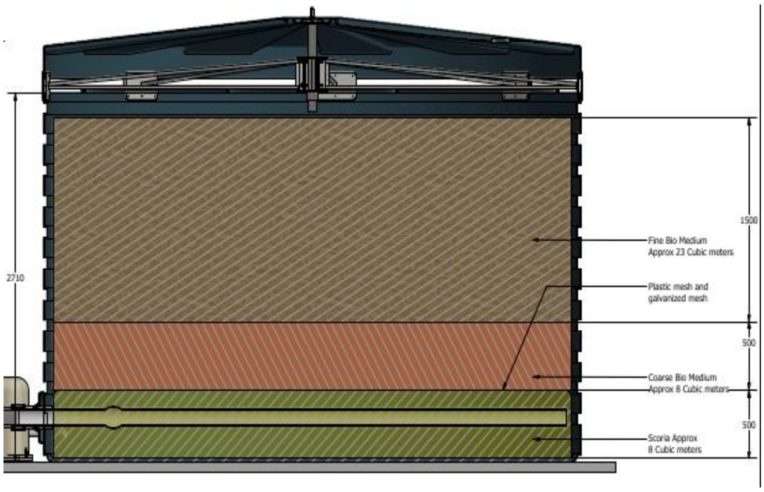
Appendix A. Biofilter Preliminary Proposed Design



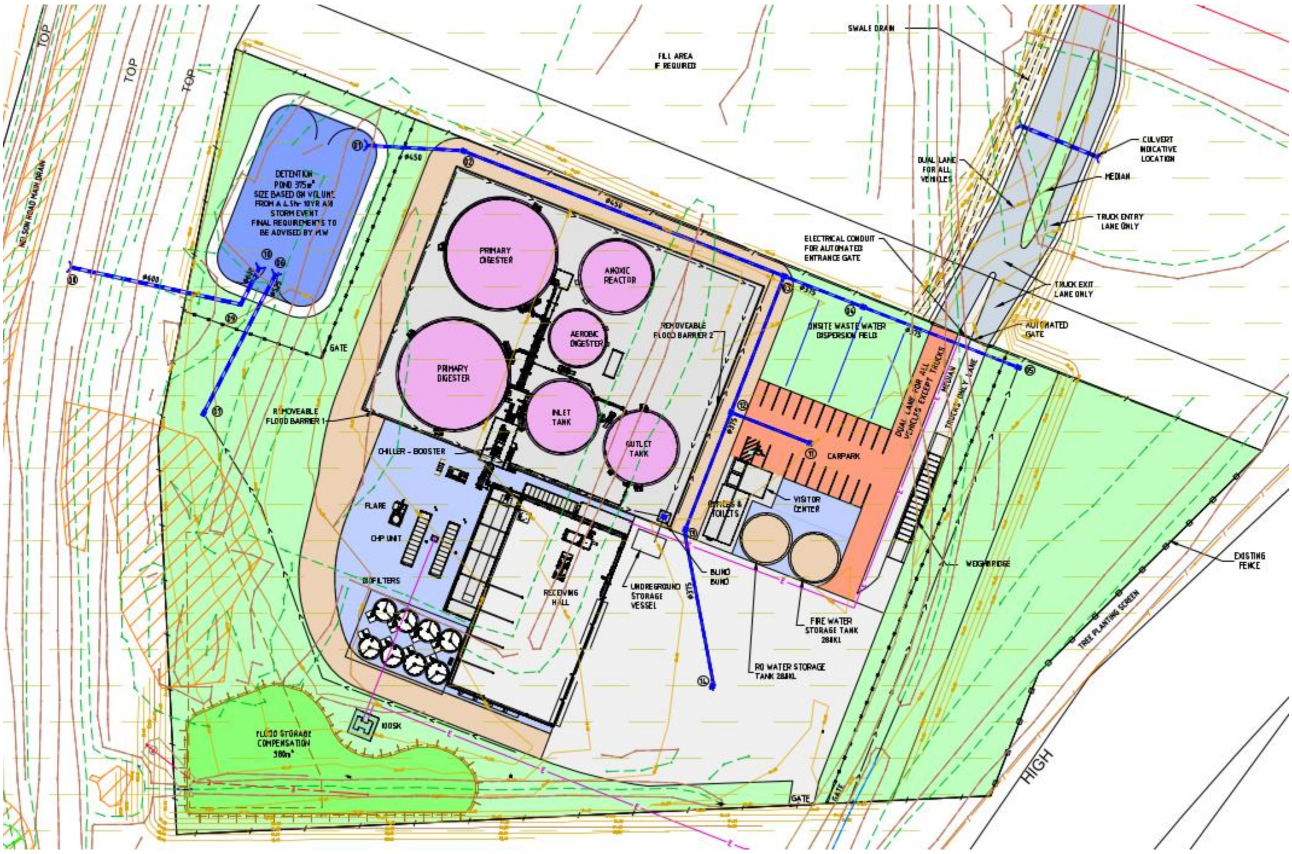
Example of Biofilters Treating Air from the Waste Reception Shed

There will be a train of 8 operating in series



Sectional View of Biofilter

Appendix B. Proposed Site Layout



Appendix C. Modelled Meteorology Figures

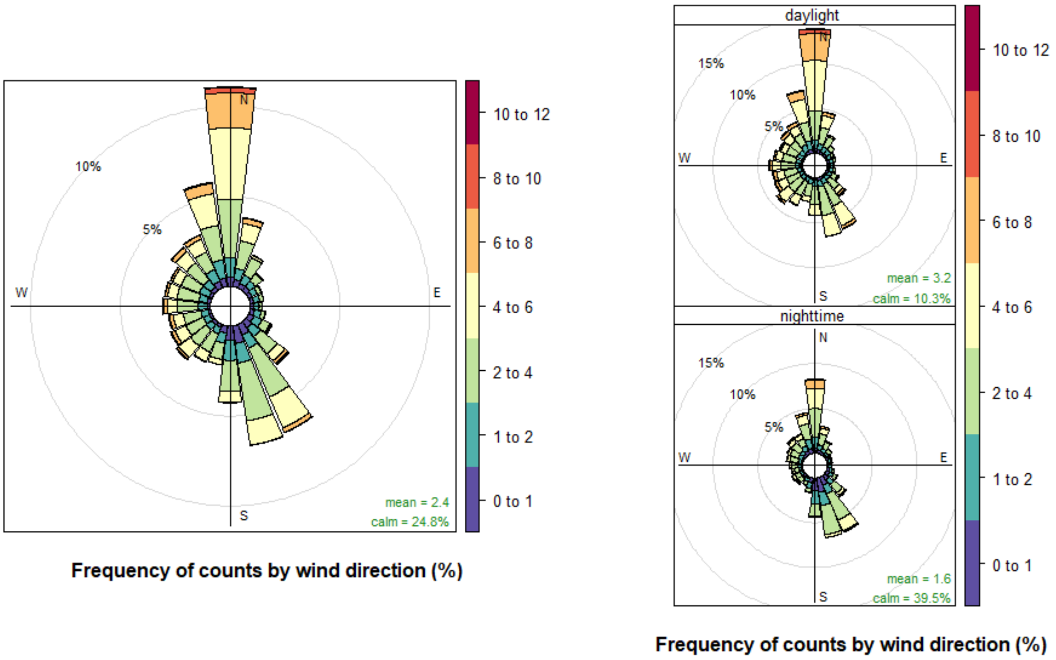


Figure 15 All data (left) and daylight & night-time (right) wind roses for measured winds at Coldstream BoM station, 2016-2020.

Figure notes:

1. Calm conditions are assumed to occur where wind speed is less than 0.5 m/s
2. Daylight and night-time hours are calculated as per the method by Meeus (1991)

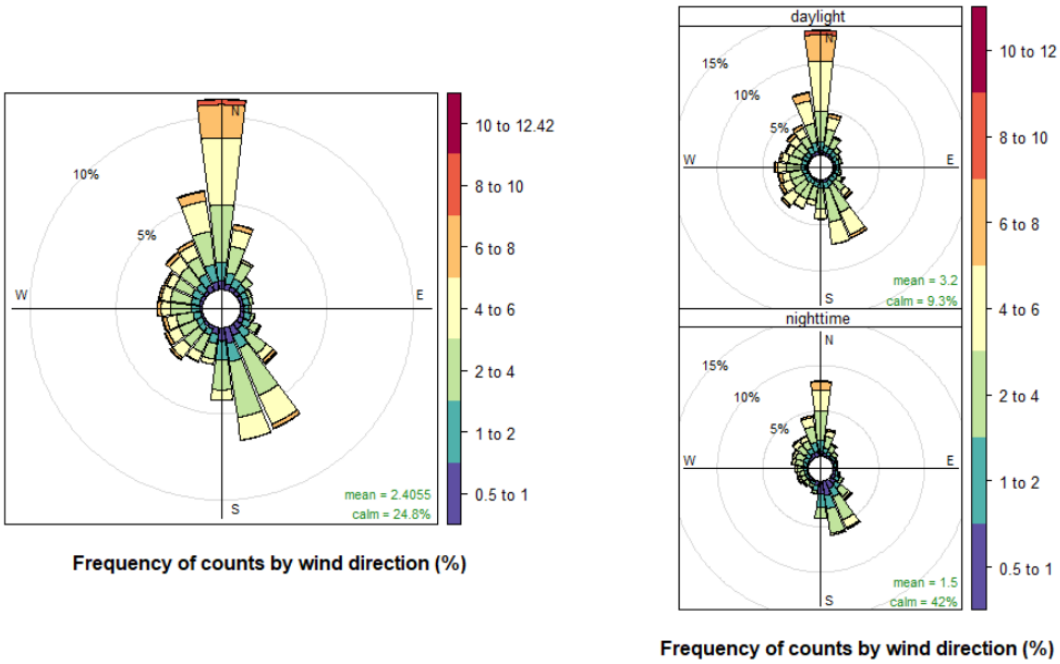


Figure 16 All data (left) and daylight & night-time (right) wind roses for CALMET predicted winds at Coldstream BoM station, 2016-2020.

