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Report

TQ HOLDINGS AUSTRALIA – AIR QUALITY AND GREENHOUSE GAS ASSESSMENT

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EXECUTIVE SUMMARY

Overview

The TQ Holdings Australia Project (the Project) is located approximately 1.5 km south-east of Coniston, New South Wales. It includes the operation and development of a large scale bulk liquids terminal for the importation and distribution of finished fuel products within NSW Ports land. The facility will be structured over three stages with an estimated 2,900 mega litres of finished fuel products being imported and distributed per annum when the site is fully developed.

An Air Quality and Greenhouse Gas Assessment has been prepared for the Project in accordance with the Secretary's Environmental Assessment Requirements for the Project.

Emissions

The key Project sources of emissions to air are expected to be volatile organic compounds (VOCs), polycyclic aromatic compounds (PAHs) and odour from tank venting.

The site emission inventory indicates that the main sources of air emissions may result from ship unloading, road tanker loading and tank breathing losses. Negligible contributions are anticipated from fugitive emissions from construction and leakages/spills during operation.

For the purposes of assessing impacts from the Project, discrete receptor locations have been selected in the area surrounding the Project.

Air Quality Modelling Assessment

Dispersion modelling has been used to predict ground level concentrations (glcs) of key pollutants associated with the Project. Emission estimates are presented for the most conservative operational scenario – Stage 3, when maximum throughput of finished fuel product is anticipated.

The results of the dispersion modelling indicate that the predicted incremental glcs for odour, VOCs, PAHs, NO_2, SO_2 and PM_{10} at the closest privately owned sensitive receptors are all below the relevant impact assessment criteria.

Greenhouse Gas Assessment

An assessment of the greenhouse gas (GHG) emissions associated with the Project indicates that average annual scope 1 emissions would be 0.2 ktpa CO2-e and represent approximately 0.0001% of Australia's commitment under the Kyoto Protocol (591.5 Mtpa) carbon dioxide equivalent [CO_2-e]).

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1 INTRODUCTION

TQ Holdings Australia is proposing to operate a large scale bulk liquids terminal (the Project) for the importation and distribution of finished fuel products on NSW Ports land, between land occupied by GrainCorp and the Port Kembla Coal Terminal. This Air Quality and Greenhouse Gas Assessment ('the Assessment') forms part of TQ Holdings Australia Projects Environmental Impact Statement (EIS) prepared by Cardno.

1.1 Study Requirements

The Assessment has been prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs) for the Project, issued on 21 January 2015 in accordance with clauses 6 and 7 of Schedule 2 of the *Environmental Planning and Assessment Regulation 2000*.

1.2 Scope of Work

Pacific Environment has identified all significant sources of air emissions and estimated the emission rates for relevant fuel products for the most conservative scenario proposed for the TQ Holdings Australia project.

- Scenario: Proposed operation of Stage 3 at maximum throughput, with tank outbreathing losses.

Air dispersion of the above scenario has been modelled to predict ground-level concentrations of the speciated VOCs and PAHs. An odour assessment on the stationary sources for the scenario has been completed with dispersion modelling. Further, the anticipated combustion emissions from the ships auxiliary engine at berth was also assessed. The emissions have been assessed to evaluate compliance with air quality assessment criteria.

Pacific Environment has completed an air quality assessment of construction activities, operational activities and a greenhouse gas (GHG) assessment quantifying the GHG associated with the Project's construction phase and operations on an annual basis. Estimations of the impact of emissions on the environment have been prepared qualitatively.

2 PROJECT DESCRIPTION AND LOCAL SETTING

2.1 Introduction

The facility at Port Kembla will operate as an import terminal, from which finished fuel products will be despatched by road tankers (and potentially by rail into the future). The terminal will primarily handle flammable and combustible petroleum products and biofuels.

The project consists of the construction and operation of three distinct stages.

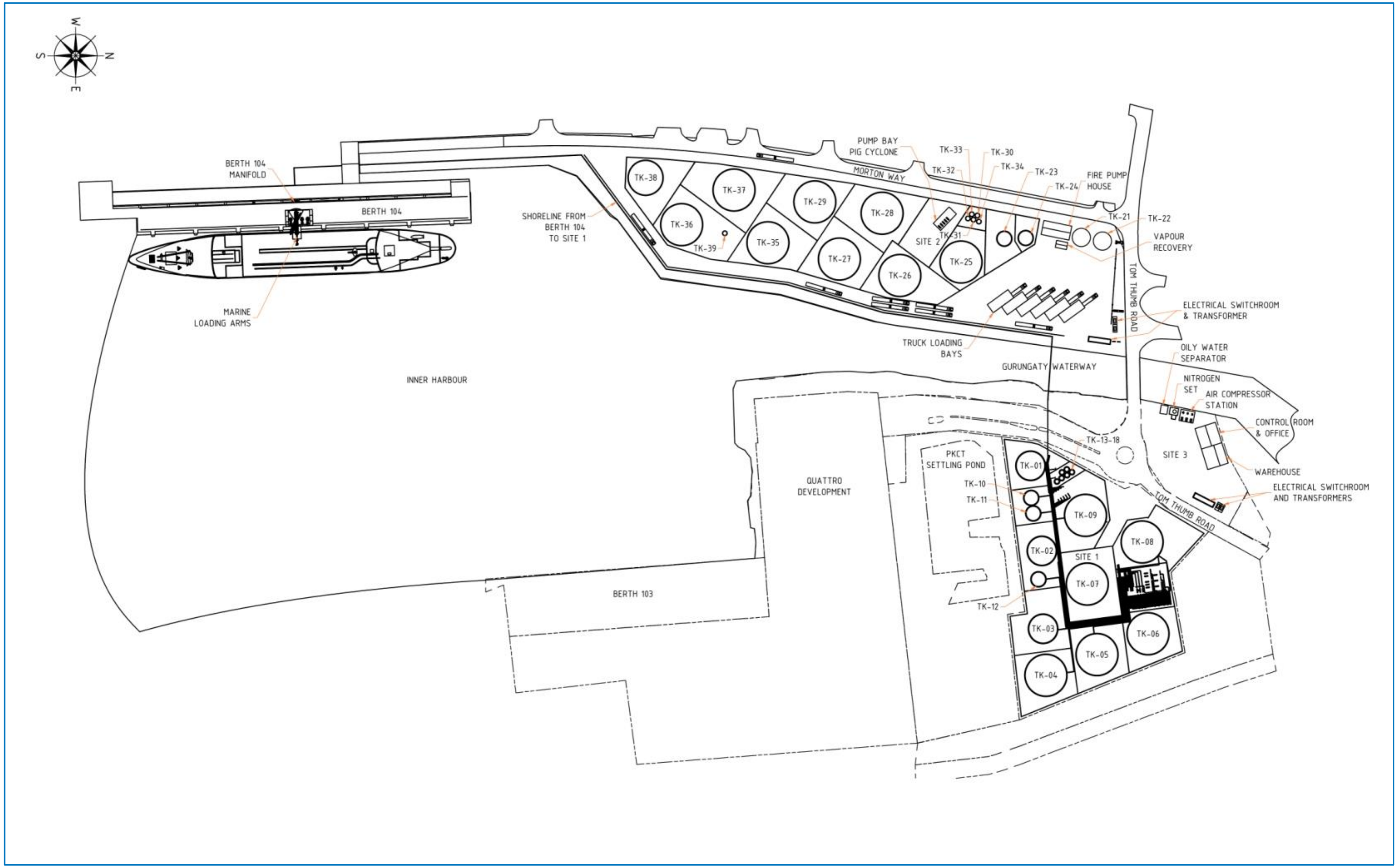
- Stage 1 – A total of 14 tanks (plus slops) with capacities up to 18,500 m^3. The tanks are 10 – 29 m in diameter and have heights ranging from 20 – 29 m. The throughput is anticipated to be 720 mega litres per annum (MLpa) at commencement, increasing to 1,200 MLpa.

- Stage 2 – This stage is expected to begin operations 6 months after the commencement of Stage 1 operations. A total of 19 tanks (plus slops) will be in use during Stage 2 (includes Stage 1 tanks) with capacities, diameters and heights as per Stage 1 dimensions. The additional capacity will allow throughput to increase to 2,000 MLpa.

- Stage 3 – An additional 4 tanks are proposed for this stage. The details and throughput of this phase are subject to future demand. The additional capacity for Stage 3 will allow the terminal throughput to increase to approximately 2,900 MLpa.

The facility is being designed to import and store up to seven fuel products. However the storage mix is dependent upon future demand, in addition to Federal Government legislation and NSW mandates regarding renewable fuels at the time the terminal is operational. The facility is anticipated to operate 24 hours a day, 365 days a year.

A conceptual plant layout is presented in **Figure 2.1** showing potential emission points and the layout of the site.



Source: TQ Holdings Australia, 2015

Figure 2.1: Concept Site Layout

2.2 Local Setting

The TQ Holdings Australia site is located on NSW Ports Land, Port Kembla, NSW. The site is in an industrial area with other major industrial development including the Port Kembla Steelworks, Port Kembla Grain Terminal, GrainCorp's Grain Terminal and Port Kembla Cement Grinding Mill surrounding the proposed facility.

In view of the adjacent industrial land uses, it is not anticipated that there will be significant concentrations of VOCs that should be considered on a cumulative basis. In any event, the NSW EPA Approved Methods does not require the evaluation of cumulative impacts (i.e. addition of existing ambient concentrations) for the assessment of VOCs and air toxics. Rather, these parameters are evaluated in terms of their incremental contribution. For this reason, it has not been deemed necessary to conduct background monitoring of ambient concentrations of VOCs / air toxics.

There are several suburbs located within a 2 km radius of the site including Coniston (north-northwest), Mount St Thomas (east-northeast) and Cringila (southwest). A number of sensitive receptors including schools and aged care facilities are located within these townships. **Figure 2.2** shows the site location and local setting.

Figure 2.2: Local Setting

The sensitive receptor locations presented in **Table 2.1** were chosen for the purpose of assessing air quality impacts from the Project. These locations are the closest potentially affected residential, recreational and other sensitive locations to the site. A discrete receptor was considered at the entry/exit to the site to evaluate impacts to truck drivers lining up at the gate for potentially long periods of time.

Table 2.1: Sensitive Receptors

Sensitive Receptor ID	Location	Easting (m)	Northing (m)	Elevation (m)	Approximate Distance from Site (m) and Direction
1	Coniston Public School	305898	6187146	14	1320
2	Wollongong Greenhouse Park	306632	6186758	7	710
3	Wollongong Baptist Church	306330	6187818	7	1800
4	Coniston Train Station	305701	6187237	18	1510
5	392 Keira St, Wollongong	306248	6187287	8	1300
6	42 Swan St, Wollongong	306376	6187564	6	1540
7	163 Kembla St, Wollongong	306639	6187527	4	1480
8	179 Corrimal St, Wollongong	306867	6187491	5	1470
9	314 Gladstone Ave, Mt St Thomas	304462	6186661	26	2260
10	240 Gladstone Ave, Mt St Thomas	304947	6186741	22	1820
11	350 Gladstone Ave, Mt St Thomas	304113	6186711	16	2610
12	111 Gladstone Ave, Mt St Thomas	305421	6186970	19	1530
13	33 Five Islands Rd, Cringila	304840	6184069	4	2750
14	Entrance to Site	306614	6186000	1	50

The impacts upon workers operating within the boundary of the port facility have not been quantitatively assessed. The scope of the air quality assessment is to evaluate off-site impacts, with impacts upon workers typically assessed through Workplace Health and Safety protocols.

It is noted however that occupational criteria for air quality metrics are typically several orders of magnitude greater than those provided for the evaluation of environmental impact, this is since environmental criteria are designed to protect the full spectrum of society, including the frail, very young and very old. Conversely, those who are exposed occupationally are assumed to be fit and healthy individuals.

Lastly, it is considered valid to inspect the dispersion modelling contours presented to assess potential occupational exposures for those working outside in the wider port complex, providing the maximum predictions presented are compared with occupational exposure criteria.

3 AIR QUALITY PARAMETERS

3.1 Expected Emissions from the Project

3.1.1 Construction

Construction related activities are expected to have limited, and transient impacts on air quality. Further, the potential for air quality impacts are considered to be greater during the operational phase of the project. For these reasons, a quantitative construction air quality assessment has not been included. Potential air quality impacts and appropriate management methods are explored further in **Section 9**.

