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Report

ENERGY FROM WASTE FACILITY – AIR QUALITY AND GREENHOUSE GAS ASSESSMENT

THE NEXT GENERATION

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EXECUTIVE SUMMARY

The Next Generation NSW Pty Ltd (TNG NSW) proposes to construct and operate an Energy from Waste (EfW) facility on land adjacent to the Genesis Xero Waste facility in Eastern Creek. This development site is part of a proposal to construct and operate NSW's largest EfW facility using residual waste as fuel which would otherwise be landfilled, to allow for a "green" electricity generation facility. The facility, fuelled by non-recyclable combustible waste material and will have a design capacity to process up to 1,350,000 tonnes of residual waste material per annum. Pacific Environment has been engaged by TNG NSW to prepare an Air Quality and Greenhouse Gas Assessment for the facility. Air quality impacts are assessed at the closest sensitive receptors, including locations such as schools and hospitals, located within the closest residential suburbs of Minchinbury and Erskine Park. Also included are the potential future receptors within the adjacent industrial estate.

The primary emissions from the EfW facility, as defined by emission limits for waste incineration set by the European Union (EU) Industrial Emissions Directive (IED; Directive 2010/75/EU), are anticipated to be as follows:

- Particulate matter (PM), assumed to be emitted as PM_{10} and $PM_{2.5}$[a].
- Hydrogen Chloride (HCl).
- Hydrogen Fluoride (HF).
- Carbon Monoxide (CO).
- Sulfur Dioxide (SO_2)
- Oxides of nitrogen (NO_x) (expressed as Nitrogen Dioxide (NO_2)).
- Heavy metals (including Mercury (Hg), Cadmium (Cd), Arsenic (As) and Chromium (Cr).
- Gaseous and vaporous organic substances (expressed as total organic carbon (TOC)).
- Dioxins and furans.

In addition to the atmospheric emissions identified in the IED, other potential emissions that have been addressed include:

- Hydrogen sulfide (H_2S).
- Chlorine (Cl_2).
- Ammonia (NH_3).
- Polycyclic aromatic hydrocarbons (PAHs).

In March 2014 the NSW Environment Protection Authority (EPA) published its Energy from Waste Policy Statement ("the EfW Policy Statement"). The EfW Policy Statement requires that any facility proposing to recover energy from waste will need to meet current international best practice. The policy also requires that emissions from EfW facilities must satisfy, as a minimum, current emission limits prescribed by the POEO (Clean Air) Regulations.

The proposed technology for the EfW facility is based on existing facilities in the United Kingdom and Europe and will incorporate best available technology (BAT) for flue gas treatment. The flue gas treatment is designed to meet the in-stack concentrations limits for waste incineration set by the EU IED, which are generally more stringent than those prescribed within the POEO (Clean Air) Regulations. The flue gas treatment system includes:

- Selective Non-Catalytic Reduction (SNCR) for reducing emissions of oxides of nitrogen (NO_x).
- Dry lime scrubbing for reducing emissions of acid gases, including hydrogen chloride (HCl) and sulfur dioxide (SO_2).
- Activated carbon injection for reducing emissions of dioxins and mercury (Hg).

[a] Particulate matter with an aerodynamic diameter of less than 10 and 2.5 micrometres respectively.

- Fabric filters for reducing emissions of particle matter (PM) and metals.
- Following flue gas treatment, emissions will be dispersed via a 100m stack.

A review of existing EfW facilities shows that the facility meets current international best practice and can satisfy the emission limit requirements of the IED.

The AERMOD atmospheric dispersion model was selected as a suitable dispersion model due to the source type, location of nearest receiver and nature of local topography.

Modelling predictions at sensitive receptors have been made and the results under normal operating conditions show:

- The maximum predicted 1-hour NO_2 is 21% of the impact assessment criterion, even when adopting the conservative assumption of 100% conversion from NO_x to NO_2
- The maximum predicted annual NO_2 is 5% of the impact assessment criterion.
- The maximum predicted 10-minute SO_2 is 1.5% of the impact assessment criterion, for 1-hour 1.3%, for 24-hour SO_2, 0.7% and for annual, 0.8%.
- The maximum predicted 24-hour PM is 0.1% of the impact assessment criterion for PM_{10} and 0.2% of that for $PM_{2.5}$.
- The maximum predicted annual PM is less than 0.1% of the impact assessment criterion for PM_{10} and 0.2% of that for $PM_{2.5}$.
- The maximum predicted CO for the 15-minute, 1-hour and 8-hour averaging periods are 0.1% or less than the relevant impact assessment criterion.
- The maximum predicted 24-hour HF is 9% of the impact assessment criterion, for 7-day 10%, for 30-day HF, 13% and for 90-day, 18%.

Modelling predictions for air toxics are assessed against the 99.9th percentile prediction, at and beyond the site boundary. The ambient concentration of H_2S is assessed against the 99th percentile prediction.

In summary, the modelling results show:

- The 99.9th percentile predicted HCl is 2% of the impact assessment criterion.
- The 99.9th percentile predicted cadmium (Cd) is 11% of the impact assessment criterion.
- The 99.9th percentile predicted mercury (Hg) is 0.5% of the impact assessment criterion.
- The 99.9th percentile predicted dioxins and furans are 0.1% of the impact assessment criterion.
- The 99.9th percentile predicted total organic carbon (TOC; as benzene) is 0.01% of the impact assessment criterion.
- The 99.9th percentile predicted NH_3 is 0.1% of the impact assessment criterion.
- The 99.9th percentile predicted PAH (as benzo(a)pyrene) is 0.4% of the impact assessment criterion.
- The 99th percentile predicted H_2S is 70% of the impact assessment criterion.

Cumulative predictions are also presented. There are no exceedances of the EPA criteria when the EfW contribution is added to maximum background concentrations under normal operating conditions.

The results of the modelling during upset conditions indicate that, under worst-case dispersion conditions, NO_2 and cadmium are predicted to exceed the NSW impact assessment criteria. A probabilistic approach has then been adopted, with results indicating that the probability of the above pollutants resulting in adverse impacts (i.e. the potential for upset conditions to coincide with worst-case dispersion conditions) would be less than 0.01%.

Additional modelling of a Regulatory Scenario indicates that application of the POEO emission limits within the Environmental Protection Licence for the facility would be sufficiently protective of health and environmental impacts while providing the facility with some operational flexibility.

The exception to this is cadmium, where an alternative in-stack concentration limit is provided.

Odour emissions from the EfW facility have been addressed in a stand-alone quantitative assessment (Pacific Environment, 2015a). The results of this assessment show that worst-case odour concentrations would be below the impact assessment criterion of 2 ou at nearest sensitive receptors.

A screening assessment of construction phase impacts identified no human receptors within 350 m of the boundary of the site. The screening assessment concluded no detailed assessment of construction phase impact is required and routinely employed 'good practice' mitigation measures for construction sites would be sufficient to control dust impacts to acceptable levels.

The operation of the facility would have a net positive GHG impact, potentially eliminating 3 million tonnes of carbon dioxide equivalents (CO_2-e) per annum. The emission intensity for electricity generated from the facility is lower than other non-renewable energy generators in NSW.

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1 INTRODUCTION

The Next Generation NSW Pty Ltd (TNG NSW) proposes to construct and operate an Energy from Waste (EfW) facility on land adjacent to the Genesis Xero Waste facility, located at Honeycomb Drive, Eastern Creek, approximately 36 km west of the Sydney CBD.

Pacific Environment has been engaged by TNG NSW to prepare an Air Quality and Greenhouse Gas Assessment as part of an Environmental Impact Statement (EIS), required under State Significant Development (SSD) provision in Schedule 1 of the State Environmental Planning Policy (State and Regional Development) 2011.

This assessment has followed the procedures outlined in the NSW Environment Protection Authority (EPA) document titled "Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW" ("The Approved Methods", NSW DEC, 2005).

1.1 Background and Context

The proposed EfW facility has been designed to comply with the NSW Environment Protection Authority (EPA) *Energy from Waste Policy Statement* ("the EfW Policy Statement"; EPA, 2014).

The development involves the construction and operation of an electricity generation plant, which will allow for unsalvageable and uneconomic residue waste from the Genesis Xero Material Processing Centre (MPC) and external Waste Transfer Station (WTS) to be used for generation of electrical power. The EfW facility is proposed to be located on Lots 2 and 3, DP 1145808.

This development site is part of a proposal to construct and operate NSW's largest EfW facility using residual waste as fuel which would otherwise be landfilled, to allow for a "green" electricity generation facility. The facility, fuelled by non-recyclable combustible waste material and will have a design capacity to process up to 1,350,000 tonnes of residual waste material per annum. The proposed works will, in addition to the EfW facility, include the adoption of a plan of subdivision and the following ancillary works:

- Subdivision of the land
- Pedestrian footpaths and routes
- Internal roadways and weighbridges (x 2)
- Direct underpass connection (Precast Arch and Conveyor Culvert) between the proposed
- Facility and the Genesis MPC
- Staff car parking for 40 vehicles (including 3 visitor parking spaces and 2 disabled parking spaces)
- Water detention and treatment basin and
- Services (Sewerage, Water Supply, Communications, Power Supply)
- Signage
- CCTV and other security measures
- External lighting
- Hard and soft landscaping and biodiversity measures.

1.2 Assessment Requirements

The Air Quality and Greenhouse Gas Assessment is guided by the Director-General's Requirements (DGRs) and Agency requirements, as outlined in Table 1-1.

Table 1-1: Agency requirements

Government Agency	Requirement	Relevant Section
DP&I	Air Quality and Human Health - including:	
	- a quantitative assessment of the potential air quality and odour impacts for the development on surrounding landowners and sensitive receptors under the relevant Environment Protection Authority guidelines;	Section 9
	- a description of construction and operational impacts, including air emissions from the transport of materials;	Section 7 and 9
	- a human health risk assessment covering the inhalation of criteria pollutants and exposure (from all pathways i.e., inhalation, ingestion and dermal) to specific air toxics;	Standalone report - note [b]
	- details of any pollution control equipment and other impact mitigation measures for fugitive and point source emissions;	Section 7
	- a demonstration of how the waste to energy facility would be operated in accordance with best practice measures to manage toxic air emissions with consideration of the European Union's *Waste Incineration Directive 2000* and the Environment Protection Authority's draft policy statement *NSW Energy from Waste*;	Section 7
	- an examination of best practice management measures for the mitigation of toxic air emissions;	Section 7
	- details of the proposed technology and a demonstration that it is technically fit for purpose.	Section 2
	Greenhouse Gas - including: - a full greenhouse gas assessment (including an assessment of the potential scope 1, 2 and 3 greenhouse gas emissions of the project, and an assessment of the potential impacts of these emissions on the environment	Section 10
	- a detailed description of the measures that would be implemented on site to ensure that the project is energy efficient.	Section 10.3
EPA	Assess the risk associated with potential discharges of fugitive and point source emissions.	Section 9
	Assessment of risk relates to environmental harm, risk to human health and amenity. Justify the level of assessment undertaken on the basis of risk factors, including but not limited to: a. proposal location; b. characteristics of the receiving environment; and c. type and quantity of pollutants emitted.	Section 3, 4, 7 and 9
	Describe the receiving environment in detail. The Proposal must be contextualised within the receiving environment (local, regional and inter-regional as appropriate). The description must include but need not be limited to: a. meteorology and climate;	Section 6

[b] A Human Health Risk Assessment has been prepared as a standalone assessment as part of the EIS.

	b. topography; c. surrounding land-use; receptors; and d. ambient air quality. e. Include a detailed description of the Proposal.	
	All processes that could result in air emissions (including odour) must be identified and described. Sufficient detail to accurately communicate the characteristics and quantity of all emissions must be provided.	Section 7
	Demonstrate that the proposed facility complies with the requirements of the NSW Energy from Waste *Draft* Policy Statement (2013). In particular: a. An international best practice techniques demonstration with respect to process design and control, emission control equipment design and control and emission monitoring with real time feedback to the controls of the process; and b. Energy Recovery Facility Technical Criteria.	Section 4, 7, 9
	Include a detailed emissions inventory for the Proposal. All point and fugitive sources are to be included in the inventory together with estimates of emission concentration and rate of all air pollutants emitted.	Section 7
	Any nominated controls must be explicitly linked to calculated emission reductions adopted in the air quality impact assessment emissions inventory, with all assumptions documented and justified.	Section 7
	Include a consideration of 'worst case' emission scenarios and impacts at proposed emission limits.	Section 9
	Account for cumulative impacts associated with existing emission sources as well as any currently approved developments linked to the receiving environment.	Section 9
	Include air dispersion modelling where there is a risk of adverse air quality impacts, or where there is sufficient uncertainty to warrant a rigorous numerical impact assessment? Air dispersion modelling must be conducted in accordance with the Approved Methods or the Modelling.	Section 8, 9
	An odour impact assessment must additionally have regard to the technical Framework and Notes for the assessment and Management of odour from discretionary sources in NSW (2006).	Section 7.11
	Include a quantitative photochemical smog assessment in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (2005).	Standalone report – note [c]
	ODOUR A quantitative assessment of the potential odour impacts from the construction and operation of the plant on surrounding landowners and sensitive receptors.	Section 7.11

[c] An ozone impact assessment / photochemical smog assessment has been prepared as a standalone assessment, submitted as part of the EIS.

2 TECHNICAL DESCRIPTION OF THE FACILITY

2.1 EfW Facility Overview

The EfW facility will operate a well-established technology known as a moving grate system with water and air cooled grate bars. Residual waste fuel is gravity fed onto the incinerator grate. The grate is continually moving thus promoting continuous mixing of the residual waste fuel with the combustion air, extracted from the tipping hall and introduced from beneath the grate into the heart of the fire. Further air is injected just above the fire to promote mixing and complete combustion of the gases.

The turbine exhaust cooling system for the EfW facility is an Air Cooled Condenser (ACC) that does not require water and does not generate an effluent discharge. Furthermore there is no visual plume impact through the ACC, as there would be for an evaporative cooling tower.

Diesel generators are installed for start-up and to maintain the furnace temperature, if required. However, during normal operation no support fuel is required to maintain a minimum combustion temperature of 850°C.

Ash from the grate is discharged into a water filled quench bath from where it is moved by conveyor to the enclosed ash storage bunkers prior to being transported off site.

Hot gases from the combustion of the residual waste fuel pass through a heat recovery boiler. The temperature of the gases is reduced from over 850°C to around 150°C. The energy from the hot gases is transferred to the boiler to produce high pressure steam. This steam is fed to the steam turbine driven generator capable of generating around 137.3 MW, which, after supplying the site electrical load is exported to the National Grid.

The technology will have a design capacity to process up to 1,350,000 tonnes of residual waste material per annum. TNG NSW's proposed implementation will be to process up to 1,105,000 tonnes per annum, using a two phased approach:

- Phase 1 (lines 1 and 2) which will require 552,500 tpa as waste.
- Phase 2 (lines 1, 2, 3 and 4) which will require 1,105,000 tpa as waste.

The first phase will include the complete construction of the Tipping Hall and Waste Bunker and combustion Lines 1 and 2 comprising of two independent boilers, Flue Gas Treatment (FGT) systems, stack as well as one turbine and one Air Cooled Condenser (ACC) and all other auxiliary equipment. The second phase will comprise of installation of combustion lines 3 and 4 with again two independent boilers, FGT systems, stack as well as one turbine and one ACC and all other auxiliary equipment. This assessment addresses the EfW facility when all four lines are operational. Some wastes would be delivered directly to the facility (by truck) with the remaining transferred from the existing Genesis Facility either via a covered electrically powered conveyor or by truck.

Without any changes to the main process, the EfW facility will be configured so that it will be possible to export heat to nearby consumers.

Operation of the EfW facility will generate three types of solid waste by-products, while producing no excess effluent during operation:

- Bottom ash
- boiler ash
- flue gas treatment residues (APC residues).

The operational parameters of waste flow, combustion air and temperatures will be automatically controlled by the Distributed Control System based on the incoming waste parameters. This will provide the necessary combustion conditions and maintain the necessary temperature and residence time in the secondary combustion chamber. As part of the operational requirements, appropriate waste sorting procedures will be refined to incorporate any Conditions of Consent issued by the Department of Planning and Environment.

The EfW facility will operate 24 hours a day, seven days a week, with occasional offline periods for maintenance. Over the entire year, it is assumed that the EfW facility would be operational for 8,000 hours as an annual average. Some residual waste fuels would be delivered directly to the EfW facility (by B-double) with the remaining transferred from the existing Genesis Xero Waste facility either via a covered electrically powered conveyor or by truck. It is anticipated that as a result of the EfW facility operations the site would receive a maximum of 252 trucks per day, comprising:

- 168 truck movements associated with the waste material
- 4 truck movements for miscellaneous deliveries such as hydrated lime or activated carbon
- 80 trucks movements for ash removal for worst case fuel.

All roads will be sealed to reduce potential for wheel generated dust emissions.

A general arrangement for the EfW facility is shown in Appendix A. A list of all adopted assumptions in this assessment is provided in Appendix B.

2.2 Flue Gas Treatment

The proposed technology for the EfW facility is based on existing facilities in the United Kingdom (UK) and rest of Europe and will incorporate best available technology (BAT) for flue gas treatment. The flue gas treatment is designed to meet the in-stack concentration limits for waste incineration set by the European Union (EU) Industrial Emissions Directive (IED; Directive 2010/75/EU).

The flue gas treatment system is designed to achieve the emission limits as required by the Industrial Emissions Directive (IED) (further discussed in Section 4.3). The flue gas treatment system includes:

- Selective Non-Catalytic Reduction (SNCR) for reducing emissions of oxides of nitrogen (NO_x).
- Dry lime scrubbing for reducing emissions of acid gases, including hydrogen chloride (HCl) and Sulfur Dioxide (SO_2).
- Activated carbon injection for reducing emissions of dioxins and mercury (Hg).
- Fabric filters for reducing emissions of particulate matter (PM) and metals.

Following flue gas treatment, emissions will be dispersed via a 100m stack. Further details of the flue gas treatment are discussed in Section 7.

The owner's engineer, Ramboll, has produced a memorandum presented in Appendix C noting that waste is ignited and burnt on the grate in the furnace at temperatures around 1,100° C and the temperature of the flue gases is thereafter kept above 850 °C for at least 2 seconds in the afterburning chamber.

The flue gas treatment stage consists of a reactor with injection of lime and activated carbon followed by a bag house filter for PM removal, including the activated carbon. In this manner, the flue gas treatment system is designed to ensure that the stack emissions comply with in-stack emission limits regardless the content in the raw, untreated flue gas within any realistic operational range.

2.3 Fuels

The following residual waste fuel types have been identified as the main sources of fuel for the EfW facility:

- Chute Residual Waste (CRW) from the Genesis MPC;
- Commercial and Industrial (C&I);
- Construction and Demolition(C&D);
- Floc waste from car and metal shredding;
- Paper pulp;

- Glass Recovery;
- Garden Organics (GO);
- Alternative Waste Treatment (AWT); and
- Material Recovery Facility waste (MRF waste) residual

As the net calorific value (NCV) of waste fuels vary depending on type, the EfW facility will operate within a range of NCVs to support operational flexibility.

2.3.1 Design Fuel

Based upon the fuel types listed above, a design fuel composition has been developed and is provided in Appendix D. This is based on typical values for each of the proposed fuels and an estimated fuel mix. Input fuel will be mixed as part of the normal operational process to produce as homogenous an input as possible. Further, technical memoranda outlining the waste composition anticipated for the EfW facility are presented in Appendix C.

It is acknowledged that fuel will comprise some fractions containing PVC and their chlorine content will be slightly above 1%, nevertheless the waste in total and as an average will not contain more than 1% chlorine (Ramboll, 2016).

This will be achieved through the extensive mixing of waste before feeding it to the combustion process. As described in Ramboll (2016), the mixing and homogenisation of the different waste streams is a very important aspect of the operation of a waste-to-energy plant and therefore it is given a very high importance. When the waste is tipped in to the bunker it has to be picked up by the crane grab so as to keep the delivery area free and allow further waste deliveries. During times with low delivery it is the duty of the crane driver (or in the case of an automatic crane of the automation system) to thoroughly mix the waste by picking it up and dropping it in a different place of the storage area in the bunker. This ensures a thorough mixing of the different waste fractions. To be fed to the combustion system the waste is again picked up by the crane grab. Further discussion is provided in in Section 4.2.

2.3.2 Fuel Source Availability

The availability of waste as fuel source is a commercial issue. Despite this, EIS and the Waste Management Report have investigated the availability of waste as a fuel source which has been discussed in the EIS and Waste Management Report. As discussed in Section 2.1, the EfW facility will be developed in two stages:

- Phase 1 (lines 1 and 2) which will require 552,500 tpa as waste.
- Phase 2 (lines 1, 2, 3 and 4) which will require 1,105,000 tpa as waste.

The eligible tonnes received currently across DADI's waste asset portfolio exceed the tonnes required for lines 1 and 2 (552,500 tpa).

In relation to identifying waste for energy for Phase 2 of the project, DADI commissioned an assessment for the availability of waste to landfill in metropolitan Sydney which is summarised in Section 2 of the Waste Management Report. Table 3 of the Waste Management Report illustrates waste available for disposal in metropolitan Sydney as of 2008/2009:

- 1,854,500 tpa of C&I waste for disposal.
- 1,075,000 tpa of C&D waste for disposal.

It is noted that recycling percentages have increased over time however, population increases have meant that waste generation overall has increased to counter increases in recycling. From the study and DADI's working knowledge of the waste markets, confidence can be placed on the availability of waste as a fuel source to meet the tonnes per annum requirements to run all four lines.

Importantly, DADI plans to commission the plant in two phases to give time to make contract arrangements with waste collectors in order to assure there is sufficient waste fuel to open lines 3 and 4. Without approval and an operating plant it is unrealistic to have these contracts in place.

It should be noted that under the current NSW waste levy it is more profitable for DADI to recycle waste as opposed to using the waste for a fuel source in the TNG Facility. Therefore, it will be the preference and aim of DADI's Genesis Xero Waste Facility to recycle as far as reasonably practicable and not divert any recycling opportunities in favour of use at the TNG Facility.

2.4 Start-up / Shut-down Conditions

The EfW facility is designed to operate continuously, therefore start-up and shutdown are infrequent events and anticipated to be required during the EfW facility's annual maintenance program. However, any required start/stop operations will be completed automatically, under the supervision of trained operators, in a controlled and safe manner.

The EfW facility will be started using fuel oil to reach safe combustion temperatures before any solid fuels are added. The flue gas cleaning system and emissions monitoring will be in operation before any solid fuel is added.

When required, the EfW facility is turned off in a controlled manner through reversing the start-up process. The solid fuel feeding is stopped, with the EfW facility then operating to ensure that all material is burnt and flue gases are cleaned out of the process. Finally, the air flows are left on to allow the boiler unit to cool before the EfW facility can be fully shut off (Ramboll, 2016).

2.5 Upset Conditions

Upset operating conditions at the EfW facility could occur for a number of reasons (Ramboll, 2016). It should be noted that during upset conditions, not all air quality parameters will simultaneously increase, but rather individual parameters may increase by an approximate factor of 10 under specific upset conditions, for example:

- Reduced efficiency of:
    - Selective Non-Catalytic Reduction (SNCR) system as a result of blockages or failure
    - particulate filtration system due to bag failure and inadequate isolation, leading to elevated particulate emissions and metals in the particulate phase.
    - lime injection system such as through blockages or failure of fans leading to elevated acid gas emissions.
- Complete failure of:
    - lime injection system leading to unabated emissions of HCl. (Note: this would require the plant to have complete failure of the bag filter system. As a plant of modern design, the plant would have shut down before reaching these operating conditions).
    - the activated carbon injection system and loss of temperature control leading to elevated concentrations of metals, organics and dioxin reformation and their unabated release.

Under any of the above circumstances, the operator will reduce or shut-down operations as soon as practicable until normal operations can be restored. In accordance with the a design to the requirements of the EU IED, such events shall under no circumstance occur for more than four hours uninterrupted where the emission values exceed the limits and no more than 60 hours per year.

2.6 Emergency Conditions

In the event of a breakdown of the steam turbine generator, the power for the site parasitic load will be supplied from the grid. It is anticipated that the steam turbine will be capable of operating in island mode. In the event of a loss of grid connection, this would allow the EfW facility to continue processing fuel with the auxiliary load supplied from the turbine generator.

Emergency diesel generators will also be available for safe shut down of the EfW facility in the event of a loss of grid connection and failure of the steam turbine to transfer to island mode operation.

To facilitate this safe shutdown and black start[d] there will be two emergency diesel generators with one dedicated to each purpose. Each diesel generator (QSK78) will have a capacity of 2.4 MW that will provide sufficient power for the four incineration lines. A photograph of the proposed diesel generators is shown in Figure 2-1.

The emergency generators will not be used during normal operation of the EfW facility. This includes during planned (scheduled) or forced (unscheduled) outages. Circumstances where the emergency generators may be used include:

- Routine maintenance and specific testing; units will operate for one hour a month.
- In the event of a fire, to provide power supply for emergency lighting and fire-fighting pumps.
- In the simultaneous event of:
    - High Voltage electric grid blackout in the Eastern Creek area or in the whole of Sydney requiring island mode operation of the EfW plant an extremely hot day in the summer time with ambient air temperatures above 35°C (depends on the final sizing of the ACC and on the steam turbine manufacturer) causing an excessively high back pressure in the ACC, in turn initiating a turbine trip and necessitating a shutdown of the whole EfW plant..

This latter event is considered to have a low probability of occurrence, with a worst case frequency estimated to be once every ten years for the two events combined (HZI, 2015).

In the event of requiring safe shutdown/black start, it is anticipated that the diesel generators would be required to run for approximately two hours, with a maximum of six hours for black start required if the plant shutdown is over a longer period of time.

[d] Black start is the process of restoring power station operation without relying on the external electric power transmission network.

Figure 2-1: Emergency diesel generator (QSK78)

3 LOCAL SETTING

The proposed EfW facility is located at Eastern Creek, approximately 36 km west of the Sydney CBD and surrounded by the residential areas of Minchinbury, Mt Druitt and Rooty Hill to the north, Erskine Park to the east and Colyton to the northwest (shown in Figure 3-1).

The site which is accessed off Honeycomb Drive at Eastern Creek is surrounded by land owned by the Corporate Group Alexandria Landfill Pty Ltd, ThaQuarry Pty Ltd, Australand, Hanson, Jacfin, the Department of Planning and Infrastructure and Sargents.

The site and surrounding land is identified as part of the '*State Environmental Planning Policy (Western Sydney Employment Area) 2009 (WSEA SEPP)*' to be redeveloped for higher end industrial and employment uses over the next decade. The site has a total area of approximately 56 hectares including the Riparian Corridor, with a specific development area circa 9 hectares.

A sensitive receptor is defined as a location where people are likely to work or reside; and may include a dwelling, school, hospital office or public recreational area in addition to known or likely future locations (NSW DEC, 2005).

Air quality impacts are assessed at the closest residential areas as shown, including particularly sensitive receptors such as schools and hospitals, as well as isolated semi-rural residential receptors off Burley Road to the southeast. Included in this assessment are the potential future receptors that may be located within the adjacent industrial estate. Listed in Appendix E are the particularly sensitive receptors (schools, childcare centres), located within the residential suburbs of Minchinbury and Erskine Park (also shown in Figure 3-1).

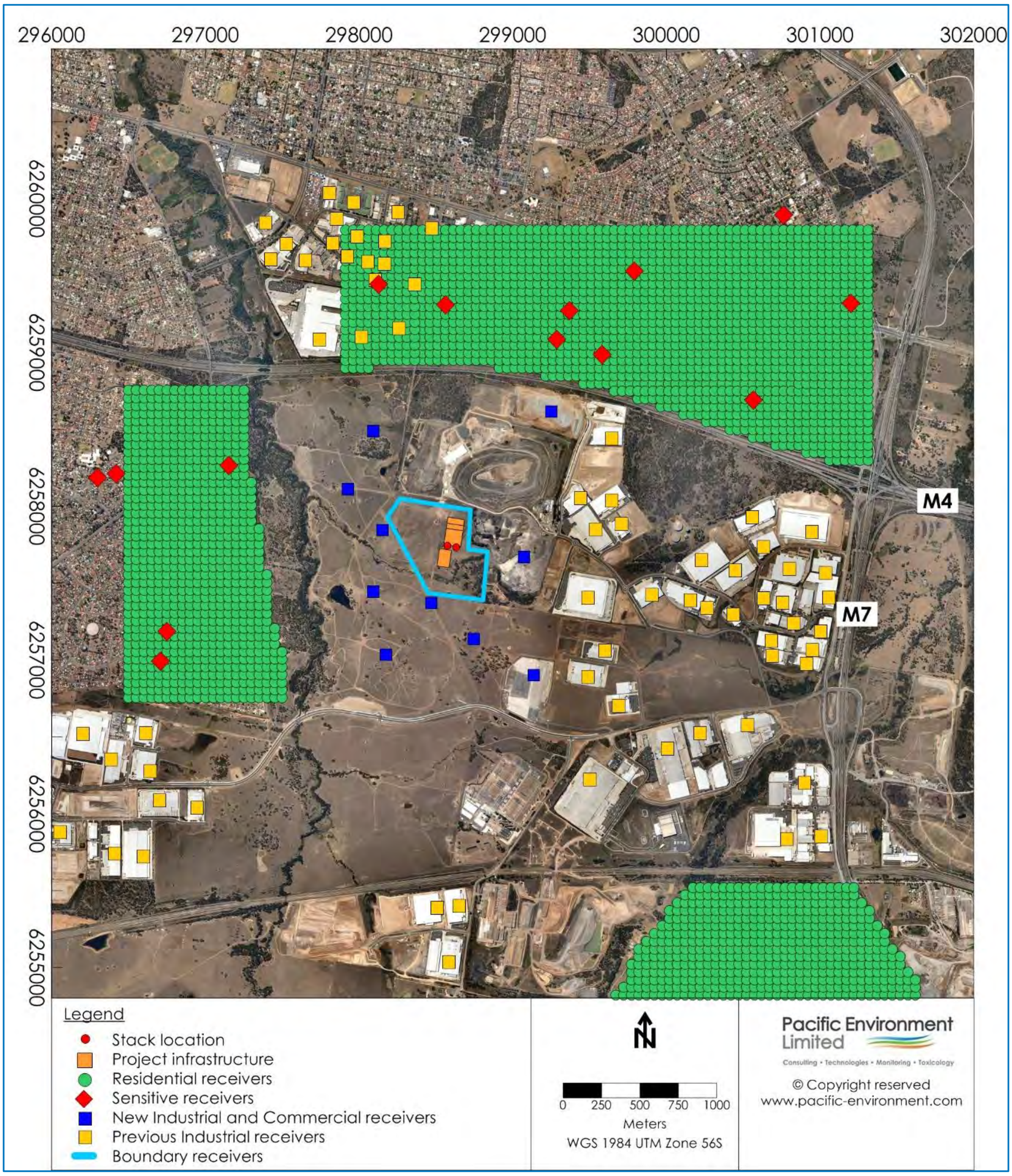


Figure 3-1: Local setting and representative sensitive receptor locations

4 LEGISLATIVE SETTING

4.1 Introduction

The EfW facility design has been developed to align with the relevant environmental, operational and safety requirements of Australian and NSW regulatory frameworks. Key performance requirements have been used to inform the development of the design and operation of the EfW facility.

The starting point for the environmental performance of the EfW facility has been the compliance with legislative standards which are required of Waste-to-Energy plants in Europe. The European Industrial Emissions Directive IED 2010/75 EC (EU IED) has also been used as the basis for the development of the NSW Energy from Waste Policy, which is the legislative framework for the proposed EfW facility.

The primary emissions from the EfW facility, as defined by emission limits for waste incineration set by the EU IED, are as follows:

- Particulate matter (PM), assumed to be emitted as PM_{10} and $PM_{2.5}$[e].
- Hydrogen Chloride (HCl).
- Hydrogen Fluoride (HF).
- Carbon Monoxide (CO).
- Sulfur Dioxide (SO_2)
- Oxides of nitrogen (NO_x) (expressed as Nitrogen Dioxide (NO_2)).
- Heavy metals (including Mercury (Hg), Cadmium (Cd), Arsenic (As), Chromium (Cr).
- Gaseous and vaporous organic substances (expressed as total organic carbon (TOC)).
- Dioxins and furans.

In addition to the emission identified in the EU IED, potential emissions also include:

- Hydrogen sulfide (H_2S).
- Chlorine (Cl_2).
- Ammonia (NH_3).
- Poly-aromatic hydrocarbons (PAHs).

The EfW facility will incorporate best available technology (BAT) for flue gas treatment designed to meet the most stringent in-stack concentrations limits and ambient air quality criteria applicable for NSW. An overview of the applicable limits and criteria are provided below.