Figure notes:

1. Calm conditions are assumed to occur where wind speed is less than 0.5 m/s
2. Daylight and night-time hours are calculated as per the method by Meeus (1991)

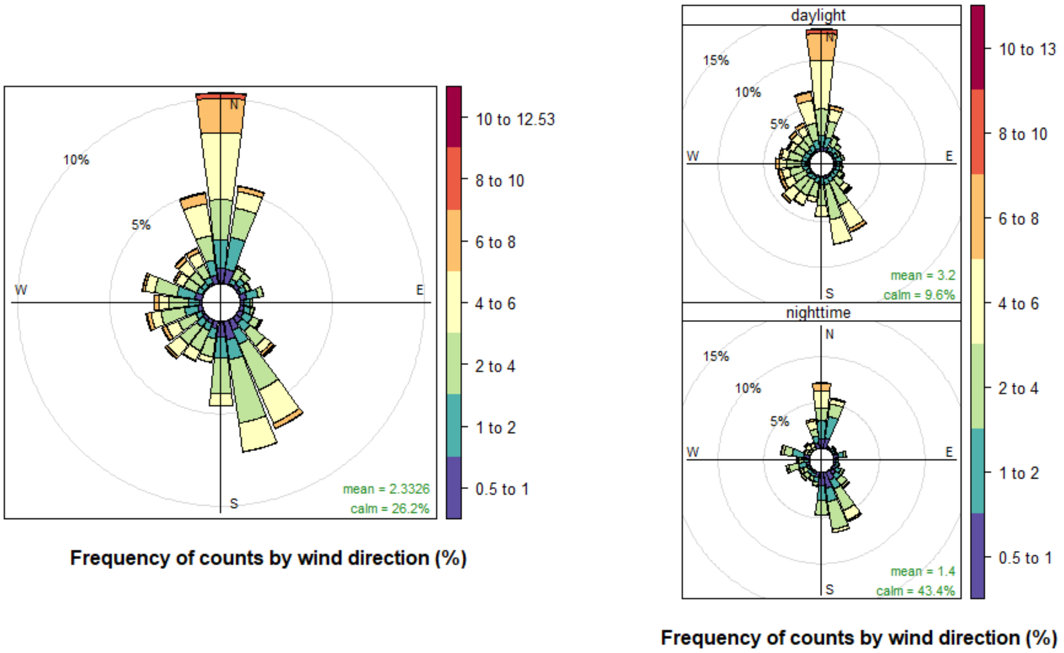


Figure 17 All data (left) and daylight & night-time (right) wind roses for CALMET predicted winds at the Project site, 2016-2020.

Figure notes:

1. Calm conditions are assumed to occur where wind speed is equal to 0.5 m/s
2. Daylight and night-time hours are calculated as per the method by Meeus (1991)

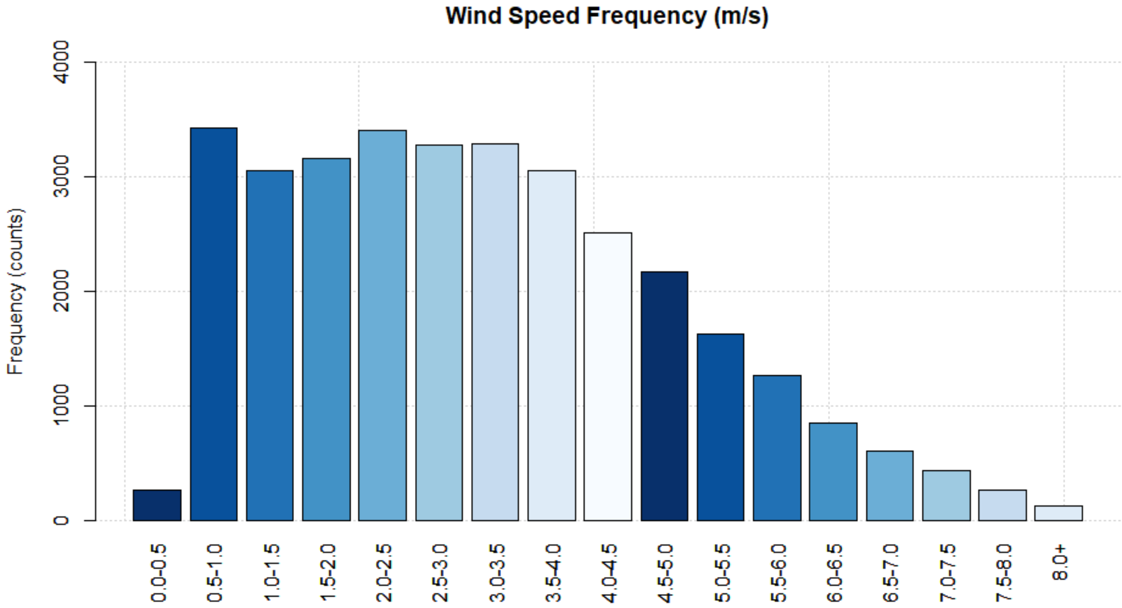


Figure 18 Frequency of occurrence of various wind speeds predicted in CALMET for Coldstream AWS location, 2016-2020.

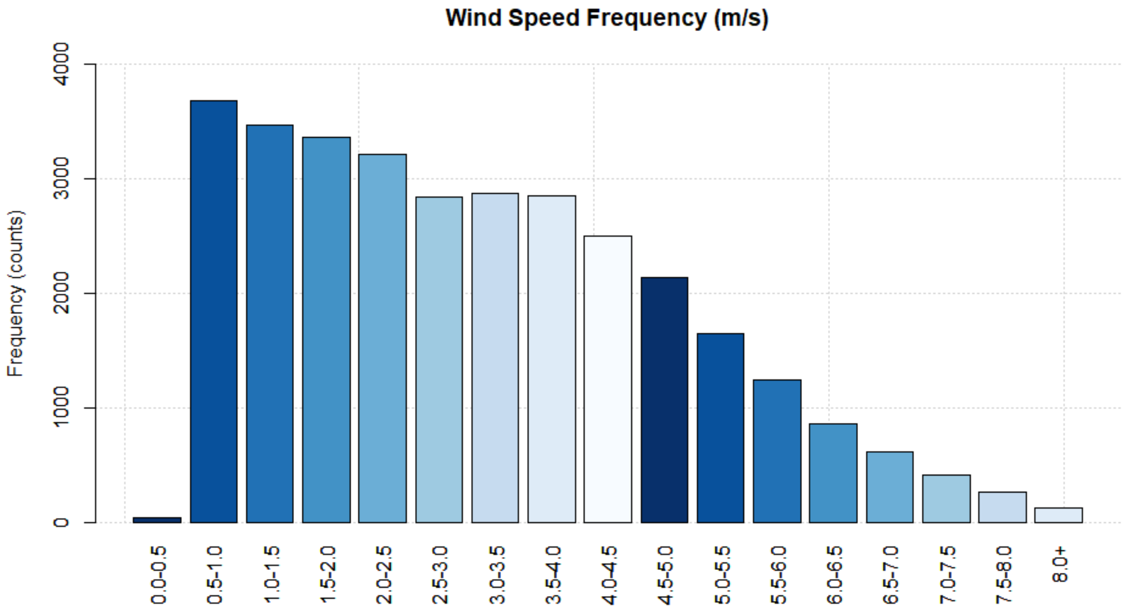


Figure 19 Frequency of occurrence of various wind speeds predicted in CALMET for Project site location, 2016-2020.

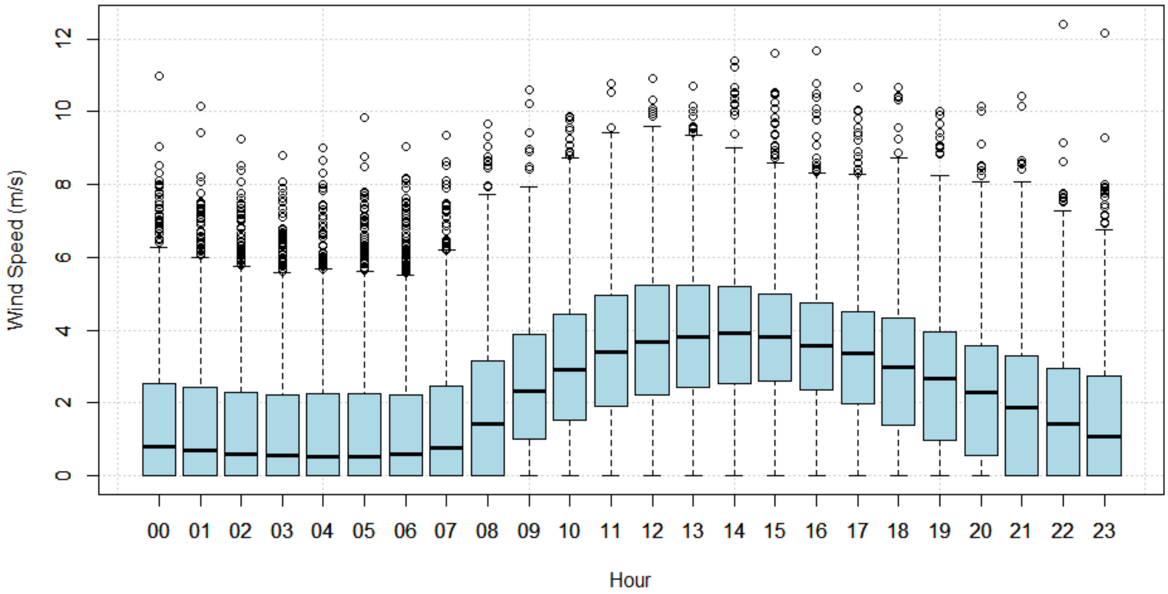


Figure 20 CALMET predicted wind speed by hour for Coldstream BoM station, 2016-2020. The box and whisker plots show the hourly minimum, first quartile, median, third quartile and maximum (excluding outliers) predicted mixing height.

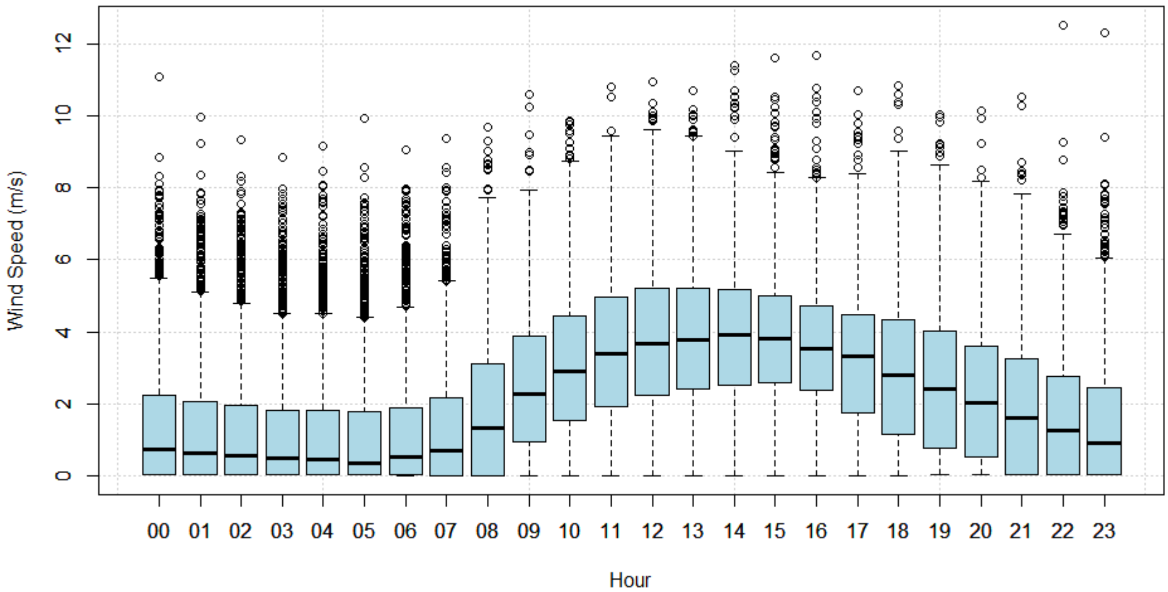


Figure 21 CALMET predicted wind speed by hour for the Project site, 2016-2020. The box and whisker plots show the hourly minimum, first quartile, median, third quartile and maximum (excluding outliers) predicted mixing height.