3.1.2 Operations

During operation of the bulk liquids storage terminal, the key emission source is anticipated to result from tank breathing losses. For volatile product bulk storage tanks, full contact internal floating roofs are installed to eliminate the vapour headspace and associated emissions during tank filling operations. The displaced vapour headspace that occurs during truck loading operations will be mitigated using a vapour recovery unit. Other emission sources from the terminal that have been considered in the assessment include:

- Combustion emissions (auxiliary engine) from the ships importing finished petroleum products at Berth 104
- Fugitive emissions resulting from Road Tanker Loading (RTL)

The displaced vapour headspace that occurs during RTL operations will be treated by the vapour recovery unit (VRU) installed on site. Further descriptions of the proposed scenarios and the anticipated emissions are outlined in **Section 5**.

Vapours associated with pigging of the shorelines and transfer lines will also be mitigated using a vapour recovery unit. Fugitive emissions associated with filling the shorelines and transfer lines, initial filling of volatile storage tanks up to the internal floating roof working level, and leakages and spills are expected to be minor and temporary. Thus, these potential emission sources are not considered further in the emission estimation and dispersion modelling. The mitigation measures that have been proposed to reduce the impact of atmospheric emissions from the terminal's operations are discussed further in **Section 10**.

3.2 Volatile Organic Compounds

Organic hydrocarbons are comprised of a collection of various volatile organic compounds (VOCs), and several of these compounds may be toxic, including benzene, ethylbenzene, toluene and xylene.

Air toxins are present in the air in low concentrations, however characteristics such as toxicity or persistence means they can be hazardous to human, plant or animal life. There is evidence that cancer, birth defects, genetic damage, immuno-deficiency, respiratory and nervous system disorders can be linked to exposure to occupational levels of air toxins. Organic hydrocarbons also include reactive organic compounds, which play a role in the formation of photochemical smog.

3.3 Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are a mixture of organic compounds released into the atmosphere as gases or particles during the incomplete combustion of organic material.

The smallest member of the PAH group is naphthalene, a two-ring compound, which is a gas at normal temperatures. Three-to five-ring PAHs occur as either gases or particles in air. PAHs with five or more rings tend to be solids which attach themselves to the surface of other particulate matter in the atmosphere.

Polycyclic Aromatic Hydrocarbons (PAHs) are expressed as a Potency Equivalency which is a numerical index that is used to compare toxicity of different PAHs. Benzo[a]pyrene is used as a marker for all PAHs and is assigned a Potency Equivalency factor (PEF) of 1.0. Other substances are then assigned PEFs that range from 0.01 to 21.8, expressing their potency relative to Benzo[a]pyrene.

The DECCW references Potency Equivalency Factors developed by the staffs of the California Air Resources Board and the Office of Environmental Health Hazard Assessment (CARB/OEHHA, 1994).

The OEHHA have compiled a list of 24 PAHs and PAH-derivatives known to be carcinogenic in animals, and a list of others with limited evidence of potential carcinogenicity in animals. The OEHHA has developed a scheme for evaluating the potential carcinogenicity of 20 of these PAHs and PAH derivatives so that the effects of airborne PAHs can be evaluated in regulatory programs.

The PEFs for these chemicals were developed by comparing the cancer activity of the chemicals relative to benzo(a)pyrene.

3.4 Combustion Emissions

The production of NO_x, SO_2, and PM_{10} will occur from combustion emissions caused by the auxiliary engine of ships hoteling at Berth 104.

The production of NO_x occurs during combustion processes due to the oxidation of nitrogen in fuel and air. The rate at which this conversion occurs depends on a number of factors including temperature, topography, local meteorological circulation patterns, the presence of an inversion, and the presence of ozone.

SO_2 emissions are generated during the combustion process of fuels containing sulfur.

3.5 Odour

The determination of air quality goals for odour and their use in assessing odour impacts is recognised as a difficult topic in air pollution science. The topic has received considerable attention in recent years and the procedures for assessing odour impacts using dispersion models have been refined considerably. There is still considerable debate in the scientific community about appropriate odour goals.

The NSW EPA has developed odour goals used to assess the likelihood of nuisance impact arising from the emission of odour.

There are two factors that need to be considered:

- what "level of exposure" to odour is considered acceptable to meet current community standards in NSW; and
- how can dispersion models be used to determine if a source of odour meets the goals which are based on this acceptable level of exposure.

The term "level of exposure" has been used to reflect the fact that odour impacts are determined by several factors the most important of which are:

- the **F**requency of the exposure;
- the **I**ntensity of the odour;
- the **D**uration of the odour episodes; and
- the **O**ffensiveness of the odour (the so-called FIDO factors).

In determining the offensiveness of an odour it needs to be recognised that for most odours the context in which an odour is perceived is also relevant. Some odours, for example the smell of sewage, hydrogen sulfide, butyric acid, landfill gas etc., are likely to be judged offensive regardless of the context in which they occur. Other odours such as the smell of jet fuel may be acceptable at an airport, but not in a house, and diesel exhaust may be acceptable near a busy road, but not in a restaurant.

In summary, whether or not an individual considers an odour to be a nuisance will depend on the FIDO factors outlined above and although it is possible to derive formulae for assessing odour annoyance in a community, the response of any individual to an odour is still unpredictable. Odour goals need to take account of these factors.

The difference between odour goals is 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 population exposed to the odour. 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.

4 AIR QUALITY CRITERIA

4.1 Air Toxics

The tanks holding organic hydrocarbons (finished fuel products) have the potential to release a collection of various fugitive VOCs and PAHs, several of which may be toxic at high concentrations.

Organic hydrocarbons may be present in the air in low concentrations, however characteristics such as toxicity or persistence means they can be potentially hazardous to human, plant or animal life. There is evidence that cancer, birth defects, genetic damage, immuno-deficiency, respiratory and nervous system disorders can be linked to exposure to occupational levels of such air toxics.

Organic hydrocarbons also include reactive organic compounds, which play a role in the formation of photochemical smog. There are no impact assessment criteria specified for total VOCs, however modelling predictions can be compared to the impact assessment criteria for individual organic pollutants that may be present in the fugitive headspace gases.

Further, the combustion emissions from the ships auxiliary engines when in berth have the potential to release a emissions to air; namely nitrogen dioxide, sulfur dioxide and particulate matter.

For the purposes of this assessment, predicted concentrations have been compared against the NSW EPA's 1-hour and 24-hour average criteria outlined in their "Approved Methods for Modelling and Assessment of Air Pollutants in NSW" (the Approved Methods)(NSW DEC, 2005). Section 7.2.2 of the Approved Methods allows for volatile organic compounds / air toxics to be assessed at the 99.9th percentile for Level 2 impact assessments.

Table 4.1 and **Table 4.2** summarise the air quality goals that are of relevance to the Project.

Table 4.1: Air Quality Standards, 99.9th Percentile for 1 hour average Concentrations

Pollutant	Standards	Averaging Period	Source
Volatile Organic Compounds / Air Toxics			
Benzene	0.029 mg/m^3	1-Hour	NSW DEC (2005)(assessment criteria)
Toluene	0.36 mg/m^3	1-Hour	NSW DEC (2005)(assessment criteria)
Xylenes	0.19 mg/m^3	1-Hour	NSW DEC (2005)(assessment criteria)
Ethylbenzene	8.0 mg/m^3	1-Hour	NSW DEC (2005)(assessment criteria)
PAHs as Benzo(a)pyrene	0.0004 mg/m^3	1-Hour	NSW DEC (2005)(assessment criteria)

Table 4.2: Air Quality Standards, 100th Percentile for 1 hour and 24 hour average Concentrations

Pollutant	Standards	Averaging Period	Source
Nitrogen dioxide (NO_2)	246 µg/m^3	1-Hour	NSW DEC (2005)(assessment criteria)
Sulfur dioxide (SO_2)	570 µg/m^3	1-Hour	NSW DEC (2005)(assessment criteria)
	228 µg/m^3	24-Hour	NSW DEC (2005)(assessment criteria)
PM_{10}	50 µg/m^3	24-Hour	NSW DEC (2005)(assessment criteria)

4.2 Odour

In addition to health impacts, the NSW OEH list impact assessment criteria for complex mixtures of odorous air pollutants. **Table 4.3** lists the odour glc criterion to be exceeded not more than 1% of the time, for different population densities.

For adjacent industrial lots a less stringent criterion should be applicable as these areas would not be expected to be populated for long continuous periods of time. However, for residential areas further away the more stringent criterion of 2 Odour Units (OU) would apply.

An odour criterion of 2 has been applied for this assessment.

Table 4.3: Odour Assessment Criteria

Population of affected community	Criterion for odorous air pollutants
Urban (2000) and/or schools and hospitals	2
~500	3
~125	4
~30	5
~10	6
≤ ~2	7

4.2.1 Peak-to-Mean Ratios

It is a common practice to use dispersion models to determine compliance with odour goals. This introduces a complication because Gaussian dispersion models are only able to directly predict concentrations over an averaging period of 3-minutes or greater. The human nose, however, responds to odours over periods of the order of a second or so. During a 3-minute period, odour levels can fluctuate significantly above and below the mean depending on the nature of the source.

To determine more rigorously the ratio between the one-second peak concentrations and 3-minute and longer period average concentrations (referred to as peak-to-mean ratio) that might be predicted by a Gaussian dispersion model, DECCW commissioned a study by Katestone Scientific Pty Ltd (1995, 1998). This study recommended peak-to-mean ratio for a range of circumstances. The ratio is also dependent on atmospheric stability and the distance from the source. For area sources in the far field, as applies in this case, the peak-to-mean ratio is 2.5 for neutral conditions (stability class A-D) and 2.3 for stable conditions (stability class E-F).

The OEH Approved Methods take account of this peaking factor and the goals shown in **Table 4.3** are based on nose response time.

5 EMISSIONS ESTIMATION

5.1 Assessment Approach

A preliminary assessment identified that VOCs in petroleum products are anticipated to comprise the most significant potential air quality emission from the Project.

On this basis, the operational state optimised for automotive fuel in Stage 3 was modelled as it represents the most conservative emission scenario proposed for the Project.

The assessment follows a conventional approach commonly used for air quality assessment in NSW and outlined in the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (EPA 2005). Dispersion modelling has been performed for the identified emission sources / parameters and the proposed operational scenarios and compared to air quality impact assessment criteria.

5.2 Pollutant Dispersion Modelling

5.2.1 TANKS

In accordance with the National Pollutant Inventory (NPI) Emission Estimation Manual for Fuel and Organic Liquid Storage (Version 3.2) (Environment Australia, 2011), the TANKS software developed by US EPA can be used for estimating tank breathing emissions from chemical storage facilities.

The version of TANKS used in this assessment is TANKS 4.0.9d. The climatic data for Australian cities was used as input and the zone chosen for the site was Sydney Airport AMO[a].

5.2.2 CALPUFF

CALPUFF is a multi-layer, multi-species non-steady state puff dispersion model that can simulate the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal (Scire *et al*., 2000). The model contains algorithms for near-source effects such as building downwash, partial plume penetration, sub-grid scale interactions as well as longer-range effects such as pollutant removal, chemical transformation, vertical wind shear and coastal interaction effects. The model employs dispersion equations based on a Gaussian distribution of pollutants across the puff and takes into account the complex arrangement of emissions from point, area, volume, and line sources.

In March 2011 the NSW EPA published generic guidance and optional settings for the CALPUFF modelling system for inclusion in the Approved Methods (TRC, 2011). The model set up for this study has been completed in consideration of these guidelines.

[a] Limited Australian climatic data zones are provided in the TANKS program. A comparison between the Sydney Airport AMO zone data and 2015 Port Kembla meteorological data identified that the climatic data inputs are comparable.

5.3 Peak-to-Mean Ratios

As discussed in **Section 4**, peak-to-mean ratios have been applied to the measured emission rates. The peak-to-mean ratios are used to cover a range of atmospheric conditions. The emissions were modelled for all stability classes and a range of wind speeds. For conditions where the odour sources are considered as volume sources or point sources with building wake effect, a peak-to-mean ratio of 2.3 is applied for both the near field and far field. Therefore, a peak-to-mean ratio of 2.3 was applied to odorous emissions.

5.4 Model Inputs

5.4.1 Air Pollutants

The respective petroleum products were entered into the program TANKS based on the information provided by TQ Holdings Australia. Emissions were assumed to occur 24 hours a day, 365 days per year. A summary of the input and output from TANKS (as modelled by Pacific Environment) for a selected storage tank (TK-07) is provided in **Appendix A**.