4.2 NSW EPA Energy from Waste Policy Statement

In March 2014 the NSW Environment Protection Authority (EPA) published its Energy from Waste Policy Statement (“the EfW Policy Statement”; EPA, 2014). The EfW Policy Statement sets out the policy framework and overarching criteria that apply to facilities in NSW proposing to thermally treat waste or waste-derived materials for the recovery of energy. Thermal treatment is defined as combustion, thermal oxidation, thermal or plasma gasification, pyrolysis and torrefaction.

Facilities proposing to thermally treat wastes that are not listed as an eligible waste fuel (such as this EfW facility) must meet the requirements of an energy recovery facility, that is must meet international best practice with respect to:

- Process design and control
- Emission control equipment
- Emission monitoring with real time feedback to process controls
- Arrangements for receipt of waste

[e] Particulate matter with an aerodynamic diameter of less than 10 and 2.5 micrometres respectively.

- Management of residues

The EfW Policy Statement notes that meeting international best practice will ensure that air toxics and particulate emissions are below levels that may pose a risk of harm to the community or environment. The EfW Policy Statement also specifies technical criteria which must be met, as outlined in Table 4-1.

Table 4-1: Technical criteria as outlined in EfW Policy Statement

Technical Criteria	
1	Combustion chamber minimum temperature of 850°C for at least 2 seconds, after the last injection of air.
2	Where waste contains >1% halogenated organic substances (expressed as chlorine), the combustion chamber temperature should be raised to 1100°C for at least 2 seconds, after the last injection of air.
3	The air emissions must satisfy, as a minimum, the Group 6 emission standards prescribed by the Protection of the Environment Operations (Clean Air) Regulation, 2010.
4	There must be continuous measurement of NO_x, CO, particles (total), total organic compounds, HCl, HF and SO_2.
5	There must be continuous measurement of temperature in the combustion chamber.
6	There must be continuous measurement of temperature, oxygen, pressure in the stack and water vapour in the exhaust gases.
7	Proof of performance trials must be conducted to demonstrate compliance with the emission standards. At least two measurements per year are required for heavy metals, PAHs and dioxins and furans (quarterly for the first year).
8	The total organic carbon (TOC) or loss on ignition (LOI) content of the slag and ash residue must be not greater than 3% and 5% respectively of the dry weight material.
9	Waste interlocks are required to prevent waste being fed before the requirement combustion temperature has been reached.
10	The net energy produced must be positive with at least 25% thermal efficiency (25% of thermal energy capture as electricity).

With regard to the second technical criterion, it is understood that the >1% chlorine trigger for waste has been incorporated because EfW Policy Statement references the original EU Waste Incineration Directive. However, the EfW Policy Statement refers simply to "waste" with > 1% chlorine, whereas the EU Waste Incineration Directive refers to "hazardous waste with halogenated organic substances >1%".

The main contribution to the chlorine content of the waste is PVC. PVC (C_2H_3Cl) itself contains approximately 57% chlorine by weight. In municipal waste typically approximately 50 % of the chlorine within the waste stream comes from PVC, in C&I waste the contribution of PVC to the overall chlorine content is expected to be even higher (Ramboll, 2016).

The European EfW experience has shown that EfW facilities typically have to handle concentrations of PVC of around 1% (MSW) with around 0.4% residual (i.e. non-PVC) chlorine contents. Residual fractions from recycling, C&D and C&I can also reportedly reach up to nearly 10%.

It is highlighted that PVC is not classified as a hazardous waste in either the EU or NSW jurisdictions.

The waste in total and as an average will not contain more than 1% chlorine (Ramboll, 2016). This will be achieved through the extensive mixing of waste before feeding it to the combustion process. Ramboll (2016) conducted a sensitivity analysis of how a changing percentage of the different fractions influences the final chlorine content of the fuel. The analysis showed that the fractions with higher chlorine content can increase by a factor of at least 5 without the resulting fuel exceeding the 1% limit specified. Such a change is highly unlikely and therefore the fuel mix is expected to remain below a composition of 1% chlorine.

Current technology (from all EfW providers) does not allow efficient energy recovery at the higher temperature of 1,100°C referenced in Point 2 in Table 4-1.

TNG NSW have expressed that the current wording of the NSW EfW Policy Statement should be amended to reflect the wording within the EU legislation that it was based upon. Within the context of the current assessment, it is understood that, while flue gas treatment is able to abate significantly greater peaks in chlorine concentration of the residual waste fuel, the waste in total and as an average will not contain more than 1% chlorine (Ramboll, 2016)and therefore subject to an 850°C combustion temperature (Appendix C). Equally, the EfW facility would not be handling any 'hazardous' waste (with or without halogenated organic substances) as referenced in the EU legislation. As such, the technical criteria around the use of higher combustion temperatures referenced within the EU legislation would not require to be invoked in any event.

4.3 Emission Limits

Under the EfW Policy Statement the stack emissions from the facility are required, as a minimum, to meet the Group 6 standards of concentration set out in the *Protection of the Environment Operations (Clean Air) Regulation 2010* ("the Clean Air Regulation"). The Clean Air Regulation sets standards for various activities and those that are applicable to an EfW facility are outlined in Table 4-2.

However, the proposed flue gas treatment will be designed to employ Best Available Technology (BAT) and achieve the emission limits specified by the EU IED[f]. The IED emissions limits (refer Table 4-3) are generally more stringent that the Clean Air Regulation limits. The proposed technology is based on existing facilities operated throughout Europe, which are designed to meet the IED limits.

Table 4-2: POEO Clean Air Regulation Standards of Concentration

Pollutant	Standard (mg/Nm^3)	Source	Activity
Solid Particles (Total)	50	Electricity generation	Any activity of plant using liquid or solid standard fuel or non-standard fuel
HCl	100	General standards	Any activity or plant
HF	50	Electricity generation	Any activity of plant using liquid or solid standard fuel or non-standard fuel
SO_2	No applicable standard		
NO_2	500	Electricity generation	Any boiler operating on a fuel other than gas, including a boiler used in connection with an electricity generator that forms part of an electricity generating system with a capacity of 30 MW or more
Type 1 & 2 substances (in aggregate)	1	Electricity generation	Any activity of plant using non-standard fuel
Cd or Hg (individually)	0.2	Electricity generation	Any activity of plant using non-standard fuel
Dioxins or furans	$1x10^{-7}$ (0.1 ng/m^3)	Electricity generation	Any activity of plant using non-standard fuel that contains precursors of dioxin or furan formation
VOC	40 (VOC) or 125 (CO)	Electricity generation	Any activity of plant using non-standard fuel
Cl_2	200	General standards	Any activity or plant
H_2S	5	General standards	Any activity or plant

Reference conditions defined as dry, 273.15 K, 101.3 kPa and 7% O_2 for all air impurities when burning a solid fuel, with the exception of dioxins and furans where the required O_2 concentration is 11% for waste incineration.

f The IED replaces the EU Waste Incineration Directive (2000/76/EC)

Table 4-3: IED Air Emission Limit Values

Pollutant	Daily Average (mg/Nm³)	Half Hourly Average(mg/Nm³)	
		100%	97%
Total Dust	10	30	10
Total Organic Carbon (TOC)	10	20	10
HCl	10	60	10
HF	1	4	2
SO2	50	200	50
NO2	200	400	200
Cd	0.05	N/A	
Thallium (Tl)	0.05		
Hg	0.05		
Type 1 and 2	0.5		
Dioxins	1E-07 (0.1 ng/m³)		
CO	50		

Reference conditions defined as dry, 273.15 K, 101.3 kPa and 11% O_2.

No emission limits are prescribed for NH_3 or PAHs under the Australian or European legislative framework. Notwithstanding, these are important emissions that have been addressed within this assessment.

In accordance with clauses 56 of the Clean Air Regulation, power station emissions during start-up and shut-down periods are exempt from the in-stack concentration limits specified in Table 4-2. In addition, clause 57A of the Clean Air Regulation states that emergency generators are also exempt if the generators are used no more than 200 hours per year.

4.4 Ambient Air Quality Criteria

The emissions from the EfW facility are also required to comply with the ground level concentrations criteria outlined in the Approved Methods (NSW DEC, 2005). Table 4-4 summarises the ambient impact assessment criteria applicable to this assessment.

Impact assessment criteria for NO_2, SO, PM_{10}, CO and HF are applied at the nearest existing or likely future off-site sensitive receptor and are reported as the 100th percentile (i.e. maximum) of the dispersion modelling prediction. For the assessment of impact, background concentrations for these pollutants needs to be considered.

Impact assessment criteria for 'air toxics' (HCl, Hg, Cd, dioxins, NH_3 and PAHs) are applied beyond the site boundary and reported as the 99.9th percentile of the dispersion modelling prediction. Only incremental impacts for these pollutants need be reported.

Table 4-4: EPA ambient impact assessment criteria

Pollutant	Criterion	Averaging Period
NO_2	246 µg/m^3	1-hour average
	62 µg/m^3	Annual average
SO_2	712 µg/m^3	10-minute average
	570 µg/m^3	1-hour average
	228 µg/m^3	24-hour average
	60 µg/m^3	Annual average
PM < 10 µm (PM_{10})	50 µg/m^3	24-hour average
	30 µg/m^3	Annual average
CO	100 mg/m^3	15-minute average
	30 mg/m^3	1-hour average
	10 mg/m^3	8-hour average
HF [(a)]	2.9 µg/m^3	24-hour average
	1.7 µg/m^3	7 days
	0.84 µg/m^3	30 days
	0.5 µg/m^3	90 days
HCl	0.114 mg/m^3	1-hour
Hg (inorganic)	0.0018 mg/m^3	1-hour
Cd	0.000018 mg/m^3	1-hour
Dioxins and furans	2.0 x 10^{-9} mg/m^3	1-hour
TOC (as benzene)[(b)]	0.029 mg/m^3	1-hour
NH_3	0.33 mg/m^3	1-hour
Cl_2	0.05 mg/m^3	1-hour
PAHs (as benzo(a)pyrene)	0.0004 mg/m^3	1-hour

Notes: a. Applies to general land use other than areas with vegetation sensitive to fluoride e.g. grape vines and stone fruit.
b. Benzene has been adopted as it has the most stringent impact assessment criterion of the BTEX (benzene, toluene, ethylbenzene and xylene) organic compounds.

The criteria in Table 4-5 are consistent with applicable standards in the *National Environment Protection Measure for Ambient Air Quality* (referred to as the Ambient Air-NEPM) (NEPC, 1998a). In May 2003, the NEPC released a variation to the Ambient Air-NEPM (NEPC, 2003) to include advisory reporting standards for fine particulate matter with an equivalent aerodynamic diameter of 2.5 µm or less ($PM_{2.5}$). The purpose of the variation was to gather sufficient data nationally to facilitate the review of the Ambient Air-NEPM, which is currently underway.

Table 4-5: $PM_{2.5}$ advisory reporting standards

Pollutant	Advisory Reporting Standard	Averaging Period
PM < 2.5 µm ($PM_{2.5}$)	25 µg/m^3	24-hour average
	8 µg/m^3	Annual average

4.5 Load Based Licensing

The load-based licensing (LBL) scheme, sets limits on the pollutant loads emitted by holders of environment protection licences and links licence fees to pollutant emissions.

Schedule 1 of the *Protection of the Environment Operations (General) Regulation 2009* sets out the licence fee system and lists assessable pollutants for energy recovery from waste and hazardous waste. The threshold limits for energy recovery are listed in Table 4-6.

Table 4-6: Threshold limits for energy recovery from waste

Air quality parameter	Threshold factor (tonnes)
Arsenic	0.00005
Benzene	0.0000011
Benzo(a)pyrene	0.00002
Fine particulates	0.7
Lead	0.035
Mercury	0.003
Nitrogen oxides and nitrogen oxides (summer)	2.5
Sulfur oxides	0.07

It is acknowledged that the EfW facility will likely be liable under the LBL scheme for a number of air quality parameters.

4.5.1 Hydrogen Sulfide

The Approved Methods also include ground-level concentration (glc) criteria for individual odorous air pollutants such as H_2S, taking account of population density in a given area. Table 4-7 lists the H_2S criteria to be exceeded not more than 1% of the time, for different population densities.

The differences between odour criteria are based on considerations of risk of odour impact rather than differences in odour acceptability between urban and rural areas. For a given odour level there will be a wide range of responses in the exposed population. In a densely populated area there will therefore be a greater risk that some individuals within the community will find the odour unacceptable than in a sparsely populated area.

An H_2S criterion of 1.38µg/m^3 would apply to the built up areas around the EfW facility in any further detailed assessment of proposed operations.

Table 4-7: Odour performance criteria for the assessment of hydrogen sulfide

Population of affected community	Criterion for H_2S 99th percentile (µg/m^3)
≤ ~2	1.38
~10	2.07
~30	2.76
~125	3.45
~500	4.14
Urban (2000) and/or schools and hospitals	4.83

5 DISPERSION METEOROLOGY

5.1 Wind Speed and Wind Direction

Air quality impacts are influenced by meteorological conditions, primarily in the form of gradient wind flow regimes, and by local conditions generally driven by topographical features and interactions with coastal influences, such as the sea breeze. The local dispersion meteorology for the site, in relation to wind speed and direction, has been reviewed based on the data available at nearby meteorological stations.

The Bureau of Meteorology (BoM) collects climatic information at the Horsley Park Equestrian Centre Automatic Weather Station (AWS), located approximately 6 km southeast of the site. The NSW Office of Environment and Heritage (OEH) operate a meteorological station at St Marys, located approximately 5 km west and at Prospect, located approximately 6 km east of the EfW.

The closest site and most representative location in terms of land use and surface roughness is the OEH monitoring site at St Marys. Annual and seasonal wind roses for 2009 and 2013 at St Marys are shown in Figure 5-1 and Figure 5-2, respectively. During both years the dominant annual winds are from the south and south-southwest with a significant portion also from the north-northwest. This pattern is similar in all seasons with summer also showing a proportion of winds from the southeast. The percentage calms (defined as wind speeds less than 0.5 m/s) are 26.2% and 30.9% for the respective years.

Sensitivity analysis was completed using the alternative Horsley Park data for 2013. The results demonstrated that use of the St Marys meteorological data provided a more conservative assessment for almost all of the investigated pollutants. The exception being the 1-hour 99th percentile H_2S results, with predictions being 7% higher than when using the St Marys dataset. For the remaining pollutants there was no change or a decrease of between 2% and 64%.

As specified in the Approved Methods, five years of data are required to be reviewed so that a representative year of meteorological conditions can be selected. Appendix F provides an analysis of the five years of meteorological data from the Horsley Park Equestrian Centre that can also be compared with the St Marys weather data. The Horsley Park meteorological data was selected for the analysis as it is a readily available and cost-effective data set to access. The review identified 2013 as a representative year for dispersion modelling with no anomalous wind patterns compared to the other years examined and is therefore considered a representative year for dispersion modelling. The prevalence of calm conditions in the western Sydney area is shown to be a common feature of the meteorology in the vicinity of the EfW facility. The percentage of calms measured at the Horsley Park Equestrian Centre ranged between 14.2% and 24.5%. However, wind measurements are made at 10m above ground level. The emission from the Project would be occurring at 100m above ground level where wind speeds are significantly higher and calm conditions far less frequent. These calm conditions are most common during autumn and winter and are often a function of temperature inversions that also occur during these cooler months. Thus, the prevalence of calm conditions in the western Sydney area is shown to be a common feature of the meteorology in the vicinity of the EfW facility. These calm conditions are most common during autumn and winter and are often a function of temperature inversions that also occur during these cooler months. Calm conditions are also associated with poor dispersion conditions.

In view of the high percentage of calm conditions for 2013 measured at St Marys, using these data for dispersion modelling will provide an additional level of conservatism in the prediction of ground level pollutant concentrations.

It is highlighted that the AERMOD modelling system allows for wind speed and direction variation in the vertical, through reference to a 'surface' meteorological input file, and a 'profile' input file. The profile input file contains information on the (logarithmic) increase in wind speed with height. Thus, it is noted that the wind speeds interacting with the stack exit (100m aloft) will not reflect any calm observation occurring within the surface input file.

As a general note, the AERMOD dispersion model is anticipated to be the most widely used dispersion model internationally, and has been the subject of many validation exercises to confirm its satisfactory performance for both calm conditions and tall stack applications using standard model validation data sets.

5.2 Meteorological File for Modelling

The compilation of the meteorological file followed Pacific Environment's quality assurance procedures that form part of an ISO 9001:2000 certified quality system.

A complete year of hourly meteorological data, collected at the St Marys station was used as input within the dispersion modelling. The meteorological data set for modelling is 98% complete (>90% data retrieval is a requirement of the Approved Methods) and was demonstrated to be a representative year.

The AERMOD dispersion model also requires cloud cover and cloud height as input and the closest meteorological station recording these parameters is Bureau of Meteorology (BoM) Bankstown Airport AWS, located approximately 19 km southeast of the EfW facility. Another option would be to use the cloud data from Richmond RAAF Base AWS. Given that both sites are located inland and with Bankstown Airport AWS being the closest to the Project it was considered the most suitable.

For AERMET the use of the Upper Air Estimator was used as it has the advantage of having no issues surrounding consistency between surface and upper air data, which is often the case when synthetic (prognostic) upper air data is referenced.

It is acknowledged that upper air profiles are available in the Sydney area. However, these profiles comprise twice daily measurements collected at Sydney Airport and therefore require interpolation for the remaining 22 hours of the day. Furthermore, Sydney Airport is located on the coastline 37 km south east of the Project with the two locations subject to very different influences on the boundary layer meteorology. For example, the height of the mixed layer in coastal areas is very different to those experienced at inland area, such as where the Project is located. These inland influences are characterised by the frequency of calm wind speeds (<0.5 m/s) associated with night time drainage flows and inversion conditions.

For the operation of AERMET, a full morning upper air sounding (RAWINSONDE) is required for winds, temperature, and dew point. Wind data are used by AERMET to produce the profile data file, and temperature is used for mixing height calculations.

Critically, there are no temperature and dew point temperature data for nearly all upper air sounding data taken in Australia. Further, there are a lot missing days and hours such that there are not a sufficient number of soundings to be useful within AERMET.

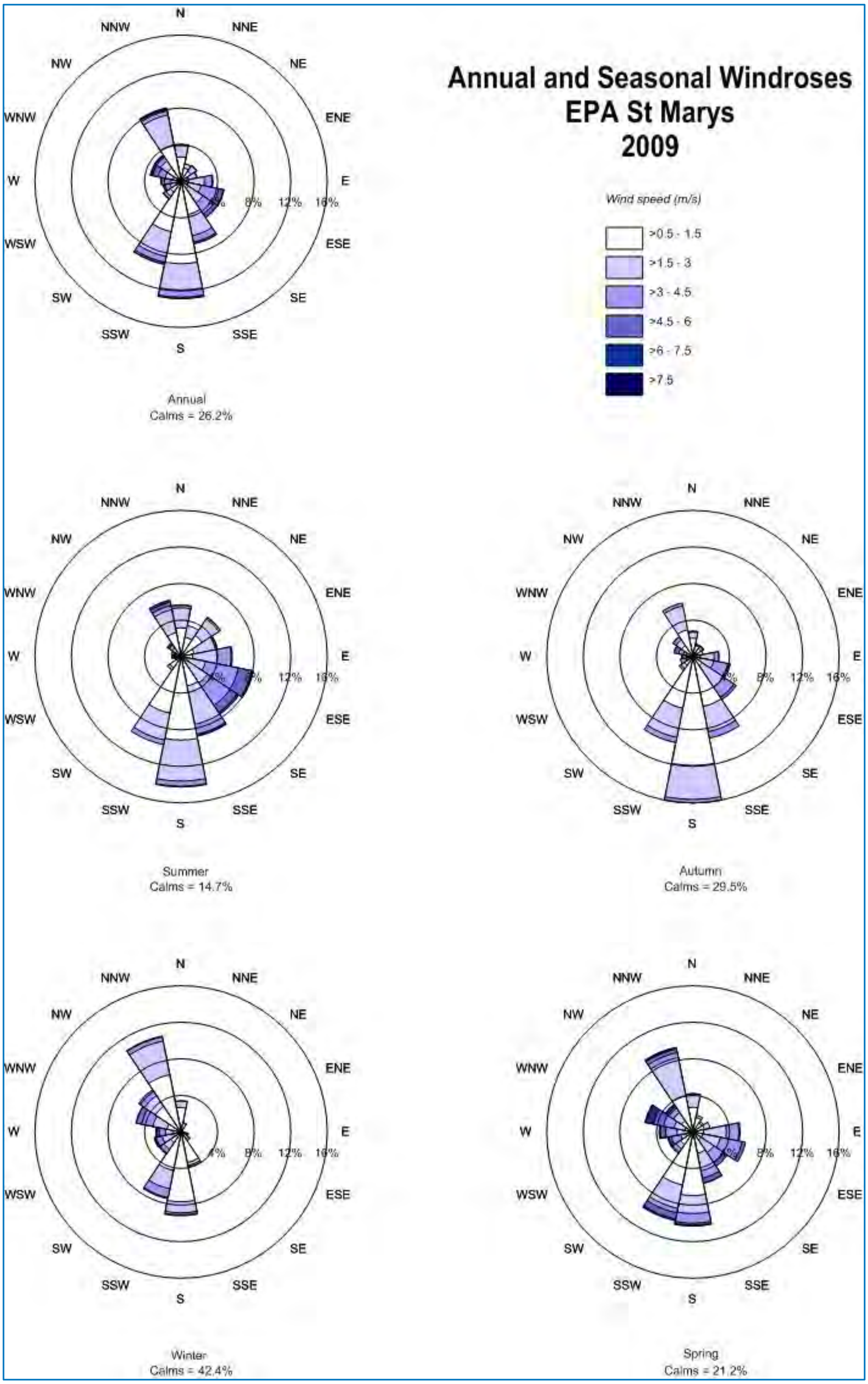


Figure 5-1: Wind roses for St Marys (2009)

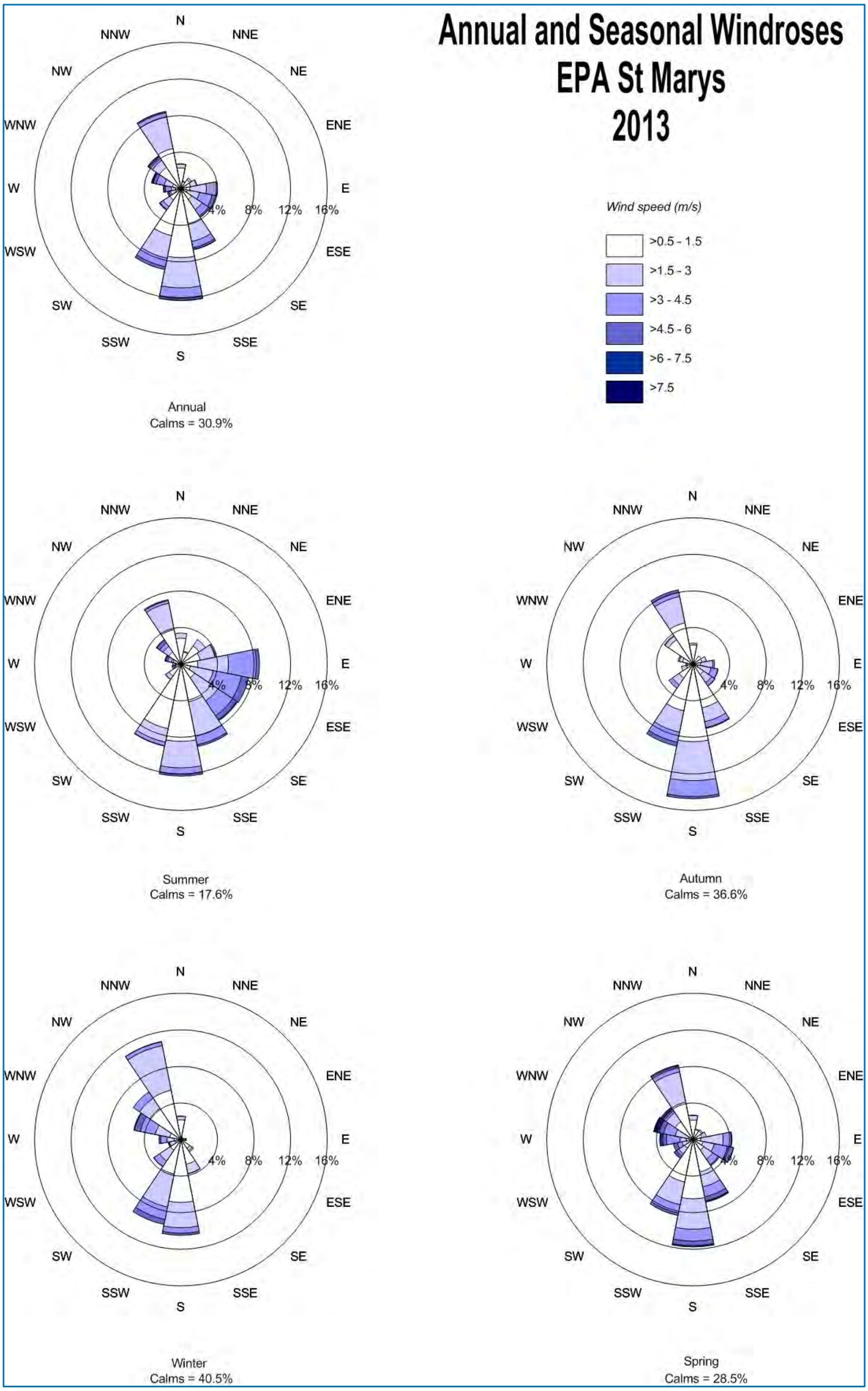


Figure 5-2: Wind roses for St Marys (2013)

5.3 Atmospheric Stability

An important aspect of pollutant dispersion is the level of turbulence in the lowest 1 km or so of the atmosphere, known as the planetary boundary layer (PBL). Turbulence controls how effectively a plume is dispersed into the surrounding air and hence diluted. It acts by increasing the cross-sectional area of the plume due to random motions. With stronger turbulence, the rate of plume dispersion increases. Weak turbulence limits dispersion and contributes to high plume concentrations downwind of a source.

Turbulence is generated by both thermal and mechanical effects to varying degrees. Thermally driven turbulence occurs when the surface is being heated, in turn transferring heat to the air above by convection. Mechanical turbulence is caused by the frictional effects of wind moving over the earth's surface, and depends on the roughness of the surface as well as the flow characteristics.

Turbulence in the boundary layer is influenced by the vertical temperature gradient, which is one of several indicators of stability. Plume models use indicators of atmospheric stability in conjunction with other meteorological data to estimate the dispersion conditions in the atmosphere.

Stability can be described across a spectrum ranging from highly unstable through neutral to highly stable. A highly unstable boundary layer is characterised by strong surface heating and relatively light winds, leading to intense convective turbulence and enhanced plume dispersion. At the other extreme, very stable conditions are often associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions plumes can remain relatively undiluted for considerable distances downwind. Neutral conditions are linked to windy and/or cloudy weather, and short periods around sunset and sunrise, when surface rates of heating or cooling are very low.

The stability of the atmosphere plays a large role in determining the dispersion of a plume and it is important to have it correctly represented in dispersion models. Current air quality dispersion models (such as AERMOD and CALPUFF) use the Monin-Obukhov Similarity Theory (MOST) to characterise turbulence and other processes in the PBL. One of the measures of the PBL is the Monin-Obukhov length (L), which approximates the height at which turbulence is generated equally by thermal and mechanical effects (Seinfeld and Pandis 2006). It is a measure of the relative importance of mechanical and thermal forcing on atmospheric turbulence.

Because values of L diverge to + and - infinity as stability approaches neutral from the stable and unstable sides, respectively, it is often more convenient to use the inverse of L (i.e., 1/L) when describing stability.

Figure 5-3 shows the hourly averaged 1/L for the Project site computed from all data in the AERMET surface file. Based on Table 5-1, this plot indicates that the PBL is stable overnight and becomes unstable as radiation from the sun heats the surface layer of the atmosphere and drives convection. The changes from positive to negative occur at the shifts between day and night. This indicates that the diurnal patterns of stability are realistic.

Table 5-1: Inverse of the Monin-Obukhov length L with respect to Atmospheric stability

1/L	Atmospheric Stability
Negative	Unstable
Zero	Neutral
Positive	Stable

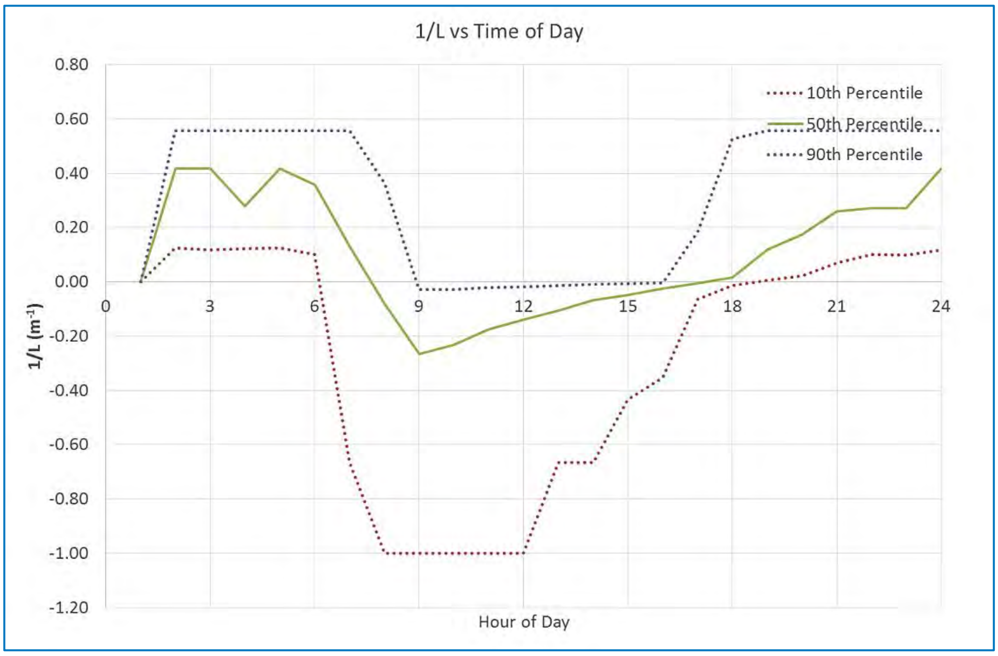


Figure 5-3: Annual statistics of 1/L by hour of the day

Figure 5-4 shows the variations in stability over the year by hour of the day, with reference to the widely known Pasquill-Gifford classes of stability. The relationship between L and stability classes is based on values derived by Golder (1972) set out in NSW DEC (2005). Note that the reference to stability categories here is only for convenience in describing stability. The model uses calculated values of L across a continuum.

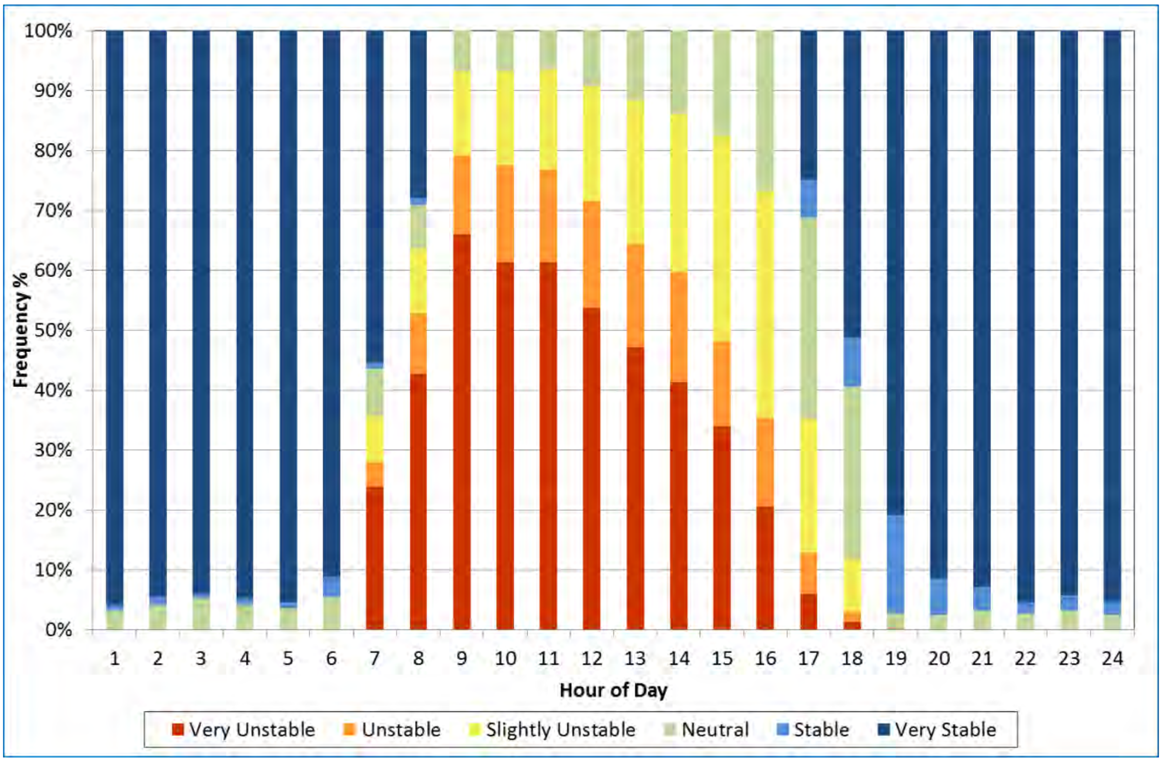


Figure 5-4: Annual distribution of stability type by hour of the day

Figure 5-4 shows that stable and very stable conditions occur for about 50% of the time, which is typical for inland locations that regularly experience temperature inversions at night. Atmospheric instability increases during the day and reaches a peak around noon as solar-driven convective energy peaks. A stable atmosphere is prevalent during the night. These profiles indicate that pollutant dispersion is most effective during the daytime and least effective at night.