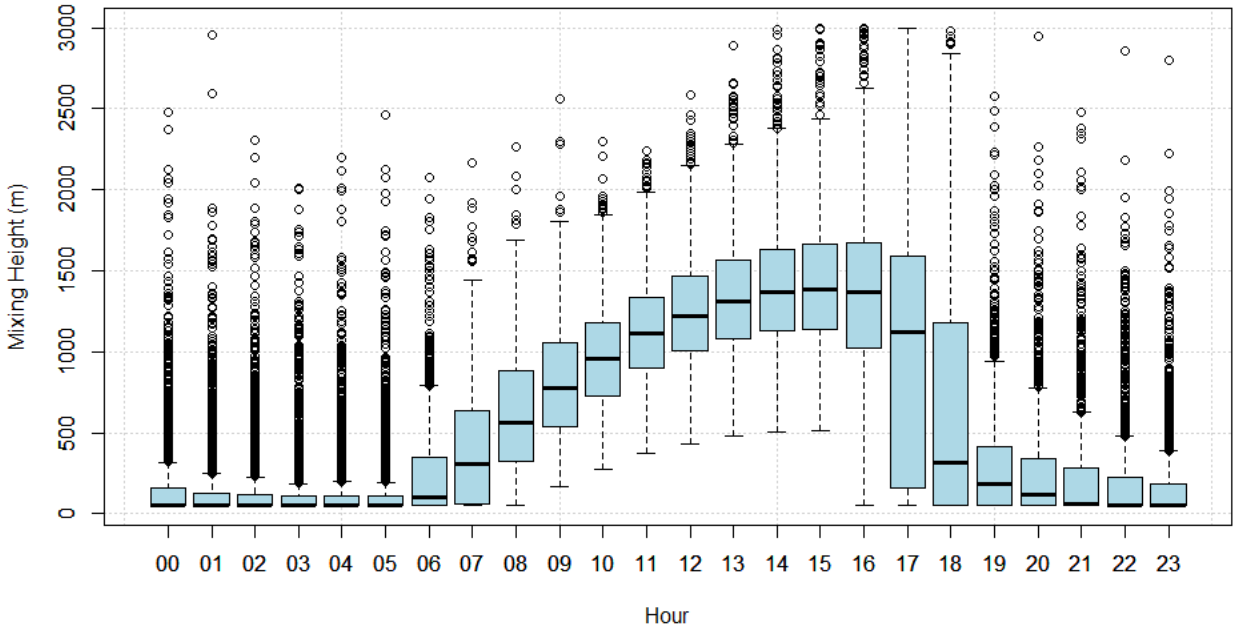


Figure 22 Predicted hour-average mixing height by hour from CALMET for Coldstream AWS location, 2016-2020. The box and whisker plots show the hourly minimum, first quartile, median, third quartile and maximum (excluding outliers) predicted mixing height.

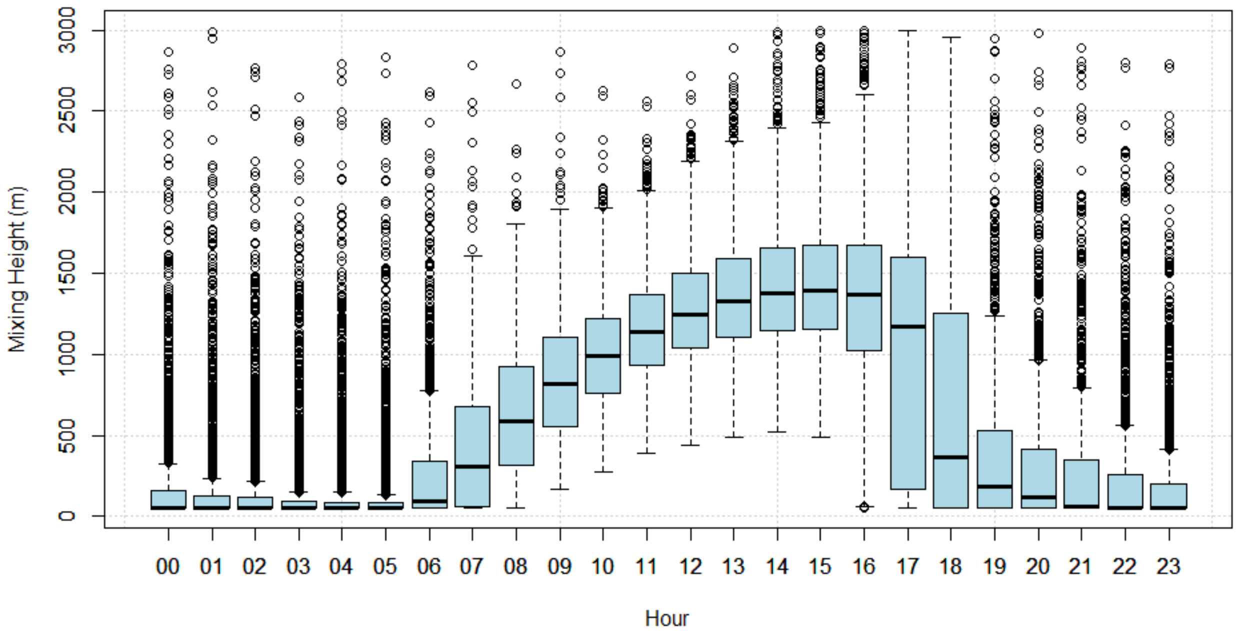


Figure 23 CALMET predicted mixing height by hour for the Project site, 2016-2020. The box and whisker plots show the hourly minimum, first quartile, median, third quartile and maximum (excluding outliers) predicted mixing height.

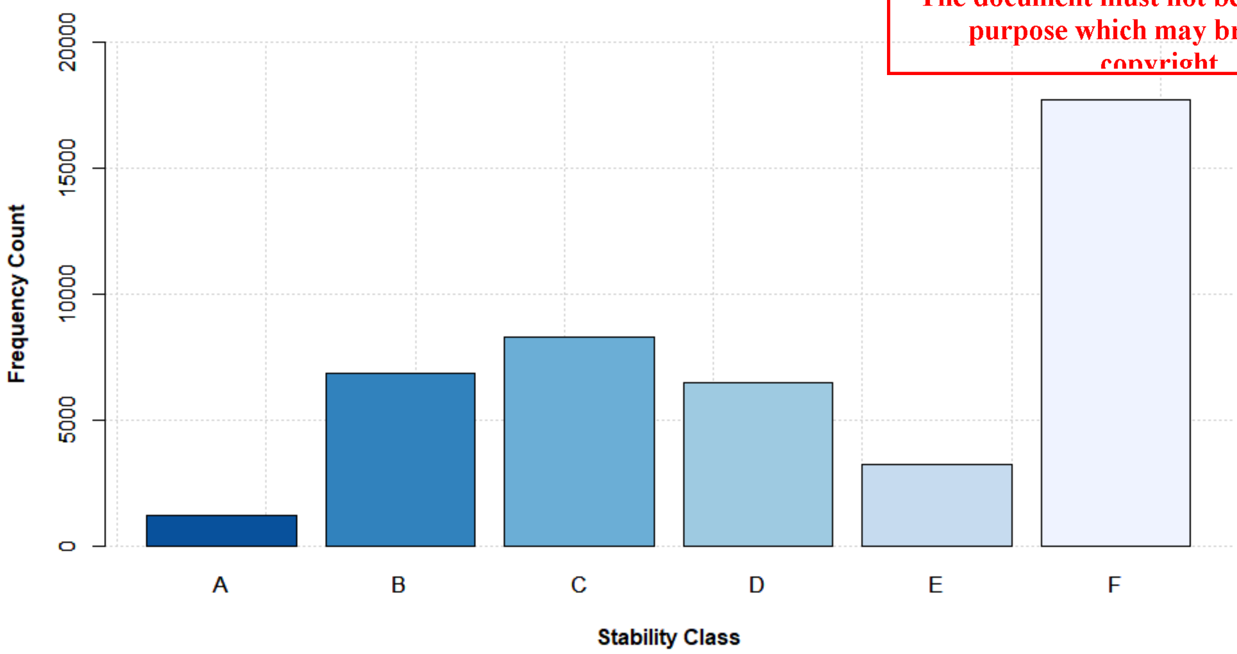


Figure 24 CALMET predicted stability class total frequency count for Coldstream BoM station, 2016-2020.

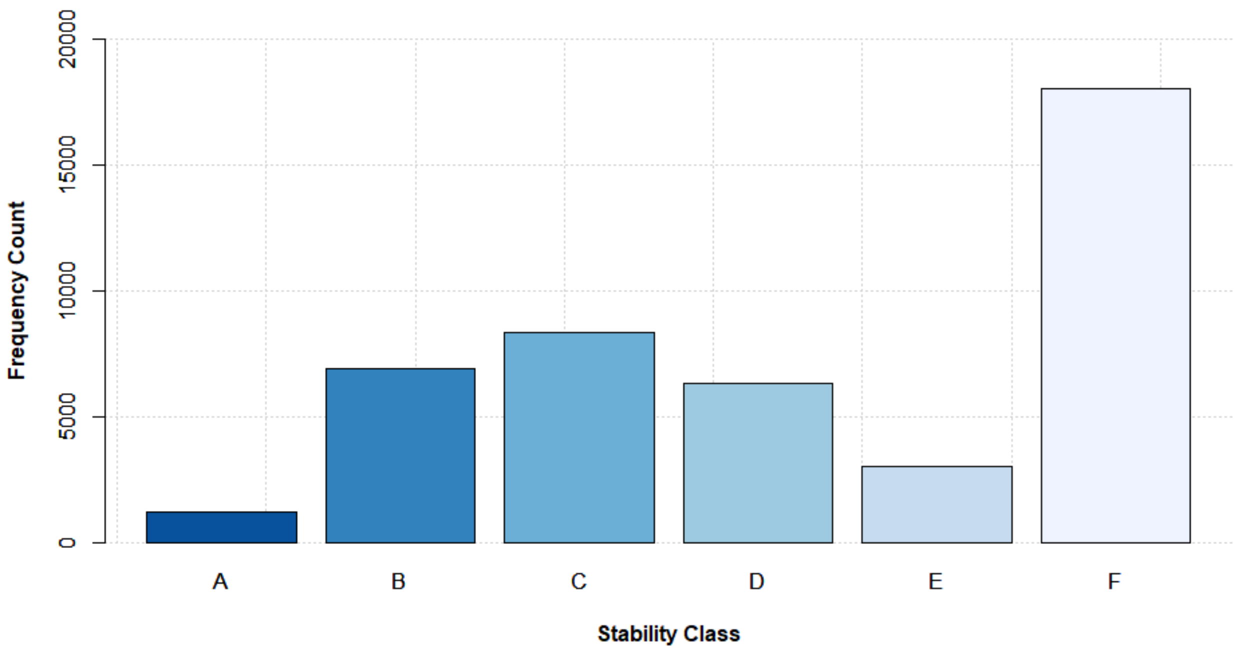


Figure 25 CALMET predicted stability class total frequency count for the Project site, 2016-2020.