The chemical properties of the fuel products to be stored were not explicitly listed within the TANKS program, given its association with US fuel products (i.e. gasoline). As a result a representation of each fuel type was selected based on the definitions provided within TANKS, with the assumptions shown in **Table 5.1**.

Table 5.1: TANKS Petroleum Product Selection

Product Fuel	TANKS Modelling Selection
Biodiesel	Distillate fuel oil no. 2
ULSD	Distillate fuel oil no. 2
PULP	PULP
P98	PULP
P95	PULP
ULP	PULP
E10	PULP
Ethanol	PULP

Emissions from tank outbreathing losses were estimated based on the output emissions from TANKS. The flowrates used in the dispersion modelling were found to be greater than data subsequently derived in the provisional tank designs by CTS Netherlands B.V. (2015). When comparing Tank 7(TK-07) of the proposed facility, the mass emission rate derived using TANKS was found to be over 15% greater than that provided by CTS Netherlands B.V. for a comparable product throughput, tank characteristic and fuel type. The reason for this difference, beyond any inherent conservatism within the TANKS emission model, is understood to be most likely since the CTS solution has a full contact internal floating roof. This greatly reduces the surface area of fluid within the tank.

This indicates that a conservative approach has been taken in the assessment through the use of TANKS. The volumetric flow rate of 0.0031 m^3/s from all the tanks modelled was obtained using an estimated vent diameter and exit velocity.

The US EPA's SPECIATE (2004) was used to characterise the total emission estimates from TANKS for all the emission sources into the distinct hydrocarbons of interest. The speciation details are provided in **Table 5.2**.

Table 5.2: SPECIATE outputs for Petrol and Diesel Products

Fuel Component	Petrol %	Diesel %
Benzene	0.753	-
Toluene	5.95	-
Xylene	7.02	-
Ethylbenzene	1.28	-
PAHs as benzo(a)pyrene	0.10	0.3

Full detail on emission source locations and flow rates from all tanks is presented in **Appendix B**. It was assumed a temperature of 25^{o}C during operations and that emission rates of the individual hydrocarbon compounds are continuous.

These established emission rates for the air quality metrics assessed were used as input into the CALPUFF dispersion model to determine VOC and PAH concentrations at ground level. The tanks on site were modelled as vertical fixed roof tanks and internal floating roof tanks as per the detailed design provided by TQ Holdings Australia.

5.4.2 Odour

A conservative estimation of the odour concentrations associated with each individual tank vent source was used. In the absence of odour concentrations relating to petroleum or diesel tank headspace, odour concentration data was referenced based on odour monitoring from tanks and road tanker headspace from other liquid hydrocarbon storage (bitumen) (GHD, 2011). Given the odorous nature of bitumen products, it is considered that referencing odour concentration data from this source in lieu of petroleum odour is conservative.

The 76,000 odour unit (OU) concentration used was found to be similar to values within Pacific Environment's internal database of odour concentrations applicable to equivalent liquid hydrocarbon storage applications.

Given the lower volatility of diesel fuel, the odour concentration at the vents of these storage tanks was assumed to be 50% of the petroleum products, or a 38,000 OU This assumption is again anticipated to be conservative.

Table 5.3 summarises the odour emission inputs into the dispersion model, where the volumetric flowrate of 0.0031 m^3/s was used, from **Section 5.4.1**.

Table 5.3: Odour Concentrations and Emission Rates adopted for Petrol and Diesel tanks[b]

	Parameter	Value
Petroleum Product	Concentration (OU)	76,000
	Emission Rate (OU m^3/s)	236
Diesel Product	Concentration (OU)	38,000
	Emission Rate (OU m^3/s)	118

A peak-to-mean ratio of 2.3 from **Section 0** was used to account for the short-term (nose-response) odour concentrations at sensitive receptors.

5.5 Evaluation of Ship Emissions

Impacts from ship emissions were assessed by assuming ship emissions may occur continuously. The auxiliary engine emission factors were referenced from the National Pollutant Inventory, Emission Estimation Technique Manual for Maritime Operations (Version 2.1) (**NPI, 2012**) presented in **Table 5.4**. Further, referencing this document, an auxiliary power rating of 600 kW was used to represent the engine capacity.

Table 5.4: Emission Factors (kg/kWh) for Auxiliary Engines (weighted average fuel burn) (NPI, 2012)

Substance	Emission Factor (kg/kWh)
NO_x	0.0145
PM_{10}	0.001
SO_2	0.0097

Referencing a comparable ship unloading operation at Port Botany (**SKM, 2007**), the inputs presented in **Table 5.5** were used in the dispersion modelling.

[b] As presented in Table 5.1, Ethanol tanks have been modelled as petroleum tanks for conservatism.

Table 5.5: Ship Stack Parameters and Emission Rates

Parameter	Value
Ship Parameters	
Ship Location	Berth 104
Easting (m)	306532
Northing (m)	6185445
Ship Height (m)	30
Stack Height (m)	37
Stack Diameter (m)	1
Exhaust Velocity (m/s)	39.7
Exhaust Temperature (K)	623
Duration	24 hr/day
Mass Emission Rates	
NO_x (g/s)	2.4
PM_{10} (g/s)	0.2
SO_2 (g/s)	1.6

5.6 Evaluation of Road Tanker Loadout Emissions

Potential emissions from the vapour recovery unit (VRU) servicing the RTL were estimated using an assumption that the VRU will operate at all times during truck loading and will have a control efficiency adequate adsorb 99.5% of potential VOC emissions from this process. The volumetric flow rate for one RTL bay has been assumed to be 100 m^3/hr (**PEL, 2015**), with a conservative estimation of two bays operating at the same time was assumed in the modelling.

Assuming a petroleum vapour density of 4 kg/m^3 and vapours in the tanker to be at half saturation, the fugitive loss of emissions equates to approximately 2 kg/m^3 (**AP&H, 2015**). Using these input variables and the speciation outputs described previously in **Table 5.2**, the resultant mass emission rates presented in **Table 5.6** were used to model road tanker loadout emissions.

Table 5.6: Road Tanker Loadout Emission Rates

Substance	Mass Emission Rate (g/s)
Benzene	0.0042
Toluene	0.033
Xylene	0.039
Ethylbenzene	0.0071
PAHs as benzo(a)pyrene	5.8E-06

5.7 Building Wake Effects

Building wake effects were included in the modelling simulations for the tank sources. Building wake effects were incorporated into the CALPUFF modelling using the PRIME downwash algorithm.

5.8 Evaluation of Vehicle Emissions

Oxides of nitrogen (NO_x) are formed during the oxidation of nitrogen in the combustion process. Oxides of nitrogen in combustion products are mainly composed of a higher proportion of nitric oxide (NO) and a small proportion of other nitrogen oxides. However with time nitric oxides react with the ambient air and form nitrogen dioxide (NO_2).

As presented in **Table 5.7**, the Project's contribution to emissions of NO_x and SO_x associated with additional vehicle movements is anticipated to be negligible in comparison to other local sources in Port Kembla. Further, the relatively low sulphur content of Australian fuels ensures that ambient concentrations of sulfur dioxide (SO_2) are low.

Table 5.7: Worst Case Traffic Impacts from Bulk Liquids Terminal

Road Section	Existing Vehicles	Vehicles from Project	Percentage Increase (%)
Masters Road	36,300	488	1.3

6 METEOROLOGY

No site specific meteorological data are available for the proposed facility at Port Kembla. To meet EPA meteorological data requirements for a Level 2 impact assessment, a longer-duration site representative meteorological data analysis has been completed to select a representative meteorological year for input into the dispersion modelling.

6.1 Long Term Meteorological Data Analysis

Figure 6.1 and **Figure 6.2** present the temperature and wind speed analysis for five years (2005 - 2009) for Wollongong Airport. **Figure 6.3** presents the long term wind speed analysis for the Bellambi monitoring site. **Figure C.1** to **Figure C.5** presents the seasonal and annual wind roses for Wollongong Airport.

It can be seen from **Figure 6.2** and **Figure C.1** to **Figure C.5** (**Appendix C**) that wind patterns are relatively similar in every year. Relatively high wind speed in different months are observed in 2006 to 2008 monitoring periods. Thus 2005 and 2009 data appear to be the most appropriate. Long term wind speed analysis of Bellambi monitoring site shows that wind speeds from the years 2008 and 2009 fitted best with the long term averages.

Based on this analysis, only year 2009 has a good fit at both locations and was chosen as the modelling year for this assessment. **Table 6.1** presents monthly climate statistics for the local area, as recorded by the Bureau of Meteorology's Port Kembla Signal Station weather station (Site Number 68053).

It is noted that the Port Kembla Harbour automatic weather station (Site Number 68253) was commissioned post-2009 and as such this data was not able to be incorporated within the meteorological modelling. However, annual windroses for this location compare well with the CALMET generated windroses presented in **Figure 6.4**.

Table 6.1: Monthly Climate Statistics for Port Kembla

Heading	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean maximum temperature (°C)	24.1	24.4	24.1	22.4	19.4	17.5	16.7	17.3	19.2	20.7	22.4	23.4
Mean minimum temperature (°C)	18.4	18.7	18	15.7	12.7	10.9	9.8	10.3	11.8	13.7	15.3	17.1
Mean rainfall (mm)	116.1	157.5	183.7	92.9	89	140.3	62.6	87.7	55	108	94.3	90.4
Mean 9am temperature (°C)	21.4	21.6	21.1	18.9	15.6	13.4	12.4	13.4	15.6	17.5	19.1	20.5
Mean 9am relative humidity (%)	77	78	76	70	67	67	63	61	61	66	68	74
Mean 9am wind speed (km/h)	17.4	16.1	14.7	14.7	16.7	17.4	17.7	18.5	18.7	19.7	19.5	18.1
Mean 3 pm temperature (°C)	22.5	22.9	22.5	21	18.2	16.2	15.5	16.1	17.4	18.6	20.3	21.6
Mean 3pm relative humidity (%)	75	76	74	68	62	61	57	57	61	67	67	72
Mean 3pm wind speed (km/h)	24.4	23.7	22.9	22.8	21.9	22	24.6	25.4	27.1	26.3	26.5	25.5

Site name: Port Kembla Signal Station, Site number: 68053, Latitude: 34.48 °S Longitude: 150.91 °E