Values of surface roughness, albedo and Bowen ratio were determined based on a review of aerial photography for a radius of 3 km centred on the EPA St Marys station. Default values for cultivated land and urban areas were chosen over two sectors across this area. The default values for these three surface characteristics required for AERMET are as follows:

- Surface roughness, which is the height at which the mean horizontal wind speed approaches zero, based on a logarithmic profile. Values adopted = 1.0 (urban) and 0.07 (cultivated land)
- Albedo, which is an indicator of reflectivity of the surface. Values adopted = 0.2075 (urban) and 0.28 (cultivated land)
- Bowen ratio, which is an indicator of surface moisture. Values adopted = 1.625 (urban) and 0.75 (cultivated land)

6 EXISTING AIR QUALITY

To assess potential impacts against the relevant air quality standards and criteria (see Section 4.4) it is necessary to have information or estimates on existing concentrations for the area in which the EfW facility would contribute to these levels.

The OEH monitoring station at St Marys collects air quality data for pollutants including PM_{10}, NO_x and O_3. The OEH monitoring station at Prospect collects air quality data for other pollutants not monitored at St Marys, including SO_2 and CO.

In addition, the adjacent Genesis facility operates a continuous PM_{10} monitor (BAM) at a residence in the suburb of Minchinbury, as a requirement of their Environmental Protection Licence (EPL).

A summary of the available air quality data is provided in the subsequent sections. Generally, air quality for the local area can be described as good, with the exception of isolated high pollution days or extreme events such as dust storms and bushfires.

6.1 Particulate Matter (PM_{10})

6.1.1 NSW OEH Monitoring at St Marys

A summary of the annual average and maximum 24-hour PM_{10} concentrations measured between January 2009 and December 2013 at St Marys are presented in Table 6-1. There were several exceedances of the 24-hour average PM_{10} criterion at St Marys in the last 5 years. During 2009 there were a number of elevated dust events including one of eastern Australia's most significant dust storms events, occurring on 23 September 2009 and recording a maximum 24 hour average concentration of 1,680µg/m³.

Table 6-1: Annual average and maximum 24 hour average PM_{10} concentrations – St Marys (µg/m³)

Year	Maximum 24-hour average (µg/m³)	Annual average (µg/m³)
EPA Criterion	*50*	*30*
2009	*1661*	23
2010	*52*	15
2011	*74*	15
2012	34	14
2013	*93*	16

A time-series of the 24-hour average PM_{10} concentration for 2013 (the year chosen for modelling) is presented in Figure 6-1. The data indicates that concentrations above the EPA criterion of 50µg/m³ were experienced on two days. It should be noted that the national air quality goal prescribed under the Ambient Air-NEPM (2008) provide for up to five exceedances of the goal per year.

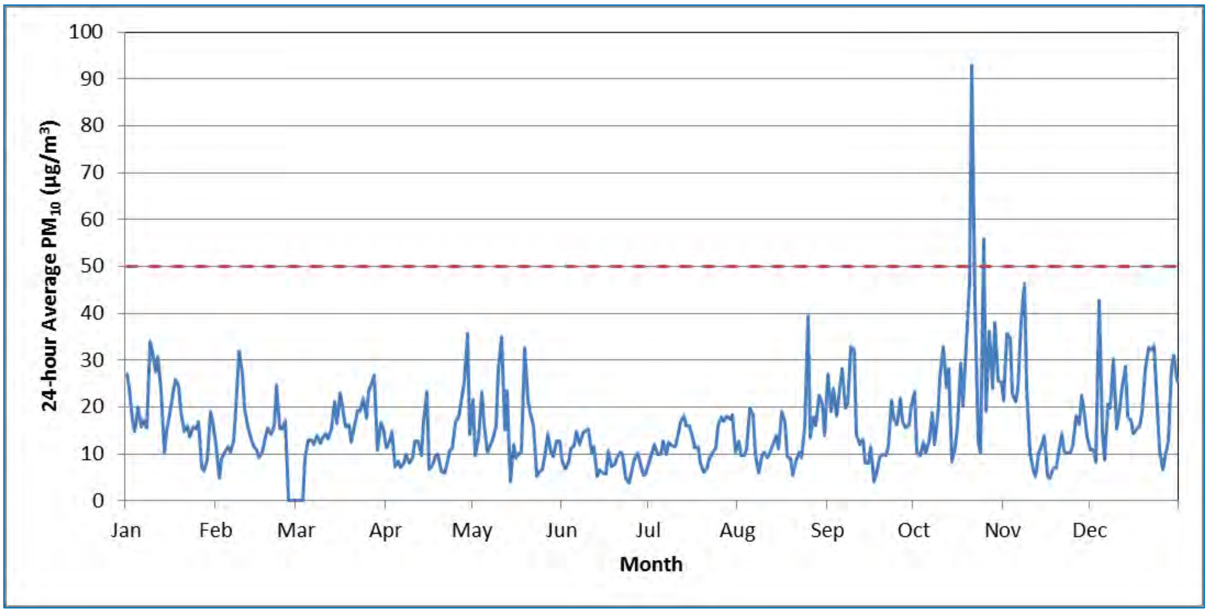


Figure 6-1: 24 hour average PM_{10} concentrations – St Marys (2013)

6.1.2 NSW OEH Monitoring at Prospect

A summary of the annual average and maximum 24-hour average PM_{10} concentration measured between January 2009 and December 2013 at Prospect are presented in Table 6-2. The annual average PM_{10} concentration at Prospect appears to display an upward trend in the past 4 years which is not reflected in the data recorded at St Marys.

Table 6-2: Annual average and maximum 24 hour average PM_{10} concentrations (µg/m^3)

Year	Maximum 24-hour average (µg/m^3)	Annual average (µg/m^3)
EPA Criteria	*50*	*30*
2009	1,680	26
2010	40	15
2011	42	16
2012	39	17
2013	82	19

6.1.1 Industry Monitoring at Minchinbury

The adjacent Genesis facility operates a BAM PM_{10} monitor at Minchinbury, which has been operational since mid-2012. The 2013 annual average at Minchinbury is the same as Prospect (19µg/m^3) and the maximum 24-hour average for the year is also similar (77µg/m^3). A plot of the 24-hour PM_{10} concentration collected between July 2012 and February 2014 is presented in Figure 6-2.

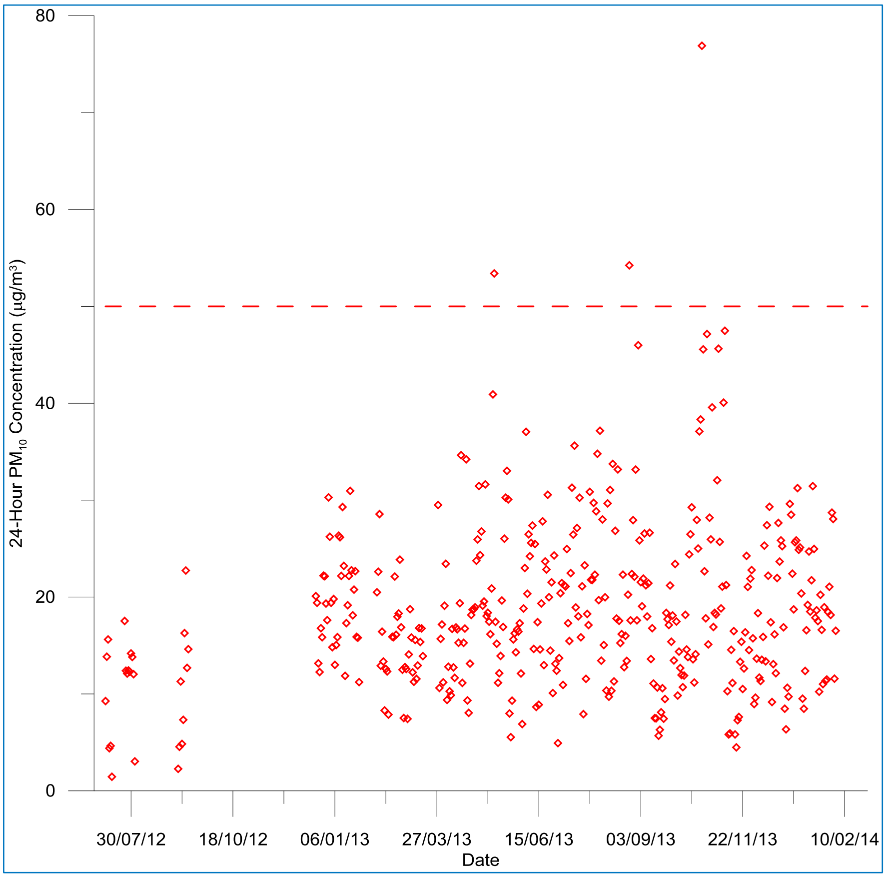


Figure 6-2: 24-Hour PM_{10} monitoring at Minchinbury

6.2 Particulate Matter ($PM_{2.5}$)

The two closest OEH monitoring stations do not currently measure $PM_{2.5}$. Rather than adopt $PM_{2.5}$ data from further afield, a $PM_{2.5}$:PM_{10} ratio (0.35:1) has been applied to the PM_{10} data measured at St Marys and Prospect. The ratio is based on PM measurements from Richmond and Liverpool between 2009 and 2013.

A summary of the calculated annual average and maximum 24-hour average $PM_{2.5}$ concentrations measured between January 2009 and December 2013 at fro St Marys are presented in Table 6-3.

Table 6-3: Annual average and maximum 24 hour average $PM_{2.5}$ concentrations (µg/m³)

Year	St Marys		Prospect	
	Maximum 24-hour average (µg/m³)	Annual average (µg/m³)	Maximum 24-hour average (µg/m³)	Annual average (µg/m³)
EPA Criteria	*25*	*8*	*25*	*8*
2009	587	8	594	9
2010	18	5	14	5
2011	26	5	15	6
2012	12	5	14	6
2013	33	6	29	7

6.3 Nitrogen Dioxide (NO_2)

6.3.1 NSW EPA Monitoring at St Marys

A summary of the NO_2 annual and 1 hour maximum data from 2009 to 2013 at St Marys is presented in Table 6-4. During this period there were no exceedances of the 1-hour maximum criterion of 246µg/m³ or the annual average criterion of 62 µg/m³.

A time-series of the 1-hour average NO_2 concentrations recorded at St Marys during 2013 (modelling year) is presented in Figure 6-3. The results indicated that hourly NO_2 concentrations are well below the EPA criterion of 246µg/m³. The maximum recorded 1-hour average concentration in 2013 was 76µg/m³.

Table 6-4: Annual average and maximum 1 hour average NO_2 concentrations – St Marys (µg/m³)

Year	Maximum 1-hour average (µg/m³)	Annual average (µg/m³)
EPA Criteria	*246*	*62*
2009	72	12
2010	74	12
2011	74	12
2012	88	10
2013	76	10

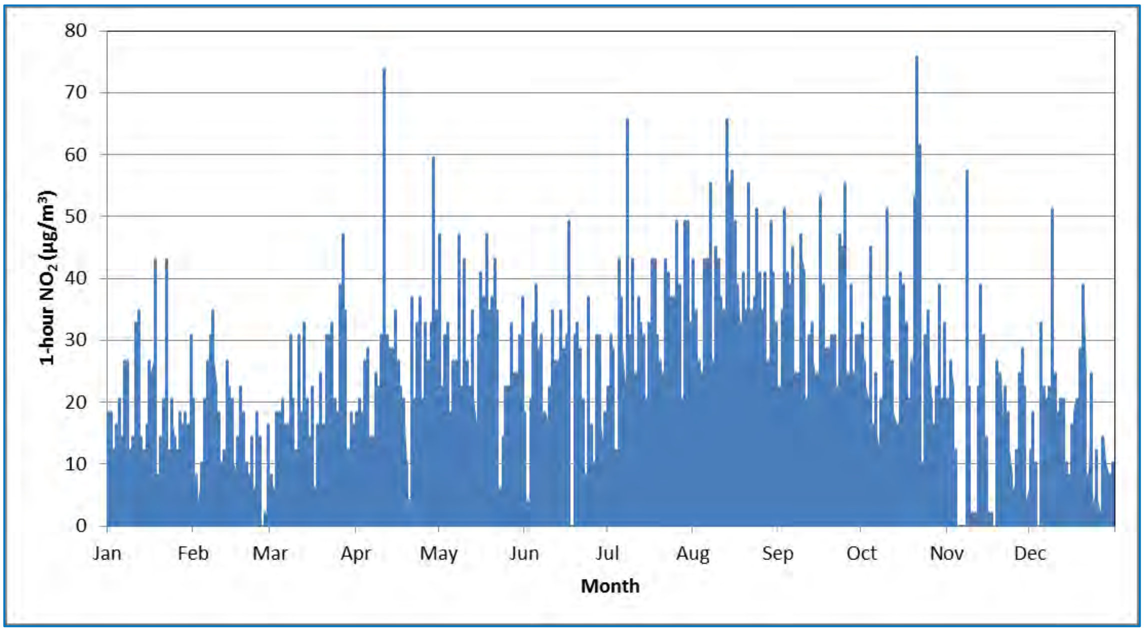


Figure 6-3: 1-hour NO_2 concentrations – St Marys (2013)

6.3.2 NSW EPA Monitoring at Prospect

A summary of the NO_2 annual and 1 hour maximum data from 2009 to 2013 at Prospect is presented in Table 6-5. During this period there were no exceedances of the 1-hour maximum criterion of 246µg/m³ or the annual average criterion of 62 µg/m³. The maximum 1-hour and annual average concentrations are generally higher than at St Marys.

Table 6-5: Annual average and maximum 1 hour average NO_2 concentrations (µg/m³)

Year	Maximum 1-hour average (µg/m³)	Annual average (µg/m³)
EPA Criteria	*246*	*62*
2009	105	23
2010	88	25
2011	80	21
2012	103	21
2013	100	23

6.4 Sulfur Dioxide (SO_2)

6.4.1 NSW EPA Monitoring at Prospect

A summary of the annual average and 1-hour maximum data for the 2009 to 2013 period at Prospect is presented in Table 6-6. During this period there were no exceedances of the 1-hour maximum criterion of 570µg/m³ or the annual average criterion of 60 µg/m³.

Table 6-6: Annual average and maximum 1 hour average SO_2 concentrations (µg/m³)

Year	Maximum 1-hour average (µg/m³)	Annual average (µg/m³)
EPA Criteria	*570*	*60*
2009	49	N/A
2010	52	3
2011	40	3
2012	34	3
2013	57	3

6.5 Carbon Monoxide (CO)

6.5.1 NSW EPA Monitoring at Prospect

A summary of the CO monitoring data from the Prospect station for the 2008 to 2012 period at Prospect is presented in Table 6-7. During this period there were no exceedances of the 1 hour maximum criterion of 30µg/m³ or the 8-hour criterion of 10 µg/m³.

Table 6-7: Maximum 8-hour average CO concentrations (mg/m³)

Year	Maximum 8-hour average (mg/m³)
EPA Criteria	*10*
2009	3
2010	2
2011	2
2012	2
2013	2

7 EMISSIONS TO AIR

As noted in Section 4.2, the EfW Policy Statement indicates that any facility proposing to recover energy from waste will need to meet current international best practice. The EfW Policy Statement also requires that emissions from EfW facilities must satisfy, as a minimum, emission limits prescribed by the Clean Air Regulations.

The proposed technology for the EfW facility is based on existing facilities in Europe and will incorporate best available technology (BAT) for flue gas treatment. The flue gas treatment is designed to meet the in-stack concentrations limits for waste incineration set by the EU IED. The IED emissions limits (Table 4-3) are generally more stringent that the Clean Air Regulation limits (Table 4-2).

7.1 Best Available Techniques

A summary of the technologies used to control emissions from waste incineration at existing EfW facilities is presented to examine what constitutes current international best practice. The purpose of the review is to demonstrate that existing technology can satisfy the emission limit requirements of the EU IED, and therefore is appropriate for the EfW facility.

7.1.1 General

In 2006 the European Commission published a reference document for best available techniques for waste incineration (EC, 2006). The Best Available Techniques Reference Documents (BREF) are made under the European directive on Integrated Pollution Prevention and Control (IPPC) (Council Directive 96/61/EC).

The BREF defines five sectors for waste incineration (mixed municipal, pre-treated municipal, hazardous, sewage sludge, chemical waste) and covers three types of thermal treatment (pyrolysis, gasification, incineration). The focus of the BAT review within the BREF is for flue gas treatment, however process control is also important and Table 7-1 presents good practice process control proposed for the EfW facility.

Table 7-1: General good practice procedures / process control

Process	Details
Types of waste received	The technology has been chosen having regard to the characteristics of waste received, which are well known from the operation of the existing Genesis facility, and based on a minimum calorific value of 12.34 MJ/kg.
	A quality control process will be established for waste received at the EfW facility.
Maintenance	Regular maintenance will ensure equipment remains in good working order
Combustion	The furnace and boiler technology is designed for optimal combustion performance
	Proposed use of automated combustion control system, including control and optimisation of oxygen supply, temperature, residence time.
	Air injection
	Minimising uncontrolled ingress of air into combustion chamber during loading.
	Minimise start up / shut downs
	Preheating the combustion chamber for lower calorific wastes.
Monitoring	The EfW facility will employ a Continuous Emissions Monitoring System (CEMS).

7.1.2 Flue Gas Treatment

A range of pollution control equipment are available for the pollutants generated at EfW facilities and an overview of existing BAT for flue gas treatment is provided below and summarised in Table 7-2.

Fabric filters (bag houses) are used in the majority of existing EfW facilities as they have high particle removal efficiency and also work in combination with scrubbing systems (i.e. activated carbon injection). Electrostatic Precipitators (ESPs) have been used in conjunction with fabric filters to provide additional level of control where needed.

Scrubbing systems are used to remove acid gases and can be wet, dry or semi-dry. Scrubbers work by adsorption, bringing flue gas into contact with a scrubbing material such as lime, sodium hydroxide or sodium carbonate. Dry/semi dry scrubbers work well in conjunction with activated carbon injection, which is typically used to remove volatile heavy metals (e.g. Hg, Pb, Cd) and dioxins and furans. The used carbon and lime, along with the adsorbed pollutants, are collected on the fabric filter.

NO_x is produced in the combustion process (combining the nitrogen and oxygen present in air) and also from the nitrogen contained within the residual waste fuel. Thermal NO_x is typically controlled with good practice combustion and flue gas recirculation (FGR). FGR lowers the excess air rate, thereby increasing the thermal efficiency and reducing the available nitrogen for NO_x formation.

The NO_x removal system comprises Selective Non-Catalytic Reduction (SNCR). With an SNCR system, ammonia water is injected into the first pass of the boiler at a temperature of approximately 900°C. Here the chemical reaction takes places, converting NO_X to nitrogen and water. With an SNCR system the requirement of an in-stack concentration of 200 mg/Nm^3 NO_x can be comfortably reached.

The SNCR technology can be optimised to reach 120 mg/Nm^3 for a sophisticated SNCR (as a daily average). The increased efficiency comes with a modest increase of CAPEX and additional consumption of ammonia.

Ammonia slippage from an SNCR system (i.e. surplus NH_3 going to atmosphere) normally constitutes in-stack concentrations of between 1 mg/Nm^3 and 10 mg/Nm^3, with an average of 4 mg of NH_3/Nm^3 (EC, 2006). The effects of ammonia slip have been conservatively factored into the upset conditions emissions scenario, which assumes in-stack concentrations of ammonia of 20 mg/Nm^3.

Table 7-2: Best Available Techniques for EfW flue gas treatment (FGT)

Substance	BAT	Comments
Particles	Fabric filters / bag filters Cyclones Electrostatic precipitators	Fabric filters are generally sufficient to meet the emissions limits than prescribed by the EU Waste Incineration Directive and typically employed at existing EfW facilities.
Hydrogen chloride (HCl) Hydrogen Fluoride (HF) Sulfur Dioxide (SO2)	Waste control Wet scrubbers Dry and semi dry scrubbers	Wet FGT results in lowest emissions; however Dry FGT has the co-benefit of removing PCDD/F and mercury (with addition of activated carbon injection). Dry/semi dry most commonly employed at existing EfW facilities.
Oxides of Nitrogen (NOx)	Reduction of thermal NOx through combustion control and Flue Gas Recirculation Selective Catalytic Reduction (SCR) Selective Non Catalytic Reduction (SNCR)	Waste and combustion control with SNCR/SCR can generally result in emissions within limits prescribed by the EU Waste Incineration Directive. SNCR typically employed at existing EfW facilities.
Carbon Monoxide Gaseous and various organic substance (TOC)	Combustion control	Activated carbon injection may provide additional benefit of VOC control.
Mercury	Wet scrubbing with injection Activated carbon injection Condensing scrubbers Resin filters	Adsorption using carbon based reagents generally needed to meet limits prescribed by the EU Waste Incineration Directive. Activated carbon injection typically employed at existing EfW facilities.
Metals	Activated carbon injection Fabric filters	Techniques that control dust will also control metal emissions and fabric filters commonly used. Activated carbon injection additionally controls volatile metals (Hg).
Dioxins and Furans (PCDD/F)	Primary (combustion control) techniques, flue gas recirculation Selective Catalytic Reduction (SCR) Catalytic filter bags Adsorption by activated carbon injection / static beds Wet scrubbing with carbon injection / carbon slurries	Secondary abatement generally needed in combination with primary (combustion control) to meet limits prescribed by the EU Waste Incineration Directive.

A review of existing EfW facilities (mostly in the UK and Europe) indicates that these BAT are routinely implemented at EfW facilities. Table 7-3 summarises the flue gas treatment that will be installed on commissioning of the TNG EfW facility (in addition to combustion and other process control).

The owner's engineer, Ramboll, has produced a technical memorandum as to 'real world' in-stack concentrations of a comprehensive list of air quality metrics, referenced from existing EfW facilities internationally. This memorandum is provided in full as Appendix C. This memorandum provides publicly available emission data from plants fired by C&I and C&D waste and / or semi dry APC system, as proposed for the TNG project. These facilities include:

- Hurth-Knapsack (Germany) – 2 x 150,000 tpa
- Heringen (Germany) – 2 x 148,500 tpa
- Premnitz (Germany) – 1 x 150,000 tpa
- Grossraschen (Germany) – 1 x 276,250 tpa
- TIRME Mallorca (Spain) – 2 x 208,000 tpa
- Riverside (UK) – 3 x 195,000 tpa.

It is acknowledged that the proposed TNG EfW Facility will process up to 1,105,000 tpa and that above examples do not process the volume of waste that is proposed.

A further technical memorandum as to 'real world' in-stack concentrations of a comprehensive list of air quality metrics, referenced from existing EfW facilities internationally is provided in Appendix C.

Table 7-3: Flue Gas Treatment for existing EfW facilities

Facility	Flue Gas Treatment	Fuel Type
Lakeside, London, UK	SNCR for NOx control Semi-dry scrubbing using lime Activated carbon injection Fabric filter 75m stack	Household and municipal waste
Issy Les Moulineaux, Paris, France	Fabric filter plus ESP Dry scrubbing using sodium bicarbonate Activated carbon injection SCR low temperature deNOx system Gas exit temperature of 200°C and velocity of 30m/s (due to short stack)	Municipal solid waste
Riverside, London, UK	Semi-dry scrubber with lime and activated carbon injection Fabric filter 85m stack	Municipal solid waste
Mainz, Germany	SNCR for NOx control High dust catalytic converter to remove surplus ammonia Spray absorption using lime milk Activated coke injection Fabric filter 95m stack	Household waste, bulky waste and commercial waste.
AEB, Amsterdam, The Netherland (1,370,000 tpa)	SNCR for NOx control ESP plus fabric filter with activated carbon/coke injection Packed bed scrubber for HCl, lime milk injection for SO2 Fabric filter Polishing scrubber	Municipal and industrial waste
Spitteleu, Vienna, Austria	SCR for NOx control ESP Wet scrubber for acid gases, lime slurry for HCl, NaOH for SO2	Municipal solid waste
Kwinana Facility, Western Australia	SNCR for NOx control Spray dryer (lime) / high temperature lime scrubbing Activated carbon injection Fabric filter	Combustion of Municipal Solid Waste (MSW) in twelve Ultra High Temperature Combustors (UHTC's)

Greatmore Facility, Buckinghamshire, UK	Ammonia injection to reduce NO_x Lime injection Injection of activated carbon Bag filter 95m stack	Municipal solid waste (MSW) using Steam condensation by the means of air-cooled vacuum condenser.
Newhaven Facility, UK	Ammonia injection Lime injection Activated carbon Fabric filter 65m stack	Mixed municipal waste.
Worcestershire EfW facility, UK	Activated carbon injection Dry lime scrubbing Selective Non-Catalytic Reduction (SNCR) Fabric filter 75m stack	Household and municipal waste
Montgomery County, Maryland, USA	Thermal deNOx using aqueous ammonia Hydrated lime injection and spray dryer adsorper Carbon injection Baghouse 84m stack	Municipal solid waste

Source: Mercier EnviRecover (2010); SLR (2010); WA EPA (2000); Veolia (2013); WSP (2013)

7.2 Emissions Performance

The emission performance of a number of case studies is summarised in WSP (2013), including some of the facilities presented in Table 7-3. A number of the case studies presented use the technology provider for the proposed EfW facility (i.e. Issy Les Moulineaux, Paris, and Riverside, London) and most apply the same flue gas treatment as the proposed EfW facility.

The data reviewed in the case studies demonstrates that emissions consistently meet the IED limits. Appendix F presents some of this data from WSP (2013).

CEMS reports for the Riverside EfW facility have also been reviewed. Riverside employs similar technology (Hitachi Zosen Inova (HZI)) and flue gas treatment to the proposed EfW facility. The CEMS reports (2011 – 2014) demonstrate that the EfW facility consistently meets the EU IED limits for the pollutants monitored by CEMS and in most cases are significantly lower.

The Riverside EfW CEMS reports are publicly available on the internet (http://www.coryenvironmental.co.uk/page/rrremissions2012.htm). A sample report is presented in Appendix F.

HZI has also provided a summary of heavy metals emissions from a number of reference plants in the UK which employ semi-dry FGT (as is proposed for the EfW facility). These results show that emissions of Hg and Cd are an order of magnitude below the EU IED limits. A summary of the data is provided in Appendix F.

7.3 Emissions during Normal Operations

Emission rates for modelling are estimated based on the EfW facility meeting the more stringent limits prescribed in the IED, as outlined in Table 4-3. In October 2015, Ramboll, the owner's engineers, updated the in-stack concentration estimates for all air quality parameters. These updated concentration estimates are based on stack testing data for existing reference facilities. More information is provided in the technical memorandum provided by Ramboll in Appendix C.

The emission rates (g/s) adopted for modelling of each stack presented in Table 7-4 are derived from the in-stack concentrations provided by Ramboll in Appendix G and the flue gas flow rate per stack (Nm^3/s) shown in Table 7-8. A summary of the in-stack concentration estimates adopted is additionally documented within Appendix G.

Table 7-4: Emission rates per stack during normal operations

Emission Parameter	In-stack concentration during normal operations (mg/m^3) (a)	Mass emission rate used to model normal operations (g/s)
Oxides of Nitrogen (NO_x expressed as NO_2)	188	24
SO_2	27	3.4
CO	23	2.9
PM	1.0	0.1
HCl	9.0	1.1
HF	4.0	0.5
Cd	0.009	0.001
Hg	0.004	0.001
Dioxins and furans	0.000000010	0.000000001
TOC (as benzene)	0.015	0.002
NH_3	2.0	0.3
H_2S	5.0	0.6
PAH (as benzo(a)pyrene)	0.0005	0.00006
C_{l2}	9.0	1.1

Notes: (a) Reference conditions defined as dry, 273.15 K, 101.3 kPa and 7% O_2 for all air impurities when burning a solid fuel.

7.4 Emissions during Start-up / Shut-down Conditions

As discussed in Section 2.3 a clean auxiliary support fuel will be used in the incinerator to regulate the temperature. It is understood that the fuel would comprise diesel, with all emissions released from the 100m stack. As the nature of the emissions from the combustion of diesel fuel would burn significantly cleaner than the residual waste fuel, and in consideration of the infrequent occurrence of start-up and shut down, emissions during such conditions have not been further assessed.

7.5 Emissions during Upset Conditions

As per the normal operations, in-stack concentrations for 'upset conditions' were provided by Ramboll (2016), shown in Appendix G. The emissions modelled are presented in Table 7-5.

Table 7-5: Emissions per stack during upset conditions

Emission parameter	In-stack concentration during upset conditions (mg/m^3) [a]	Mass emission rate used to model upset conditions (g/s)
Oxides of Nitrogen (NO_x expressed as NO_2)	1880	238.8
SO_2	270	34.3
CO	230	29.2
PM	150	19.1
HCl	90	11.4
HF	40	5.1
Cd	0.09	0.011
Hg	0.013	0.002
TOC (as benzene)	0.15	0.019
NH_3	20	2.5

Notes: (a) Reference conditions defined as dry, 273.15 K, 101.3 kPa and 7% O_2 for all air impurities when burning a solid fuel.

When considering upset operating conditions it is always a matter of balance between stated upset emission level, the probability of occurrence, and the duration of emission at such elevated rates. Very high emission rates would occur rarely and for short time because plant shutdown would likely be an imminent consequence, whereas slightly elevated levels could occur occasionally and for some length of time until the necessary actions are put into force.

In the event of upset conditions strict management measures should be followed to ensure that elevated emissions are minimised.

7.6 Emissions during operation of emergency diesel generators

Two emergency diesel generators will operate as part of the Project. Dispersion modelling has been used to assess the ground level concentrations during the operation of the diesel generators during emergency conditions. The adopted mass emission rates and stack parameters are provided in Table 7-6.

To reiterate that already outlined in Section 2.6, the diesel generators are only required in case of an emergency when there is a black out of the power grid and the plant fails to run in "island mode" (island mode is the generation of power by the turbine/generator of the plant for internal use without any connection to the power grid). The generators will then ensure a safe shutdown of the plant. The operation time of these generators is therefore maximum a few hours per event. Further, the generators are not used to maintain the furnace temperature.

A manufacturer's guarantee has been provided by Cummins (2015) that the emergency diesel generators will operate within the POEO Regulation emission limits. A copy of the emission performance specifications for the emergency diesel generators is provided as Appendix H.

The owner's engineers have confirmed (Pers. Comm. Martin Brunner, Ramboll) that benzene composition within the emergency diesel generator exhaust is anticipated to be well below 1%, and this assumption has been adopted for modelling purposes. It is anticipated that this can be confirmed during the commissioning stack testing. If not the case, generators can be retrofitted with catalysts to further reduce in-stack benzene concentrations, as required.

Table 7-6: Pollutant mass emission rates for each emergency diesel generator

Parameters	Input
Stack coordinates (UTM)	298536 mE, 6257776 mN 298683 mE, 6257757 mN
Stack height	3.2 m
Stack diameter	0.5 m
Exit velocity	39 m/s
Exit temperature	736 K
NOx mass emission rate	3.10 g/s
CO mass emission rate	1.41 g/s
PM mass emission rate	0.20 g/s
VOCs mass emission rate	3.10 g/s

7.7 NSW Clean Air Regulation in-stack Concentration Limits

The POEO Regulation in-stack concentration criteria relevant to this assessment are presented in Table 7-7. To inform future Environmental Protection Licensing of the EfW facility, in addition to the normal and upset conditions, ground level concentrations resulting from a Regulatory scenario (in-stack concentrations at the POEO emission limits) have also been presented in Section 9.

Table 7-7: POEO (Clean Air) Regulation Emission Limits

Emission parameter	POEO Regulation limit (mg/m^3)
Oxides of Nitrogen (NOx expressed as NO_2)	500
SO_2	n/a
CO	125
PM	50
HCl	n/a
HF	n/a
Cd	0.20
Hg	0.20
Dioxins and furans	$1.0x10^{-7}$
TOC	40
NH_3	n/a
H_2S	5
PAH (as benzo(a)pyrene)	n/a

Reference conditions defined as dry, 273.15 K, 101.3 kPa and 7% O_2 for all air impurities when burning a solid fuel, with the exception of dioxins and furans where the required O_2 concentration is 11% for waste incineration.