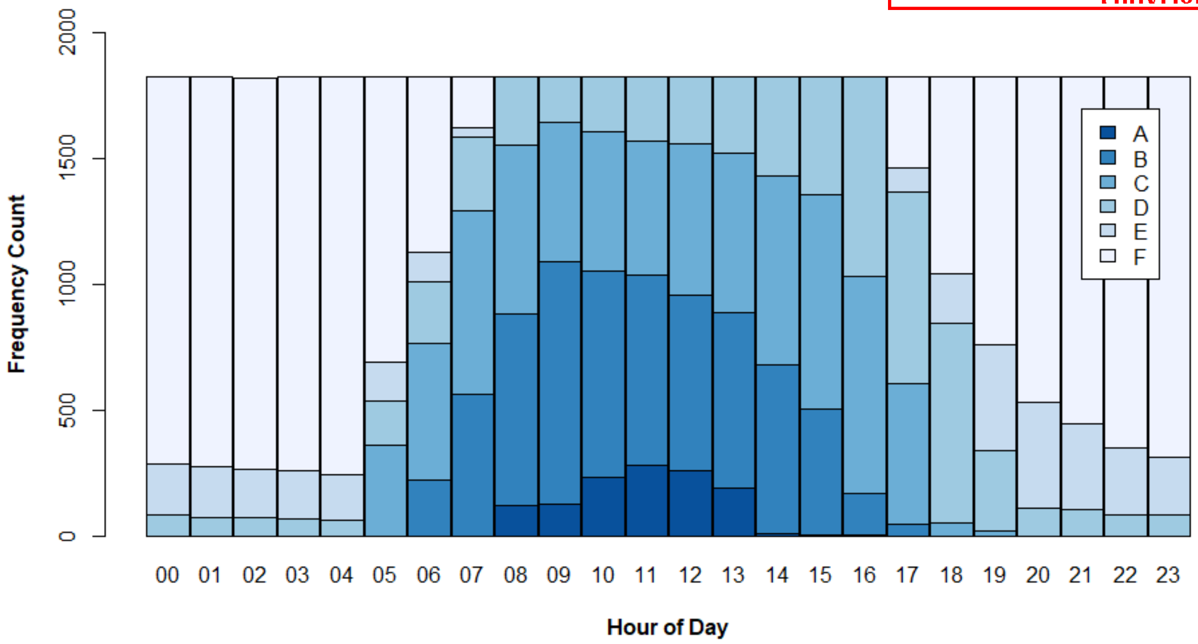


Figure 26 CALMET predicted stability class count by hour for Coldstream AWS location, 2016-2020.

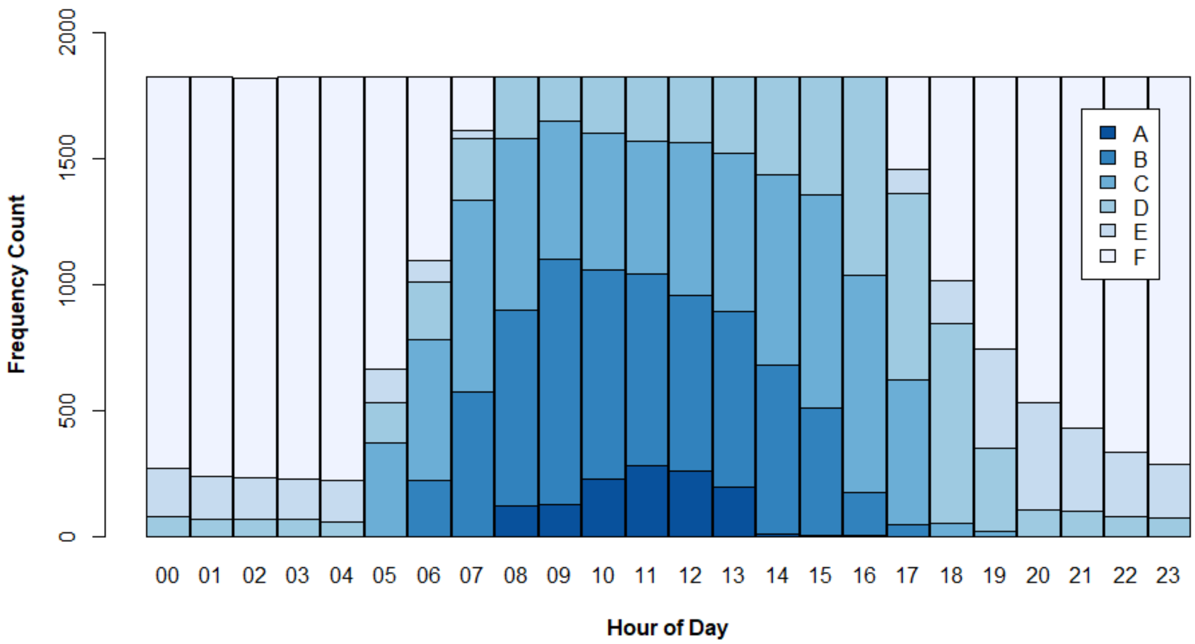


Figure 27 CALMET predicted stability class count by hour of data for the Project site, 2016-2020.

Appendix D. Modelled Concentration Figures

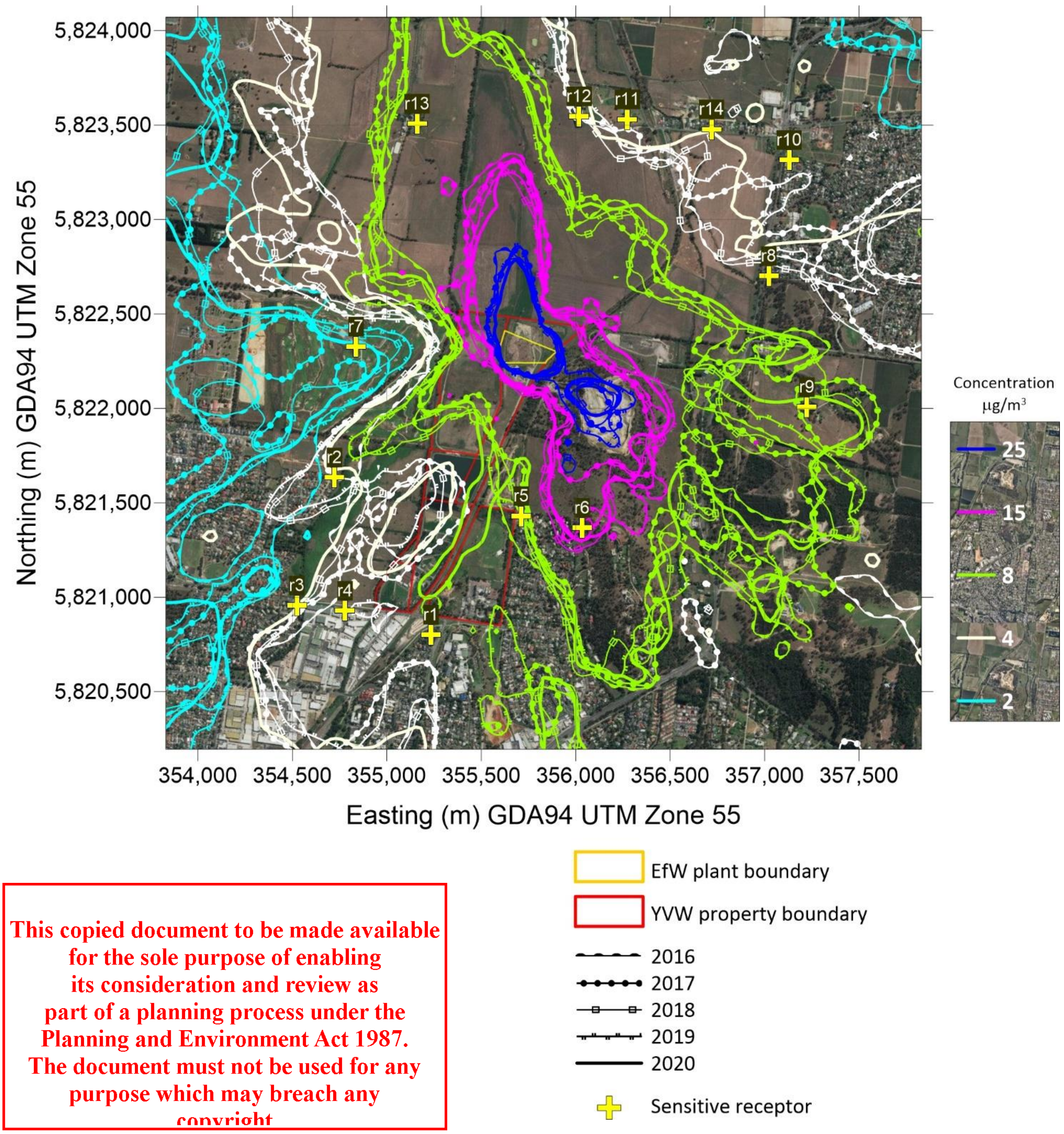


Figure 28 Predicted cumulative NO_2 concentration (µg/m³), 1-hour average, 99.9th percentile.