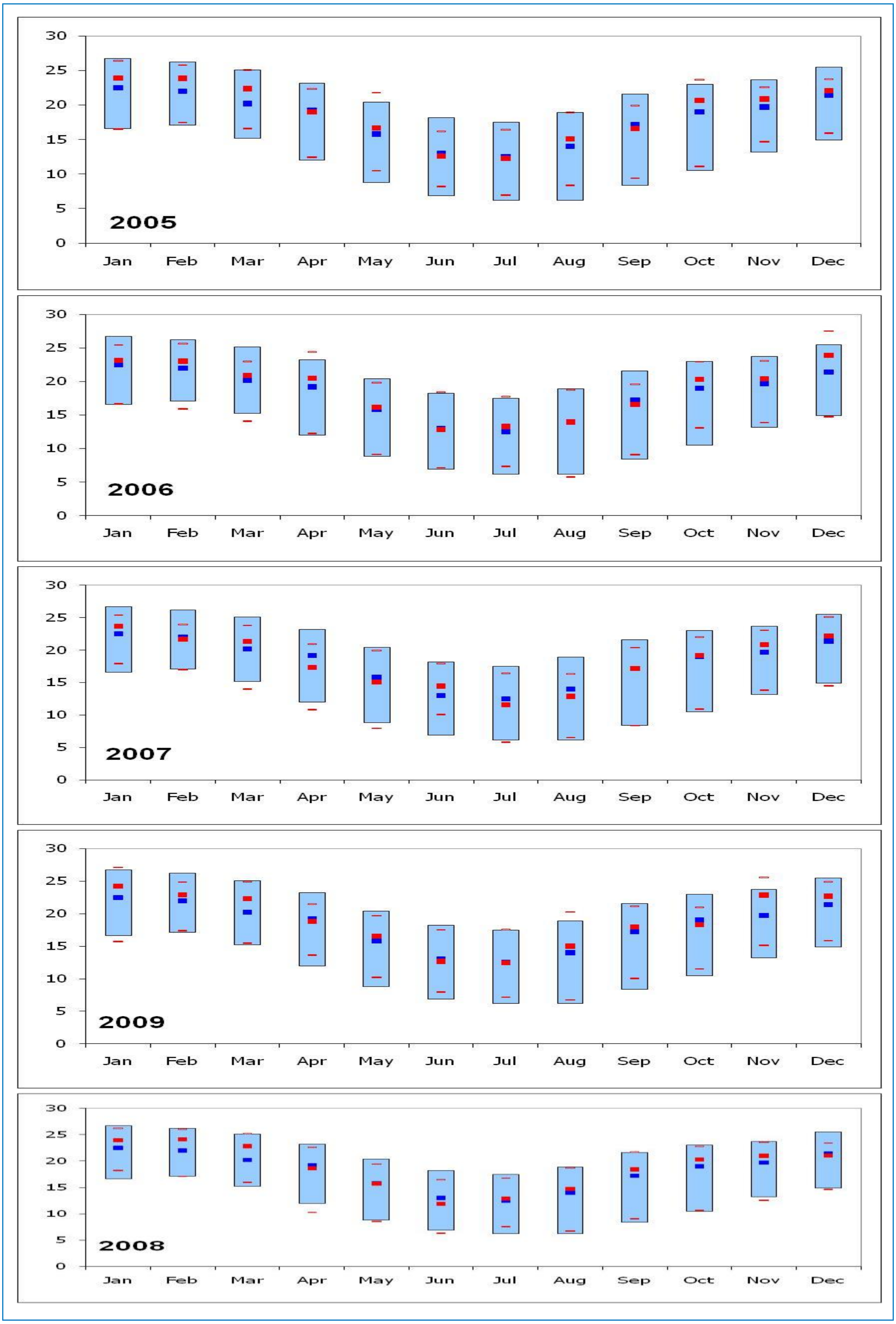


Figure 6.1: Long Term Temperature Analysis for Wollongong Airport

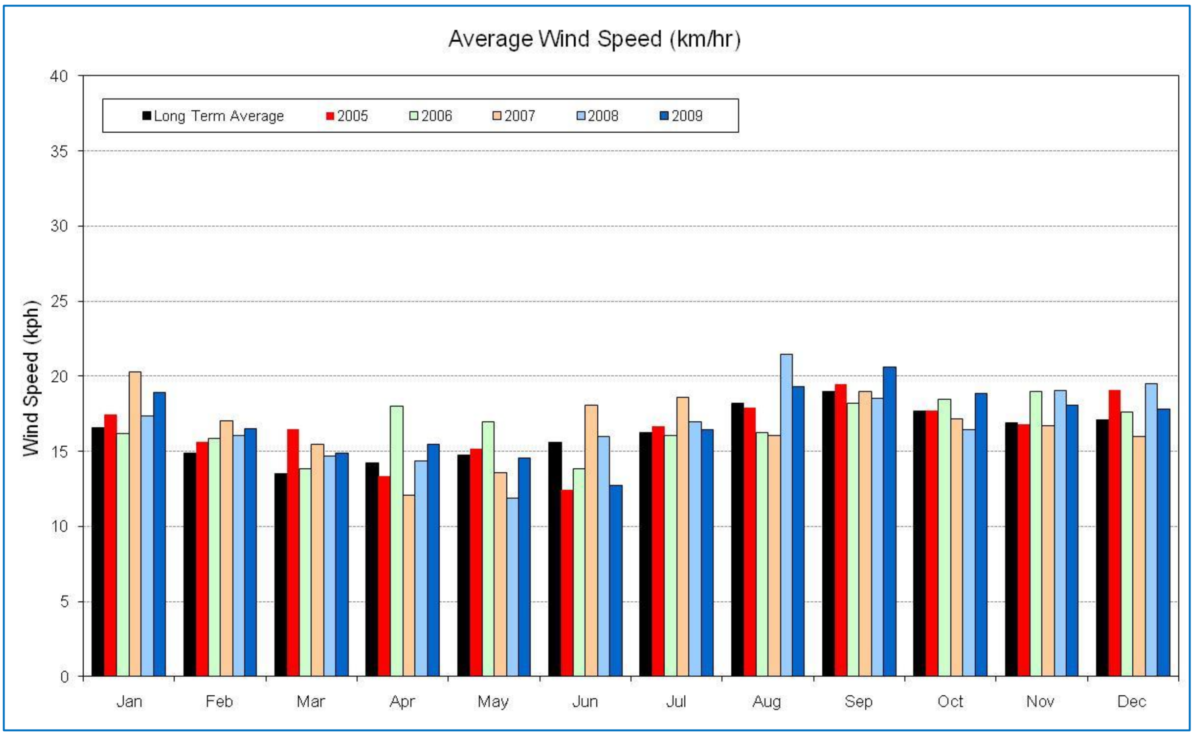


Figure 6.2: Long Term Wind Speed Analysis for Wollongong Airport

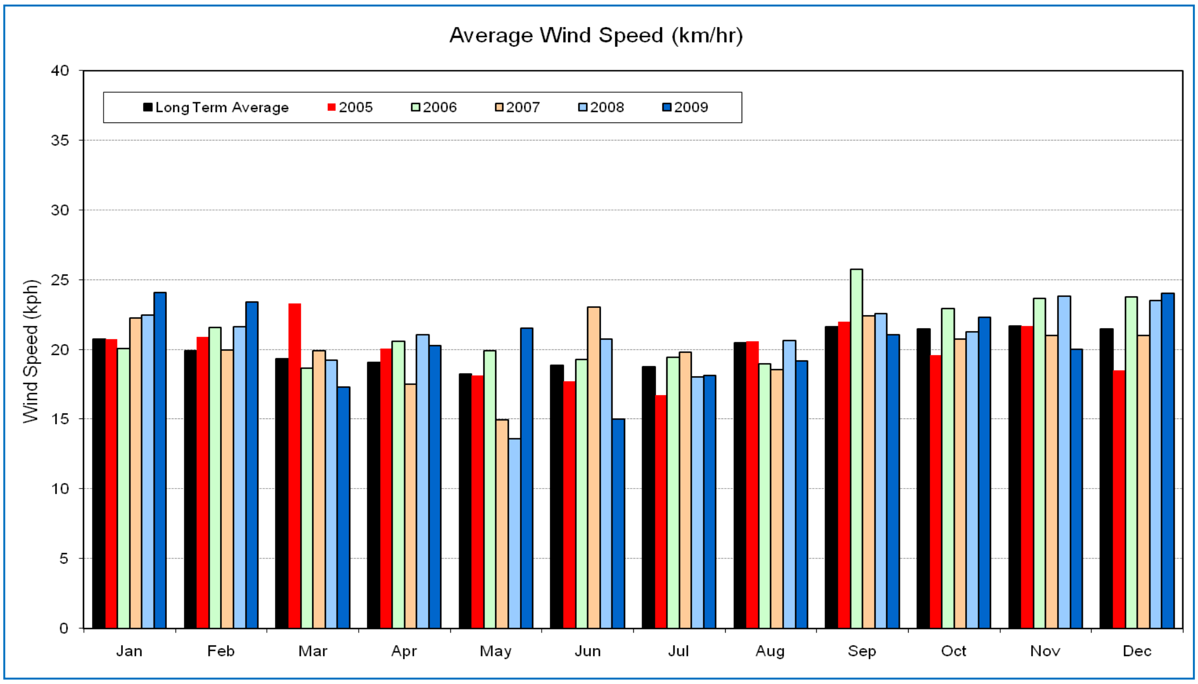


Figure 6.3: Long Term Wind Speed Analysis for Bellambi

6.2 Onsite Meteorological Data Analysis (CALMET)

Figure 6.4 presents CALMET generated on-site annual and seasonal windroses for the modelling year (2009) used in the dispersion modelling**.** On an annual basis, the most common winds are from the northeast and west southwest. Very few winds originate from the northwest and southeast quadrants. During summer and spring, winds from the northeast are predominant and during autumn and winter, winds are predominantly from the west southwest.

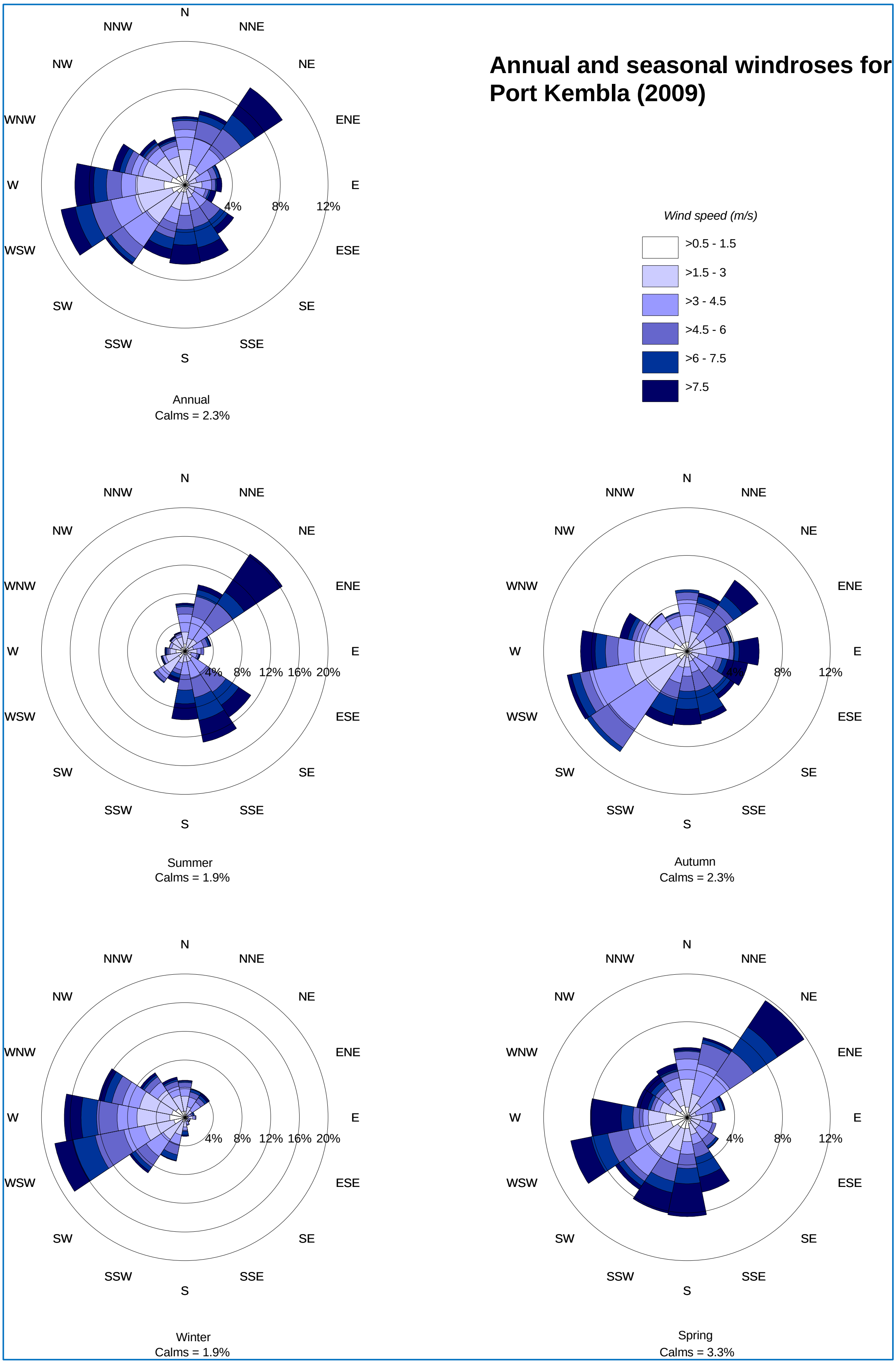


Figure 6.4: Annual and Seasonal Windroses for the Site (CALMET generated)

6.3 Atmospheric Stability

An important aspect of pollutant dispersion is the level of turbulence in the lowest 1 km of the atmosphere, known as the planetary boundary layer (PBL). Turbulence controls how effectively a plume is diffused 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 diffusion increases. Weak turbulence limits diffusion 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 diffusion. 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 6.5 shows the hourly averaged 1/L for the Project site computed from all data in the CALMET extract file. Based on **Table 6.2** this plot indicates that, as to be expected, 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 6.2: Inverse of the Monin-Obukhov length L with respect to Atmospheric Stability