There are no provisions in NSW legislation or policy documents that prescribe the allowable number of hours emission limits can be exceeded. The Proponent acknowledges the requirements to comply with the Clean Air Regulation and EPL limits at all times.

In the event that the emission limit does not satisfy the ground level concentration criterion then a more stringent in-stack emission limit would be proposed.

7.8 Stack Parameters

The EfW facility will be designed in two phases (TNG1 and TNG2), with a dedicated stack servicing each phase. Each stack will comprise two waste lines. For the purposes of this assessment, the emissions associated with the two waste lines reporting to each stack have been combined. The modelled stack parameters for each of stack are provided in Table 7-8.

Ramboll produced a technical memorandum in which they document flue gas flow rates and exit parameters that have been derived during the detailed design process. The exit parameters advised by the owner's engineers are provided within their technical memorandum included as Appendix C

Table 7-8: Stack parameters for modelling

Parameter	Original Air Quality Assessment	Revised (Current) Modelling
Stack Location (m, MGA, Zone 56)	298632.9 (E) 6257733.5 (N)	
	298574.6 (E) 6257741.3 (N)	
Base Elevation (m, AHD)	~65	
Stack Height (m)	100	
Stack Diameter (m)	2.5	2.2
Temperature (°C)	120	
Flue Gas Flow (Nm³/s)	139.3	127.0
Gas Exit Flow Rate (Am³/s)	175.8	165.2
Gas Exit Velocity (m/s)	35.8	21.7

Nm$_3$/s = reference gas flow, dry at 11% O_2. Am$_3$/s = actual gas flow, wet, corrected for temperature

7.9 Release of Dioxins/Furans

Ramboll have provided a dedicated memorandum on the subject of dioxin control within Appendix C, which speaks directly to emission performance and implications under the Stockholm Convention. The following aspects are highlighted:

- The flue gas treatment stage consists of a reactor with injection of lime and activated carbon for dioxin adsorption followed by a bag house filter for dust separation, including the activated carbon particles with dioxin adsorbed.
- The flue gas treatment system ensures that the stack emissions comply with the emission requirement of 0.1 ng/m^3 (at reference conditions; EC, 2010) regardless the content in the raw, untreated flue gas within any realistic operational range.
- This technology is compliant with provisions of the EU Best Available Techniques as described in the BAT reference note (EC, 2006).
- The dioxin content of the incoming waste is anticipated to grossly exceed the sum of the outputs such that the TNG EfW facility is a net destructor of dioxin (atmospheric emissions of dioxin are expected to comprise less than 1% of the content of the incoming waste).
- The total dioxin emission from the TNG EfW facility is estimated to be around 0.02% of the Australian inventory, and 0.05% of the contribution from Australian backyard incineration activities.

Appendix E.1 directly addresses the TNG EfW facility's emission performance and associated implications under the Stockholm Convention. The following aspects of this memorandum are highlighted:

- When waste is directed to the TNG EfW facility, less waste will be available for open and other uncontrolled burning of waste, including unintended landfill fires. This is anticipated to have a large beneficial impact on the control of persistent organic pollutants (POPs) from waste management because emissions from uncontrolled burning of waste are several orders of magnitude higher than from a modern EfW facility.

- The Stockholm Convention specifically mentions the following to be considered in determining best available techniques for dioxin control; "*Use of improved methods for flue-gas cleaning such as thermal or catalytic oxidation, dust precipitation, or adsorption*".
- The TNG EfW facility will be constructed using the Best Available Techniques (BAT) as described in the convention. It uses dust precipitation and adsorption in the flue gas treatment system.
- All residues from the process (bottom ash and flue gas treatment residue, including fly ash) are expected to be well below the "low POP content" threshold for wastes. This means that the Stockholm Convention does not require further treatment of the residues prior to disposal when it comes to the dioxin content.

The presence of ultra-fine and sub-micron particulate in the environment is acknowledged. It is highlighted that the particulate generated by the EfW facility is expected to be less than 2.5 micrometres in aerodynamic diameter ($PM_{2.5}$) with particle size distributions similar to conventional combustion sources.

Related to this topic, it is noted that deposition data has been requested as input to the revised Health Risk Assessment (AECOM, 2015). Given that particulate matter less than 2.5 micrometres are not readily affected by gravitational settling, to generate a non-zero outcome, deposition modelling has been completed based on a 10 micrometre (PM_{10}) size fraction. This is considered conservative for deposition purposes, and in reality the PM_{10} size fraction is anticipated to be equivalent to (i.e. lie within) the $PM_{2.5}$ size fraction.

7.10 Treatment of Emissions of Oxides of Nitrogen (NO_x)

Nitrogen oxides (NO_x) emitted from combustion are comprised mainly of nitric oxide (NO) and nitrogen dioxide (NO_2). Typically, at the point of emission, NOx would consist of approximately 90-95% of NO and 5-10% of NO_2. The dominant mechanism for short-term conversion of NO to NO_2 is through oxidation with atmospheric ozone (O_3) as an exhaust plume travels from source. Therefore, to predict the ground-level concentration of NO_2 (regulated oxide of nitrogen) it is important to account for the transformation of NO_x to NO_2. Ultimately, all NO emitted into the atmosphere will be oxidised to NO_2 and to other higher oxides of nitrogen. The rate at which this oxidation takes place depends on prevailing atmospheric conditions including temperature, humidity and the presence of other substances in the atmosphere such as O_3. It can vary from a few minutes to many hours. If the dispersion is sufficient to have diluted the plume to the point where the concentration is very low, it is unimportant that the oxidation has taken place. However, if the oxidation is rapid then high concentrations of NO_2 can occur when inadequate dispersion / dilution conditions exist. For this report we have conservatively assumed 100% conversion of NO_x to NO_2.

7.11 Treatment of dust deposition

The Human Health Risk Assessment requires the deposition of particulate-phase pollutants (dioxins/furans, PAHs and all metals) to be calculated. Given that particulate matter less than 2.5 micrometres ($PM_{2.5}$) are not readily affected by gravitational settling, to generate a non-zero outcome, deposition modelling has been completed based on a 10 micrometre (PM_{10}) size fraction. This is considered conservative for deposition purposes, and in reality the PM_{10} size fraction is anticipated to be equivalent to (i.e. lie within) the $PM_{2.5}$ size fraction.

7.12 Odour

Residual waste fuel will arrive to the EfW facility in covered trucks or via an enclosed conveyor from the Genesis facility. The EfW facility will employ high speed roller doors for truck access to ensure fugitive odour emissions are minimal. All residual waste fuel storage and unloading will take place within the tipping hall building, which is kept at negative pressure with air extracted from the building will be used as excess air in the boiler. Odour emissions from the EfW facility have been addressed in a stand-alone quantitative assessment (Pacific Environment, 2016a). The results of this assessment show that the odour concentrations would be below the impact assessment criterion of 2 ou.

7.13 Fugitive Dust Emissions

As discussed in Section 2, residual waste fuel would be transported onsite via sealed roads. The use of sealed roads is considered an effective management strategy in the reduction of fugitive dust emissions, specifically those related to wheel generated dust emissions.

As already discussed, the tipping hall building will also operate under negative pressure whereby air within the building will be used as excess air for the boilers, limiting the release fugitive dust emissions generated within the shed to the ambient environment (as this will subsequently pass through the FGT's bag house).

On the basis of the above, the EfW facility is considered to have minimal potential for the generation of fugitive dust emissions provided good dust management practices are adhered to. Therefore this aspect has not been addressed further.

7.14 Emissions from Trucks Entering the Site

As discussed in Section 2.1, a maximum of 252 trucks would enter the site per day, resulting in localised diesel vehicle emissions with the air quality metrics of interest being NO_x, CO, $PM_{2.5}$, SO_x and VOCs. These additional emission sources are anticipated to be negligible in view of the location of the Project abutting the M4 and M7 motorways (see Figure 3-1).

For example, the average daily traffic count for 2016 on the M4 at Homebush is 88,700 vehicles and at near Penrith (north of Loftus Street) is 59,600 vehicles per day (RMS, 2016) (no traffic data were available for Eastern Creek or for the M7 Motorway). The additional truck movements associated with the Project equates to a 0.3% to 0.4% increase of vehicles per day. Such a small change in vehicle numbers is anticipated to make a non-discernible difference in local air quality.

Furthermore, not only are some of the closest residential residences situated in much closer proximity to the respective motorways, but the motorways also are located between the Project and the majority of these receptors.

7.15 Construction

The main air pollution and amenity issues at construction sites are:

- Annoyance due to dust deposition (soiling of surfaces) and visible dust plumes.
- Elevated PM_{10} concentrations due to dust-generating activities.
- Exhaust emissions from diesel-powered construction equipment.

Exhaust emissions from on-site plant and site traffic are unlikely to have a significant impact on local air quality, and in the majority of cases they will not need to be quantitatively assessed (IAQM, 2014). Very high levels of soiling can also damage plants and affect the health and diversity of ecosystems.

Dust emissions can occur during the preparation of the land (*e.g.* demolition and earth moving) and during construction itself, and can vary substantially from day to day depending on the level of activity, the specific operations being undertaken, and the weather conditions. A significant portion of the emissions results from site plant and road vehicles moving over temporary roads and open ground. If mud is allowed to get onto local public roads, dust emissions can occur at some distance from the construction site (IAQM, 2014).

The risk of dust impacts from a demolition/construction site causing loss of amenity and/or health or ecological impacts is related to the following (IAQM, 2014):

- The nature of the activities being undertaken.
- The duration of the activities.
- The size of the site.
- The meteorological conditions (wind speed, direction and rainfall). Adverse impacts are more likely to occur downwind of the site and during drier periods.
- The proximity of receptors to the activities.
- The sensitivity of the receptors to dust.
- The adequacy of the mitigation measures applied to reduce or eliminate dust.

It is difficult to quantify dust emissions from construction activities. Due to the variability of the weather it is impossible to predict what the weather conditions would be when specific construction activities are undertaken. Any effects of construction on airborne particle concentrations would also generally be temporary and relatively short-lived. Moreover, mitigation should be straightforward, as most of the necessary measures are routinely employed as 'good practice' on construction sites.

Construction dust impacts are typically assessed as a qualitative assessment. The impacts of construction have not been modelled; rather a risk based approach is used based on a method outlined in IAQM (2014). The IAQM guidance is designed primarily for use in the UK, although it may be applied elsewhere.

7.15.1 Construction Activities

Activities on construction sites can be divided into three types to reflect their different potential impacts, and the potential for dust emissions is assessed for each activity that is likely to take place. It is noted that there will be no demolition and therefore demolition works is not assessed.

The activities considered are:

- Earthworks. This covers the processes of soil stripping, ground levelling, excavation and landscaping. Earthworks will primarily involve excavating material, haulage, tipping and stockpiling.
- Construction. Construction is any activity that involves the provision of new structures, modification or refurbishment. A structure will include a residential dwelling, office building, retail outlet, road, etc.
- Track-out. This involves the transport of dust and dirt by HDVs from the construction/demolition site onto the public road network, where it may be deposited and then re-suspended by vehicles using the network.

The construction works will follow a staged approach as summarised in Table 7-9.

Table 7-9: EfW facility construction timeframes

Stage		Timeframe
Stage 1	Site establishment and clearance	2 weeks
Stage 2	Excavation/Services Lead-in	6-10 months
Stage 3	Structure	5 months
Stage 4	Technology provider plant Installation Structural Steel Works	16-18months 4-6 months
Stage 5	Façade/Roofing	4 months
Stage 6	Fit out/Landscaping	5 months

7.15.2 Assessment Procedure

The IAQM assessment procedure for assessing risk is shown in Figure 7-1. The assessment is used to define appropriate mitigation measures to ensure that there will be no significant effect.

The assessment methodology considers three separate dust impacts:

- Annoyance due to dust soiling.
- The risk of health effects due to an increase in exposure to PM_{10}.
- Harm to ecological receptors.

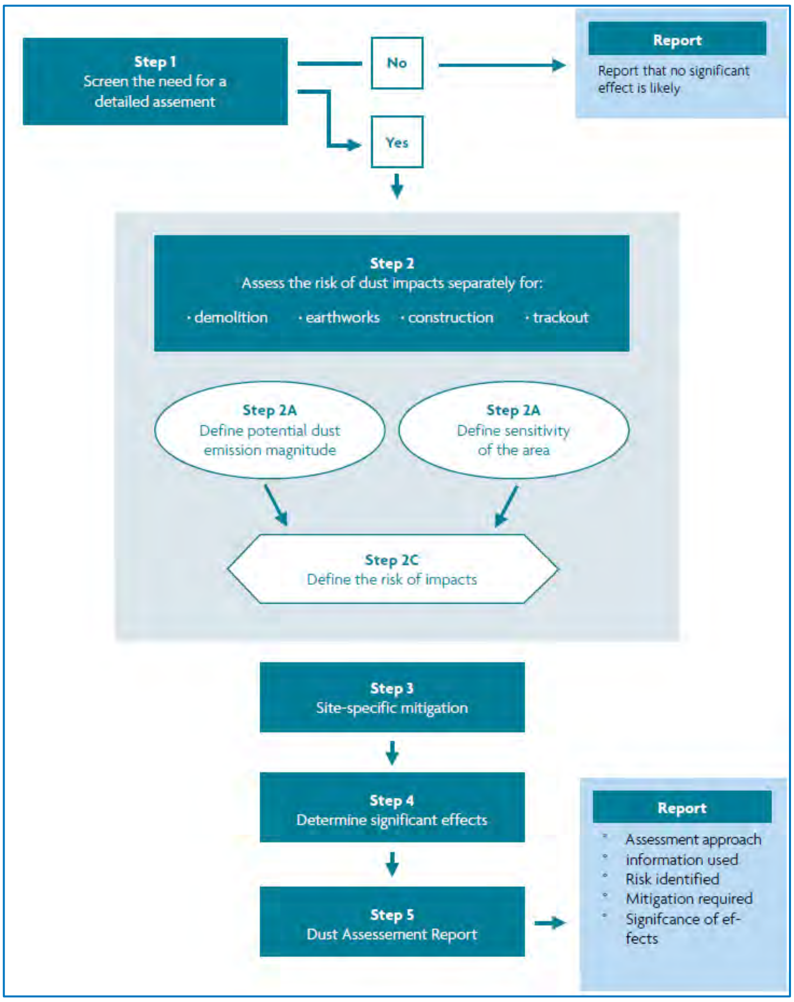


Figure 7-1: Steps in an assessment of construction dust (IAQM, 2014)

7.15.3 Step 1: Screening

Step 1 is a screening assessment to determine if detailed assessment is required. A construction dust assessment will normally be required where:

- There are human receptors within 350 m of the boundary of the site and/or within 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from the site entrance(s).
- There are ecological receptors within 50 m of the boundary of the site and/or within 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from the site entrance(s).

A 'human receptor', refers to any location where a person or property may experience the adverse effects of airborne dust or dust soiling, or exposure to PM_{10} over a time period relevant to air quality standards and goals. In terms of annoyance effects, this will most commonly relate to dwellings, but may also refer to other premises such as buildings housing cultural heritage collections (e.g. museums and galleries), vehicle showrooms, food manufacturers, electronics manufacturers, amenity areas and horticultural operations (e.g. salad or soft-fruit production). An 'ecological receptor' refers to any sensitive habitat affected by dust soiling. This includes the direct impacts on vegetation or aquatic ecosystems of dust deposition, and the indirect impacts on fauna (e.g. on foraging habitats) (IAQM, 2014).

In the context of the site, the nearest human receptors are works at the Genesis Xero MPC and the adjacent Hanson site. In the case of Genesis Xero MPC, the site is likely already exposed to dust arising from proximity to the former quarry and the operation of waste processing facility. In the case of the Hanson, it is noted that the site is currently vacant. Residential receptors are located at some distance, 1 km to the west and north well beyond the 350m buffer.

As the proposal involves the removal of existing vegetation from the site (and vegetation on the adjacent Hanson site has been approved for removal) there is limited potential to affect ecological receptors. The Ropes Creek Tributary to the south, despite its degraded state would be considered an ecological receptor.

Nevertheless, the context of the area is not considered to be sensitive to dust associated with construction works, owing to the nature of the existing land uses and therefore no quantitative assessment of construction phase impact has been completed.

It is assumed that routinely employed 'good practice' mitigation measures for construction sites would be sufficient to control dust impacts to acceptable levels. Such methods would include, but not be limited to the use of water sprays to suppress dust, stockpile management and planting of native cooch grass at the lay down pads as soon as practicable following completion of works. These mitigation measures would be detailed within the Construction Environmental Management Plan for the site.

Furthermore, Brookfield Multiplex and AT&L have considered the potential soil migration from the site as a consequence of the proposed construction works and each has identified a range of management and mitigation options that may be implemented to avoid and mitigate impacts on the receiving environment.

8 MODELLING APPROACH

The overall approach to the assessment has followed the Approved Methods using the Level 2 assessment methodology. The Approved Methods specify how assessments based on the use of air dispersion models should be completed. They include guidelines for the preparation of meteorological data to be used in dispersion models and the relevant air quality criteria for assessing the significance of predicted concentration and deposition rates from the EfW facility. The approach taken in this assessment has followed as closely as possible the approaches provided within the Approved Methods.

8.1 Modelling System

AERMOD was chosen as a suitable dispersion model due to the source type, location of nearest receiver and nature of local topography. AERMOD is the US EPA's recommended steady-state plume dispersion model for regulatory purposes. AERMOD replaced the Industrial Source Complex (ISC) model for regulatory purposes in the US in December 2006. Ausplume, a steady state Gaussian plume dispersion model developed by the Victorian EPA and frequently used in Australia for simple near-field applications is based on ISC, which has now been replaced by AERMOD. While AERMOD has not been explicitly listed as an approved model by the EPA in the Approved Methods, AERMOD has been used for a number of assessments that have been approved by NSW EPA (Pacific Environment 2013a; 2013b).

A significant feature of AERMOD is the Pasquil-Gifford stability based dispersion is replaced with a turbulence-based approach that uses the Monin-Obukhov length scale to account for the effects of atmospheric turbulence based dispersion.

The AERMOD system includes AERMET, used for the preparation of meteorological input files and AERMAP, used for the preparation of terrain data. Ground level concentrations were modelled across a 10km by 10km domain at 100m resolution. The size of the modelling domain is considered adequate to capture the maximum predicted ground level concentrations associated with the Project's activities, including emissions from the proposed 100m stacks.

Terrain data was sourced from NASA's Shuttle Radar Topography Mission Data (3 arc second [~90m] resolution) and processed to create the necessary input files.

AERMET requires surface and upper air meteorological data as input. Wind speed, wind direction, temperature, relative humidity and sea level pressure were source from the EPA St Marys meteorological station. Cloud cover and cloud height were sourced from the BoM Bankstown Airport AWS. In the absence of upper air sounding data for the area, upper air parameters were calculated using the upper air estimator within the Lakes Environment AERMODview software package.

Appropriate values for three surface characteristics are required for AERMET as follows:

- Surface roughness, which is the height at which the mean horizontal wind speed approaches zero, based on a logarithmic profile.
- Albedo, which is an indicator of reflectivity of the surface.
- Bowen ratio, which is an indicator of surface moisture.

Values of surface roughness, albedo and bowen ratio were determined based on a review of aerial photography for a radius of 3 km centred on the EPA St Marys station. Default values for cultivated land and urban areas were chosen over two sectors across this area.

8.2 Building Wake Effects

Wind flow is often disrupted in the immediate vicinity of buildings. Plumes emitted nearby are assumed to be unaffected by building wakes if they manage to reach building height plus 1.5 times the lesser of building height or projected building width. If this is not the case, pollutants can be brought to ground within a highly turbulent, generally recirculating cavity region in the immediate lee of the building and/or be subject to plume downwash and enhanced dispersion in a turbulent region which extends further downwind behind the building.

A simplified building geometry was incorporated for simulation of building wake effects, modelled using BPIP-PRIME model, as shown in Figure 8-1. BPIP-PRIME uses heights and corner locations of buildings in the vicinity of the plume to simulate the effective height and width of the structures. The downwash algorithm calculates effective building dimensions relative to the plume, resolved down to ten degree intervals. AERMOD then calculates the impact of these buildings on plume dispersion and consequently on GLCs.

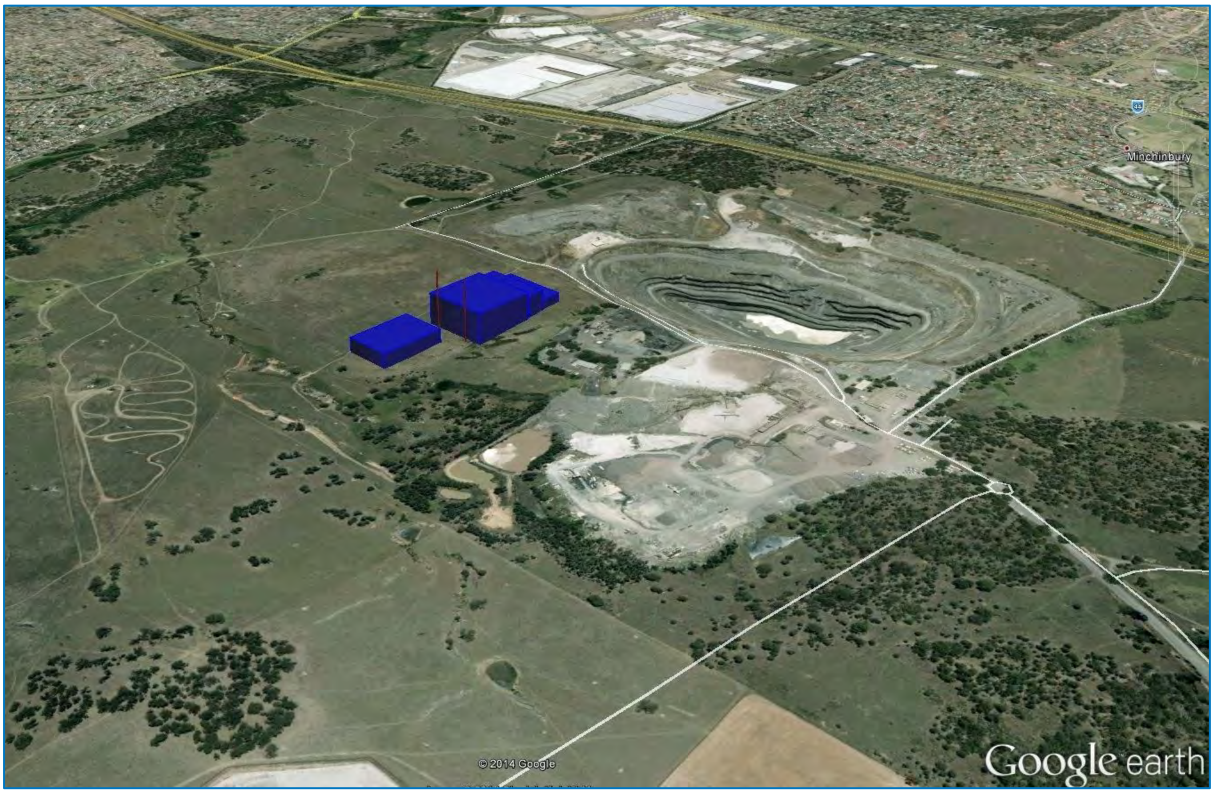


Figure 8-1: Visualisation of the Incorporation of EfW Building Dimensions within the Model

8.3 Sub-hourly Predictions

The AERMOD model outputs ground level concentration predictions for averaging periods of 1-hour and greater. For sub-hourly averaging periods, such as for CO and SO_2, predictions were based on the power-law formula from Borgas (2000) to estimate short-term peak values referencing longer-term average concentrations. For example, to determine a 10-minute peak value from a one-hour value the formula is:

$$C_{10} = C_{60} \times (60/10)^{0.35}$$

C_{10} is the estimated peak value and C_{60} is the average one-hour value.

9 LOCAL AIR QUALITY ASSESSMENT

The concentrations of the air quality parameters assessed in this study were determined for boundary, residential, industrial (including potential future industrial/commercial) and community receptors located in the local area (see Section 3).

Contour plots have also been prepared to show the spatial distribution of the assessed pollutants, and these are provided in Section 9.1. Contour plots of pollutant concentrations show the areas that are predicted to be affected by the EfW Project under worst-case dispersion conditions. It is important to note that the contour figures are presented to provide a visual representation of the predicted (worst-case) impacts spatially. To produce the contours it is necessary to make interpolations, and as a result the contours will not always match exactly with predicted impacts at any specific location. The actual predicted pollutant concentrations at nearby receivers are presented in tabular form.

Note that 1-hour ground level concentrations of particulate matter (PM) size fractions have been modelled (Appendix J). The results are provided as an input to the Health Risk Assessment for the project (AECOM, 2016). Given that there are no air quality criteria relevant to 1-hour PM, these results are not discussed in detail within this document.

9.1 Incremental Ground Level Concentrations

9.1.1 Normal Operations

A summary of the predicted ground level concentration (GLC) for each pollutant is presented in Table 9-1. GLCs are presented at and beyond the site boundary, as well as the maximum prediction at sensitive receptors.

Contour plots of predicted GLCs are presented Figure 9-1 to Figure 9-14.

Table 9-1: Summary of predicted ground level concentrations during normal operations

Pollutant	Averaging period	Units	Criteria	Highest prediction at and beyond site boundary	Highest prediction at sensitive receptor
NO_2 (a)	1 hour	µg/m³	246	77.1	51.5
	Annual	µg/ m³	62	3.4	3.1
SO_2	10-minute	µg/ m³	712	15.9	10.6
	1 hour	µg/ m³	570	11.1	7.4
	24 hours	µg/ m³	228	1.9	1.7
	Annual	µg/ m³	60	0.49	0.45
CO	15-minute	mg/ m³	100	0.01	0.008
	1 hour	mg/ m³	30	0.009	0.006
	8 hours	mg/ m³	10	0.007	0.006
PM_{10}	24 hours	µg/ m³	50	0.07	0.06
	Annual	µg/ m³	30	0.018	0.017
$PM_{2.5}$	24 hours	µg/ m³	25	0.07	0.06
	Annual	µg/ m³	8	0.018	0.017
HCl	1 hour	mg/ m³	0.14	0.004	0.003
HF	24 hours	µg/ m³	2.9	0.28	0.26
	7 days	µg/ m³	1.7	0.21	0.17
	30 days	µg/ m³	0.84	0.15	0.11
	90 days	µg/ m³	0.5	0.1	0.09
Cd (b)	1 hour	mg/ m³	0.000018	0.0000037	0.000002
Hg (b)	1 hour	mg/ m³	0.00018	0.0000015	0.00000087
Dioxins and furans (b)	1 hour	mg/ m³	2.00×10^{-9}	3.7×10^{-12}	2.2×10^{-12}
TOC (as benzene) (b)	1 hour	mg/ m³	N/A	5.6×10^{-6}	3.3×10^{-6}
NH_3 (b)	1 hour	mg/ m³	0.33	0.0007	0.0004
H_2S (c)	1 hour	µg/ m³	1.38	1.2	0.96
PAH (as benzo(a)pyrene) (b)	1 hour	mg/ m³	0.0004	0.0000020	0.0000014

Note: (a) based on the assumption of 100% conversion from NO_x to NO_2 [g]
(b) expressed as the 99.9th percentile of the dispersion modelling prediction
(c) expressed as the 99th percentile of the dispersion modelling prediction

Modelling predictions at selected closest residences in the suburbs of Minchinbury and Erskine Park are presented in Appendix J to further inform the Health Risk Assessment.

Modelling results for criteria pollutants are assessed against the maximum prediction at sensitive receptors. In summary, the modelling results show:

- The maximum predicted 1-hour NO_2 is 21% of the impact assessment criterion, even assuming 100% conversion from NO_x to NO_2

[g] As discussed, we have conservatively assumed 100% conversion of NO_x to NO_2.

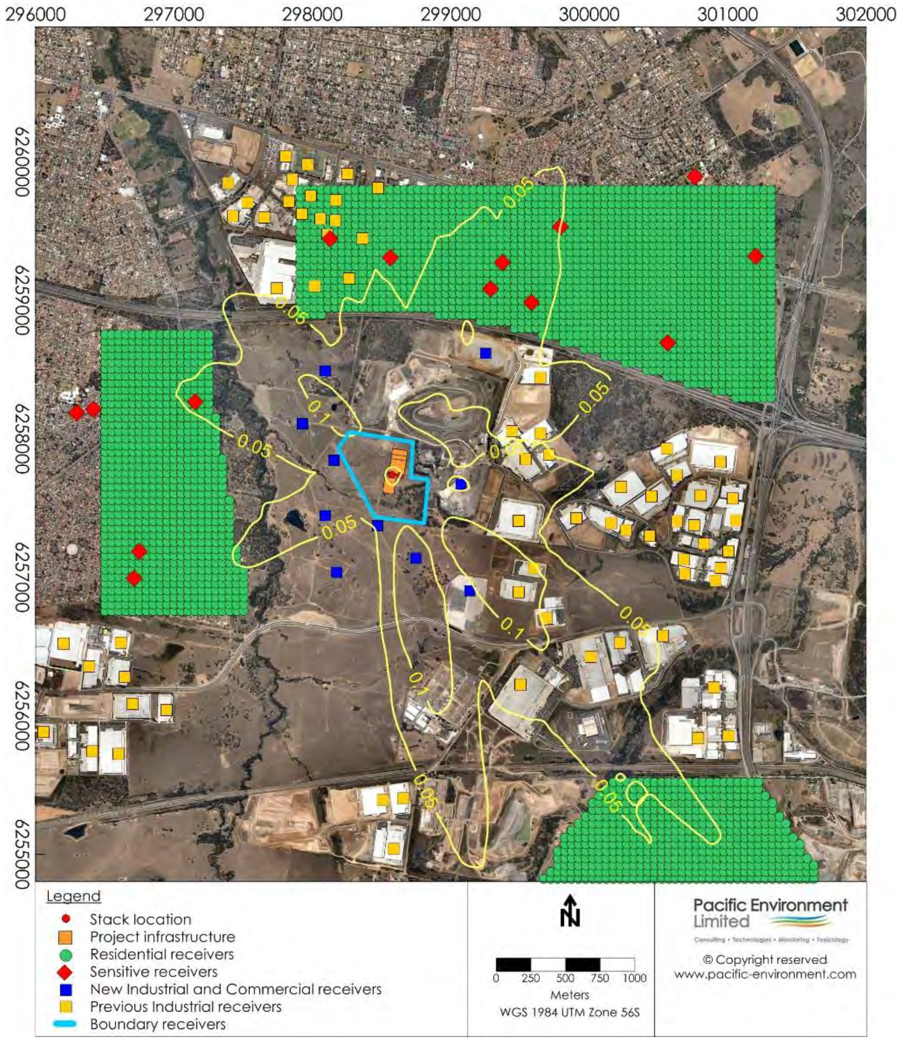
- The maximum predicted annual NO_2 is 5% of the impact assessment criterion.
- The maximum predicted 10-minute SO_2 is 1.5% of the impact assessment criterion, for 1-hour 1.3%, for 24-hour SO_2, 0.7% and for annual, 0.8%.
- The maximum predicted 24-hour PM is 0.1% of the impact assessment criterion for PM_{10} and 0.2% of the advisory reporting standard for $PM_{2.5}$.
- The maximum predicted annual PM is less than 0.1% of the impact assessment criterion for PM_{10} and 0.2% of the advisory reporting standard for $PM_{2.5}$.
- The maximum predicted CO 15-minute, 1-hour and 8-hour averaging periods are 0.1% or less than the relevant impact assessment criterion.
- The maximum predicted 24-hour HF is 9% of the impact assessment criterion, for 7-day 10%, for 30-day HF, 13% and for 90-day, 18%.

For the pollutants above it is also important to consider cumulative impacts due to existing "background" air quality, and other sources of pollution in the area. The cumulative predictions are presented in Section 9.2.1.