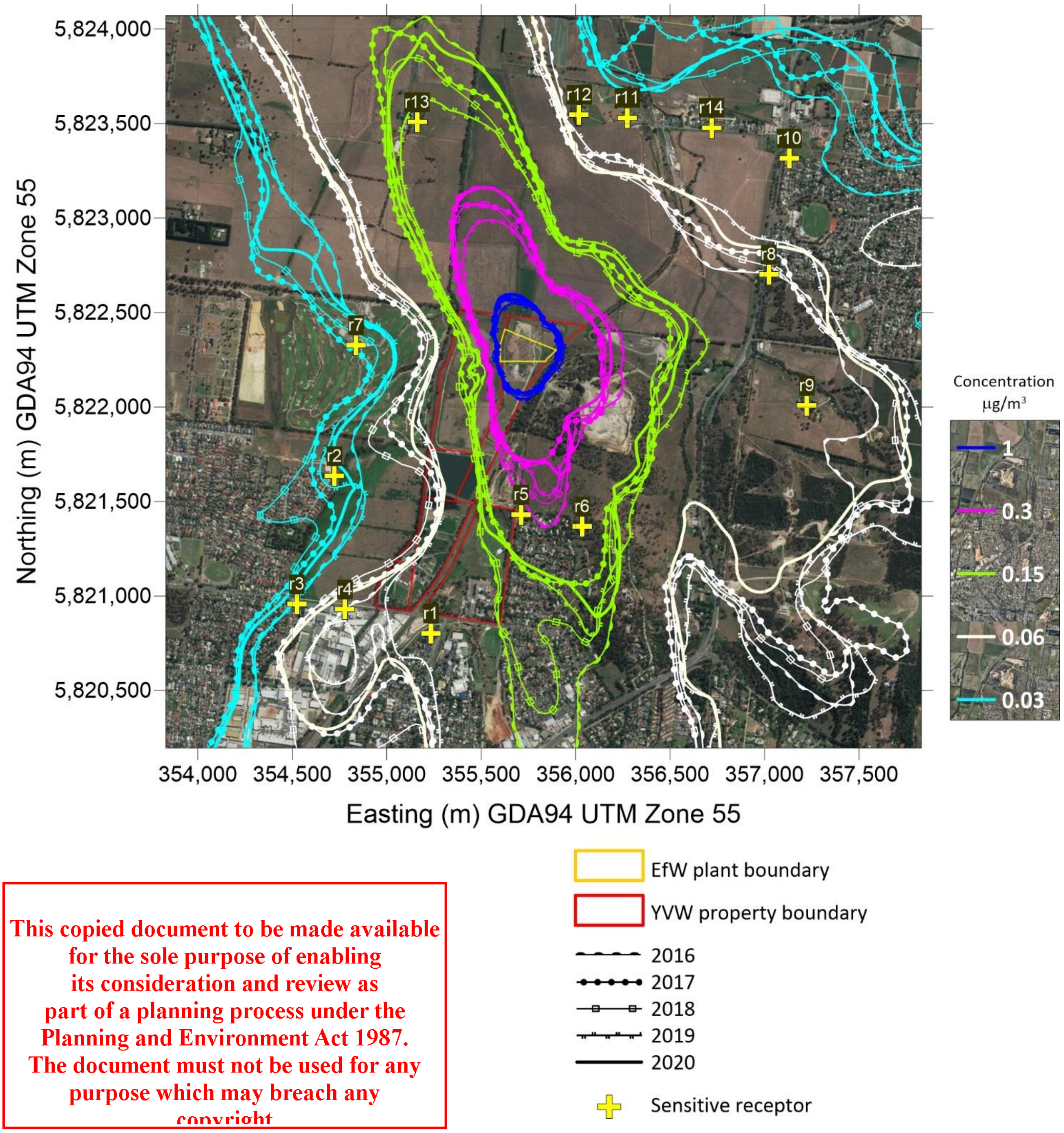
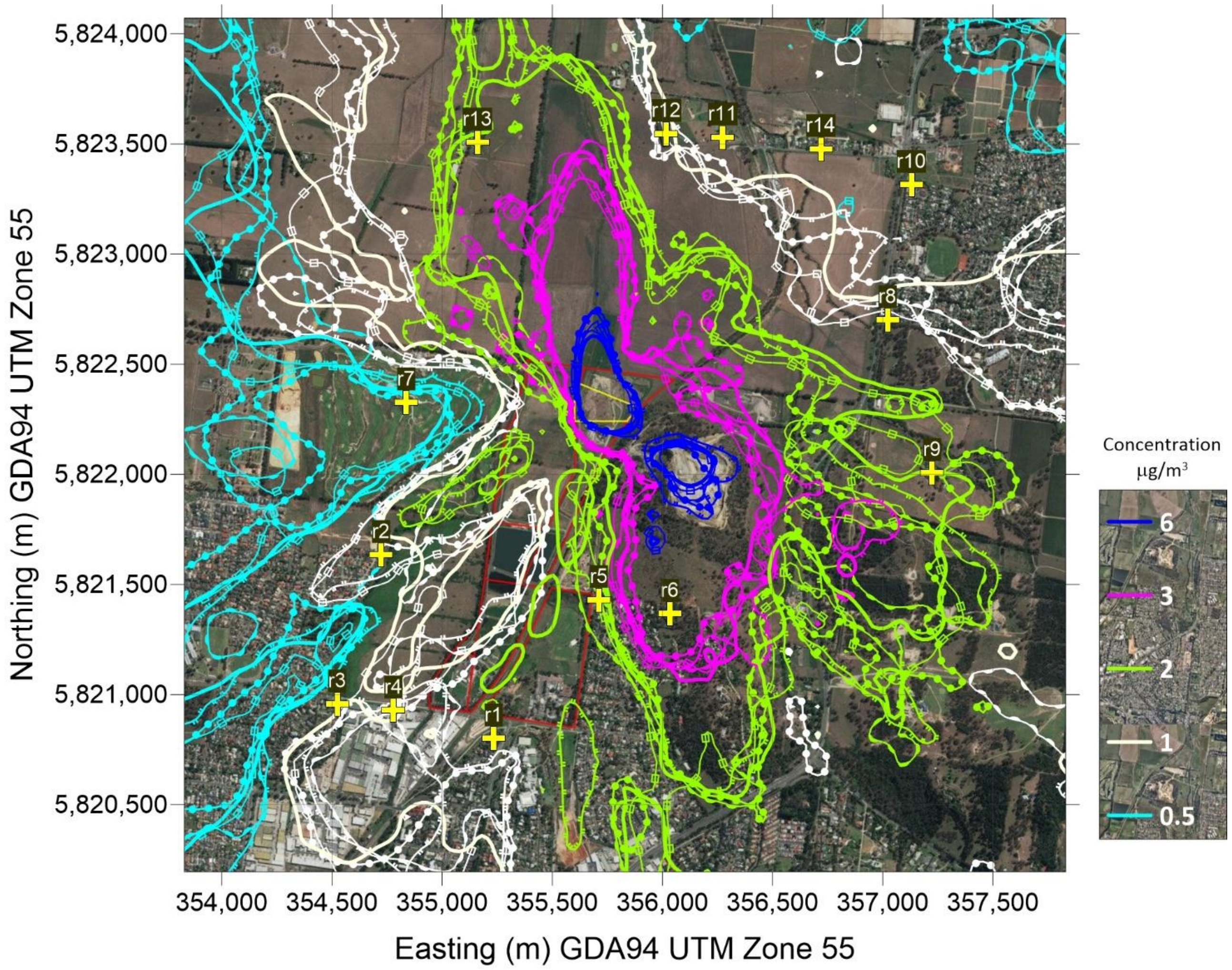


Figure 29 Predicted cumulative NO_2 concentration (µg/m³), maximum annual average.



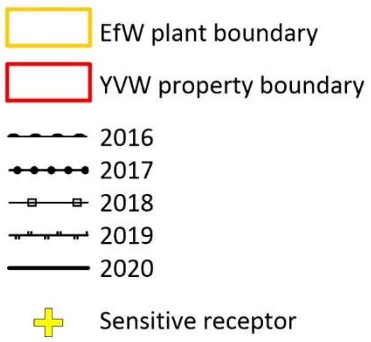


Figure 30 Predicted cumulative SO_2 concentration ($\mu g/m^3$), 1-hour average, 99.9th percentile.

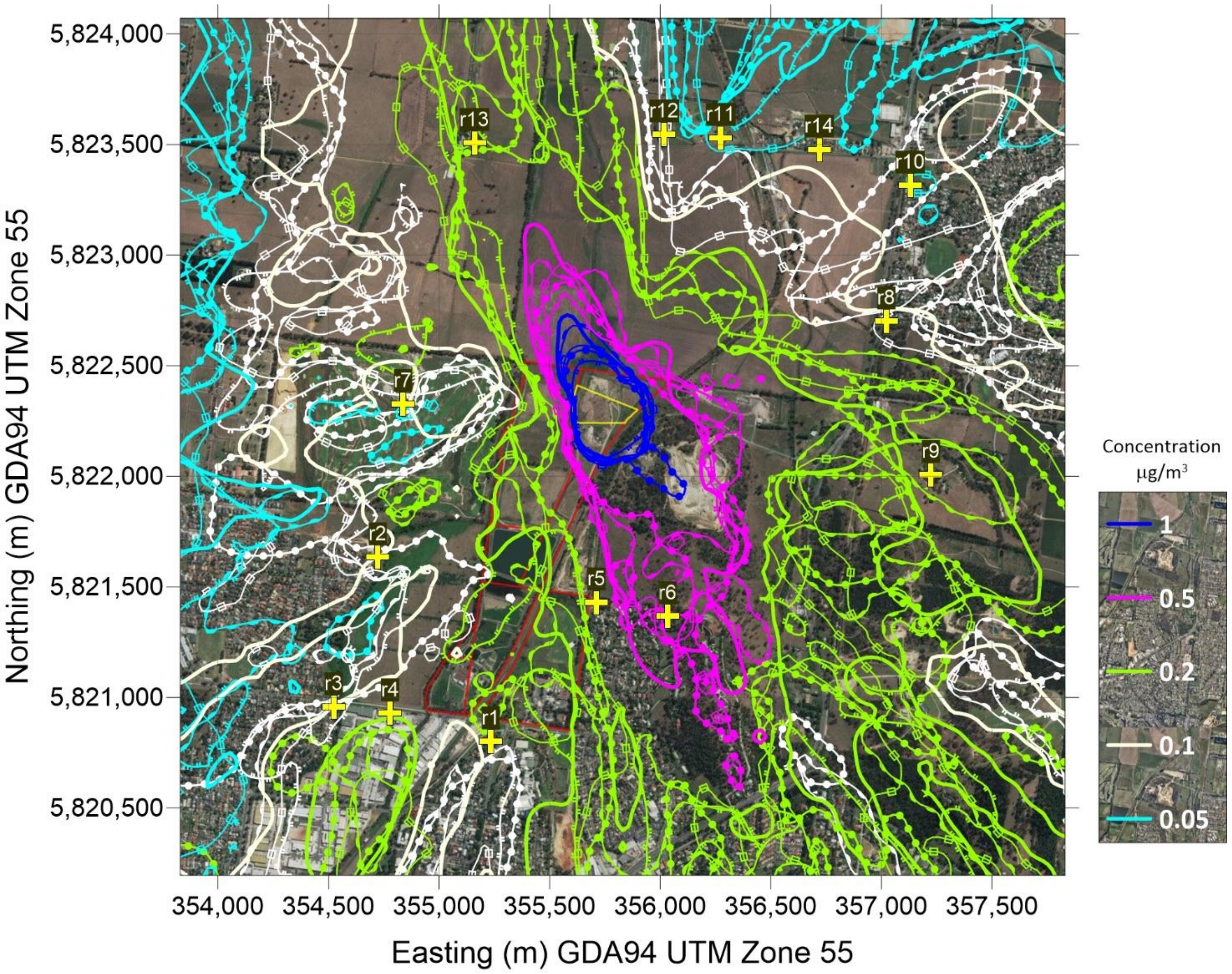


Figure 31 Predicted cumulative SO_2 concentration (μg/m^3), maximum 24-hour average.