1/L	Atmospheric Stability
Negative	Unstable
Zero	Neutral
Positive	Stable

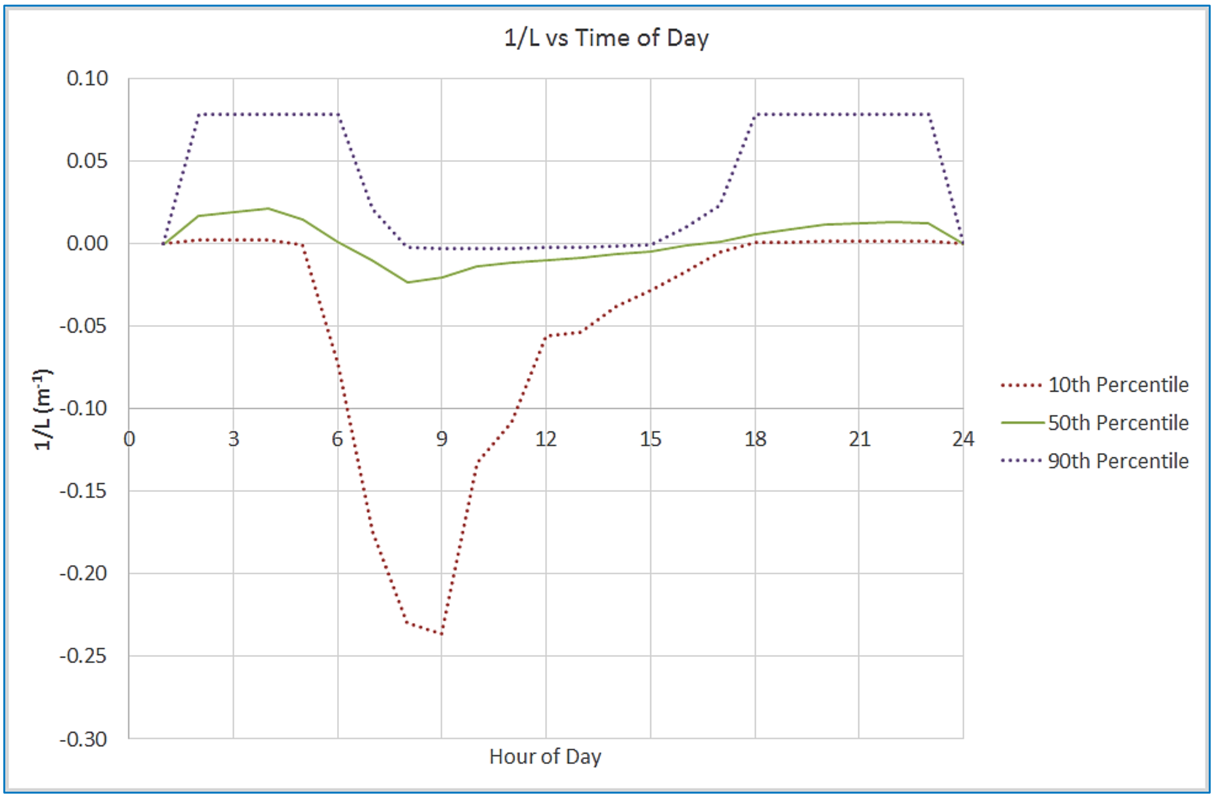


Figure 6.5: Annual statistics of 1/L by hour of the day

Figure 6.6 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 EPA (2005). Note that the reference to stability categories here is only for convenience in describing stability. The CALMET/CALPUFF modelling system uses calculated values of L across a continuum.

Figure 6.6 shows that stable and very stable conditions occur for about 40-50% of the time, which is typical for on-shore locations that experience temperature inversions at night. Atmospheric instability increases during the morning and reaches a peak around 8 am. 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.

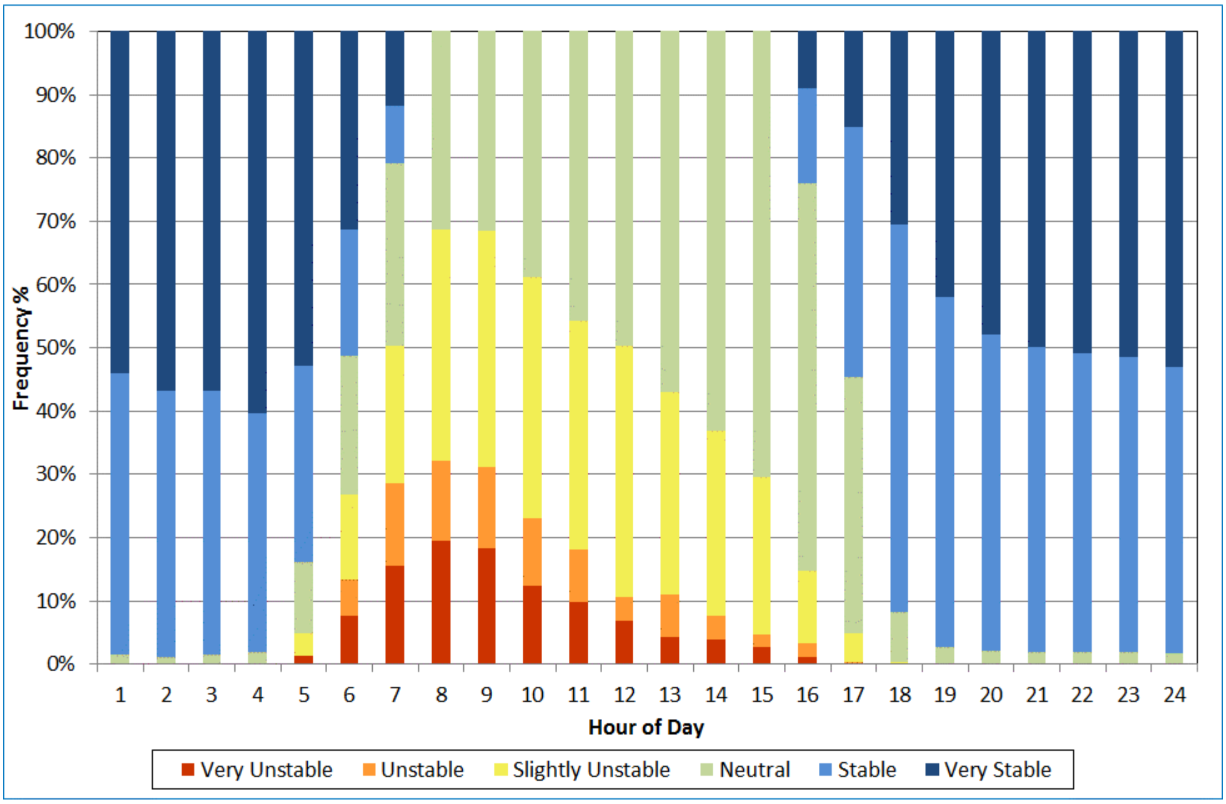


Figure 6.6: Annual distribution of stability type by hour of the day

7 DISPERSION MODELLING

7.1 Tank Venting

Modelling results are presented for Stage 3 of operations to represent the worst case operational scenario. Air dispersion resulting from tank venting has been modelled to predict ground-level concentrations of odour, speciated VOCs and PAHs.

The predicted results for each discrete receptor are presented in **Table 7.1** referencing the NSW EPA's assessment criteria.

Table 7.1: Dispersion Modelling Results – Tank Venting

Discrete Receptor ID	Odour	Benzene	Toluene	Xylene	Ethylbenzene	PAH (as Benzo[a]pyrene)
	(OU)[1]	(mg/m3)	(mg/m3)	(mg/m3)	(mg/m3)	(mg/m3)
	1-second	1-hour	1-hour	1-hour	1-hour	1-hour
	Assessment Criterion					
	2	0.029	0.36	0.19	8.0	0.0004
1	0.1	1.29E-04	1.02E-03	1.20E-03	2.19E-04	1.23E-07
2	0.2	2.71E-04	2.14E-03	2.52E-03	4.60E-04	2.51E-07
3	0.1	7.91E-05	6.25E-04	7.37E-04	1.34E-04	7.63E-08
4	0.1	1.08E-04	8.55E-04	1.01E-03	1.84E-04	1.04E-07
5	0.1	1.20E-04	9.52E-04	1.12E-03	2.05E-04	1.16E-07
6	0.1	1.10E-04	8.68E-04	1.02E-03	1.87E-04	1.06E-07
7	0.1	1.03E-04	8.11E-04	9.57E-04	1.75E-04	9.95E-08
8	0.1	1.07E-04	8.42E-04	9.94E-04	1.81E-04	1.03E-07
9	0.0	1.19E-04	9.42E-04	1.11E-03	2.03E-04	1.14E-07
10	0.0	9.27E-05	7.33E-04	8.64E-04	1.58E-04	8.74E-08
11	0.0	5.79E-05	4.57E-04	5.40E-04	9.84E-05	5.64E-08
12	0.1	1.13E-04	8.96E-04	1.06E-03	1.93E-04	1.09E-07
13	0.0	7.65E-05	6.05E-04	7.14E-04	1.30E-04	8.42E-08
14	1.9	1.06E-03	8.37E-03	9.87E-03	1.80E-03	9.7E-07

NOTE: [1] 99th percentile, 1-second nose response
All other results reported as 99.9th percentile, 1-hour average

The impact of odour from the proposed facility at the nearest sensitive receptor locations is predicted to be negligible. The maximum odour concentration will be recorded at the sites entrance (Receptor 14). At the closest residential receptor (Receptor 2), it is predicted that in the worst-case to comprise well below the odour criterion.

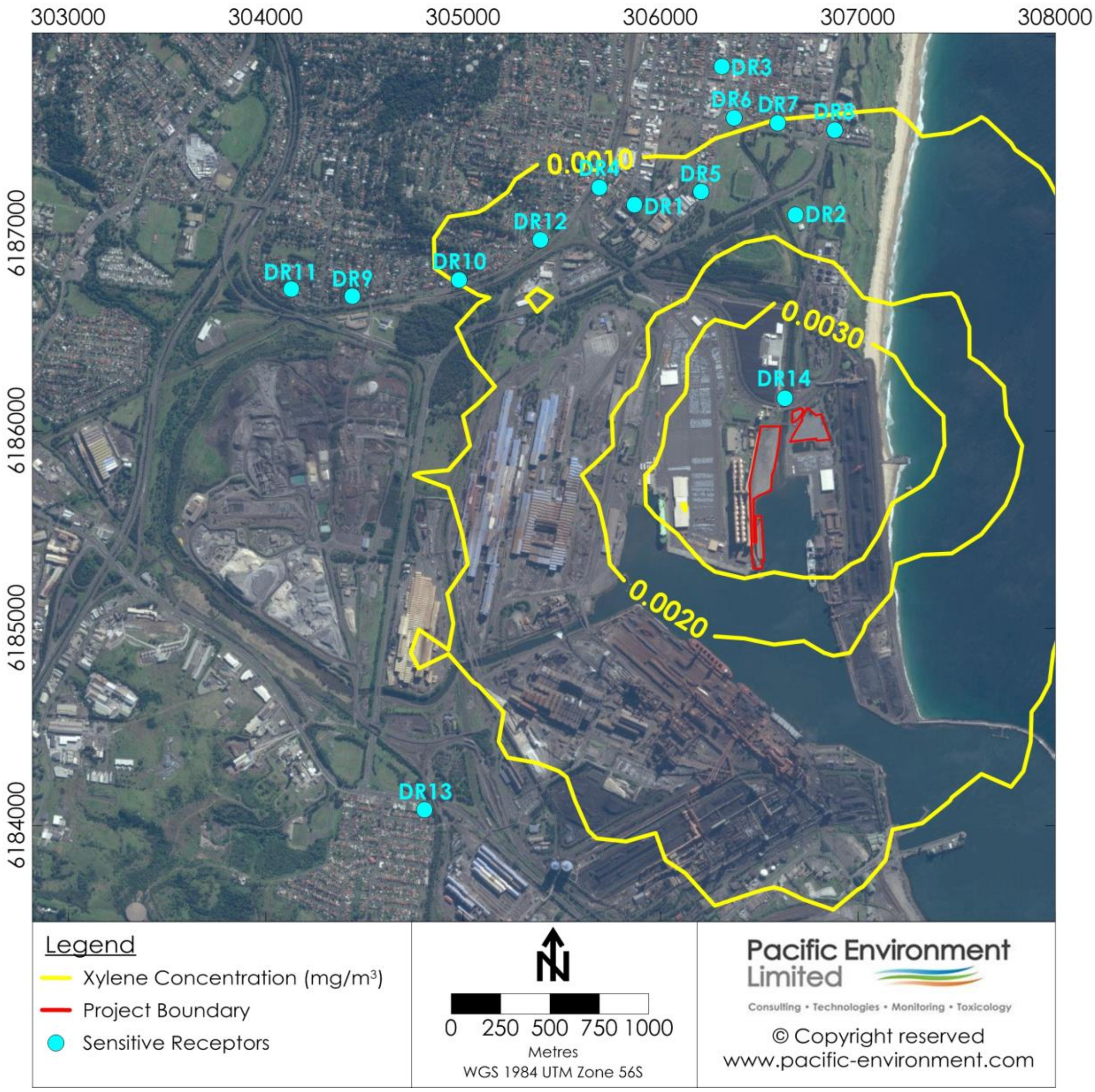
Figure 7.1 presents the 99th percentile 1-second contour plot for Odour (OU) resulting from tank venting.