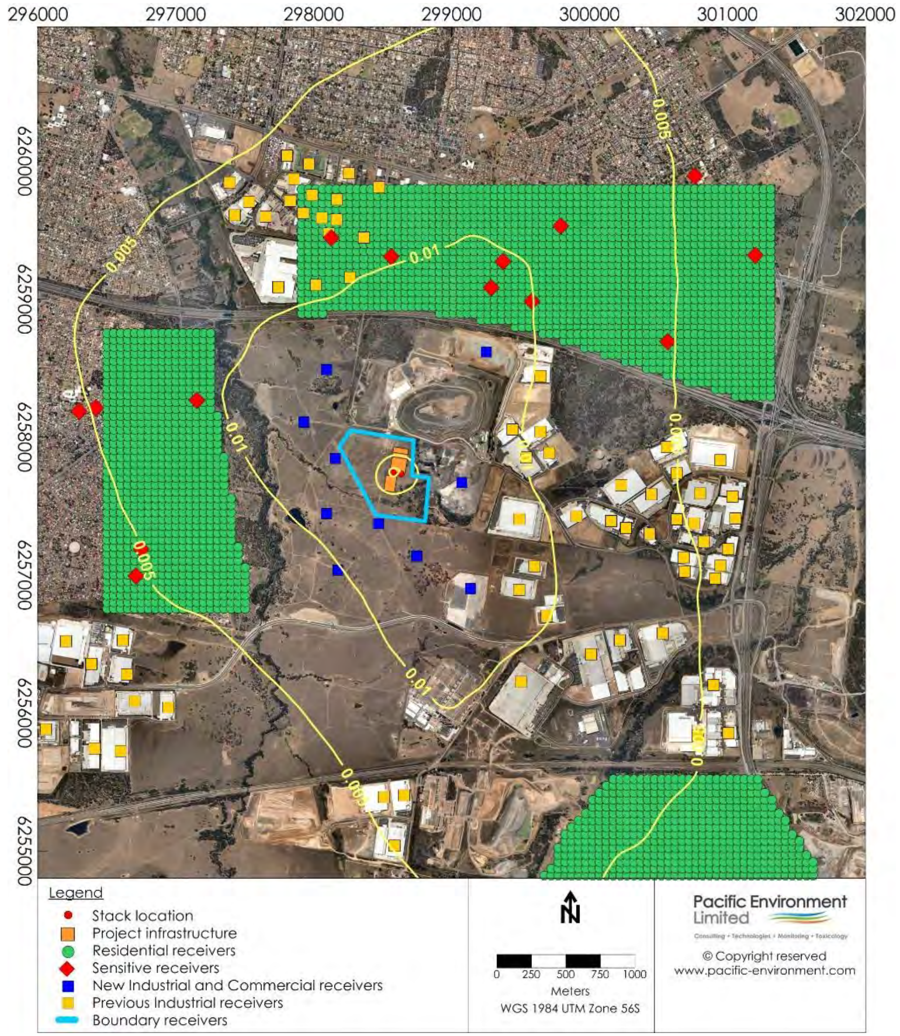
Modelling predictions for air toxics are assessed against the 99.9th percentile prediction, at and beyond the site boundary. The individual odour compound H_2S is assessed against the 99th percentile prediction.

In summary, the modelling results show:

- The 99.9th percentile predicted HCl is 2% of the impact assessment criterion.
- The 99.9th percentile predicted cadmium is 11% of the impact assessment criterion.
- The 99.9th percentile predicted mercury is 0.5% of the impact assessment criterion.
- The 99.9th percentile predicted dioxins and furans are 0.1% of the impact assessment criterion.
- The 99.9th percentile predicted TOC (as benzene) is 0.01% of the impact assessment criterion.
- The 99.9th percentile predicted NH_3 is 0.1% of the impact assessment criterion.
- The 99.9th percentile predicted PAH (as benzo(a)pyrene) is 0.4% of the impact assessment criterion.
- The 99th percentile predicted H_2S is 70% of the impact assessment criterion.

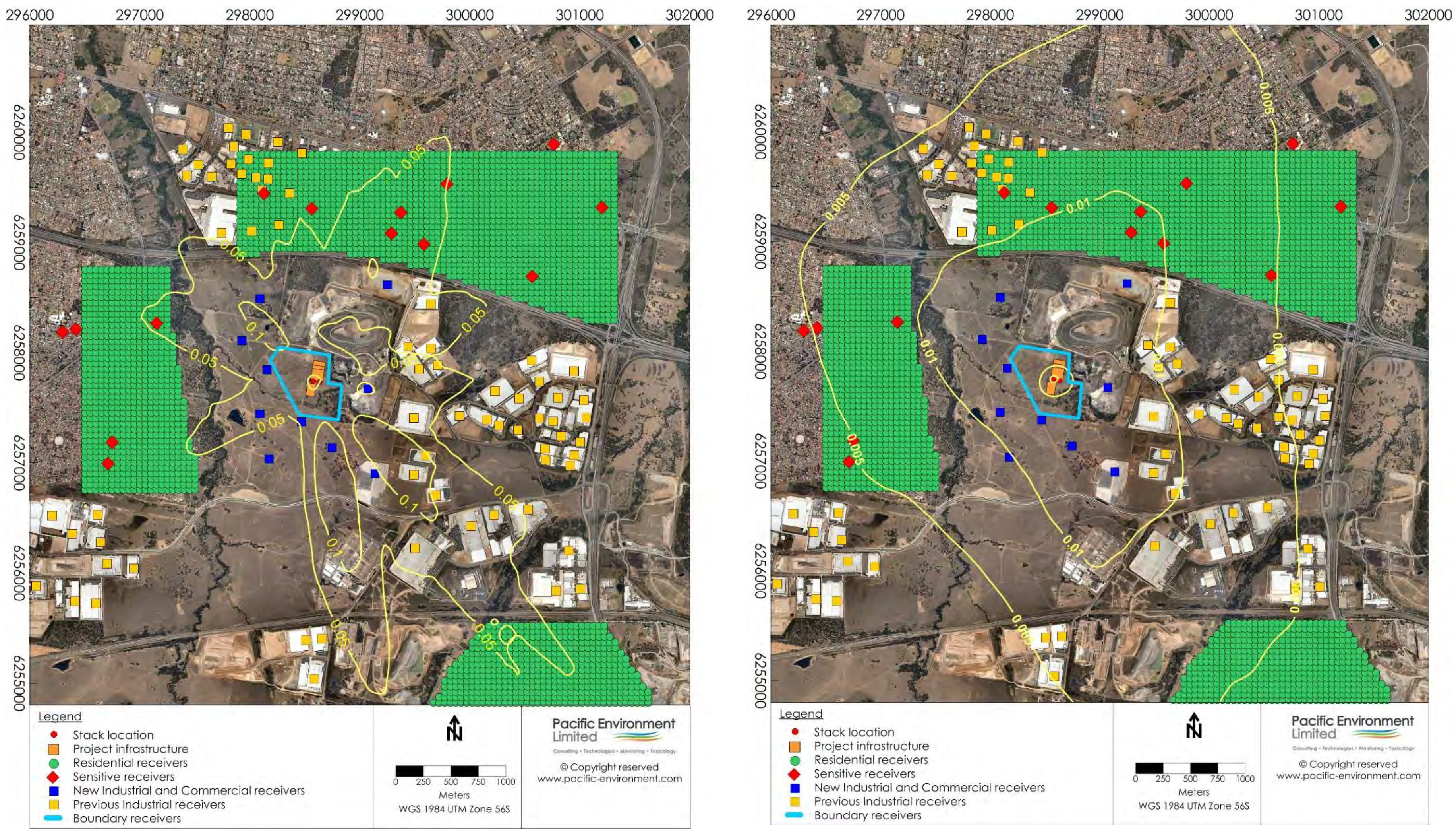


Maximum 24-Hour PM_{10} (goal = 50 µg/m^3)



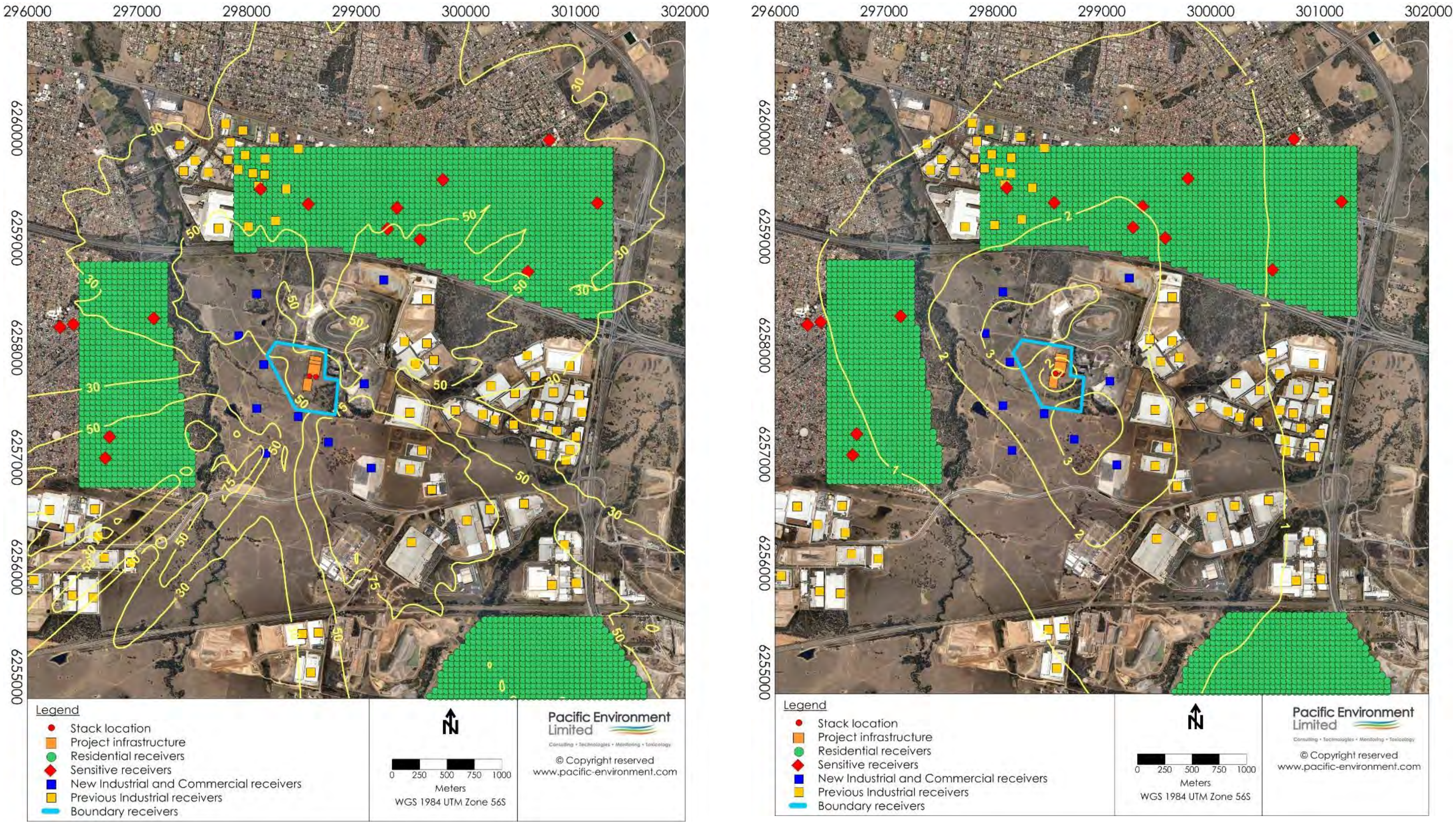
Annual Average PM_{10} (goal = 30 µg/m^3)

Figure 9-1: Maximum predicted Ground Level PM_{10} Concentration – µg/m^3



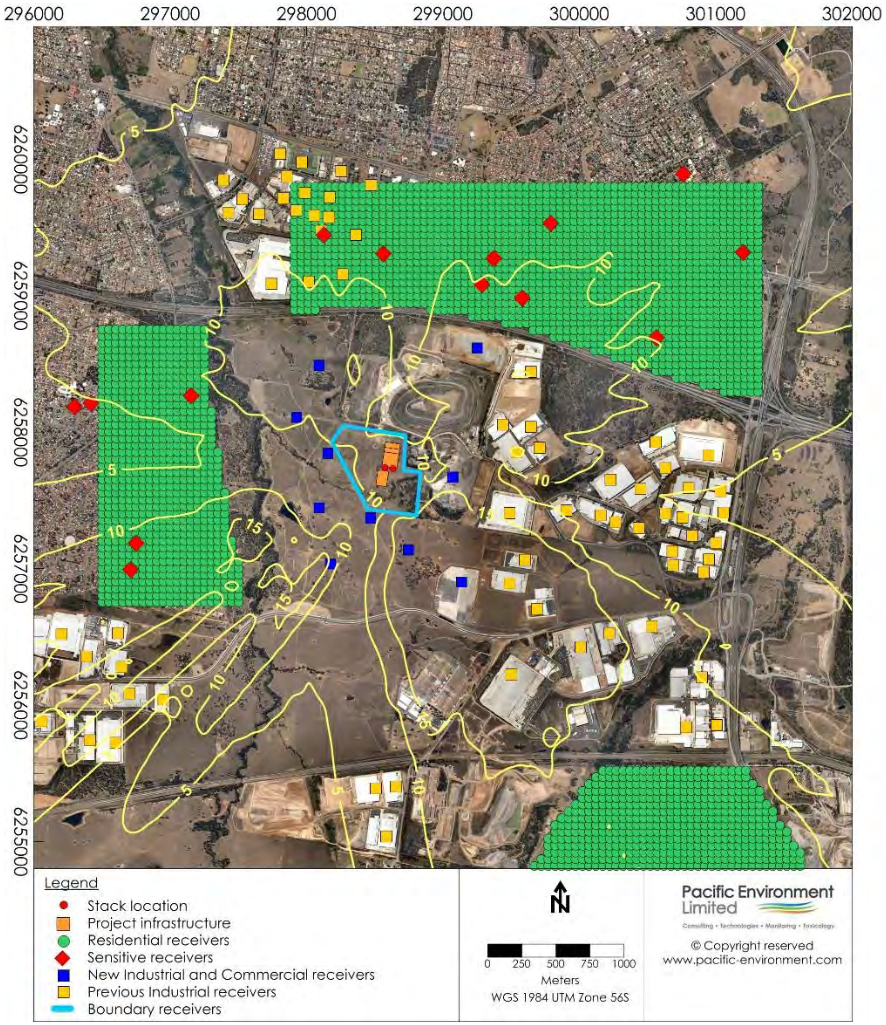
Maximum 24-Hour $PM_{2.5}$ (goal = 25 µg/m^3) Annual Average $PM_{2.5}$ (goal = 8 µg/m^3)

Figure 9-2: Maximum Predicted Ground Level $PM_{2.5}$ Concentration – µg/m^3

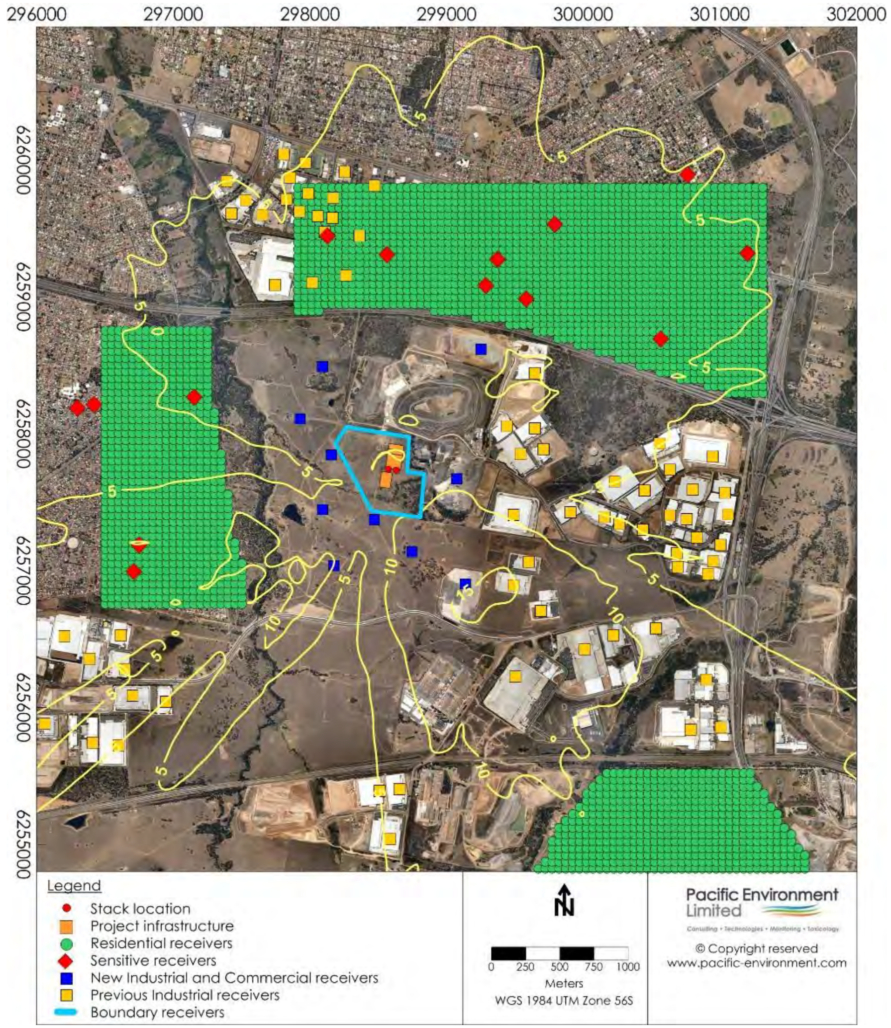


Maximum 1-Hour NO_2 (goal = 246 µg/m³) Annual Average NO_2 (goal = 62 µg/m³)

Figure 9-3: Maximum Predicted Ground Level NO_2 Concentration – µg/m³

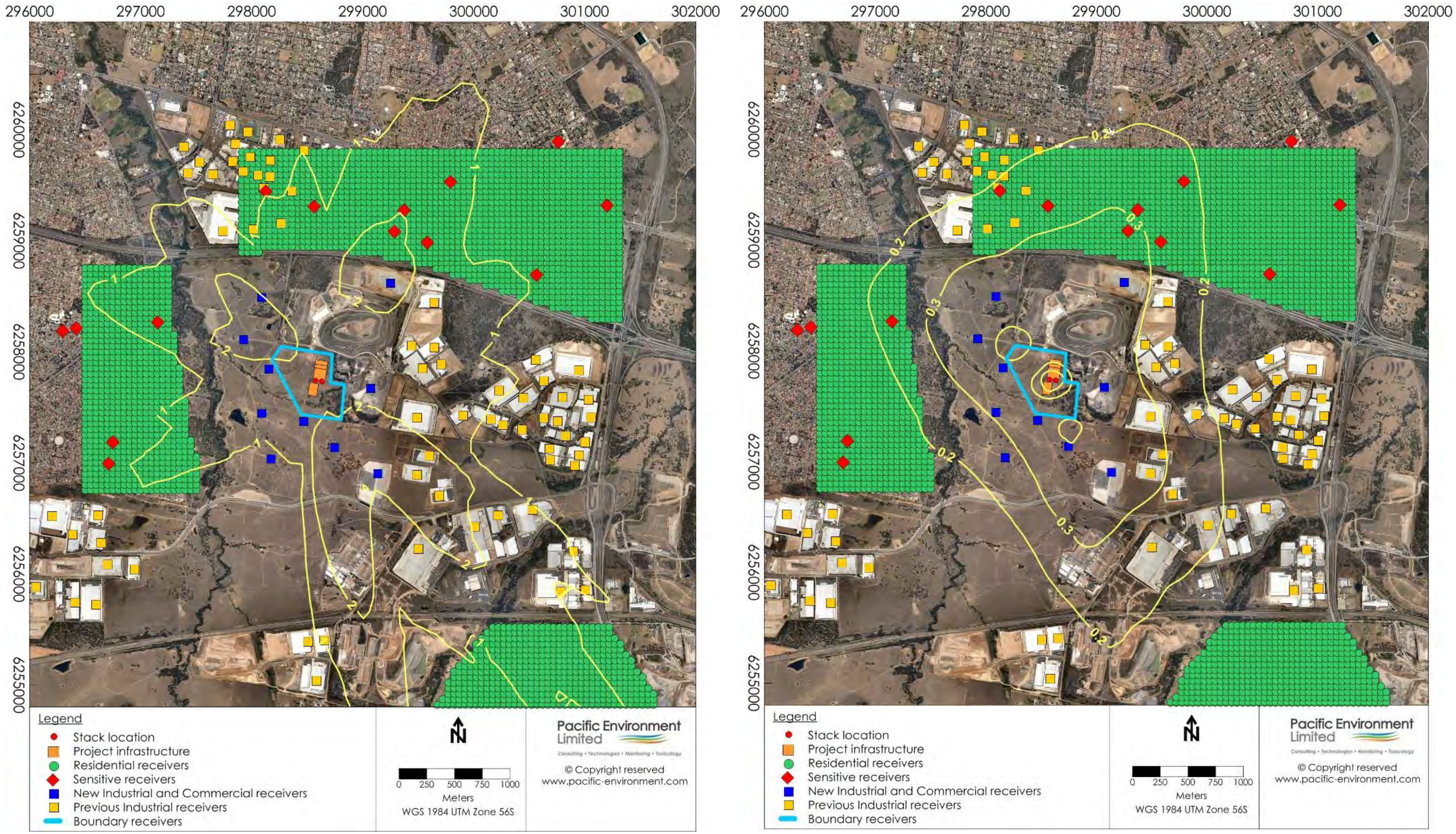


Maximum 10-Minute SO_2 (goal = 712 µg/m^3)



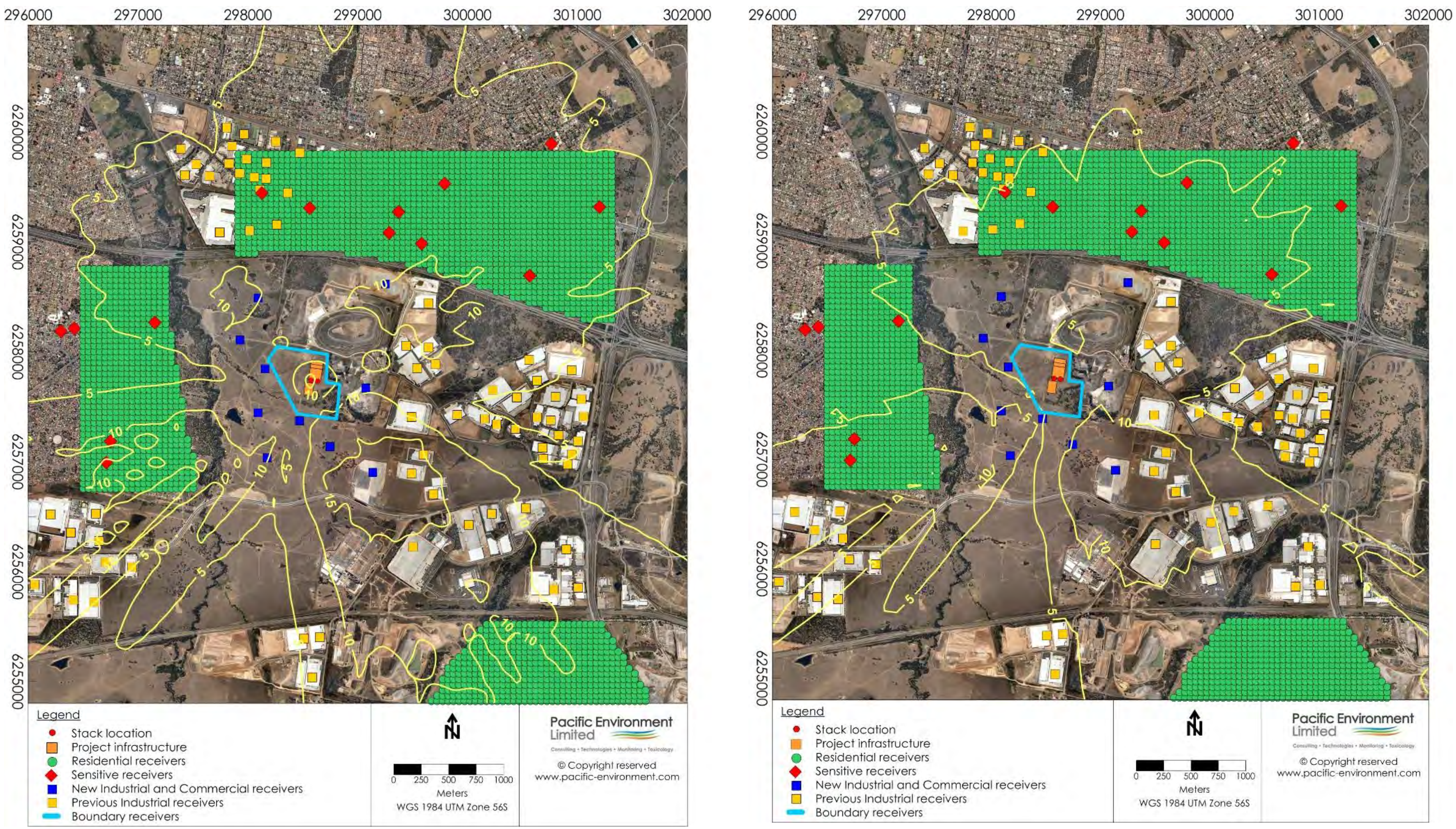
Maximum 1-Hour SO_2 (goal = 570 µg/m^3)

Figure 9-4: Maximum Predicted Ground Level SO_2 Concentration – µg/m^3



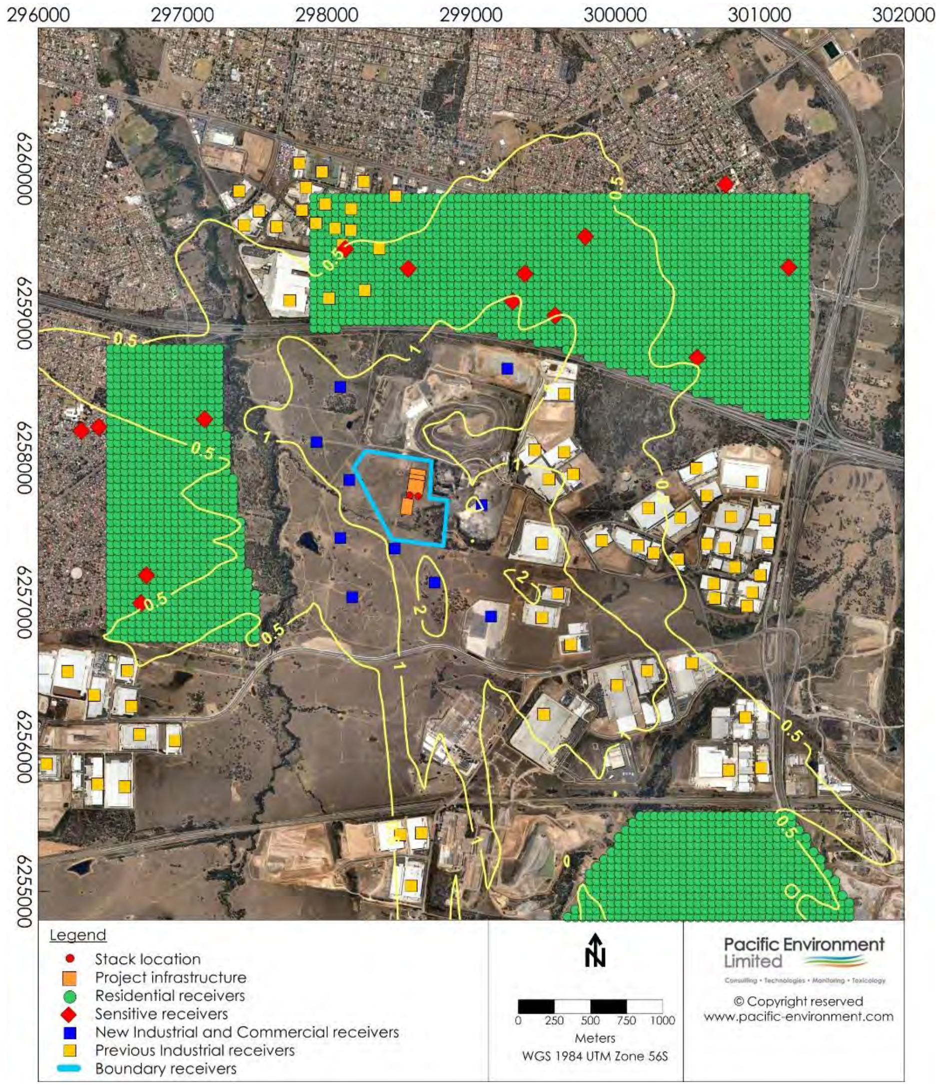
Maximum 24-Hour SO_2 (goal = 228 µg/m³) Annual Average SO_2 (goal = 60 µg/m³)

Figure 9-5: Maximum Predicted Ground Level SO_2 Concentration – µg/m³



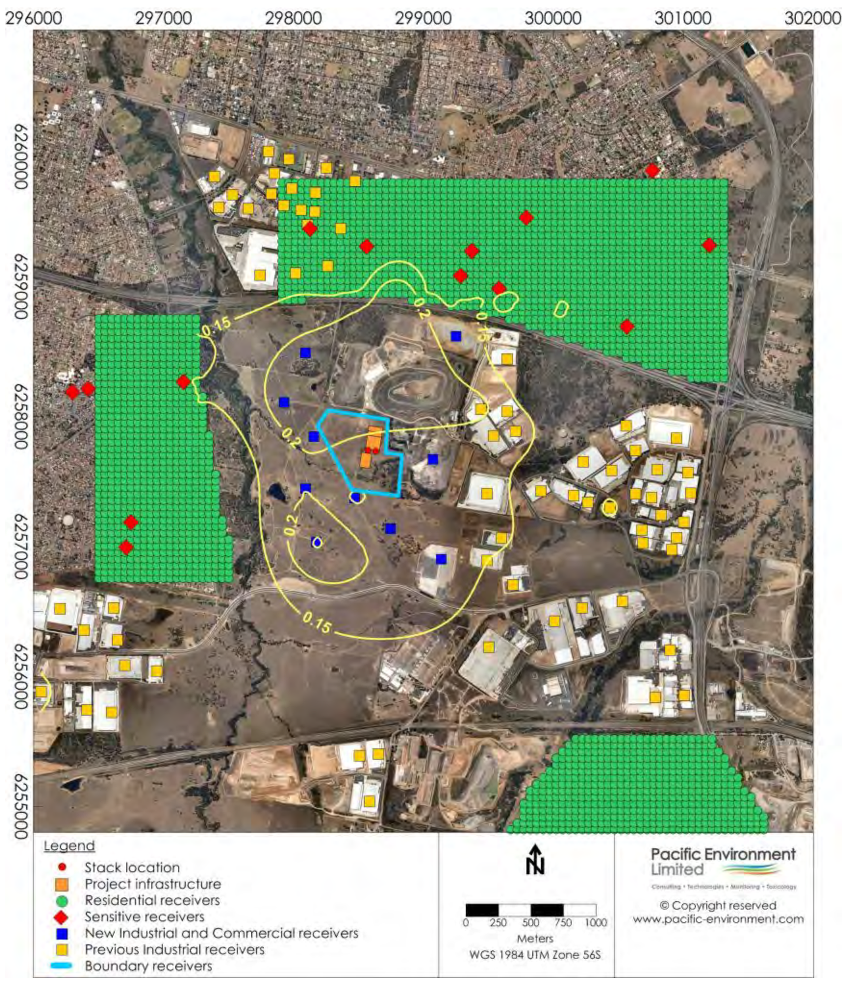
Maximum 15-Minute CO (goal = 100 mg/m³)　　Maximum 1-Hour CO (goal = 30 mg/m³)

Figure 9-6: Maximum Predicted Ground Level CO Concentration – mg/m³

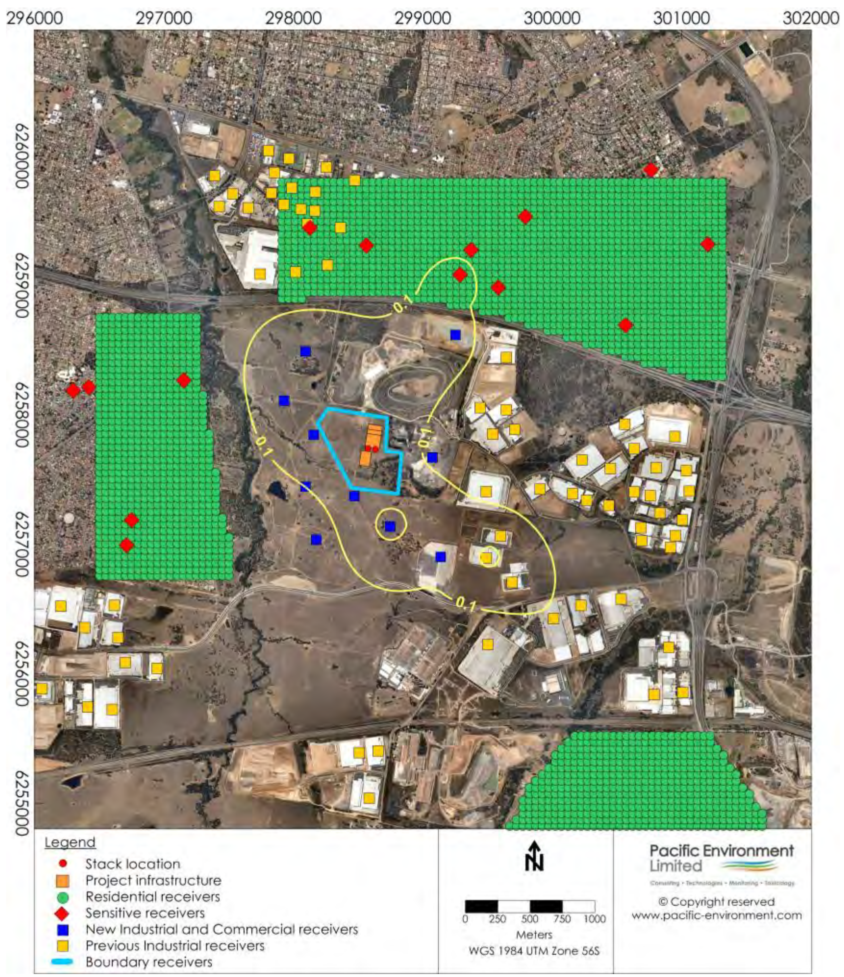


Maximum 8-Hour CO (goal = 10 mg/m³)