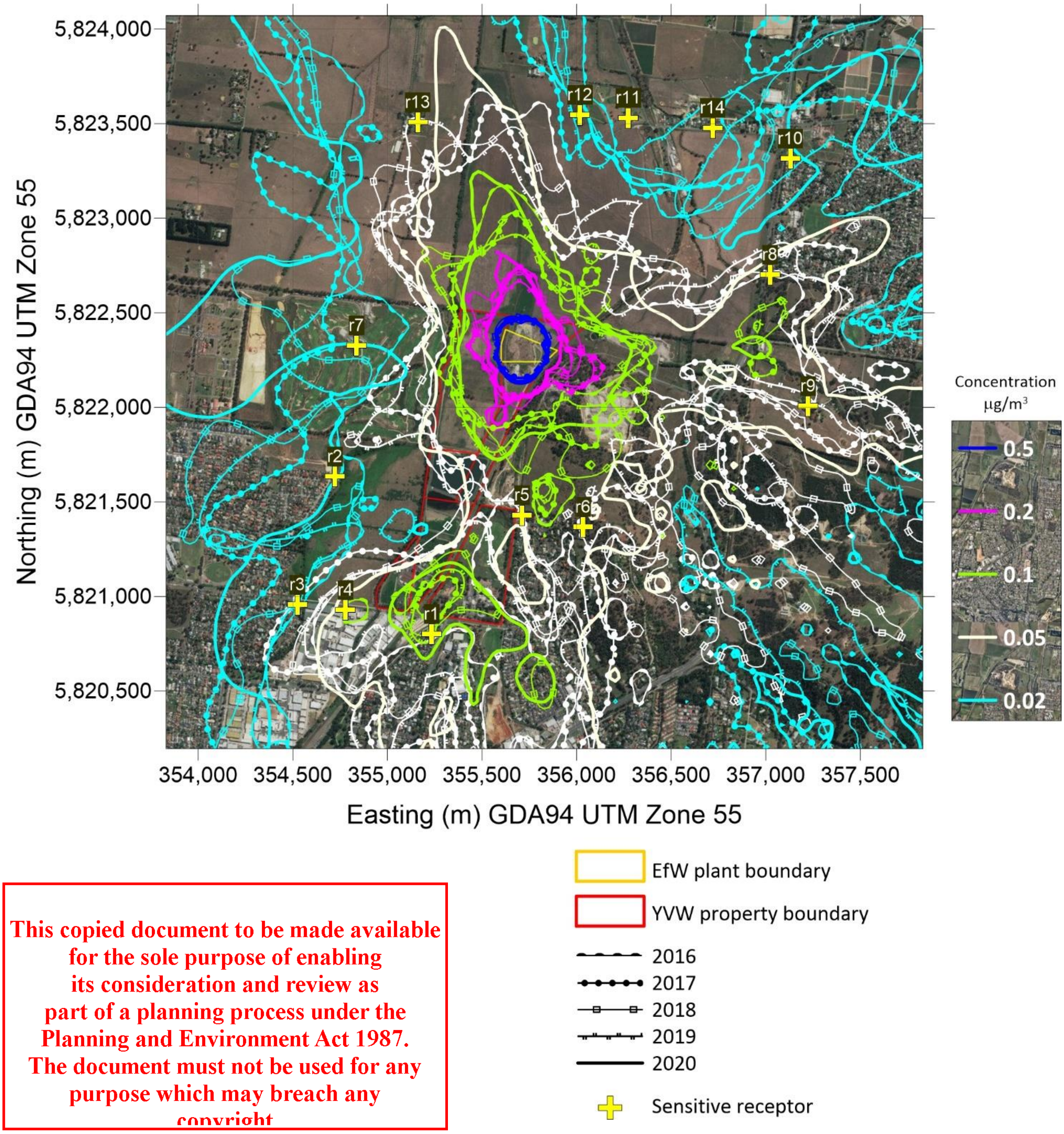


Figure 32 Predicted Project only PM_{10} concentration (µg/m^3), maximum 24-hour average.

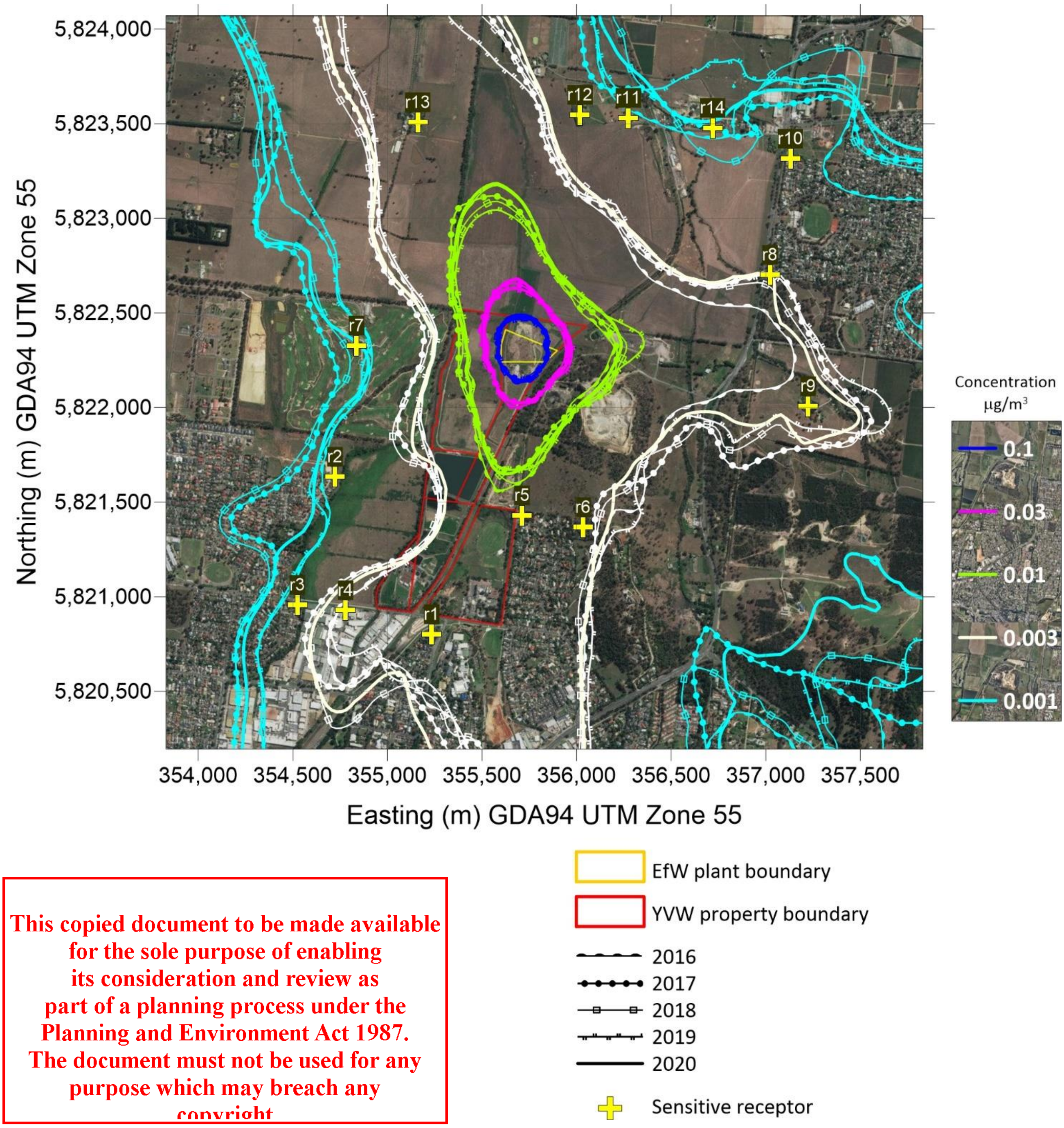


Figure 33 Predicted Project only PM_{10} concentration (µg/m³), maximum annual average.