Species: Odour	Averaging Time: 1-second	Percentile: 99th	Stage: 3 (automotive fuel option)	Location: TQ Holdings Australia, Port Kembla
Model Used: CALPUFF v6.42	**Units:** OU	**Criterion:** 2	**Met Data:** Jan 2009 – Dec 2009 (CALMET)	**Plot:** A Rouggos

Figure 7.1: Predicted 99th Percentile 1-second Odour Concentrations for Stage 3

Predicted air quality impacts from Xylene represents the most significant air quality metric evaluated. As with odour, the receptor at the entrance to site (Receptor 14) is predicted in the worst-case to comprise a concentration equivalent to 5% of the air pollutant criterion. None of the other evaluated air quality metrics are anticipated to either exceed or indeed approach their corresponding assessment criteria and it is therefore expected that the air quality impact of emissions from tank venting and wider Project activities on the surrounding environment will be acceptable.

Figure 7.2 presents the 99.9th percentile 1-hour contour plot for Xylene concentrations (mg/m³) resulting from tank venting.



Species: Xylene	Averaging Time: 1-hour	Percentile: 99.9th	Stage: 3 (automotive fuel option)	Location: TQ Holdings Australia, Port Kembla
Model Used: CALPUFF v6.42	**Units:** mg/m³	**Criterion:** 0.19	**Met Data:** Jan 2009 – Dec 2009 (CALMET)	**Plot:** A Rouggos

Figure 7.2: Predicted 99.9th Percentile 1-hour Xylene Concentrations for Stage 3

7.2 Ship Unloading

Atmospheric emissions resulting from ship unloading (i.e. use of auxiliary engines in berth) has been modelled to predict ground-level concentrations of NOx[c], SO_2 and PM_{10} on the area surrounding the facility.

The predicted results for each discrete receptor are presented in **Table 7.2** referencing the relevant NSW EPA assessment criteria.

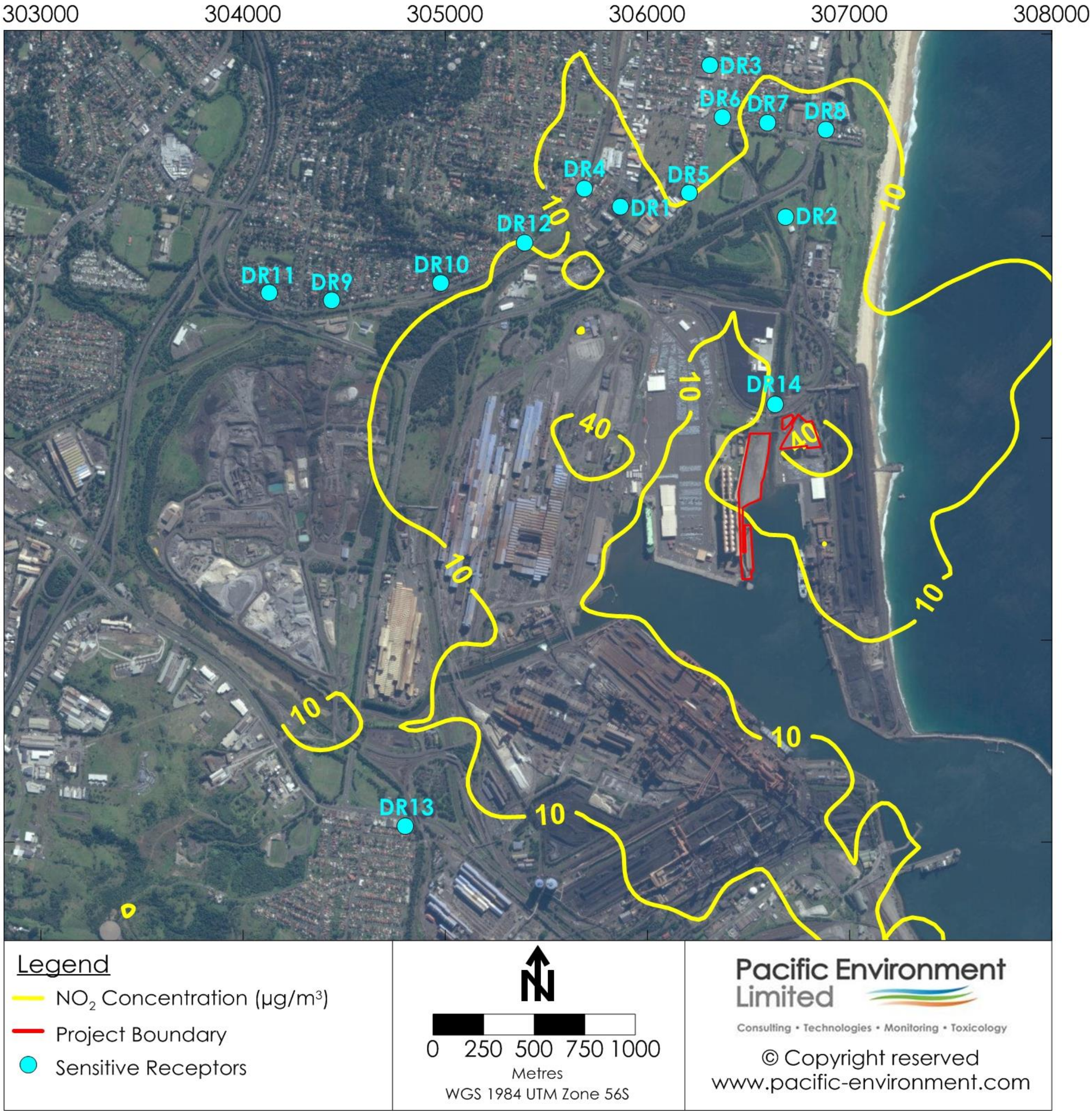
Table 7.2: Dispersion Modelling Results – Ship Unloading

Discrete Receptor ID	NO_2	SO_2		PM_{10}
	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)
	1-hour	1-hour	24-hour	24-hour
	Assessment Criteria			
	246	570	228	50
1	15.8	10.6	0.7	0.1
2	22.6	15.1	1.5	0.2
3	5.5	3.7	0.5	0.1
4	11.4	7.6	0.7	0.1
5	8.6	5.7	1.0	0.1
6	7.9	5.3	0.6	0.1
7	12.2	8.1	0.9	0.1
8	13.9	9.3	0.9	0.1
9	7.5	5.0	0.9	0.1
10	8.7	5.8	0.7	0.1
11	5.6	3.7	0.8	0.1
12	9.7	6.5	0.9	0.1
13	7.0	4.7	0.4	0.1
14	13.2	8.8	0.6	0.1

Predicted air quality impacts from NO_2 represent the most significant air quality metric evaluated for ship unloading. Receptor 2 is predicted in the worst-case to comprise a concentration equivalent to 9% of the NO_2 criterion. None of the other evaluated air quality metrics are anticipated to approach their corresponding assessment criteria and it is therefore expected that the air quality impact of emissions from ship unloading on the surrounding environment will be acceptable.

Figure 7.3 presents the 100th percentile 1-hour contour plot for NO_2 concentrations (µg/m³) resulting from ship unloading.

[c] Assumed 100% conversion from NOx to NO_2.



Species: NO_2	Averaging Time: 1-hour	Percentile: 100th	Stage: Ship unloading (use of auxiliary engines in berth)	Location: TQ Holdings Australia, Port Kembla
Model Used: CALPUFF v6.42	**Units:** µg/m³	**Criterion:** 246	**Met Data:** Jan 2009 – Dec 2009 (CALMET)	**Plot:** A Rouggos

Figure 7.3: Predicted 100th Percentile 1-hour NO_2 Concentrations for Ship Unloading (use of auxiliary engines)

Finally, it is noted that there will be no anticipated additional emission of tank vapours during ship unloading activities. This is since the full contact internal floating roof technology proposed (to be installed on all bulk storage tanks with flammable liquids) ensures that there is no vapour headspace to be potentially displaced during tank filling operations.

7.3 Road Tanker Loading

Atmospheric emissions resulting from road tanker loading has been modelled to predict ground-level concentrations of speciated VOCs and PAHs on the area around the facility.

The predicted results for each discrete receptor are presented in **Table 7.2** referencing the relevant NSW EPA criteria. All sensitive receptors are predicted to experience maximum ground level concentrations less than 1 percent of their criterion associated with road tanker loading activities. The low impacts predicted are principally as a result of the VRU proposed to mitigate emissions.

Table 7.3: Dispersion Modelling Results – Road Tanker Loading

Discrete Receptor ID	Benzene	Toluene	Xylene	Ethylbenzene	PAH (as Benzo[a]pyrene)
	(mg/m3)	(mg/m3)	(mg/m3)	(mg/m3)	(mg/m3)
	1-hour	1-hour	1-hour	1-hour	1-hour
	Assessment Criterion				
	0.029	0.36	0.19	8.0	0.0004
1	4.6E-04	3.6E-03	4.3E-03	7.8E-04	6.4E-07
2	1.4E-03	1.1E-02	1.3E-02	2.3E-03	1.9E-06
3	1.8E-04	1.4E-03	1.7E-03	3.0E-04	2.5E-07
4	2.9E-04	2.3E-03	2.7E-03	5.0E-04	4.1E-07
5	4.3E-04	3.4E-03	4.0E-03	7.4E-04	6.0E-07
6	2.5E-04	2.0E-03	2.3E-03	4.2E-04	3.5E-07
7	2.7E-04	2.1E-03	2.5E-03	4.6E-04	3.7E-07
8	2.6E-04	2.0E-03	2.4E-03	4.4E-04	3.6E-07
9	9.3E-05	7.4E-04	8.7E-04	1.6E-04	1.3E-07
10	1.5E-04	1.2E-03	1.4E-03	2.5E-04	2.0E-07
11	6.9E-05	5.4E-04	6.4E-04	1.2E-04	9.6E-08
12	2.6E-04	2.1E-03	2.4E-03	4.4E-04	3.6E-07
13	7.8E-05	6.2E-04	7.3E-04	1.3E-04	1.1E-07
14	9.0E-04	7.1E-03	8.4E-03	1.5E-03	1.2E-06

Given the minor concentrations predicted to result from road tanker loading on site, contour plots have not been provided for this operational scenario.

8 GREENHOUSE GAS ASSESSMENT

8.1 Introduction

GHG emissions have been estimated based on the methods outlined in the following documents:

- National Greenhouse and Energy Reporting (Measurement) Determination 2008 - Technical Guidelines for the Estimation of Greenhouse Gas Emissions by Facilities in Australia (DoE, 2014).
- Australian National Greenhouse Accounts – National Greenhouse Accounts Factors (DoE, 2014).

The GHG Protocol establishes an international standard for accounting and reporting of GHG emissions. The GHG Protocol has been adopted by the International Standard Organisation, endorsed by GHG initiatives (such as the Carbon Disclosure Project) and is compatible with existing GHG trading schemes. Three 'scopes' of emissions (scope 1, scope 2 and scope 3) are defined for GHG accounting and reporting purposes, as described below and in **Figure 8.1**. This terminology has been adopted in Australian GHG reporting and measurement methods and has been employed in this assessment. The 'scope' of an emission is relative to the reporting entity. Indirect scope 2 and scope 3 emissions would be reportable as direct scope 1 emissions from another facility.