Figure 9-7: Maximum Predicted Ground Level CO Concentration – mg/m³

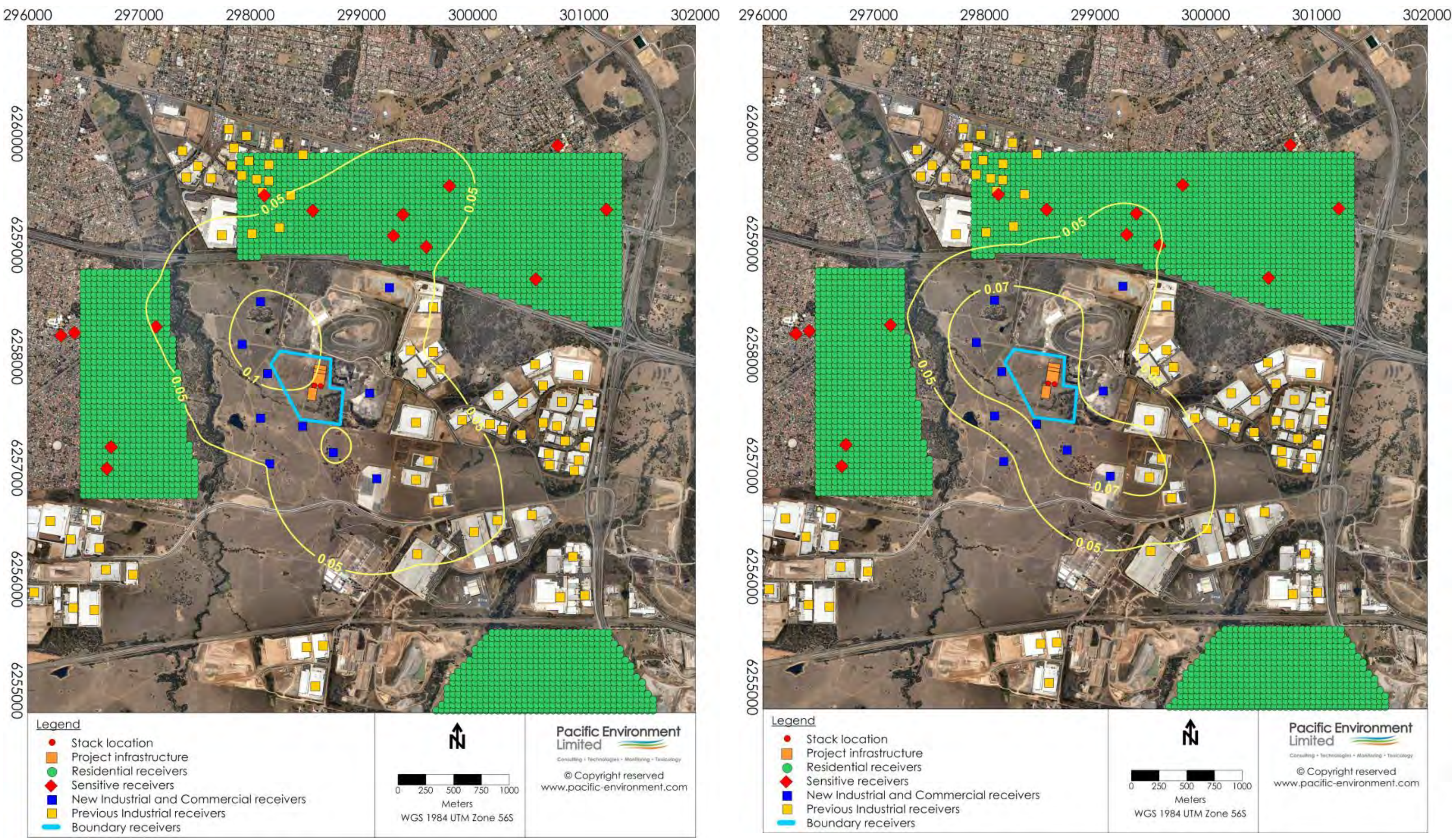


Maximum 24-Hour HF (µg/m³) (goal = 2.9 µg/m³)



Maximum 7-day HF (µg/m³) (goal = 1.7 µg/m³)

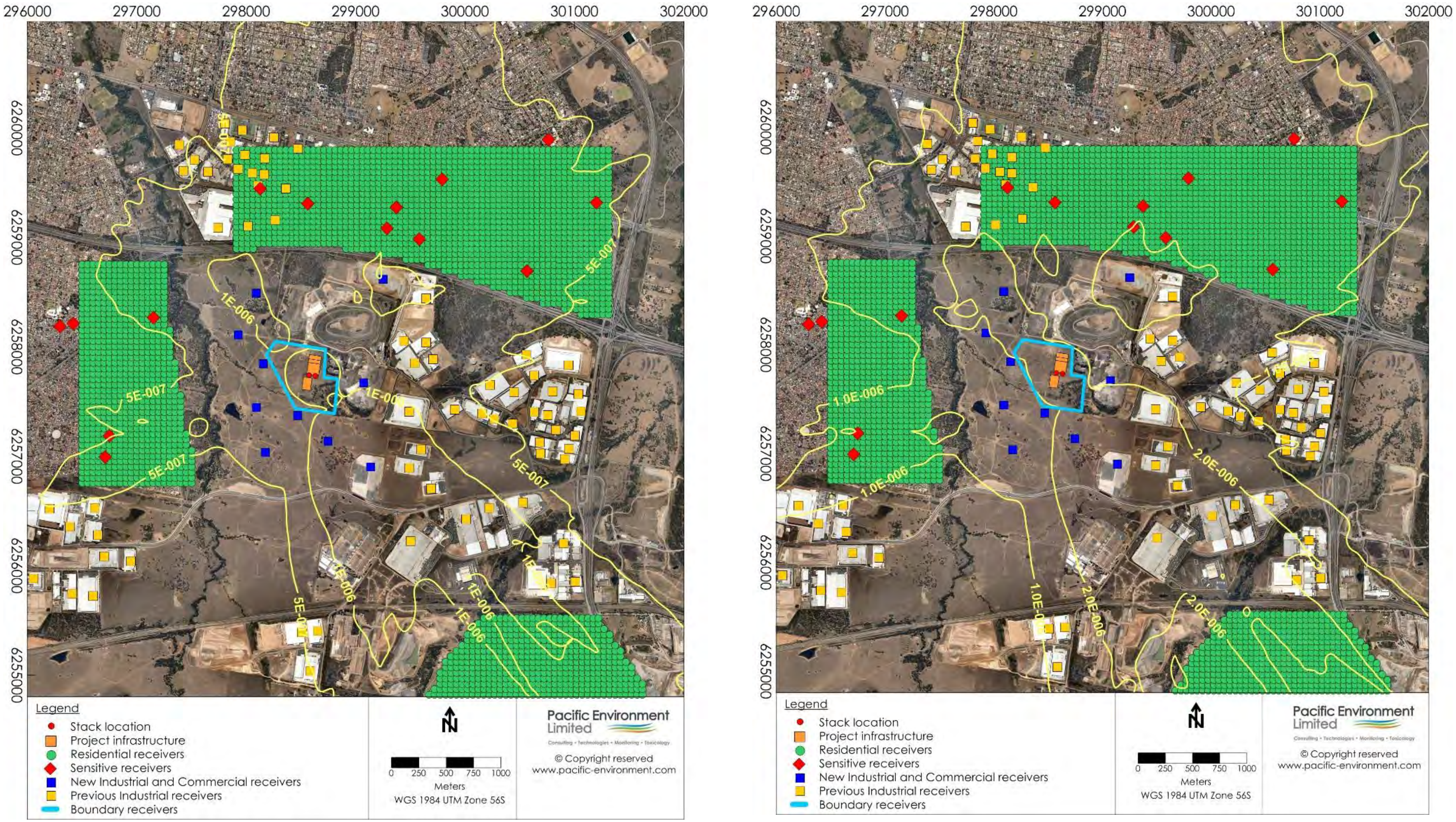
Figure 9-8: Maximum Predicted Ground Level HF Concentration



Maximum 30 day HF (µg/m³) (goal = 0.84 µg/m³)

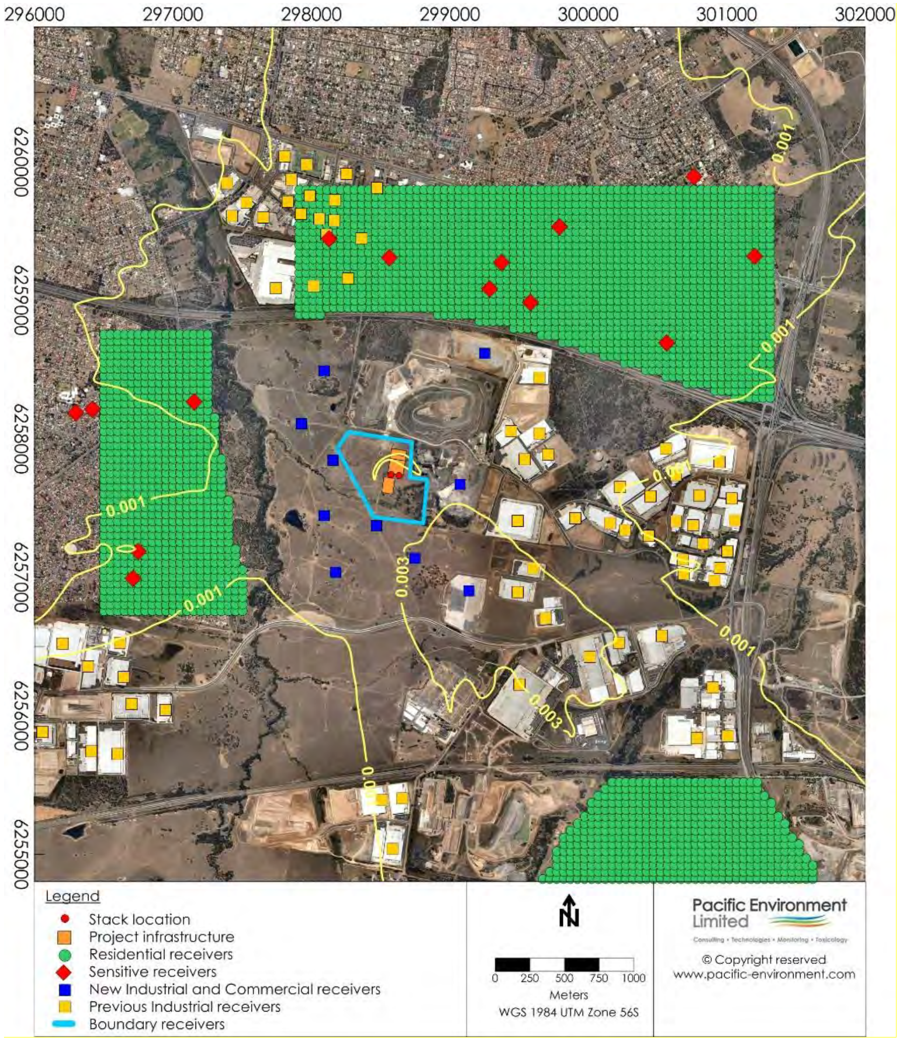
Maximum 90 day HF (goal = 0.5 mg/m³)

Figure 9-9: Maximum Predicted Ground Level HF Concentration

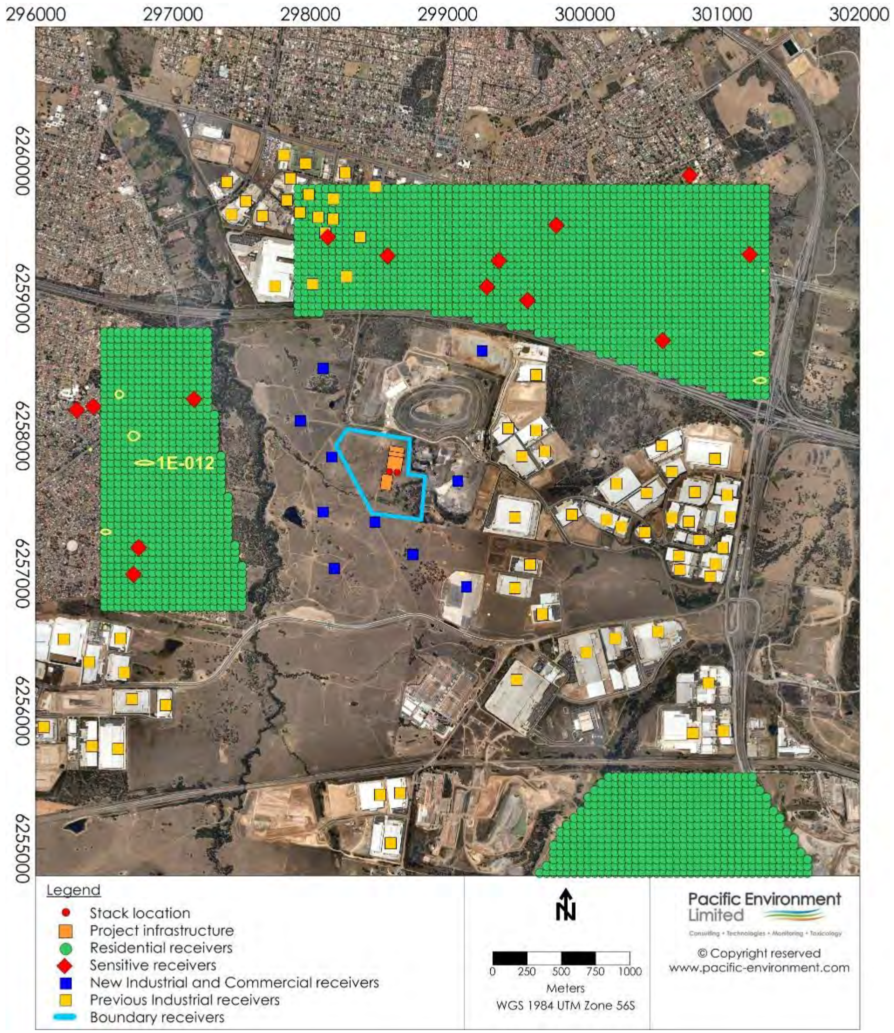


99.9th percentile 1-Hour Mercury (goal = 0.0018 mg/m³)   99.9th percentile 1-Hour Cadmium (goal = 0.000018 mg/m³)

Figure 9-10: 99.9th Percentile Predicted Ground Level Metals Concentration – mg/m³

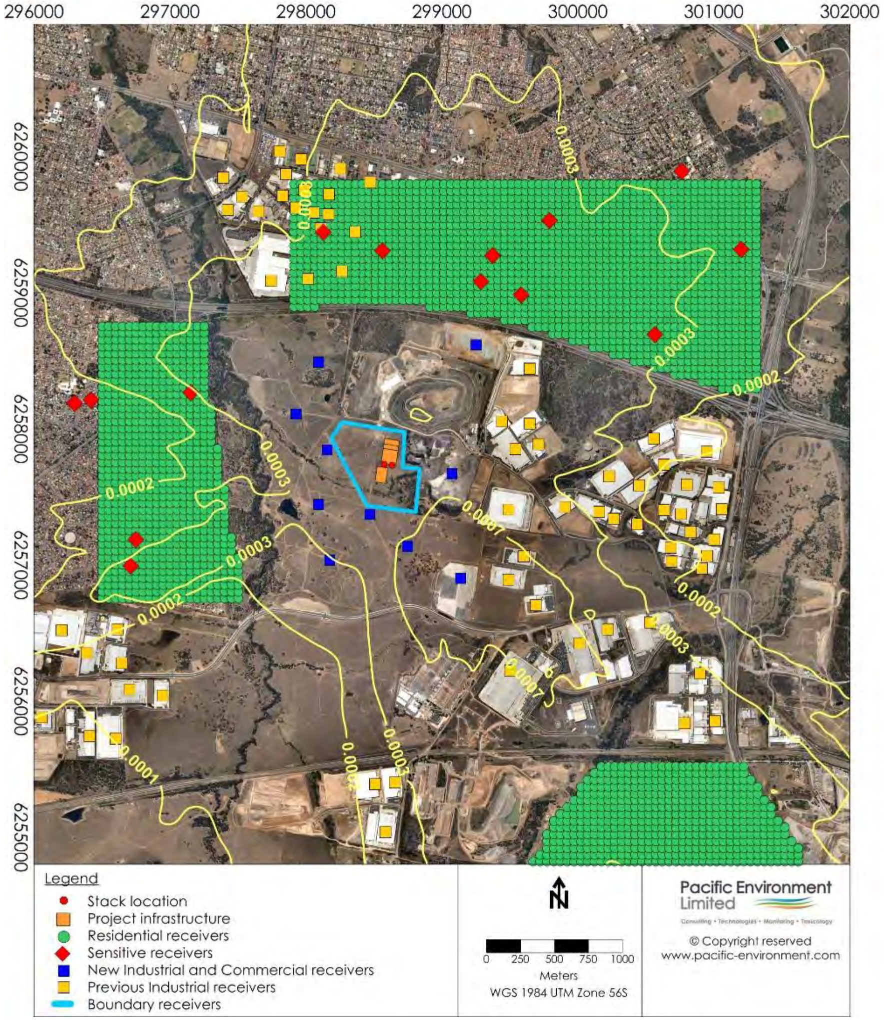


99.9th percentile 1-Hour HCl (goal = 0.14 mg/m³)



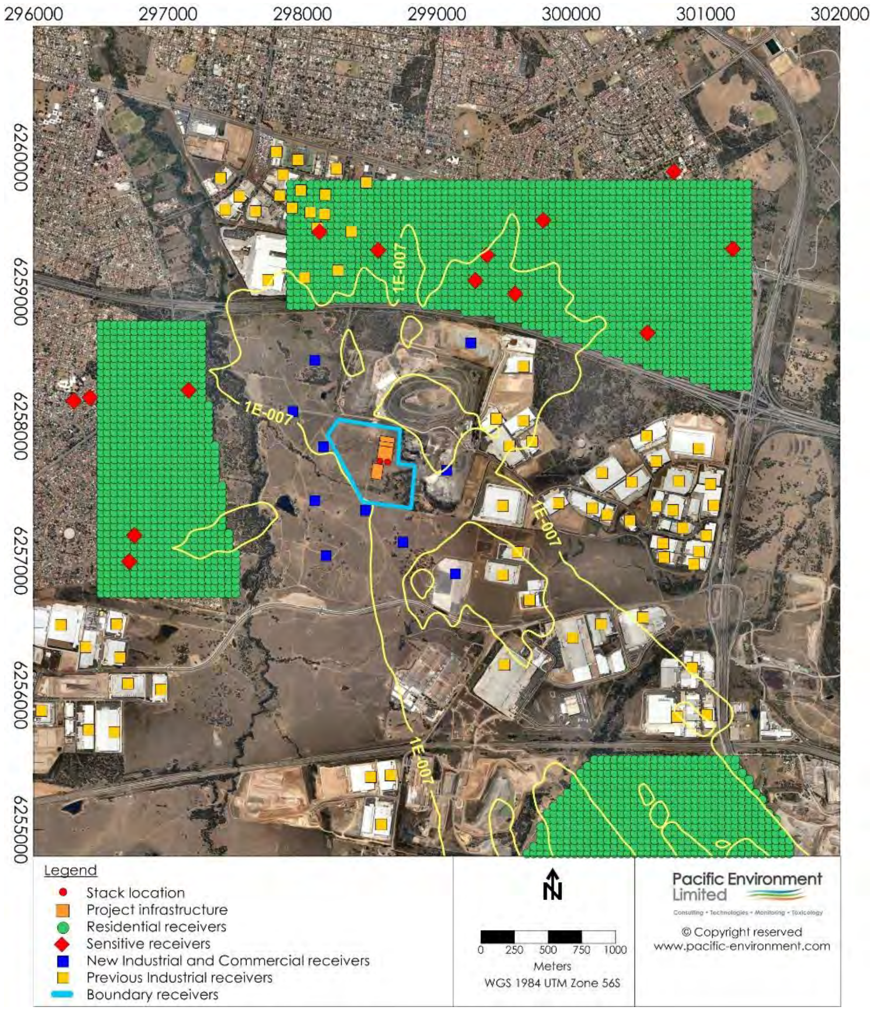
99.9th percentile 1-Hour Dioxins and Furans (goal = 2.0x10^{-9} mg/m³)

Figure 9-11: 99.9th Percentile Predicted HCl and Dioxin/Furan Ground Level Concentration – mg/m³

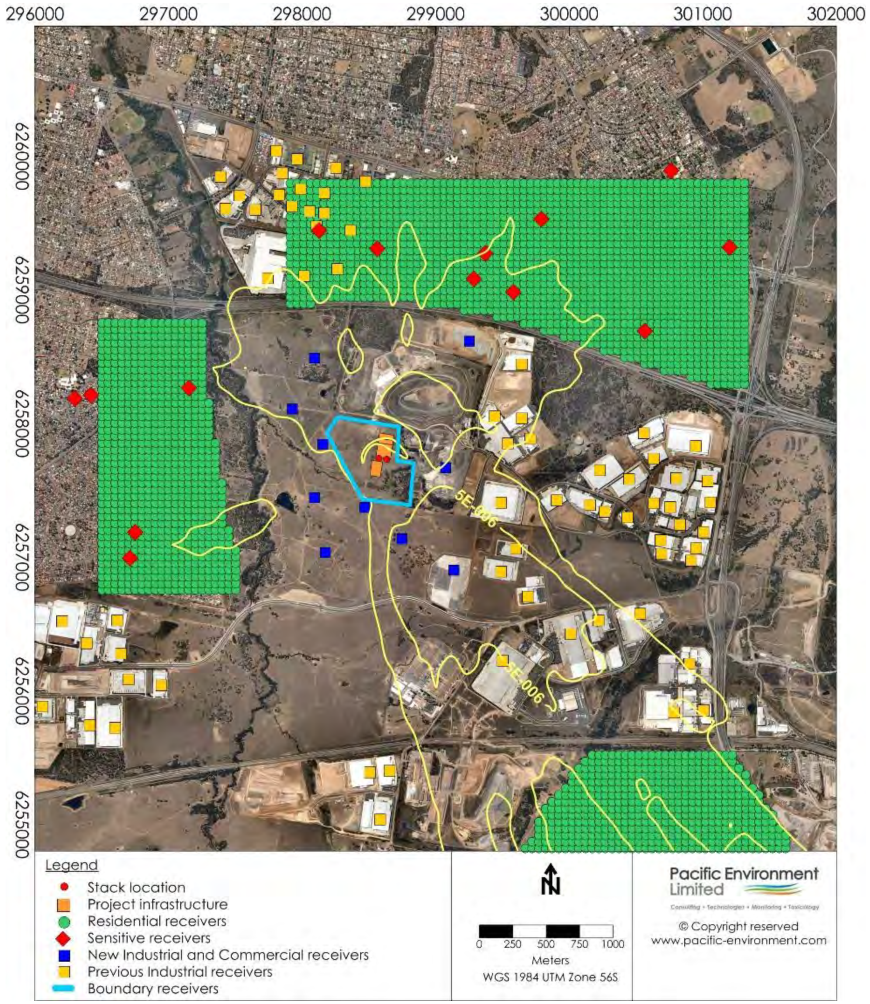


99.9th percentile 1-Hour NH_3 (goal = 0.33mg/m^3)

Figure 9-12: 99.9th Percentile Predicted Ammonia Ground Level Concentration

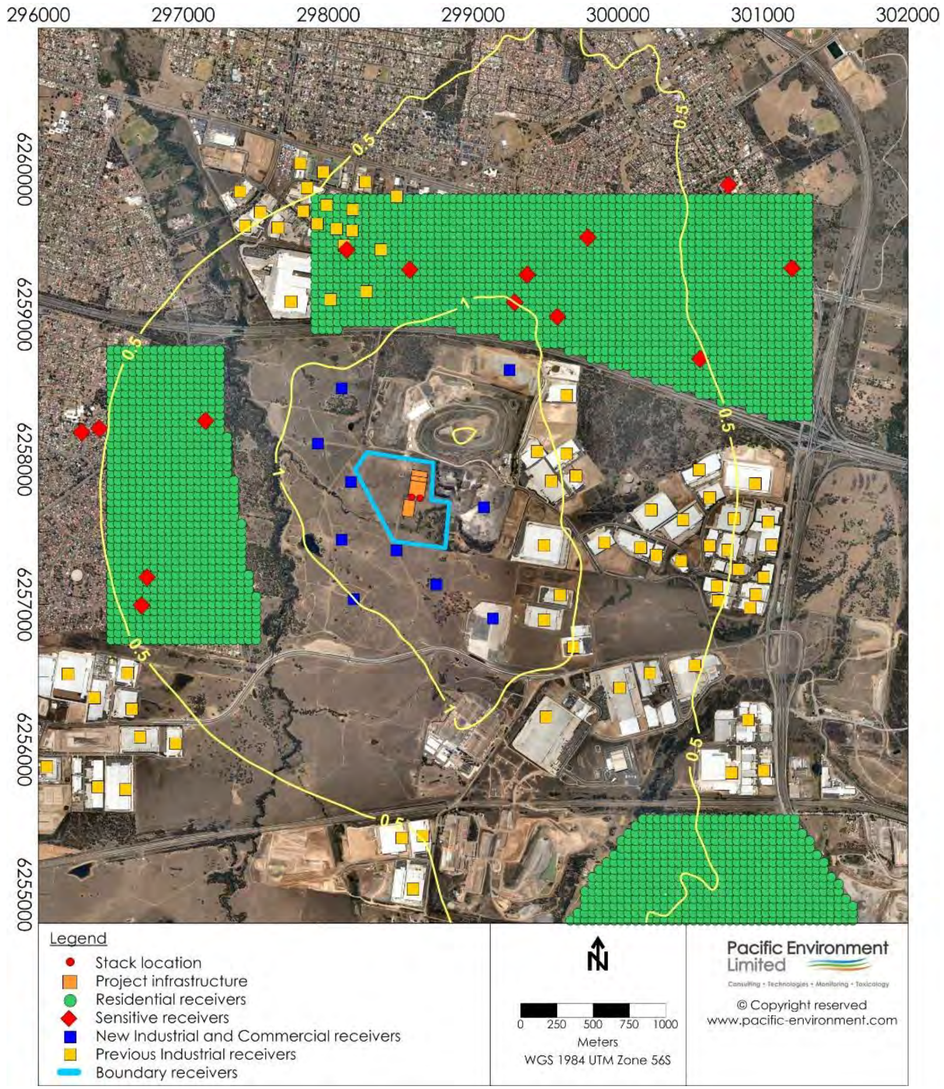


99.9th percentile 1-Hour PAH (as benzo(a)pyrene) (goal = 0.0004mg/m³)



99.9th percentile 1-Hour VOC (benzene goal = 0.029mg/m³)

Figure 9-13: 99.9th Percentile Predicted PAH and VOC Ground Level Concentration



99th percentile 1-Hour H_2S (goal = 1.38µg/m³)

Figure 9-14: 99th Percentile Predicted Hydrogen Sulfide Ground Level Concentration

9.1.2 Upset Conditions

A summary of the predicted maximum ground level concentrations (GLCs) for each pollutant is presented in Table 9-2. GLCs are presented at and beyond the site boundary, as well as the maximum prediction at sensitive receptors. Predictions above the relevant NSW impact assessment criterion are shown in bold.

Long term averaging periods (annual, 90 day, 30 day, 7 day and 1 day) have not been included. This is because the any upset emission scenario is anticipated to last a maximum of a matter of hours (likely less). Therefore prediction over longer averaging periods is not relevant for this scenario.

Table 9-2: Summary of predicted ground level concentrations during upset conditions

Pollutant	Averaging period	Units	Criterion	Highest prediction at and beyond site boundary	Highest prediction at sensitive receptor
NO_2 (a)	1 hour	µg/m³	246	771	515
SO_2	10-minute	µg/ m³	712	159	106
	1 hour	µg/ m³	570	111	74
CO	15-minute	mg/ m³	100	0.1	0.1
	1 hour	mg/ m³	30	0.09	0.06
HCl	1 hour	mg/ m³	0.14	0.04	0.03
Cd (b)	1 hour	mg/ m³	0.000018	0.000034	0.00002
Hg (b)	1 hour	mg/ m³	0.00018	0.000005	0.000003
Dioxins and furans (b)	1 hour	mg/ m³	2.00×10^{-9}	1.9×10^{-10}	1.1×10^{-10}
TOC (as benzene) (b)	1 hour	mg/ m³	N/A	0.00006	0.00003
NH_3 (b)	1 hour	mg/ m³	0.33	0.008	0.004

Note: (a) based on the assumption of 100% conversion from NO_x to NO_2 [h]
(b) expressed as the 99.9th percentile of the dispersion modelling prediction

Modelling results for criteria pollutants are assessed against the maximum prediction at sensitive receptors. In summary, the modelling results show that during upset conditions:

- The maximum predicted 1-hour NO_2 is 209% of the impact assessment criterion, assuming 100% conversion from NO_x to NO_2.
- The maximum predicted 10-minute SO_2 is 15% of the impact assessment criterion, and for 1-hour 13%.
- The maximum predicted CO 15-minute, and 1-hour averaging periods are 0.3% or less than the relevant impact assessment criterion.

For the pollutants above it is also important to consider cumulative impacts due to existing "background" air quality, and other sources of pollution in the area. The cumulative predictions are presented in Section 9.1.2.

Modelling predictions for air toxics are assessed against the 99.9th percentile prediction, at and beyond the site boundary and indicate under upset conditions:

- The 99.9th percentile predicted HCl is 21% of the impact assessment criterion.
- The 99.9th percentile predicted cadmium is 111% of the impact assessment criterion.

[h] As discussed, we have conservatively assumed 100% conversion of NO_x to NO_2.

- The 99.9th percentile predicted mercury is 2% of the impact assessment criterion.
- The 99.9th percentile predicted dioxins and furans are 6% of the impact assessment criterion.
- The 99.9th percentile predicted TOC (as benzene) is 0.1% of the impact assessment criterion.
- The 99.9th percentile predicted NH_3 is 1.3% of the impact assessment criterion.

As shown in Table 9-2 and noted above, there are two pollutants that are predicted to exceed the NSW impact assessment criteria and include NO_2 and Cd.

To assess these exceedances during upset conditions, a probabilistic approach has been adopted. As already discussed in Section 2.5, adopting a design to the requirements of the EU IED entails that such events shall under no circumstance occur for more than four hours uninterrupted where the emission values exceed the limits and no more than 60 hours per year. The probability that upset conditions will actually result in adverse air quality impacts at ground level is therefore a function of the maximum allowable hours of upset per year (60/8,760) multiplied by the predicted frequency of exceedance per annum for each pollutant. The resultant probabilities are therefore:

- NO_2 – 0.007% probability
- Cd – 0.002% probability
- Based on the above it can be inferred that in reality, the probability of the above pollutants resulting in adverse air quality impacts at ground level due to upset conditions would be extremely low.

9.1.3 Operation of Emergency Diesel Generators

As noted in Section 4.3, the diesel generators would not operate for more than 200 hours per year and for a few hours during any one event, therefore the predicted ground level concentrations from these sources have been compared against the short term assessment criteria only.

The atmospheric dispersion model results attributable to operation of the emergency diesel generators, concurrent with stack emissions are conservatively estimated in Table 9-3. The predicted ground level concentrations for the most impacted sensitive receptor at or beyond the site boundary for NO_2, CO, PM_{10}, $PM_{2.5}$ and benzene have been provided.

In addition to worst-case predictions associated with operation of the emergency diesel generators, Table 9-3 also provides the predicted maximum ground level concentrations for the most impacted sensitive receptor during operation of the stacks at or beyond the site boundary for NO_2, CO, PM_{10}, $PM_{2.5}$ and benzene. As shown, the predicted maximum concentration of the generators and stacks in aggregate results in a concentration that is less than the respective criteria for the assessed pollutants. Note that this is a highly conservative assessment as it is not anticipated that the maximum concentrations from these two distinct sources would occur at either the same time or location, given the substantial difference in exit parameters between the sources.