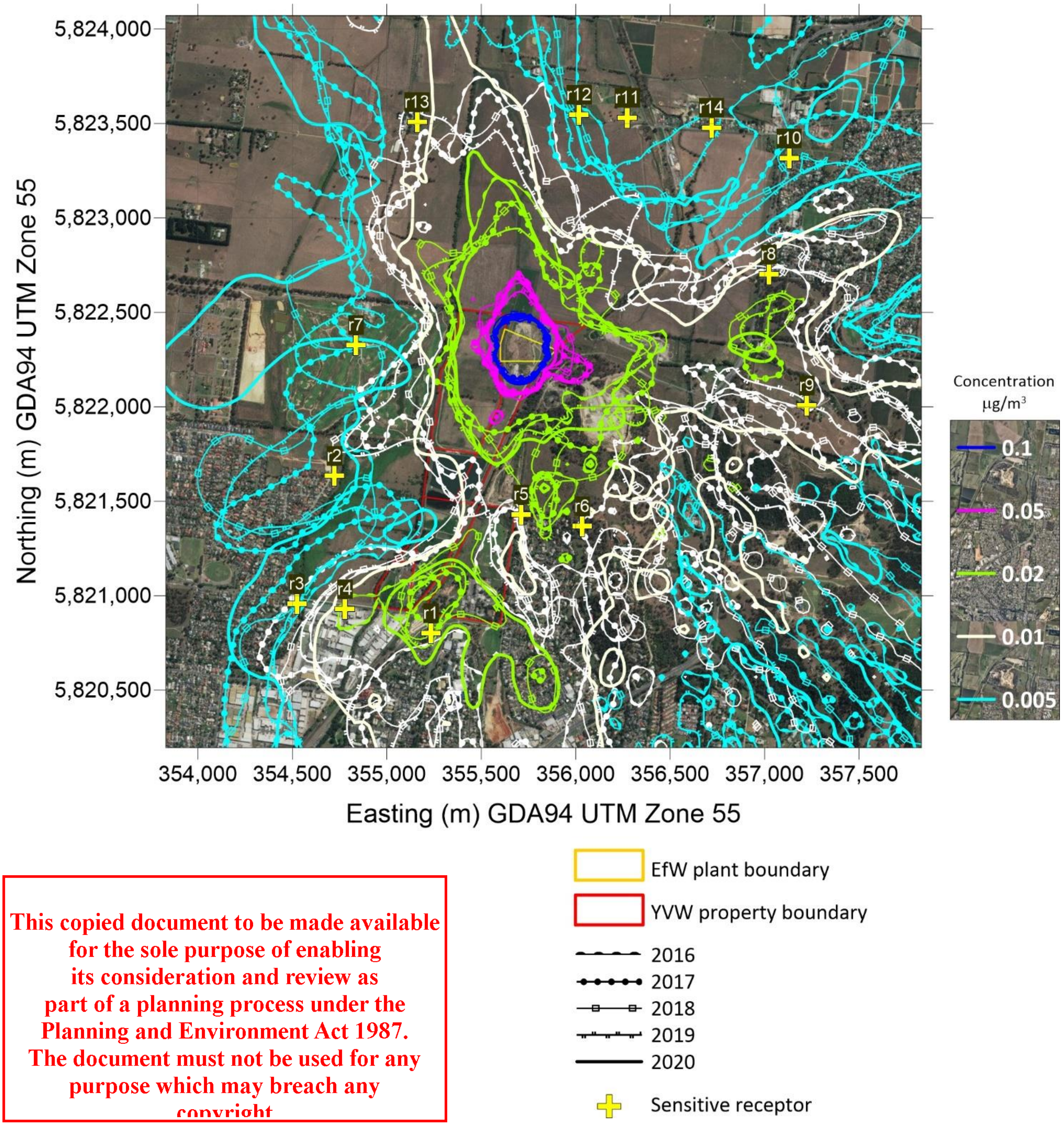


Figure 34 Predicted Project only $PM_{2.5}$ concentration (μg/m^3), maximum 24-hour average.

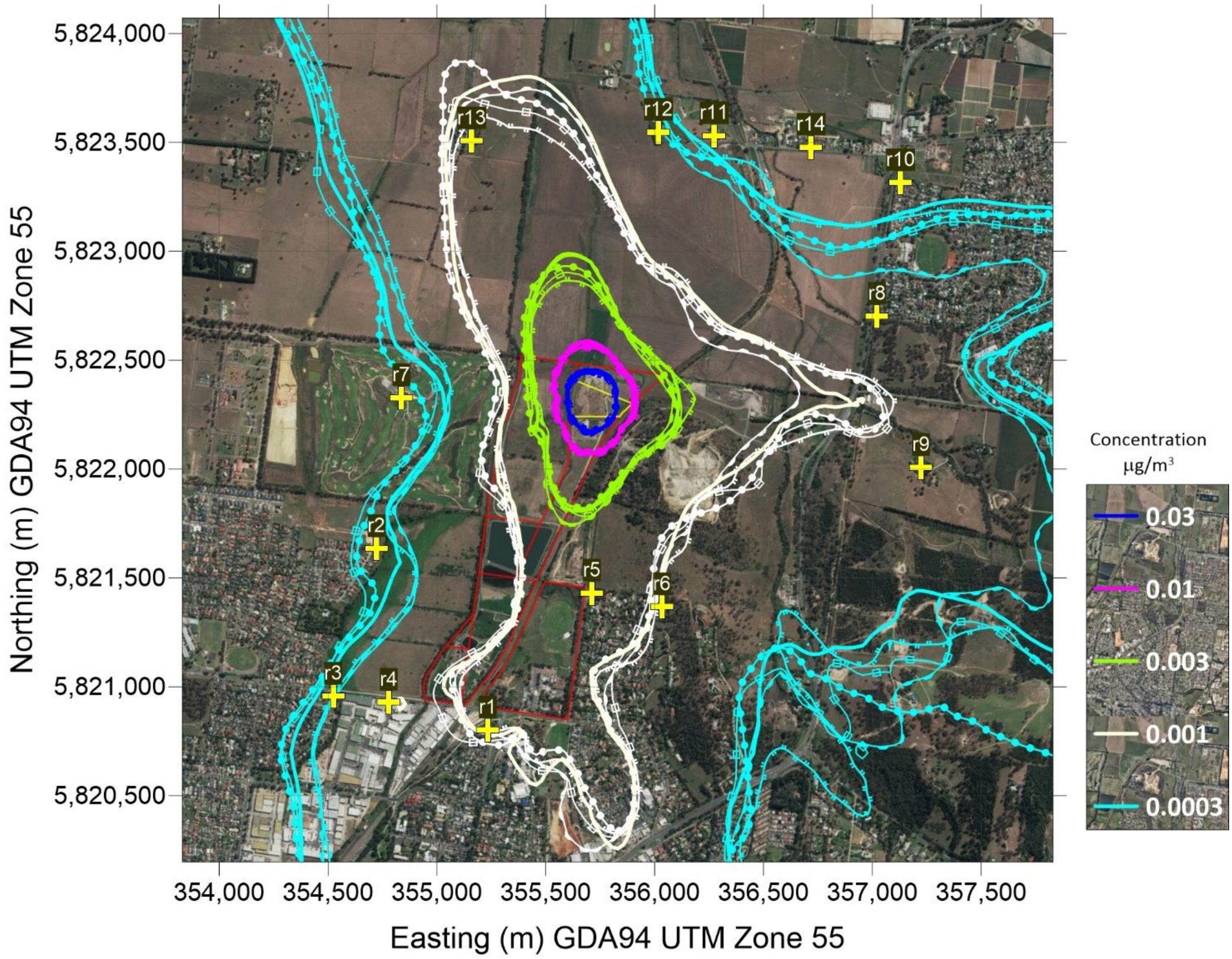


Figure 35 Predicted Project only $PM_{2.5}$ concentration (µg/m³), maximum annual average.

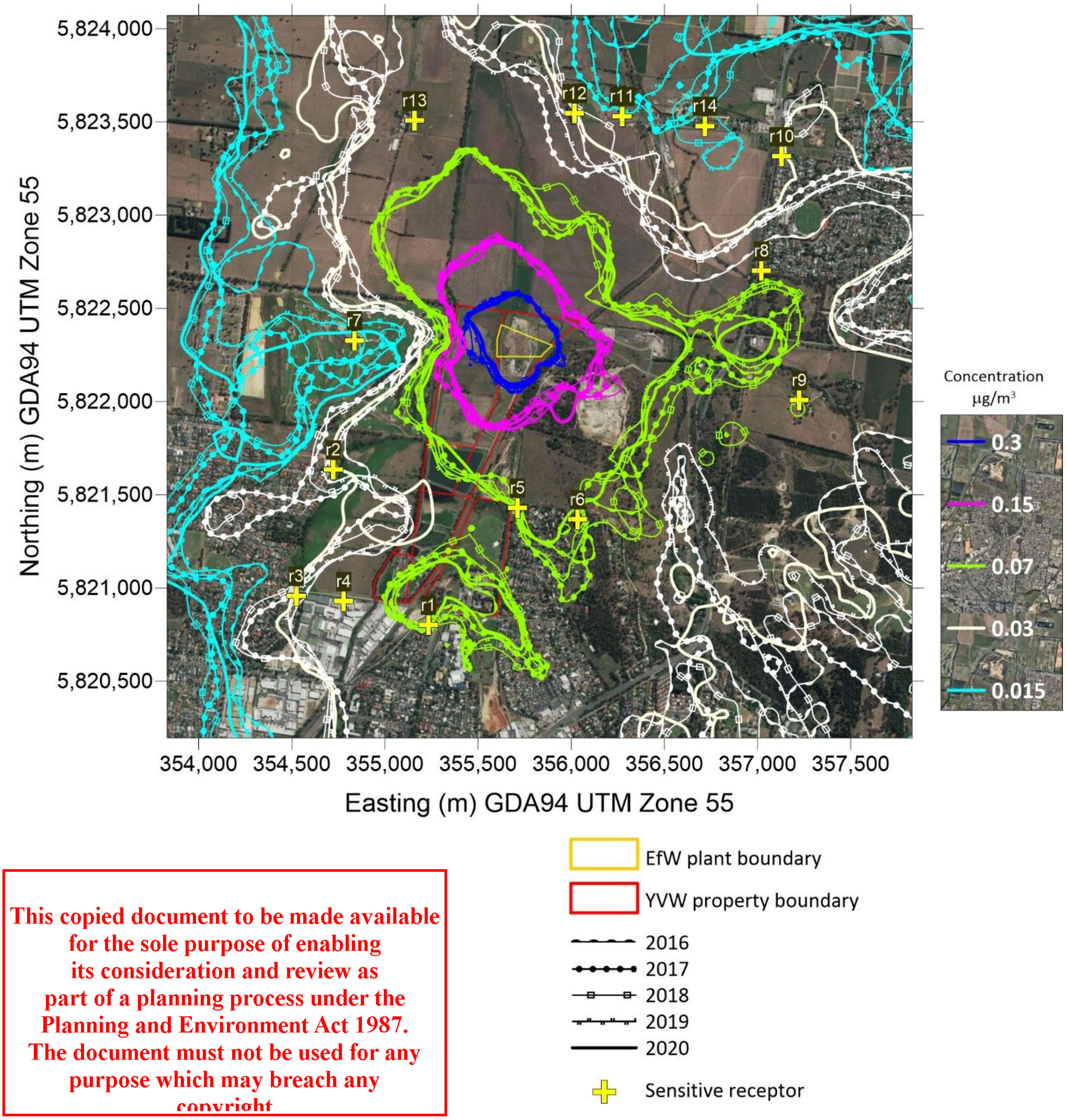


Figure 36 Predicted Project only benzene (TVOC indicator) concentration (µg/m³), 1-hour average, 99.9th percentile.