1) Scope 1: Direct Greenhouse Gas Emissions

Direct GHG emissions are defined as those emissions that occur from sources that are owned or controlled by the reporting entity. Direct GHG emissions are those emissions that are principally the result of the following types of activities undertaken by an entity:

- Generation of electricity, heat or steam. These emissions result from combustion of fuels in stationary sources.
- Physical or chemical processing. Most of these emissions result from manufacture or processing of chemicals and materials (e.g. the manufacture of cement, aluminium, etc.).
- Transportation of materials, products, waste and employees. These emissions result from the combustion of fuels in entity owned/controlled mobile combustion sources (e.g. trucks, trains, ships, aeroplanes, buses and cars). For this assessment, this would include the transport of employees and intermittent use of generators and cranes during operations.
- Fugitive emissions. These emissions result from intentional or unintentional releases (e.g. equipment leaks from joints, seals, packing and gaskets; CH_4 emissions from coal mines and venting); hydrofluorocarbon emissions during the use of refrigeration and air conditioning equipment; and CH_4 leakages from gas transport.

2) Scope 2: Energy Product Use Indirect Greenhouse Gas Emissions

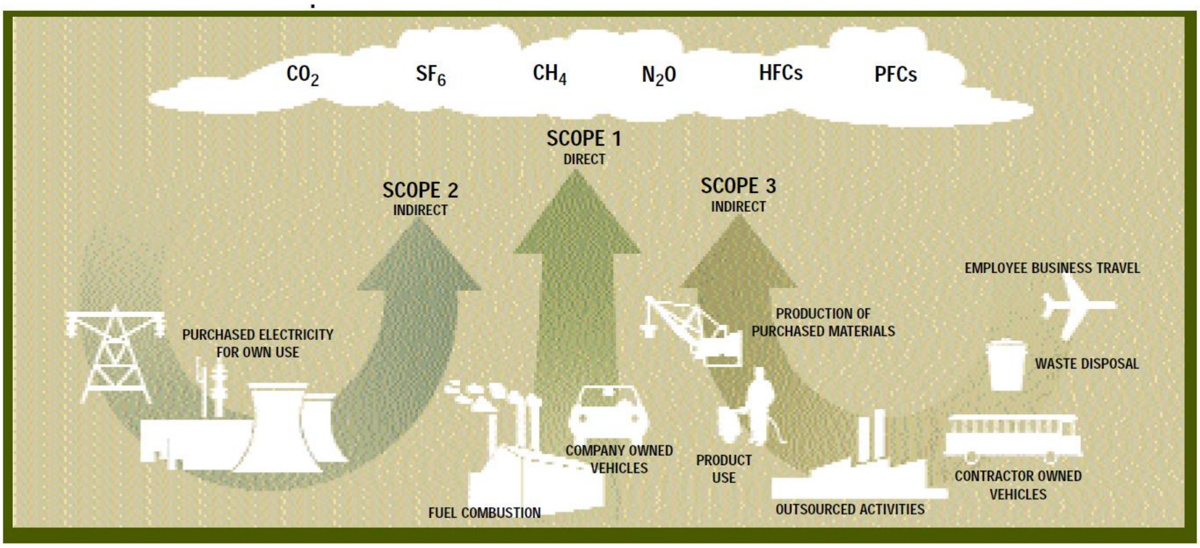
Scope 2 emissions are a category of indirect emissions that account for GHG emissions from the generation of purchased energy products (principally, electricity, steam/heat and reduction materials used for smelting) by the entity. Scope 2 in relation to the project covers purchased electricity, defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity.

3) Scope 3: Other Indirect Greenhouse Gas Emissions

Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. Some examples of scope 3 activities provided in the GHG Protocol are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services.

In the case of the Project, scope 3 emissions would include the emissions associated with the heavy vehicle transportation and combustion of product fuels, as well as the minor emissions associated with the transport of fuel used onsite. The GHG Protocol provides that reporting scope 3 emissions is optional. 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. However, the GHG 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 GHG 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 part of the assessment, an explanation of anticipated greenhouse gases from scope 3 emissions has been included.



Source: Figure 3, WRI/WBCSD, 2004

Figure 8.1: Overview of Scopes and Emissions across a Reporting Entity

8.2 Greenhouse Gas Emission Estimates

8.2.1 Construction

Greenhouse gas (GHG) emissions from construction will primarily result from fuel combustion on site. It is anticipated that the key equipment to be used in the earthworks, foundations and assembly stages of the construction will include excavators, rollers, graders, concrete trucks, cranes and piling rigs.

The construction of the site is anticipated to be a routine exercise occurring primarily during daytime hours. The initial construction phase is anticipated to commence in October 2015 and continue in varying degrees of intensity until Stage 2 of operations commences in December 2017. The timing of stage 3 is unknown at present. It is anticipated that given the transient nature of works paralleled with the minor construction fleet, greenhouse gas emissions from the construction phase will not be significant[d]. For this reason, a quantitative assessment of construction phase GHG emissions has not been undertaken.

8.2.1 Operations

Inventories of GHG emissions can be calculated using published emission factors. Different gases have different greenhouse warming effects (referred to as global warming potentials, or GWPs) and emission factors take into account the GWPs of the gases created during combustion. The estimated emissions are referred to in terms of a carbon dioxide – equivalent (CO_2-e) emissions by applying the relevant GWP. The GHG assessment has been conducted using the NGA Factors, published by the DoE (2014).

Project-related GHG sources included in the assessment are as follows:

Scope 1:

- Fuel consumption (diesel) during operations.
- Emissions associated with on-site electricity generation (diesel generators during construction phase).

Scope 2:

- Indirect emissions associated with purchased electricity brought into the organisational boundary.

Scope 3:

- Indirect emissions associated with the production and transport of fuels.
- Emissions from product fuel transportation.
- Emissions from the use of the product fuels.

A summary of the annual GHG emissions (scope 1 and 2) is provided in **Table 8.1.** Full details of all calculations are provided in **Appendix E**.

[d] The greenhouse gas emissions from the construction phase are expected to be in the same order of magnitude as stage 1 of operations as per **Table 8.1**.

Table 8.1: Summary of Annual Greenhouse Gas Emissions

	Scope 1 Emissions (t CO_2-e)	Scope 2 Emissions (t CO_2-e)	
Stage	**Diesel**	**Electricity (per Stage)**	**Electricity (Cumulative)**
1	69	3,171	-
2	108	1,582	4,753
3	154	826	5,580
Post Stage 3	154	6,143	-

Notes: Totals may have minor discrepancies due to rounding.

As outlined in the **Table 8.1**, the electricity and diesel consumption is anticipated to increase from Stage 1 through to Stage 3 as product throughput increases. Post Stage 3, it has been assessed that approximately 6,150 tonnes of CO_2 emissions will result from electricity usage annually and 150 tonnes of CO_2 emissions will be associated with diesel usage annually from the terminal.

8.3 Scope 3 Assessment

The primary Scope 3 emissions from the Project will include the short term construction phase related equipment and transportation requirements as well as the longer term operational phase transportation of the product from site and the end use combustion emissions of the fuels.

TQ Holdings Australia is considering the future use of rail to transport finished fuel products once new infrastructure is developed to meet the demand criteria, thus reducing future greenhouse emissions from this process.

9 CONSTRUCTION IMPACTS

9.1 Overview

This Section deals with the potential impacts of the construction phase of the project. 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[e].
- Exhaust emissions from diesel-powered construction equipment[f].

Very high levels of soiling can also damage plants and affect the diversity of ecosystems.

It is very 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. It is therefore usual to provide a qualitative assessment of potential construction dust impacts. A largely qualitative approach has also been used, and the impacts of construction have not been specifically modelled. The approach used for this assessment is based on that described by IAQM (2014). The aim is to identify risks and to recommend appropriate mitigation measures.

The IAQM guidance is designed primarily for use in the UK, although it may be applied elsewhere. Here, the guidance has been adapted for use in NSW, taking into account factors such as the assessment criteria for ambient PM_{10} concentrations.

9.2 Construction Activities

A wide range of construction equipment is likely to be used for the construction of the Project and the associated infrastructure. This includes:

- Excavators
- Cranes
- Concrete trucks
- Heavy vehicles
- Light vehicles
- Rollers

The initial construction phase is anticipated to commence in October 2015 and continue in varying degrees of intensity until Stage 2 of operations commences in December 2017. The timing of stage 3 is unknown at present. The assessment of each construction activity in isolation could lead to an underestimation of risk. Therefore, for the construction assessment the activities were combined according to the single worst case scenario.

[e] There are other potential impacts, such as the release of heavy metals, asbestos fibres or other pollutants during the removal of contaminated soils.

[f] 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).

9.3 Assessment Procedure

Activities on construction sites can be divided into four types to reflect their different potential impacts, and the potential for dust emissions is assessed for each activity that is likely to take place. These activities are:

- *Demolition*. Demolition is any activity that involves the removal of existing structures. This may also be referred to as de-construction, specifically when a building is to be removed a small part at a time.
- *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 site onto the public road network, where it may be deposited and then re-suspended by vehicles using the network.

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

The assessment is used to define appropriate mitigation measures to ensure that there will be no significant effect.

9.4 Screening

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).

It can be seen from **Figure 2.2** (from **Section 2**) that all sensitive receptors (as defined by NSW EPA) are located at least 350 m off the boundary of the proposed facility at Port Kembla. Therefore in view of the outcomes of the construction screening analysis potential construction impacts are considered to be minimal. Supporting this screening process is an Ecological Impact Assessment completed by **Cardno (2015)**. The report identified that the Project will have a negligible impact on local ecology in the Port Kembla region.

10 COMPLIANCE WITH POEO (CLEAN AIR) REGULATION 2010

Part 6 of the Protection of the Environment Operations (Clean Air) Regulation 2010 (the "Clean Air Regulation") specifies control equipment required for volatile organic liquids in areas of the Sydney, Newcastle and Wollongong Metropolitan areas.

Requirements are outlined for control equipment for large storage tanks (Clause 63), large loading plants (Clause 64) and small storage tanks (Clause 65).

Given that the bulk liquids terminals is located in Port Kembla, the operations are exempt from the requirements for control equipment for large loading plants and small storage tanks; however the requirements for control equipment for large storage tanks must be met.

The following control equipment on large storage tanks is required:

- A drainage system comprising of a small sump or tundish fitted under each water draw-off valve and connected to a totally enclosed drain, or
- For volatile organic liquid stored in a tank with a vapour pressure ≤75 kPa the tank must have either a floating metal roof, a floating cover constructed of material impervious to vapour that floats on the liquid surface inside a fixed roof, or a vapour disposal or recovery system that meets the requirements of the Clean Air Regulation.
- For volatile organic liquid stored in a tank with a vapour pressure >75 kPa the tank must have a vapour disposal or recovery system that meets the requirements of the Clean Air Regulation.

It is also noted that clauses 66 and 67 of the Clean Air Regulation outline the requirements for control equipment for large tank vehicles, as well as methods for loading and unloading large tank vehicles.

It is understood that, through the full contact internal floating roof technology proposed, combined with the use of VRUs for road tanker loadout and pigging activities, the facility will meet the relevant requirements of the Clean Air Regulation.

11 MITIGATION MEASURES

Regardless of the minimal air quality impact of the project's construction and operation on local air quality, TQ Holdings Australia have committed to a number of mitigation strategies to ensure that the bulk liquids terminal operates at the highest standards.

11.1 Construction

It is recommended that before construction proceeds, an Air Quality Management Plan (AQMP) is developed as part of the Construction Environmental Management Plan (CEMP) that would cover:

- Methods to monitor the effects of construction activities.
- Measures required to minimise dust and vehicle emissions during the construction of the project.

Recommended mitigation measures to reduce potential emissions during construction activities are listed below and represent best practice management tools for construction site dust control.

- The number and sizes of stockpiles will be kept to a minimum.
- Dust suppression shall be undertaken during construction and clearing activities, particularly during high wind conditions. Haul roads and other unsealed areas may be watered to suppress dust.
- Ensure that all vehicles and machinery are fitted with appropriate emission control equipment, maintained frequently and serviced to the manufacturers' specification.
- Minimise construction equipment idling time.

11.2 Operation

11.2.1 Product Unloading

Each shoreline will be equipped with a pig launcher and receiver in order to clear fuel product into the tank and leave the line clear for the next product. Pig propulsion will be via nitrogen pressure using a reticulation system for the terminal nitrogen tank.