Table 9-3: Conservative estimation of ground level concentrations during operation of emergency diesel generators

Parameter	Averaging period	Units	Criteria	Predicted concentration at most affected sensitive receptor (generator)	Predicted concentration at most affected sensitive receptor (stacks)	Maximum background
NO_2	1 hour	µg/m³	246	160	77.1	N/A [1]
CO	15-minute	mg/m³	100	0.23	0.012	7
	1 hour	mg/m³	30	0.14	0.009	4
	8 hour	mg/m³	10	0.07	0.007	2
PM_{10}	24 hour	µg/m³	50	0.9	0.07	49

$PM_{2.5}$	24 hour	µg/m³	25	0.9	0.07	17
Benzene [3]	1 hour	mg/m³	29	3	6.9×10^{-7}	N/A [2]

Note 1: Nitrogen dioxide predictions have been made using the Ozone Limiting Method and as such, the values presented take account of contemporaneous background observations
Note 2: Consistent with Section 7.2.2 of NSW DEC, 2005, the predictions of benzene are compared against the ground level concentration criterion as increment only, at the 99.9th percentile.
Note 3: Benzene has been assumed to comprise 1% of the total VOC emission.

Table 9-3 indicates that predicted concentrations of all parameters are anticipated to be below the relevant NSW EPA ground level concentration criteria during operation of the emergency diesel generators.

9.1.4 POEO Emission Limits (Regulatory Scenario)

As noted in Section 7.7, to inform future Environmental Protection Licensing of the EfW facility, in addition to the normal and upset conditions, ground level concentrations resulting from a Regulatory scenario (in-stack concentrations at the POEO emission limits) have been presented.

A summary of the ground level concentrations (GLCs) for each pollutant when released at the POEO emission limits is presented in Table 9-4. GLCs are presented at and beyond the site boundary, as well as the maximum prediction at sensitive receptors. Predictions above the relevant NSW impact assessment criterion are shown in bold.

Table 9-4: Summary of predicted ground level concentrations at POEO emission limits

Pollutant	Averaging period	Units	Criteria	Highest prediction at and beyond site boundary	Highest prediction at sensitive receptor
NO_2 [(a)]	1 hour	µg/m³	246	205	137
	Annual	µg/ m³	62	9	8
CO	15-minute	mg/ m³	100	0.07	0.04
	1 hour	mg/ m³	30	0.05	0.03
	8 hours	mg/ m³	10	0.04	0.03
PM_{10}	24 hours	µg/ m³	50	2.6	2.3
	Annual	µg/ m³	30	0.9	0.8
$PM_{2.5}$	24 hours	µg/ m³	25	2.6	2.3
	Annual	µg/ m³	8	0.9	0.8
Cd [(b)]	1 hour	mg/ m³	0.000018	0.00008	0.00004
Hg [(b)]	1 hour	mg/ m³	0.00018	0.00007	0.00004
Dioxins and furans [(b)]	1 hour	mg/ m³	2.00×10^{-9}	3.7×10^{-11}	2.2×10^{-11}
TOC [(b)]	1 hour	mg/ m³	N/A	0.015	0.009
H_2S [(c)]	1 hour	µg/ m³	1.38	1.2	0.96

Note: (a) based on the assumption of 100% conversion from NO_x to NO_2 [i]
(b) expressed as the 99.9th percentile of the dispersion modelling prediction

Modelling results for criteria pollutants are assessed against the maximum prediction at sensitive receptors. In summary, the modelling results show that when emitting at the POEO emission limits:

[i] As discussed, we have conservatively assumed 100% conversion of NO_x to NO_2.

- The maximum predicted 1-hour NO_2 is 56% of the impact assessment criterion, even assuming 100% conversion from NO_x to NO_2
- The maximum predicted annual NO_2 is 13% of the impact assessment criterion.
- The maximum predicted 24-hour PM increment is 5% of the impact assessment criterion for PM_{10} and 9% of the impact assessment criterion for $PM_{2.5}$.
- The maximum predicted annual PM is 3% of the impact assessment criterion for PM_{10} and 10% of the impact assessment criterion for $PM_{2.5}$.
- The maximum predicted CO 15-minute, 1-hour and 8-hour averaging periods are 0.1% or less than the relevant impact assessment criterion.

For the pollutants above it is also important to consider cumulative impacts due to existing background air quality. The cumulative predictions relevant to the Regulatory Scenario are presented in Section 9.2.3.

Modelling predictions for air toxics are assessed against the 99.9th percentile prediction, at and beyond the site boundary and show that when emitting at the POEO emission limits:

- The 99.9th percentile predicted cadmium is approximately two times the impact assessment criterion.
- The 99.9th percentile predicted mercury is 22% of the impact assessment criterion.
- The 99.9th percentile predicted dioxins and furans are 1.1% of the impact assessment criterion.
- The 99.9th percentile predicted TOC (as benzene) is 31% of the impact assessment criterion.

As shown in Table 9-2 and noted above, there is one pollutant (Cd) that is predicted to exceed the NSW impact assessment criteria when the facility is operated under the POEO in-stack limits.

However, as noted in Section 9.1.1, under normal operations (assumed in-stack Cd concentration of 0.009 mg/Nm^3), the maximum prediction of Cd at and beyond the site boundary is anticipated to be 3.7 x 10^{-6} mg/m^3, or 21% of the relevant NSW EPA ground level concentration criterion.

Based on the linear relationship between in-stack concentration and maximum predictions for this parameter, it can be seen that a roughly four-fold increase in the in-stack concentration assumption for normal operations would still be anticipated to satisfy the NSW EPA ground level concentration criterion.

On the above basis, it is suggested that an in-stack concentration limit for Cd of 0.04 mg/Nm^3 would be sufficiently protective of health and environmental impacts while providing the facility with some operational flexibility. This proposed emission limit would be captured within a statement of commitment for the Project.

9.2 Cumulative Assessment

To assess impacts against the relevant air quality criteria, it is necessary consider the existing background concentrations of the air quality metrics in question. The existing background air quality environment is described in Section 6.

9.2.1 Normal Operations

The maximum predicted GLCs for products of combustion from the EfW facility are combined with maximum background levels and presented in Table 9-5. This provides a conservative estimate of cumulative impact as the probability of a maximum observed value occurring at the time of a maximum predicted value is very small.

There are no exceedances of the EPA criteria when the EfW facility contribution is added to maximum background.

Table 9-5: Cumulative assessment for criteria pollutants during normal operations

Pollutant	Averaging period	Units	Criteria	Maximum GLC at sensitive receptor	Maximum background	Cumulative concentration
NO_2 [(a)]	1 hour	µg/m³	246	51.5	100	151.5
	Annual	µg/ m³	62	3.1	23	26.1
SO_2	10-minute	µg/ m³	712	11	107	118
	1 hour	µg/ m³	570	7.4	57	64.4
	24 hours	µg/ m³	228	1.7	0.7	2.4
	Annual	µg/ m³	60	0.45	3	3.45
CO	15-minute	mg/ m³	100	0.01	14	14.01
	1 hour	mg/ m³	30	0.006	7	7.006
	8 hours	mg/ m³	10	0.006	2	2.006
PM_{10}	24 hours	µg/ m³	50	0.06	49	49.06
	Annual	µg/ m³	30	0.017	19	19.017
$PM_{2.5}$	24 hours	µg/ m³	25	0.06	17	17.06
	Annual	µg/ m³	8	0.017	7	7.02

Note: (a) based on the assumption of 100% conversion from NO_x to NO_2 [j]

[j] As discussed, we have conservatively assumed 100% conversion of NO_x to NO_2.

9.2.2 Upset Conditions

The maximum predicted GLCs for products of combustion from the EfW facility during upset conditions are combined with maximum background levels and presented in Table 9-6. This again provides a conservative estimate of cumulative impact as the probability of a maximum observed value occurring at the time of a maximum predicted value (under upset conditions – maximum 60 hours per annum) is extremely small.

Table 9-6: Cumulative assessment for criteria pollutants

Pollutant	Averaging period	Units	Criteria	Maximum GLC at sensitive receptor	Maximum background	Cumulative concentration
NO_2 [(a)]	1 hour	µg/m³	246	771	100	871
SO_2	10-minute	µg/ m³	712	158	107	309
	1 hour	µg/ m³	570	111	57	165
CO	15-minute	mg/ m³	100	0.1	14	7
	1 hour	mg/ m³	30	0.1	7	4

Note: (a) based on the assumption of 100% conversion from NO_x to NO_2 [k]

9.2.3 POEO Emission Limits (Regulatory Scenario)

The maximum predicted GLCs for products of combustion from the EfW facility are combined with maximum background levels and presented in Table 9-7.

There are no exceedances of the EPA criteria when the EfW facility contribution is added to maximum background, with the exception of PM, which results in a cumulative concentration marginally above the 24-hour PM_{10} criterion of 50 µg/m³. However, this occurs on a day when the background PM concentration is already high (at 49.2µg/m³) and the probability of the EfW facility resulting in additional exceedances of the impact assessment criterion is considered to be low.

This is demonstrated in Figure 9-15 which shows a time-series plot of the background 24-hour PM_{10} concentration recorded at Prospect with the EfW facility increment (from the most impacted sensitive receptor) stacked on top. The EfW facility clearly adds a very small increment to the existing background, however is predicted to result in one additional exceedances of the air quality goal. Figure 9-15 indicates that these exceedances are a result of the high background PM_{10} concentrations, rather than the incremental increase from the EfW facility. It is also noted that this assumes the facility operates at the POEO emission limit for PM continuously, which would not be an operational reality.

[k] As discussed, we have conservatively assumed 100% conversion of NO_x to NO_2.

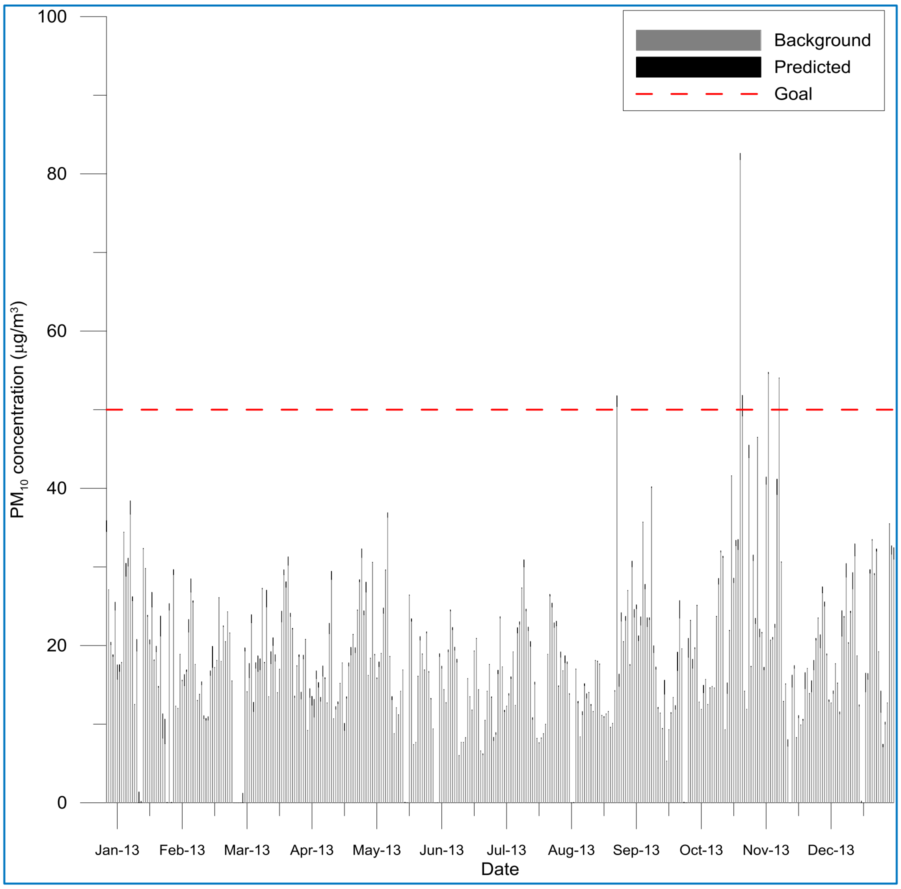


Figure 9-15: Predicted cumulative PM_{10} at most affected sensitive receptor adopting POEO Emission Limits

Table 9-7: Cumulative assessment for criteria pollutants while at POEO Emission Limits

Pollutant	Averaging period	Units	Criteria	Maximum GLC at sensitive receptor	Maximum background	Cumulative concentration
NO_2 (a)	1 hour	µg/m³	246	137	100	237
	Annual	µg/ m³	62	8	23	31
CO	15-minute	mg/ m³	100	0.04	14	14.04
	1 hour	mg/ m³	30	0.03	7	7.03
	8 hours	mg/ m³	10	0.03	2	2.03
PM_{10}	24 hours	µg/ m³	50	2.3	49	51.3
	Annual	µg/ m³	30	0.8	19	19.8
$PM_{2.5}$	24 hours	µg/ m³	25	2.3	17	19.3
	Annual	µg/ m³	8	0.8	7	7.8

Note: (a) based on the assumption of 100% conversion from NO_x to NO_2[I]

[I] As discussed, we have conservatively assumed 100% conversion of NO_x to NO_2.

In summary, based on the information provided above and within Section 9.1.4, it is considered that application of the POEO emission limits within the Environmental Protection Licence for the facility would be sufficiently protective of health and environmental impacts while providing the facility with some operational flexibility.

The exception to this is cadmium, where an alternative in-stack concentration limit is provided within Section 9.1.4.

It is noted that the proposed technology for the EfW facility is based on existing facilities in Europe and will incorporate best available technology (BAT) for flue gas treatment. The flue gas treatment is designed to meet the in-stack concentrations limits for waste incineration set by the EU IED. The IED emissions limits (Table 4-3) are generally more stringent that the Clean Air Regulation limits (Table 4-2). On the above basis, environmental licencing based on the IED limits (or hourly extrapolations of these performance standards) would also be a suitable alternative regulatory approach.

9.3 NO_x Load to Air Shed

9.3.1 Impacts on Regional Air Quality

NO_x is a precursor to the formation of ozone and ozone concentrations in the Sydney region have exceeded the Ambient Air-NEPM ozone standards every year since 1994 (DECCW, 2010). The Sydney region is therefore considered an ozone non-attainment area and if the NO_x emission from a new facility exceeds a threshold of 90 tonnes/year, an ozone impact assessment may be required under the NSW EPA proposed ozone impact assessment framework (not yet released at the time of writing).

Assuming the EfW facility emits NO_x at the EU IED limit for 8,000 hours of the year, the annual NO_x load to the Sydney air shed would be approximately 800 tonnes/year, thereby triggering further assessment. The potential for regional photochemical smog / ozone impacts are investigated in a standalone study, submitted as part of the Environmental Assessment (Pacific Environment, 2016b).Based on the outcomes of the regional ozone modelling the annual NO_X load was revised so as to comply with the requirements of Environ (2011). The daily average NO_x emissions limit was revised down to be a daily average of 120 mg/m^3 with a total annual NOx load of ~440 tonnes per year (assuming continuous operation). Further detail of this is provided within Pacific Environment, 2016b.

9.3.2 Load Based Licensing

As discussed in Section 4.5 the NO_x load based licensing threshold is 2.5 tonnes/year. Based on the anticipated NO_x emissions of ~440 tonnes/year the EfW exceeds this threshold and it is therefore anticipated that the EfW facility will be subject to a load based licence limit on total NO_x emissions, as well as summertime NO_x emissions, prescribed by EPA on issuance of the EfW facility's EPL.

10 GREENHOUSE GAS ASSESSMENT

10.1 Introduction

The World Resources Institute / World Business Council for Sustainable Development Greenhouse Gas Protocol (the GHG Protocol) originally documented the different scopes for greenhouse gas (GHG) emission inventories. The GHG Protocol is the most widely used international accounting tool for government and business leaders to understand, quantify, and manage greenhouse gas emissions. This corporate accounting and reporting standard is endorsed by the Australian Department of Climate Change and Energy Efficiency.

The GHG Protocol defines three scopes for developing inventories leading to reporting of emissions. These scopes help to delineate direct and indirect emission sources, improve transparency, and provide a degree of flexibility for individual organisations to report based on their organisational structure, business activities and business goals.

Three scopes of emissions (also shown in Figure 10-1) are defined in the GHG Protocol:

- 'Scope 1' emissions: direct GHG emissions occurring from sources owned or controlled by the company – for example vehicle fleet and direct fuel combustion. Any negative emissions (sequestration), for example from a plantation owned by the entity, would also be included in Scope 1.
- 'Scope 2' emissions: indirect GHG emissions from purchasing electricity or heat from other parties; and
- 'Scope 3' emissions: indirect emissions which occur due to the company's business activities, but from sources not owned or controlled by the company - for example emissions from employee business-related air travel.

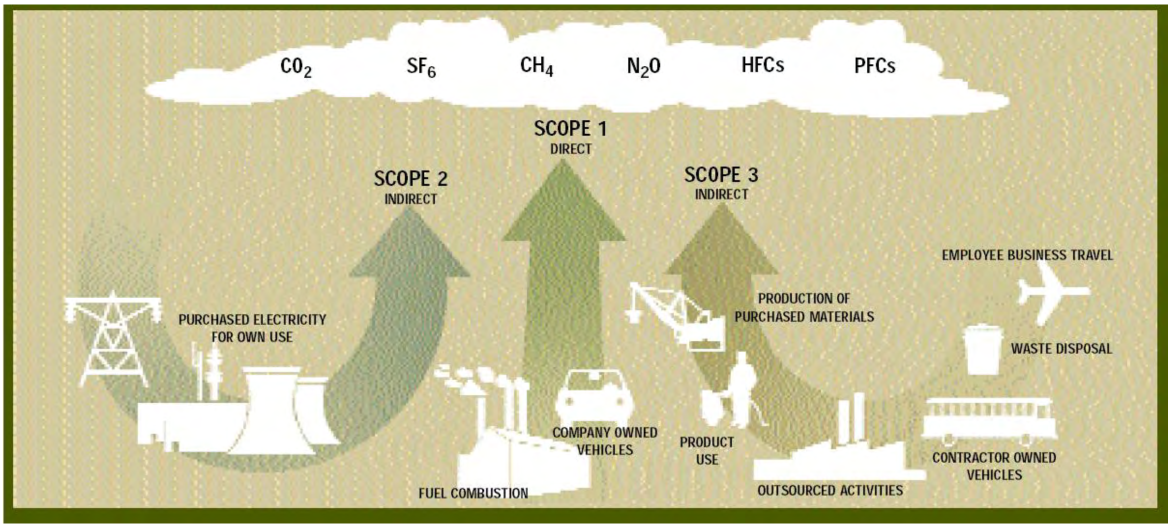


Figure 10-1: Overview of Scopes and Emissions across a Value Chain

10.2 Reporting Guidelines

The GHG assessment is guided by, and makes reference to the National Greenhouse and Energy Reporting (Measurement) Determination 2008 (the "NGER Measurement Determination") incorporating the National Greenhouse and Energy Reporting (Measurement) Amendment Determination 2012 (No. 1).

The National Greenhouse and Energy Reporting Regulations 2008 (the NGER Regulations) describe the detailed requirements for reporting under the NGER Act 2007. The National Greenhouse and Energy Reporting (Measurement) Technical Guidelines (the NGER Technical Guidelines) have been intended to support reporting under the NGER Act 2007. They have been designed to assist corporations in understanding and applying the NGER Measurement Determination.

The NGER Technical Guidelines outline calculation methods and criteria for determining GHG emissions, energy production, energy consumption and potential GHG emissions embodied in natural gas.

Under the NGER Act, Scope 1 and 2 emissions must be accounted for by the organisation. Reporting of Scope 3 is optional and has been addressed in this assessment qualitatively as the Scope 3 emissions would be minor. The EfW facility will have negligible Scope 2 emissions (of the site will be a net exporter of electricity) and the focus of this assessment is therefore on Scope 1 emissions.

10.3 Emission Estimates

10.3.1 Scope 1 GHG emissions from Waste Incineration

The calculation of GHG emissions for waste incineration is based on the maximum volume of material that will be combusted during any one year (see Section 2.1). The compositional data and chemical analysis used for these calculations are provided in Appendix D (Ramboll, 2016).

Combusted ash residue that is to be landfilled will not result in GHG emissions and therefore has not been considered. This is because the ash does not release methane as the available carbon has already been consumed during combustion (US EPA, 2014).

Part 5.5, Section 5.3 of the NGER Technical Guidelines outlines Method 1 for the calculation of carbon dioxide emissions from waste incineration, as follows:

$$E_i = Q_i \times CC_i \times FCC_i \times OF_i \times 3.664$$

where:

E_i is the emissions of CO_2 released from the incineration of waste type (*i*) measured in CO_2-e tonnes.
Q_i is the quantity of waste type (*i*) incinerated by the plant during the year, measured in tonnes.
CC_i is the carbon content of waste type (*i*).
FCC_i *is the proportion of carbon in* waste type (*i*) that is fossil origin (i.e. not biomass).
OF_i is the oxidation factor of waste type (*i*)

The estimated GHG emissions from waste incineration are presented in Table 10-1.

Table 10-1: Method 1 estimation of GHG emissions from waste incineration

Waste (tpa)	Carbon Content (%)	% carbon that is fossil origin[1]	Oxidation Factor	CO_2-e (tpa)
1,350,000	31.44%	33.14%	0.98*	505,069

Note: [1] It is assumed that this includes plastic film, dense plastic, textiles, combustibles, hazardous and other combustibles of Appendix G.
* Not known, default of 1 applied.

10.3.2 Scope 1 GHG Emissions (substitution of grid electricity)

The facility is designed to have a total thermal input of 471.9 MW (117.98 MW for each combustion line) and an assumed net average annual electrical efficiency of 29.1%. Based on this information the EfW facility is designed to export 137.3 MWe (29.1% x 471.9 MW). As the auxiliary load for the EfW facility is 14.6 MW the EfW facility would therefore export to the main electricity grid, thus substituting a requirement for approximately 137.3 MW of more GHG emission intensive electricity generation.

An estimated of the GHG emissions that would be substituted from the grid is presented, based on an assumption that the EfW facility would operate for 8,000 hours per annum.

The GHG emissions from grid have been estimated as follows:

$$Y = Q \times \frac{EF}{1000}$$

where:
Y is the Scope 2 emissions measured in CO_2-e tonnes.
Q is the quantity of electricity diverted (kilowatt hours).
EF is the scope 2 emission factor for NSW (*i*).

GHG emissions which would be diverted from the main grid are presented in Table 10-2.

Table 10-2: Estimation of GHG emissions (substitution of grid electricity)

Net Output (MW)	Operational hours (per year)	Electricity diverted from grid (kWh per year)	Emission factor for grid electricity in NSW (kg CO_2-e/kWh)	CO_2-e diverted from main electricity grid (tpa)
137.3	8,000	1,098,400,000	0.86	944,624

10.3.3 Scope 1 GHG Emissions Diverted from Landfilling

By removing biomass waste from the landfill, emissions of methane[m] from the decomposition of waste are eliminated. It is acknowledged that some landfills combust the methane via a flare or gas engine. However, this is not currently the case at the Genesis facility and would not form part of the future operations for the site (and has therefore not been considered).

Emissions of methane from disposal of waste to landfill are estimated based on the NGER Scheme Method 1 for emissions of methane from landfills. A simplified estimation is made based on the assumption that all methane is released in the same year that the solid waste is disposed and the accumulated or opening stock of degradable organic carbon is not considered.

The carbon content of the residual waste fuel is based on the information provided for the design fuel mix (Ramboll, 2016). For reference, the fuel composition data is provided in Appendix D.

Emissions are estimated as follows:

$$CO_2 - e\ (tonnes) = DOC\ \times MCF\ \times F\ \times 1.336 \times 21$$

where:
DOC is the quantity of degradable organic carbon, estimated from % of carbon in the waste and a DOC fraction of 0.43 has been assumed for conservatism[n].
MCF is the methane correction factor (1)
F is the fraction of CH_4 in landfill gas (0.5)
1.336 convert C mass to CH_4 mass.
21 converts CH_4 to CO_2-e

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[m] Biomass emissions of CO_2 are considered to be climate neutral, and therefore not reported from either landfill or waste incineration. Emissions of methane are reported for landfilling and emissions of CO_2 for non-biomass (fossil origin) are reported for incineration.

[n] By using a DOC fraction for 'garden and green' (which is lower than other organic wastes) we have potentially underestimated GHG emissions from landfilling. This results in a conservatively low estimate of GHG emission diverted from landfill.

The estimated GHG emissions that would be diverted from landfilling activities (assuming 1,350,000 tonnes landfilled per annum under the Business As Usual scenario) are presented in Table 10-1.

Table 10-3: Method 1 estimation of methane emissions from landfill

Waste diverted from landfill (tpa)	Carbon Content (%)	DOC	CH_4 (tpa)	CO_2-e (tpa)
1,350,000	31.44%	182,509	121,916	2,560,239

Note: * Not known, default of 1 applied.

10.3.4 Scope 3 GHG Emissions

The Greenhouse Gas Protocol allows optional reporting of scope 3 emissions. If an organisation believes that scope 3 emissions are a significant component of the total emissions inventory, these can be reported along with scope 1 and scope 2 emissions. However, the Greenhouse Gas Protocol notes that reporting scope 3 emissions can result in double counting of emissions and can also make comparisons between organisations and/or products difficult (because reporting is voluntary). Double counting needs to be avoided when compiling national (country) inventories under the Kyoto Protocol. The Greenhouse Gas Protocol also recognises that compliance regimes are more likely to focus on the "point of release" of emissions (i.e., direct emissions) and/or indirect emissions from the purchase of electricity. As already noted in Section 10.2, scope 3 emissions are anticipated to be minor. Nevertheless, we have identified the following scope 3 emissions that would likely be released as a result of the EfW facility's operations:

- Employees commuting to and from work.
- Employee business travel.
- Extraction, production and transport of purchased diesel fuel consumed.
- Fuel consumption transporting waste to the site.

10.3.5 Net GHG Emissions for EfW Facility

The emission intensity for electricity generated from waste incineration is lower than that derived from the NSW electricity grid (refer Section10.4) and therefore a net reduction in GHG emissions is achieved when electricity from this source is exported to the NSW grid.

Similarly, by removing biodegradable wastes from the landfill, significant emissions of methane from the decomposition of that waste are also avoided.

A summary of the estimated net GHG emissions resulting from the EfW facility are shown in Table 10-4. The operation of the EfW facility would have a net positive GHG impact, potentially avoiding 3 million tonnes of CO_2-e per annum.

Table 10-4: Estimation of net GHG emissions

Tpa CO_2-e from waste incineration	Tpa CO_2-e alternative to grid	Tpa CO_2-e diverted from landfill	Net GHG emissions (tpa CO_2-e)
505,069	944,6242	2,560,239	-2,999,794

10.4 Benchmarking GHG intensity

Emissions intensity of electricity generation is expressed as the rate of emissions (tonnes or kg of CO_2-e) per net unit of electricity produced (MWh or kWh).

The estimated emissions intensity for the proposed EfW facility is 0.53 tonnes CO_2-e/MWh generated. For 2014, the emissions intensity for the NSW grid was 0.93 tonnes CO_2-e/MWh generated (AEMO, 2015). Over time it is anticipated that the emission intensity for NSW would decrease through the introduction of less carbon intensive sources of energy.

The projected electricity consumption over the next 10 years for NSW is shown in Figure 10-2, along with the portion of total consumption that would be generated by the EfW facility. This contribution of the EfW facility to NSW electricity supply is approximately 2% for each financial year.

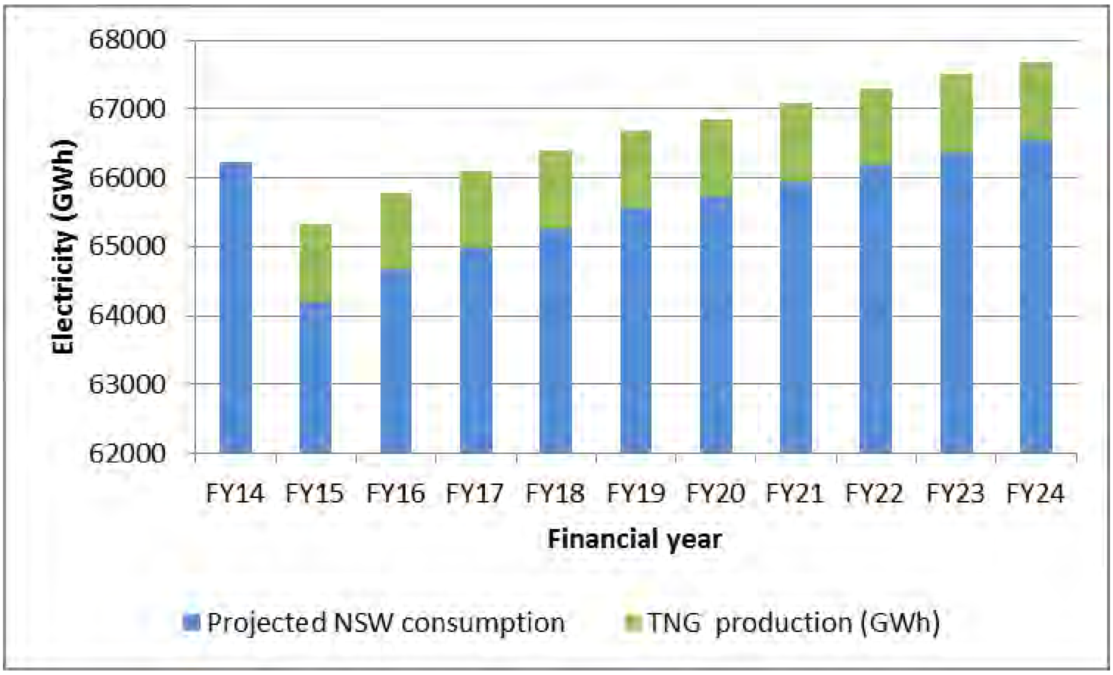
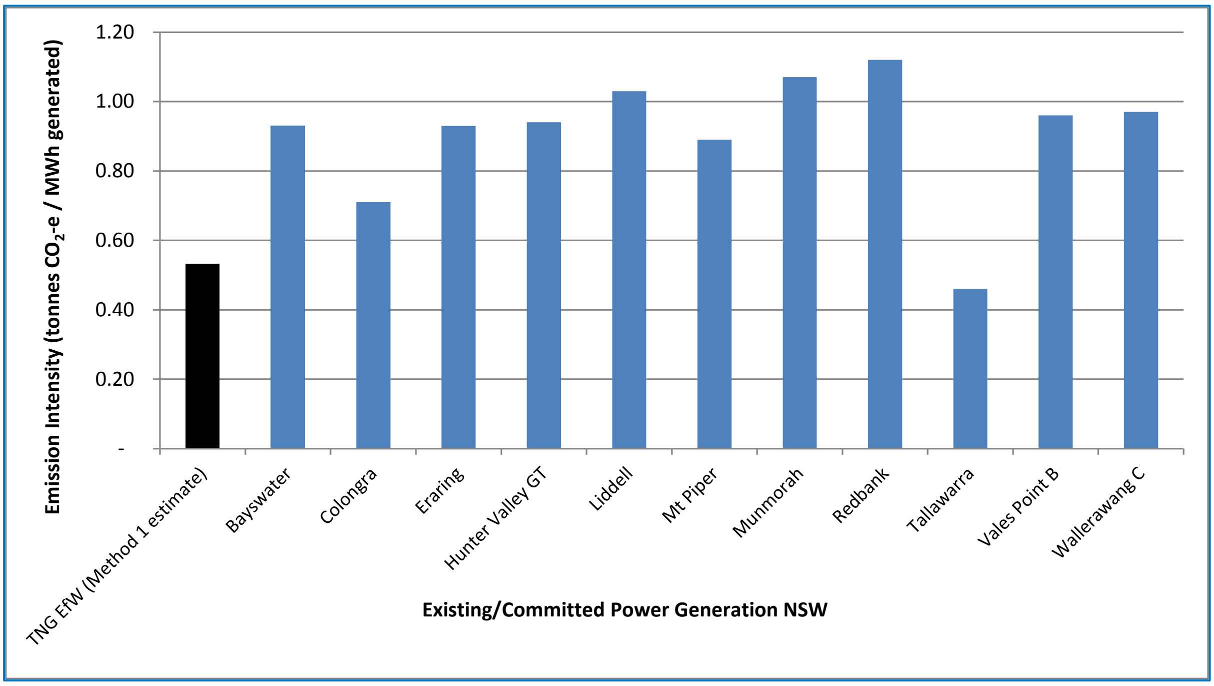


Figure 10-2: Projected NSW electricity consumption (AEMO, 2014)

A comparison has also been made with the emissions intensity measure of kg CO_2-e/MWh$_{\text{sent out}}$ based on data presented for major NSW generators in the ACIL Tasman report on *Fuel resources, new entry and generation costs in the NEM* (Acil Tasman, 2009). The data presented in Figure 10-3 are based on Scope 1 emissions for fuel usage.