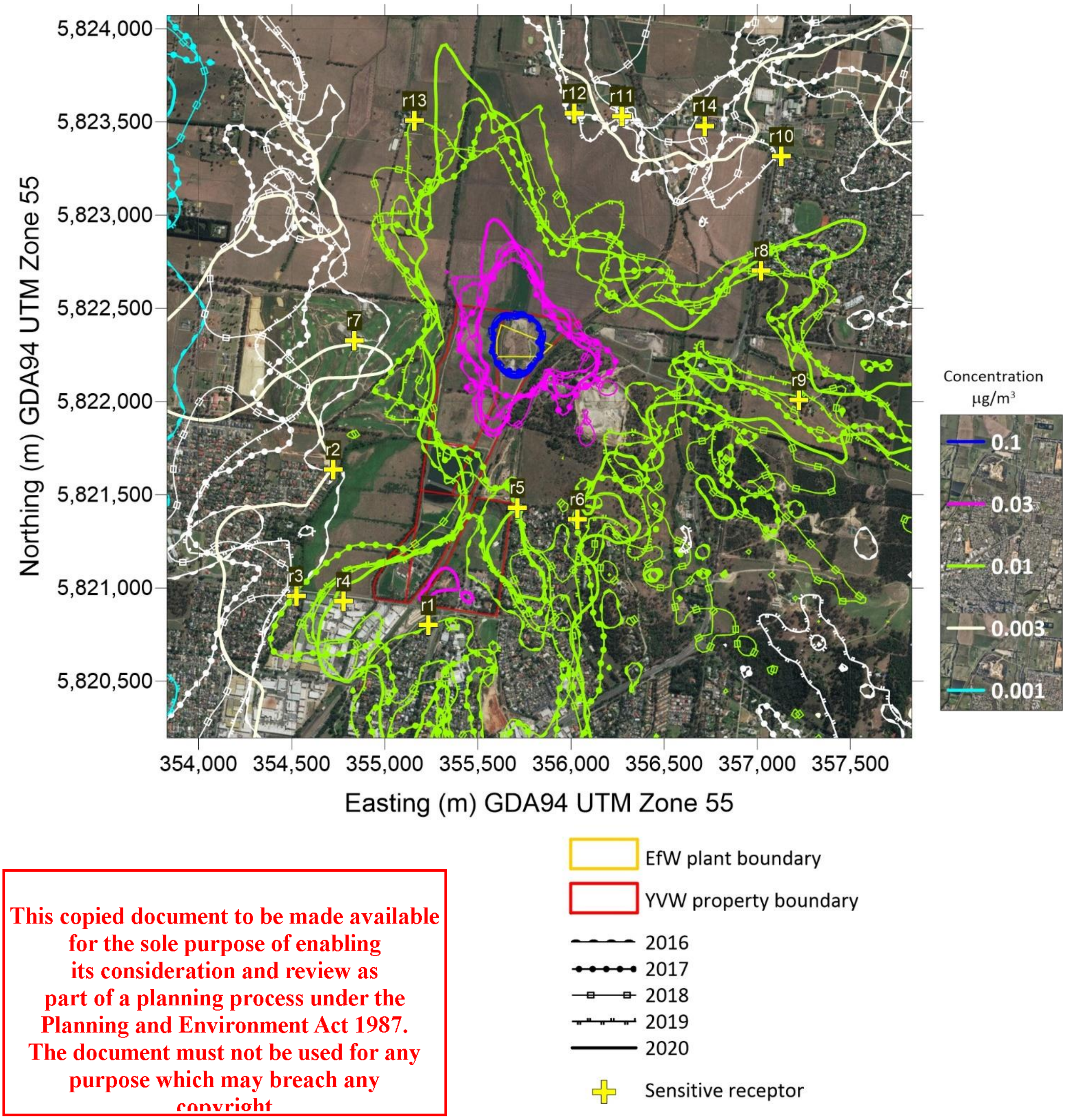


Figure 37 Predicted Project only benzene (TVOC indicator) concentration (µg/m³), maximum 24-hour average.

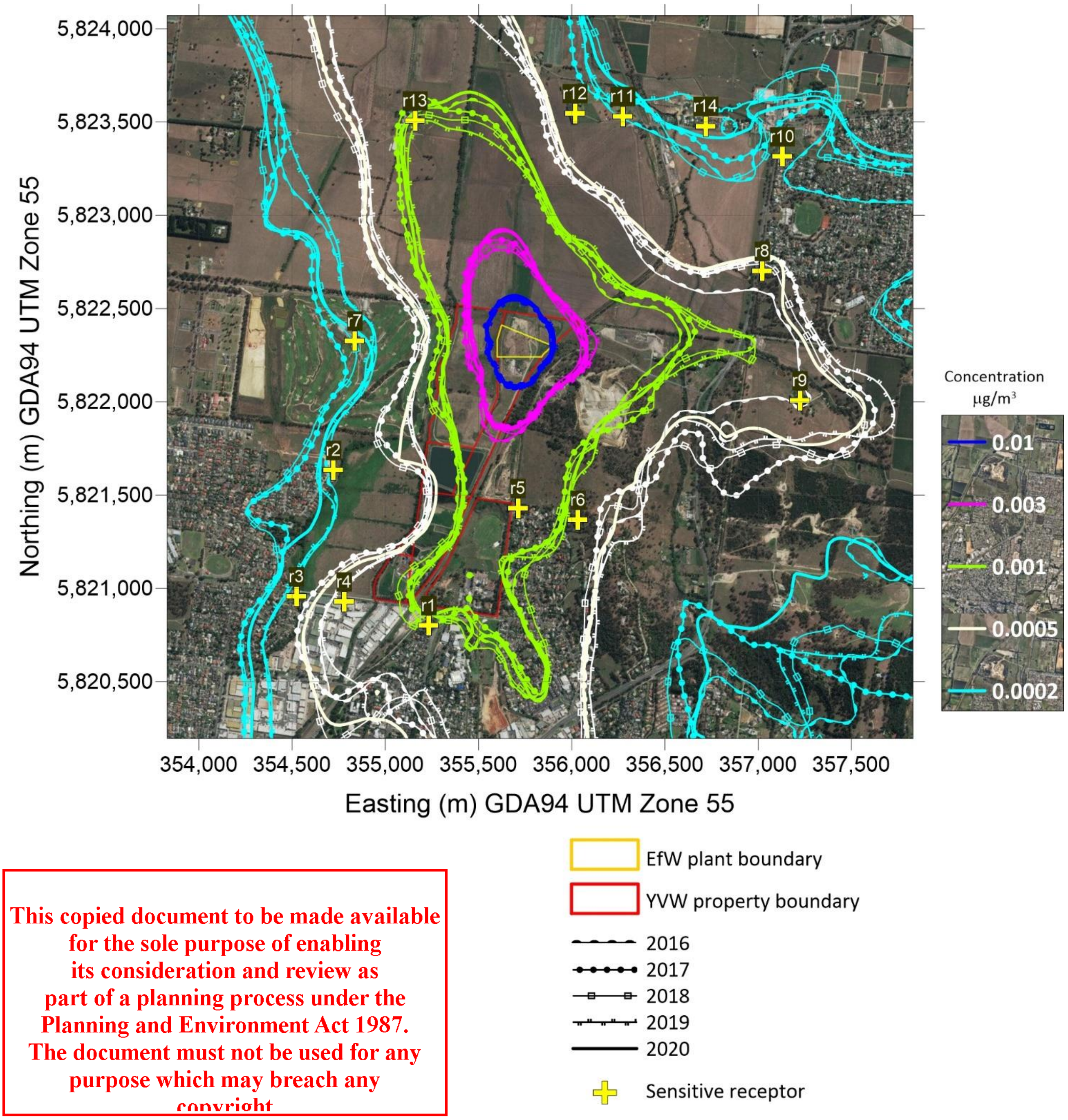


Figure 38 Predicted Project only benzene (TVOC indicator) concentration (µg/m³), maximum annual average.

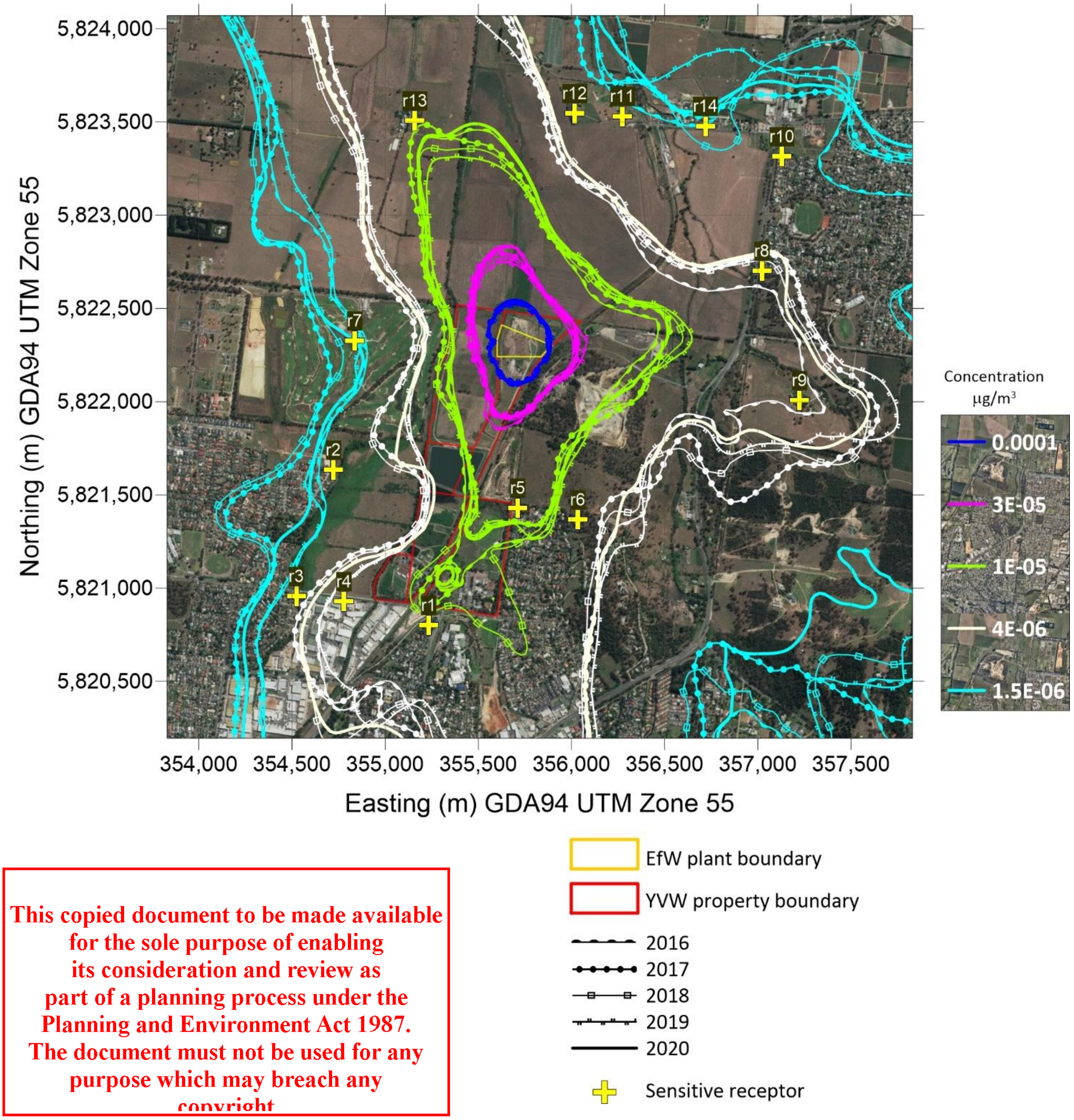


Figure 39 Predicted Project only benzo(a)pyrene (PAHs indicator) concentration (μg/m³), maximum annual average.