Data Source: ACIL Tasman, 2009

Figure 10-3: Emission intensity comparison for existing / committed NSW generators

Peak landfill methane production rates typically occur between five and seven years after waste has been landfilled (US EPA, 2000), with almost all gas is produced within 20 years after waste being placed in situ (ATSDR, 2001).

In view of the above, it can be inferred that the emission reduction associated with diverted landfill emissions would be realised gradually until they are fully realised by year six[o].

Figure 10-4 provides a representation of the net greenhouse gas emission (reduction) on an annual basis, assuming a 25 year facility life. The cumulative emission reduction over a 25 year period would thus be 68.5 Mt CO_2-e.

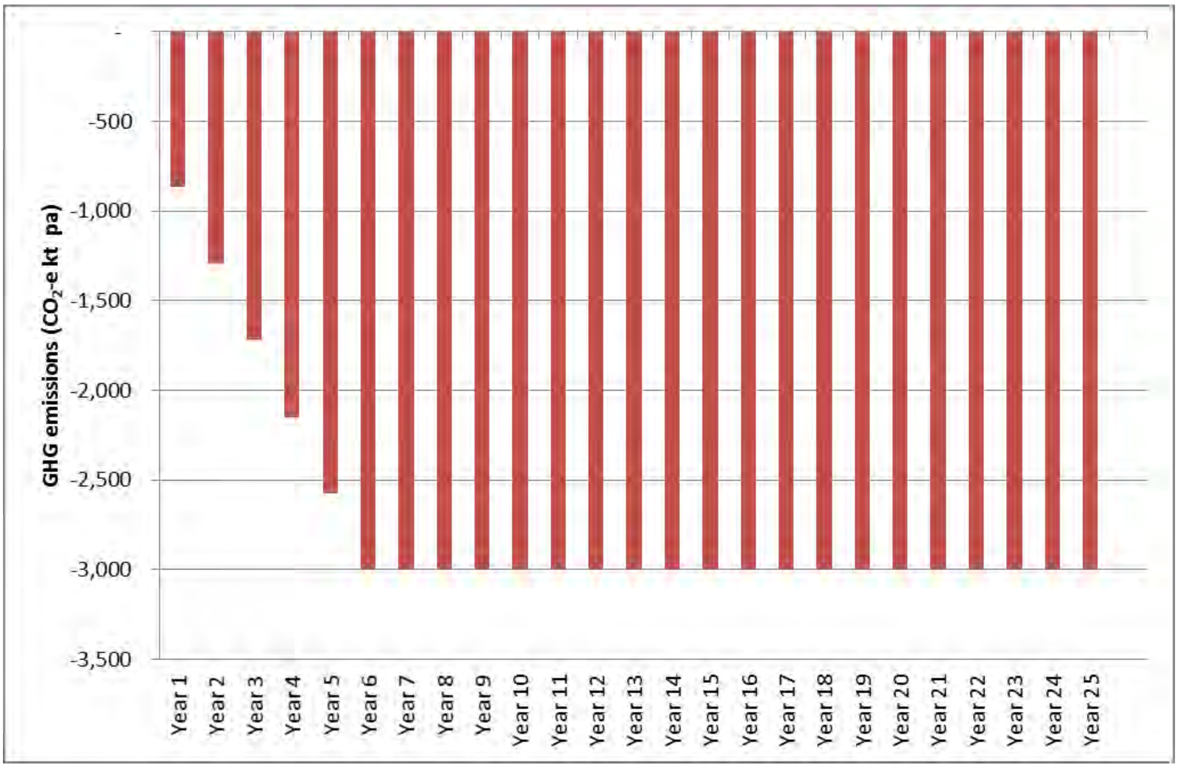


Figure 10-4: Net greenhouse gas emission estimates for the EfW facility on an annual basis

[o] It has been assumed that the ramp up to peak production is linear and occurs by Year 6.

11 CONCLUSION

Pacific Environment has been engaged by TNG NSW to prepare an Air Quality and Greenhouse Gas Assessment for the construction and operation of an Energy from Waste (EfW) facility. The proposed technology for the EfW facility is based on existing facilities in the UK and rest of Europe and will incorporate best available technology (BAT) for flue gas treatment, designed to meet the stringent in-stack concentrations limits for waste incineration set by the IEU Industrial Emissions Directive (IED).

Dispersion modelling predictions have been based on the above assumptions, and the results for normal operations show:

- The maximum predicted 1-hour NO_2 is 21% of the impact assessment criterion, even assuming 100% conversion from NO_x to NO_2
- The maximum predicted annual NO_2 is 5% of the impact assessment criterion.
- The maximum predicted 10-minute SO_2 is 1.5% of the impact assessment criterion, for 1-hour 1.3%, for 24-hour SO_2, 0.7% and for annual, 0.8%.
- The maximum predicted 24-hour PM is 0.1% of the impact assessment criterion for PM_{10} and 0.2% of the advisory reporting standard for $PM_{2.5}$.
- The maximum predicted annual PM is less than 0.1% of the impact assessment criterion for PM_{10} and 0.2% of the advisory reporting standard for $PM_{2.5}$.
- The maximum predicted CO 15-minute, 1-hour and 8-hour averaging periods are 0.1% or less than the relevant impact assessment criterion.
- The maximum predicted 24-hour HF is 9% of the impact assessment criterion, for 7-day 10%, for 30-day HF, 13% and for 90-day, 18%.

Modelling predictions for air toxics are assessed against the 99.9th percentile prediction, at and beyond the site boundary. The individual odour compound H_2S is assessed against the 99th percentile prediction.

In summary, the modelling results for these additional parameters show:

- The 99.9th percentile predicted HCl is 2% of the impact assessment criterion.
- The 99.9th percentile predicted cadmium is 11% of the impact assessment criterion.
- The 99.9th percentile predicted mercury is 0.5% of the impact assessment criterion.
- The 99.9th percentile predicted dioxins and furans are 0.1% of the impact assessment criterion.
- The 99.9th percentile predicted TOC (as benzene) is 0.01% of the impact assessment criterion.
- The 99.9th percentile predicted NH_3 is 0.1% of the impact assessment criterion.
- The 99.9th percentile predicted PAH (as benzo(a)pyrene) is 0.4% of the impact assessment criterion.
- The 99th percentile predicted H_2S is 70% of the impact assessment criterion.

Cumulative predictions are also presented. There are no exceedances of the EPA criteria when the EfW contribution is added to maximum background concentration under normal operating conditions.

The results of the modelling during upset conditions indicate that, under worst-case dispersion conditions, NO_2 and Cadmium are predicted to exceed the NSW impact assessment criteria. A probabilistic approach has then been adopted, with results indicating that probability of the above pollutants resulting in adverse impacts (i.e. the potential for upset conditions to coincide with worst-case dispersion conditions) would be less than 0.01%.

Additional modelling of a Regulatory Scenario indicates that application of the POEO emission limits within the Environmental Protection Licence for the facility would be sufficiently protective of health and environmental impacts while providing the facility with some operational flexibility.

The exception to this is cadmium, where an alternative in-stack concentration limit is provided.

A semi-quantitative screening assessment of construction phase impacts identified no human receptors within 350 m of the boundary of the site. The screening assessment concluded no detailed assessment of construction phase impacts is required and routinely employed 'good practice' mitigation measures for construction sites would be sufficient to control dust impacts to acceptable levels.

The operation of the EfW facility would have a net positive GHG impact, potentially eliminating 3 million tonnes of CO_2-e per annum. The emission intensity for electricity generated from waste incineration is significantly lower than that derived from the current NSW electricity grid.

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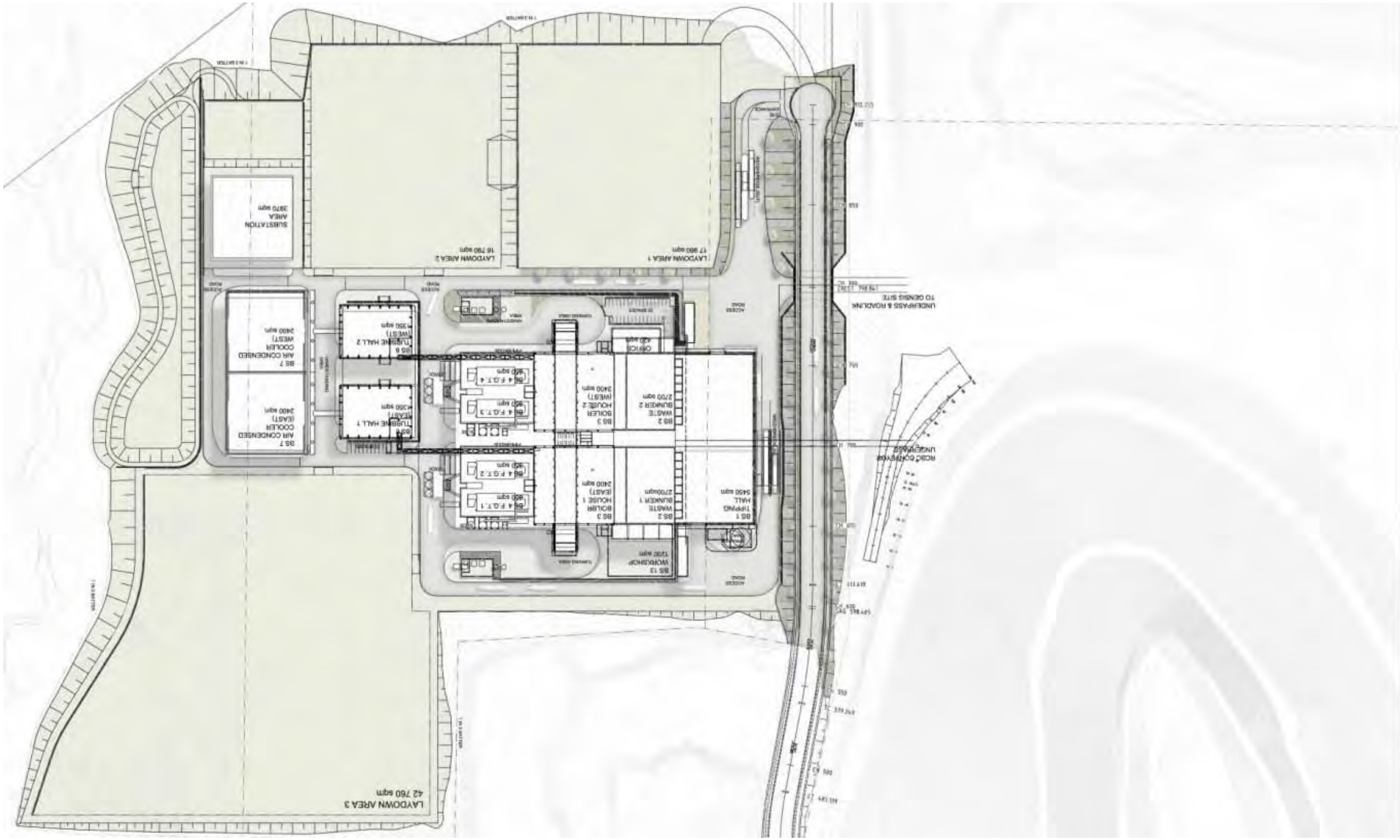
Appendix A GENERAL ARRANGEMENT OF EFW FACILITY


LAYDOWN AREA 1
17 960 sqm
LAYDOWN AREA 2
16 780 sqm
SUBSTATION
AREA
3870 sqm
LAYDOWN AREA 3
42 760 sqm

Appendix B ASSUMPTIONS

B.1 ASSUMPTIONS

General

The EfW facility will operate 24 hours a day, 7 days a week, with occasional offline periods for maintenance. Over the entire year, it is assumed that the EfW facility would be operational for 8,000 hours as an average.

The waste in total and as an average will not contain more than 1% chlorine (Ramboll, 2016). This is further discussed in Section 4.2.

The flue gas treatment system includes:

- Selective Non-Catalytic Reduction (SNCR) for reducing emissions of oxide of nitrogen.
- Dry lime scrubbing for reducing emissions of acid gases, including hydrogen chloride (HCl) and Sulfur Dioxide (SO_2).
- Activated carbon injection for reducing emissions of dioxins and mercury.
- Fabric filters for reducing emissions of particles and metals.
- Following flue gas treatment, emissions will be dispersed via a 100m stack. Further details of the flue gas treatment are discussed in Section 7.

The EfW facility is designed to operate continuously, therefore start-up and shutdown are infrequent events and anticipated to be required during the plants annual maintenance programme.

In accordance with the EU IED, such events shall under no circumstance occur for more than 4 hours uninterrupted where the emission values exceed the limits on no more than 60 hours per year.

To facilitate the safe shutdown and black start there will be two emergency diesel generators with one dedicated to each purpose. Each diesel generator (QSK78) will have a capacity of 2.4 MW that will provide sufficient power for the four waste lines. Routine maintenance and specific testing will occur for one hour, once a month.

Emissions

Air quality parameters anticipated to be released are as follows:

- Particulate matter (PM), assumed to be emitted as PM_{10} and $PM_{2.5}$.
- Hydrogen Chloride (HCl).
- Hydrogen Fluoride (HF).
- Carbon Monoxide (CO).
- Sulfur Dioxide (SO_2)
- Oxides of nitrogen (NO_x) (expressed as Nitrogen Dioxide (NO_2)).
- Heavy metals (including Mercury (Hg), Cadmium (Cd), Arsenic (As), Chromium (Cr).
- Organic substances (expressed as total organic compounds (TOC)).
- Dioxins and furans.
- Hydrogen sulfide (H_2S).
- Chlorine (Cl_2).
- Ammonia (NH_3).
- Poly-aromatic hydrocarbons (PAHs).

In the main, the 'normal' and 'upset' emission rates (g/s) adopted for modelling of each stack are derived from the in-stack concentrations provided by Ramboll in Appendix G and the flue gas flow rate per stack (Nm^3/s) shown in Table 7-8. A summary of the in-stack concentration estimates adopted is additionally documented within Appendix G.

Ammonia slippage from an SNCR system normally ranges between 1 to 10 mg/Nm^3, with an average of 4 mg of NH_3/Nm^3 (European Commission, 2006). The effects of ammonia slip have been conservatively factored into the upset conditions emissions scenario, which assumes in-stack concentrations of ammonia of 20 mg/Nm^3.

Meteorology

The review identified 2013 as a representative year for dispersion modelling with no anomalous wind patterns compared to the other years examined and is therefore considered a representative year for dispersion modelling.

Background used for cumulative assessment

A $PM_{2.5}$:PM_{10} ratio (0.35:1) has been applied to the PM_{10} data measured at St Marys and Prospect for the $PM_{2.5}$ background. The ratio is based on PM_{10} measurements from Richmond and Liverpool between 2009 and 2013.

Pollutant	Averaging period	Units	Criteria	Maximum background
NO_2	1 hour	µg/m^3	246	100
	Annual	µg/ m^3	62	23
SO_2	10-minute	µg/ m^3	712	107[(a)]
	1 hour	µg/ m^3	570	57
	24 hours	µg/ m^3	228	0.7
	Annual	µg/ m^3	60	3[(a)]
CO	15-minute	mg/ m^3	100	14
	1 hour	mg/ m^3	30	7
	8 hours	mg/ m^3	10	2
PM_{10}	24 hours	µg/ m^3	50	49[(a)]
	Annual	µg/ m^3	30	19
$PM_{2.5}$	24 hours	µg/ m^3	25	17 [(c)]
	Annual	µg/ m^3	8	7 [(b)]

Note: (a) Excludes days already over the 50 µg/m^3

(b) Calculated background. See Section 6.2.

Modelling

The stack temperature is taken from the technical specifications for a similar facility in the UK. A stack diameter of 2.2m is chosen to achieve an exit velocity of greater than 15 m/s, based on the provided volumetric flow rates (Ramboll, 2016).

A stack height of 100m has been adopted as compliance with the NSW impact assessment criteria was demonstrated at this height.

AERMOD was chosen as a suitable dispersion model due to the source type, location of nearest receiver and nature of local topography.

Terrain data was sourced from NASA's Shuttle Radar Topography Mission Data (3 arc second [~90m] resolution) and processed to create the necessary input files.

Values of surface roughness, albedo and bowen ratio were determined based on a review of aerial photography for a radius of 3 km centred on the EPA St Marys station. Default values for cultivated land and urban areas were chosen over two sectors across this area.

Building wake heights associated with the proposed on-site structures have been incorporated into the model.

For sub-hourly averaging periods, such as for CO and SO_2, predictions were based on the power-law formula from Borgas (2000) to estimate short-term peak values from longer-term average concentrations.

Results

GLCs for NO_2 were based on the assumption of 100% NO_x to NO_2 conversion.

Longer term averaging periods (24-hour, annual, 90 day, 30 day and 7 day) have not been included for the upset conditions modelling scenario. This is because the upset conditions would last for a period of no more than four hours.

Assuming the EfW facility emits NO_x at the EU IED limit for 8,000 hours of the year, the annual NO_x load to the Sydney air shed would be approximately 800 tonnes/year, thereby triggering further assessment. The potential for regional photochemical smog / ozone impacts are investigated in a standalone study, submitted as part of the Environmental Assessment (Pacific Environment, 2015b).

Greenhouse Gas Assessment

Scope 2 emissions (purchase of electricity) is not required to be quantified (the EfW facility is a net exporter of electricity) and the focus of this assessment is therefore on Scope 1 emissions. Scope 3 is optional and has been addressed in this assessment qualitatively as the Scope 3 emissions would be minor.

The maximum volume of material that will be combusted during any one year is assumed to be 1,350,000 tonnes.

The EfW facility is assumed to operate for 8,000 hours per year.

The EfW facility requires 7.5 MW of electricity to operate.

The carbon content of the residual waste fuel is based on the information provided for the design fuel mix (Ramboll, 2016).

DOC fraction for wood 'garden and green' (0.43) provides a conservatively low estimate of GHG emissions from landfilling. This results in a conservatively low estimate of GHG emissions diverted from landfill.

MEMORANDUM

To:	Damon Roddis	**Organisation:**	Pacific Environment
cc:	Skye Playfair Redman	**Organisation:**	Urbis
From:	Rosalind Flavell	**Our Ref:**	S1624-0010-0163RSF
Date:	29 January 2015	**No. of Pages:**	5
Subject:	Advice To Address EPA Comments		

Damon,

Please find enclosed a detailed description of how we would propose to assess the impact of the facility operating during periods of upset, start up and shut down. In addition we have provided some advice on likely emissions of ammonia.

1 Periods of Upset Operating Conditions

1.1 Definition

Article 46(6) of the Industrial Emissions Directive (IED) (Directive 2010/75/EU) states that:

> *"... the waste incineration plant ... shall under no circumstances continue to incinerate waste for a period of more than 4 hours uninterrupted where emission limit values are exceeded.*
>
> *The cumulative duration or operation in such conditions over 1 year shall not exceed 60 hours."*

Article 47 continues with:

> *"In the case of a breakdown, the operator shall reduce or close down operations as soon as practicable until normal operations can be restored."*

In addition Annex VI, Part 3, 2 states the emission limit values applicable in the circumstances described in Article 46(6) and Article 47:

> *"The total dust concentration in the emissions into the air of a waste incineration plant shall under no circumstances exceed 150 mg/Nm3 expressed as a half-hourly average. The air emission limit values for TOC and CO set out in points 1.2 and 1.5(b) shall not be exceeded."*

The conditions detailed in Article 46(6) are considered to be "Upset Operating Conditions".

1.2 Reasons for occurrence

Upset operating conditions such as those defined may occur as a result of the following:

- reduced efficiency of the Selective Non-Catalytic Reduction (SNCR) system as a result of blockages or failure of the reagent injection system, leading to elevated oxides of nitrogen emissions;
- reduced efficiency of particulate filtration system due to bag failure and inadequate isolation, leading to elevated particulate emissions and metals in the particulate phase;
- reduced efficiency of lime injection system such as through blockages or failure of fans leading to elevated acid gas emissions;

- complete failure of the lime injection system leading to unabated emissions of hydrogen chloride. (Note: this would require the plant to have complete failure of the bag filter system. As a plant of modern design, the plant would have shut down before reaching these operating conditions); or
- complete failure of the activated carbon injection system and loss of temperature control leading to elevated concentrations of metals and dioxin reformation and their unabated release.

1.3 Likely emission concentrations

There is no monitoring data available from existing facilities during 'upset operations'. In the absence of monitoring data plausible worst-case assumptions are used based on consultation with the UK Environment Agency based on their knowledge of plausible upset emissions. It will be worth consulting with HZI to ensure that they agree with the predicted NOx emissions under upset operating conditions.

No data on flow characteristics (flow rate, temperature etc) during these upset operating conditions is available and there is no reason to expect these parameters to change, so for the purposes of any assessment the design flow characteristics are applied.

Table 1: Emission Concentrations

Pollutant	Permitted Emission (mg/Nm^3 unless stated)		Plausible Upset Emission (mg/Nm^3 unless stated)	% Above Max Permitted Emission
	Daily Average	½ hourly max		
Oxides of nitrogen	200	400	550(1)	38
Particulate matter (PM_{10}s)	10	30	150(2)	400
Sulphur dioxide	50	200	450	125
Hydrogen chloride	10	60	900(3)	1,400
Hydrogen fluoride	1	4	90(4)	2,150
TOC (VOCs)	10	20	20(2)	0
CO	50	100	100(2)	0
Dioxins	0.1 ng/Nm^3		10 ng/Nm^3 (4)	9,900
Group 1 Metals - Mercury	0.05		0.75	1400
Group 2 Metals - Cadmium etc	0.05		0.75	1400

Reference conditions for all emissions dry, 11% oxygen, 283K.

(1) To be confirmed with HZI.

(2) Taken from the Annex VI Part 3 of the IED.

(3) Based on information presented in an Environment Agency document.

(4) As requested by the Environment Agency.

It is assumed that all metals are in the particulate phase, therefore metal emissions during predicted upset operation will increase in proportion to the increase in particulate emissions. Reference monitoring methods for metals require periodic monitoring with emission concentrations expressed as an average over a sampling period of up to 8 hours. For the purpose of any assessment the ratio applied to the daily limit for particulates should be applied to the metals emissions. As such the predicted plausible upset emissions for each group of metals (Groups 1 and 2) should be calculated as 15 times the predicted emission concentration.

1.3.1 Plausible upset emissions of group 3 metals

For the purposes of assessing upset operating conditions a number of assumptions are usually made with regard to the plausible upset emissions of the group 3 metals.

(1) The group 3 metals which have a short or long term EAL are considered (antimony, arsenic, chromium, copper, lead, manganese, nickel, vanadium).

(2) The permitted emission concentrations for each group 3 metal is taken as the maximum monitored from "Environment Agency Guidance to Applicants on Metals Impact Assessment for Stack Emissions (September 2012, Version 3)".

(3) The permitted emission concentration of chromium (VI) is based on the ratio of the effective chromium (VI) emission concentration to total metal emissions, as presented in the "Environment Agency Guidance to Applicants on Metals Impact Assessment for Stack Emissions (September 2012, Version 3)".

(4) It is assumed that metals are in the particulate phase, therefore metal emissions during predicted upset operation will increase in proportion to the increase in particulate emissions. Reference monitoring methods for metals require periodic monitoring with emission concentrations expressed as an average over a sampling period of up to 8 hours. For the purpose of any assessment the ratio applied to the daily limit for particulates is applied to the group 3 metals. As such the predicted plausible upset emission for each group 3 metal is calculated as 15 times the predicted emission concentration.

The plausible upset emissions concentrations are presented in Table 2 for group 3 metals.

Table 2: Predicted Group 3 Metal Emission Concentrations

Pollutant	Permitted Emission based on Max Monitored Emission Concentrations (µg/Nm³)	Predicted Plausible Upset Emission (µg/Nm³)	% Above Max Permitted Emission
Antimony	11.5	172.5	1,400
Arsenic	3	45	1,400
Chromium	52.1	781.5	1,400
Chromium (VI)	0.01355	0.20319	1,400
Copper	16.3	244.5	1,400
Lead	36.8	552	1,400
Manganese	36.5	547.5	1,400
Nickel	136.2	2,043	1,400
Vanadium	1	15	1,400

Reference conditions for all emissions dry, 11% oxygen, 283K

1.4 How assessed

In the UK we assess the impact of the plant operating at the upset operating conditions against the relevant short term EALs. For instance an assessment is not made of the plant continually operating at the upset operating conditions for a continuous period of more than 4 hours.

To determine the impact for comparison with the long term objectives it is assumed that the plant operates at the plausible upset operating conditions for 60 hours and the remaining 8,700 hours at the daily limit. The impact is then assessed against the relevant long term EALs.

2 Plant start-up and shutdown

Start-up of the facility from cold will be conducted with clean support fuel (low sulphur light fuel oil). During start-up waste will not be introduced onto the grate unless the temperature within the oxidation zone is above the 850°C as required by Article 50, paragraph 4(a) of the IED. During start-up, the flue gas treatment plant will be operational as will be the combustion control systems and emissions monitoring equipment.

The same is true during plant shutdown where waste will cease to be introduced to the grate. The waste remaining on the grate will be combusted, the temperature not being permitted to drop below 850°C through the combustion of clean support auxiliary fuel. During this period the flue gas treatment equipment is fully operational, as will be the control systems and monitoring equipment. After complete combustion of the waste, the auxiliary burners will be turned off and the plant will be allowed to cool.

Start-up and shutdown are infrequent events. The facility is designed to operate continuously, and ideally only shutdown for its annual maintenance programme.

In relation to the magnitude of dioxin emissions during plant start-up and shutdown, research has been undertaken by AEA Technology on behalf of the Environment Agency. Whilst elevated emissions of dioxins (within one order of magnitude) were found during shutdown and start-up phases where the waste was not fully established in the combustion chamber, the report concluded that:

"The mass of dioxin emitted during start-up and shutdown for a 4-5 day planned outage was similar to the emission which would have occurred during normal operation in the same period. The emission during the shutdown and restart is equivalent to less than 1 % of the estimated annual emission (if operating normally all year)."

There is therefore no reason why such start-up and shutdown operations will affect the long term impact of the facility.

3 Ammonia slip

We have assumed that the facility will use Selective Non-Catalytic Reduction (SNCR) rather than Selective Catalytic Reduction (SCR). The IED NOx limit is easily achieved using SNCR. SCR can achieve much lower NOx levels but at a significant cost to the project.

The BREF states that ammonia slippage from a SNCR system normally range from 1 to 10 mg/Nm^3, with an average of 4 mg of NH3/Nm^3. For the purpose of the permit and planning application in the UK we would normally assume the upper end of the range (i.e. 10 mg/Nm^3) to allow for some flexibility. However, if local sites are highly sensitive to ammonia or nitrogen deposition a more stringent limit may be requested. It will be worth requesting the guarantee from HZI.

If you have any questions please feel free to contact us.

Yours sincerely
FICHTNER Consulting Engineers Limited

Rosalind Flavell
Environmental Consultant

Stephen Othen
Technical Director

Appendix C RAMBOLL TECHNICAL MEMORANDA

ENERGY

MEMO

Job	**Response to Submissions: SD_6236:** **TNG Energy from Waste Facility, Eastern Creek,** **Dioxin in Energy from Waste facilities** **Reference:** **Australand, Air quality and** **Blacktown District Environment Group on Domestic Incineration**
Client	**DADI**
Memo no.	
Date	**10/08/2015**
To	**Ian Malouf, DADI**
From	**Tore Hulgaard**
Copy to	**Geert Stryg** **Martin Brunner**

Date 10/08/2015

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1. Introduction

This memo is background memo elaborated with reference to "Consolidated Agency Submissions from 2015 Exhibition" (subsequently referred to as "2015 Exhibition") .

The memo describes general principles of dioxin destruction, formation and removal in Energy from Waste (EfW) facilities.

The dioxin emission and other dioxin containing outputs are described and put in perspective.

The dioxin related issues highlighted in the 2015-Exhibition are addressed, including the remarks of Australand under the heading of Air quality and Ozone; "

- The assumption that there will be no dioxins/furans leaving the primary secondary combustion chamber
- Absence of reference to, and compliance with, the Stockholm Convention

This memo also addresses dioxin emission from uncontrolled incineration, with reference to the note of the 2015-Exhibition under the heading Blacktown District Environmental Group, Domestic Incineration.

Rambøll Danmark A/S
DK reg.no. 35128417

Member of FRI

2. What is Dioxin?

Dioxin is not just one chemical substance. It is a group of substances that share a range of similarities, and most are toxic but to varying degrees. Reference is usually made to the most toxic of them, the so-called Sevoso dioxin or 2,3,7,8 TCDD (TCDD is tetrachlorodibenzo-para-dioxin).

Dioxins are of concern because they have been characterised as likely to be human carcinogens. Dioxins are solid substances at ambient temperatures and therefore deposit on land. Once deposited the destruction rate is low, why they are considered persistent.

Dioxin emissions and measurements in general are usually presented as toxicity equivalents (TEQ) of 2,3,7,8 TCDD which is a sum of around 20 selected dioxins and furans weighted according to their respective toxicities. Furans are dioxin like and therefore calculated together with dioxins.

In the EU Industrial Emissions Directive (IED) which is used as reference for the TNG EfW, 20 dioxins and furans are specified, and dioxin measurements according to IED are reported as international TEQ (I-TEQ)[1]. For instance the emissions of TNG EfW is reported as I-TEQ with a limit value of 0.1 ng/m^3 (at reference conditions).

Dioxins are mainly formed in the course of combustion processes including waste incineration, metal production, landfill fires and other uncontrolled combustion. Dioxins could also be generated as byproducts of chemical production.

3. The Stockholm Convention

The Stockholm Convention on Persistent Organic Pollutants[2] (POPs) was adopted on 22 May 2001 in Stockholm, Sweden. The Convention entered into force on 17 May 2004.

The Stockholm Convention on Persistent Organic Pollutants is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment.

The convention includes originally 12 pollutants. The list has been expanded over the years and now includes around 23 pollutants. They are grouped into three categories: one banning production and use, one restricting production and use and one being the result of unintentional production. Dioxins and furans emissions from waste incineration are in the latter group (Annex C of the convention).

---

[1] Different organisations and norms operate with different number of dioxin and furans and slightly different weighting factor, which may give slightly different TEQ values for the same emission.

[2] Stockholm Convention on Persistent Organic Pollutants (POPs) as amended in 2009, available from http://chm.pops.int/Home/tabid/2121/Default.aspx

3.1 Does the facility comply with the provisions of the Stockholm Convention?

Annex C (section A of part V) of the Convention includes general consideration including "Improvements in waste management with the aim of the cessation of open and other uncontrolled burning of wastes, including the burning of landfill sites."

The high level consequence of constructing the facility is that when waste is directed to the EfW-facility, less waste shall be available for open and other uncontrolled burning of waste, including unintended landfill fires. This is in agreement with the Stockholm Convention and it shall have a large beneficial impact on the dioxin pollution from waste management because emissions (in nanograms per tonne) from uncontrolled burning of waste is several orders of magnitude higher than the air emission from an EfW facility.

When it comes to facilities that may produce dioxins as unintended by-products, as described in Article 5, "Each Party" (meaning state that is bound by convention) shall promote the use of Best Available Techniques and Best Environmental Practices.

On the matter of dioxin abatement at the facility, it is specifically mentioned in the Convention the following to be considered in determining best available techniques; "Use of improved methods for flue-gas cleaning such as thermal or catalytic oxidation, dust precipitation, or adsorption".

The EfW facility will be constructed using the Best Available Techniques (BAT) as described in the convention. It uses dust precipitation and adsorption in the flue gas treatment system, two of the techniques mentioned in the Convention. As described in Concept Design Report, each unit would be fitted with a flue gas treatment system including the addition of activated carbon as adsorbent to minimise the emissions of dioxins, and a bag filter to remove particulates. This technology is furthermore in agreement with provisions of the EU Best Available Techniques as described in the BAT reference note[3].

The technology ensures compliance with the EU air emission requirement of 0.1 ng/m^3 (ref. standard temperature and pressure, dry flue gas at 11% O_2).

When it comes to the solid outputs they are also in agreement with the Convention, because the dioxin concentrations in each of the residues is below the threshold for "low POP content".

As stated in article 6, paragraph 2 (c), of the Convention, cooperation between the Parties and Basel Convention shall work to establish, as appropriate, the concentration levels of the chemicals listed in order to define the low persistent organic pollutant content. Wastes consisting of, containing or contaminated with POPs above the low POP content should, in accordance with article 6, paragraph 1 (d) (ii), be disposed of in such a way that the POP content is destroyed or irreversibly transformed or otherwise disposed of in an environmentally sound manner when destruction or irreversible transformation does not represent the environmentally preferable option."

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[3] EU Commission 2006, Integrated Pollution Prevention and Control, Reference Document on the Best Available Techniques for Waste Incineration.