The pigging facilities will be equipped with containment and sump for hydrocarbon and pump out. Once pigged clear, the line is depressurised into a cyclone column that separates hydrocarbon droplets and vapours vented from the shorelines. The collected liquid is then pumped across to the slops tank, and the vapour fed into the Vapour Recovery Unit to recover the remaining hydrocarbon vapours.

When the vessel has finished pumping and the surveyor has confirmed the ship's tank is empty and dry, the ships manifold valve is closed and the MLA cleared by draining and pumping in a closed system. The shore pipeline is then pigged to the tank, the line depressurised (as detailed above), pig removed from the receiver and the line left in nitrogen at atmospheric pressure.

These processes are included to mitigate against potential emissions from product unloading. The pigging operations and vapour recovery underlie the assumption of not including this phase of the operational process in the emissions estimation.

11.2.2 On-Site Operations

The piping design will minimise the potential for surge overpressure via the provision of expansion loops, soft-seat valve closures, non-slam check valves in tanks and product piping. Product pumps will have variable speed drives with soft start up and shut down to prevent surging.

Pipework which is normally full with product that has closed sections is protected by thermal relief around isolation valves. This ensures that no product (and emissions) are lost to the environment.

Furthermore, bunds will ensure that in the unlikely case of leakages, fuel products will not seep into groundwater and leave the site. Bunds containing pipework and equipment that is normally full with product include level detection and hydrocarbon detection so that any leakage can be readily detected, in addition to routine operator inspections. These site bunds incorporate a pump out system to drain any spilled product to a closed slops handling system.

As detailed previously, full contact internal floating roofs will be installed on all bulk storage tanks with flammable liquids to effectively mitigate against vapour headspace emissions during tank filling operations.

11.2.3 Product Loading

TQ Holdings Australia will utilise a vapour recovery unit to recover vapours and minimise emissions associated with the loading of fuels into road tankers. The vapour recovery unit will be located near the truck loading gantry. The recovered product will be pumped into the slops tank near the truck loading bay for eventual recovery into a nominated bulk tank.

Product is recovered by carbon absorption in either one of two absorption vessels, which are regenerated by vacuum. At any one time, it is expected that one vessel is being desorbed while the other is on the line.

Vapours from the vacuum process will be passed through a liquid vapour separator vessel then into a packed absorption tower which is supplied by a cold gasoline stream from the duty gasoline tank. The gasoline absorbs the vapours within the tower and the gasoline is returned to the duty gasoline tank. Residual vapours are repassed through the active absorption vessel to recover the remaining product.

Details regarding control efficiency of the units is yet to be concluded, however as stated in the literature typical efficiencies are in excess of 99.5%. It is anticipated that the technology implemented in the vapour recovery units for the terminals will recover a percentage equivalent to this value, supporting the assumption that primary emissions from the Project are expected to be from tank venting.

12 CONCLUSION

Pacific Environment has completed an air quality and greenhouse gas assessment for the TQ Holdings Australia Project, in accordance with the SEARs.

One worst case operating scenario for Stage 3 of operations has been assessed to represent the potential air quality impacts that the Project would have on sensitive receptors (e.g. residences) in the vicinity of the Project. Dispersion modelling was conducted to predict the ground level concentrations for all relevant volatile organic compounds, polycyclic aromatics hydrocarbons and odour anticipated to be emitted due to tank breathing losses. Further, dispersion modelling was completed to evaluate the impacts of ship unloading (use of auxiliary engines in berth) and road tanker loading.

The results of the dispersion modelling indicate that there are no privately owned receptors, recreation areas or on-site locations predicted to exceed the NSW EPA's average criteria for the air quality metrics assessed or the NSW EPA's nose-response criteria for odour. The results indicate that the operation of the bulk liquids terminal will have negligible impact on the air quality in Port Kembla and surrounding townships.

A GHG assessment completed for the Project demonstrates that average annual direct emissions from the Project (0.2 ktpa CO2-e) would represent approximately 0.0001% of Australia's commitment under the original Kyoto Protocol and a very small portion of global greenhouse emissions.

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Appendix A TANKS OUTPUT

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Identification and Physical Characteristics

Identification	
User Identification:	TK-07
City:	
State:	
Company:	
Type of Tank:	Internal Floating Roof Tank
Description:	ULP, Flammable
Tank Dimensions	
Diameter (ft):	95.14
Volume (gallons):	4,916,889.00
Turnovers:	10.37
Self Supp. Roof? (y/n):	Y
No. of Columns:	0.00
Eff. Col. Diam. (ft):	0.00
Paint Characteristics	
Internal Shell Condition:	Light Rust
Shell Color/Shade:	White/White
Shell Condition	Good
Roof Color/Shade:	White/White
Roof Condition:	Good
Rim-Seal System	
Primary Seal:	Mechanical Shoe
Secondary Seal	None
Deck Characteristics	
Deck Fitting Category:	Typical
Deck Type:	Welded

Deck Fitting/Status	Quantity
Access Hatch (24-in. Diam.)/Unbolted Cover, Ungasketed	1
Automatic Gauge Float Well/Unbolted Cover, Ungasketed	1
Roof Leg or Hanger Well/Adjustable	30
Sample Pipe or Well (24-in. Diam.)/Slit Fabric Seal 10% Open	1
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	1

Meteorological Data used in Emissions Calculations: Sydney Airport Amo, NSW (Avg Atmospheric Pressure = 14.74 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

TK-07 - Internal Floating Roof Tank

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
PULP	All	65.51	60.82	70.20	63.52	5.4479	N/A	N/A	66.5000			92.00	Option 4: RVP=9.5, ASTM Slope=3

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TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

TK-07 - Internal Floating Roof Tank

Annual Emission Calcaulations	
Rim Seal Losses (lb):	4,214.1684
Seal Factor A (lb-mole/ft-yr):	5.8000
Seal Factor B (lb-mole/ft-yr (mph)^n):	0.3000
Value of Vapor Pressure Function:	0.1148
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	5.4479
Tank Diameter (ft):	95.1400
Vapor Molecular Weight (lb/lb-mole):	66.5000
Product Factor:	1.0000
Withdrawal Losses (lb):	101.0759
Number of Columns:	0.0000
Effective Column Diameter (ft):	0.0000
Annual Net Throughput (gal/yr.):	50,988,138.9300
Shell Clingage Factor (bbl/1000 sqft):	0.0015
Average Organic Liquid Density (lb/gal):	5.6000
Tank Diameter (ft):	95.1400
Deck Fitting Losses (lb):	2,330.8014
Value of Vapor Pressure Function:	0.1148
Vapor Molecular Weight (lb/lb-mole):	66.5000
Product Factor:	1.0000
Tot. Roof Fitting Loss Fact.(lb-mole/yr):	305.2000
Deck Seam Losses (lb):	0.0000
Deck Seam Length (ft):	0.0000
Deck Seam Loss per Unit Length Factor (lb-mole/ft-yr):	0.0000
Deck Seam Length Factor(ft/sqft):	0.0000
Tank Diameter (ft):	95.1400
Vapor Molecular Weight (lb/lb-mole):	66.5000
Product Factor:	1.0000
Total Losses (lb):	6,646.0458

Roof Fitting/Status	Quantity	Roof Fitting Loss Factors KFa(lb-mole/yr)	KFb(lb-mole/(yr mph^n))	m	Losses(lb)
Access Hatch (24-in. Diam.)/Unbolted Cover, Ungasketed	1	36.00	5.90	1.20	274.9307
Automatic Gauge Float Well/Unbolted Cover, Ungasketed	1	14.00	5.40	1.10	106.9175
Roof Leg or Hanger Well/Adjustable	30	7.90	0.00	0.00	1,809.9605
Sample Pipe or Well (24-in. Diam.)/Slit Fabric Seal 10% Open	1	12.00	0.00	0.00	91.6436
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	1	6.20	1.20	0.94	47.3492

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: Annual

TK-07 - Internal Floating Roof Tank

	Losses(lbs)				
Components	Rim Seal Loss	Withdrawal Loss	Deck Fitting Loss	Deck Seam Loss	Total Emissions
PULP	4,214.17	101.08	2,330.80	0.00	6,646.05

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Appendix B SOURCE DETAIL

Tank ID	Easting (m)	Northing (m)	Height above ground level (m)	TANKS, Total Flowrate (kg/yr)	Benzene (g/s)	Toluene (g/s)	Xylene (g/s)	Ethylbenzene (g/s)	PAHs (g/s)
TK-01	306684	6185966	20.8	110	2.62E-05	2.07E-04	2.44E-04	4.45E-05	1.15E-08
TK-02	306744	6185974	20.8	278	6.65E-05	5.25E-04	6.20E-04	1.13E-04	2.91E-08
TK-03	306798	6185976	20.8	278	6.65E-05	5.25E-04	6.20E-04	1.13E-04	2.91E-08
TK-04	306831	6185979	28.2	785	1.87E-04	1.48E-03	1.75E-03	3.18E-04	8.21E-08
TK-05	306817	6186014	28.2	785	1.87E-04	1.48E-03	1.75E-03	3.18E-04	8.21E-08
TK-06	306801	6186049	28.2	785	1.87E-04	1.48E-03	1.75E-03	3.18E-04	8.21E-08
TK-07	306768	6186007	28.2	3015	7.20E-04	5.69E-03	6.71E-03	1.22E-03	6.52E-07
TK-08	306737	6186045	28.2	2985	7.13E-04	5.63E-03	6.65E-03	1.21E-03	6.45E-07
TK-09	306719	6186005	28.2	2994	7.15E-04	5.65E-03	6.66E-03	1.22E-03	6.47E-07
TK-11	306718	6185968	20.5	1208	2.88E-04	2.28E-03	2.69E-03	4.90E-04	2.61E-07
TK-12	306764	6185972	20.5	26	6.18E-06	4.88E-05	5.76E-05	1.05E-05	2.71E-09
TK-13	306696	6185985	4.8	753	1.80E-04	1.42E-03	1.68E-03	3.05E-04	1.63E-07
TK-14	306694	6185987	4.8	753	1.80E-04	1.42E-03	1.68E-03	3.05E-04	1.63E-07
TK-16	306690	6185993	4.8	753	1.80E-04	1.42E-03	1.68E-03	3.05E-04	1.63E-07
TK-17	306690	6185988	4.8	753	1.80E-04	1.42E-03	1.68E-03	3.05E-04	1.63E-07
TK-18	306687	6185991	4.8	753	1.80E-04	1.42E-03	1.68E-03	3.05E-04	1.63E-07
TK-23	306530	6185949	20.5	1208	2.88E-04	2.28E-03	2.69E-03	4.90E-04	2.61E-07
TK-24	306541	6185952	20.5	1208	2.88E-04	2.28E-03	2.69E-03	4.90E-04	2.61E-07
TK-25	306544	6185918	28.2	3015	7.20E-04	5.69E-03	6.71E-03	1.22E-03	6.52E-07
TK-26	306553	6185875	28.2	2985	7.13E-04	5.63E-03	6.65E-03	1.21E-03	6.45E-07
TK-27	306542	6185833	28.2	2994	7.15E-04	5.65E-03	6.66E-03	1.22E-03	6.47E-07
TK-28	306511	6185862	28.2	785	1.87E-04	1.48E-03	1.75E-03	3.18E-04	8.21E-08
TK-29	306502	6185816	28.2	785	1.87E-04	1.48E-03	1.75E-03	3.18E-04	8.21E-08
TK-30	306513	6185932	4.8	753	1.80E-04	1.42E-03	1.68E-03	3.05E-04	1.63E-07
TK-31	306516	6185929	4.8	753	1.80E-04	1.42E-03	1.68E-03	3.05E-04	1.63E-07
TK-32	306514	6185925	4.8	753	1.80E-04	1.42E-03	1.68E-03	3.05E-04	1.63E-07

Tank ID	Easting (m)	Northing (m)	Height above ground level (m)	TANKS, Total Flowrate (kg/yr)	Benzene (g/s)	Toluene (g/s)	Xylene (g/s)	Ethylbenzene (g/s)	PAHs (g/s)
TK-33	306512	6185928	4.8	753	1.80E-04	1.42E-03	1.68E-03	3.05E-04	1.63E-07
TK-35	306519	6185721	4.8	3015	7.20E-04	5.69E-03	6.71E-03	1.22E-03	6.52E-07
TK-36	306495	6185757	28.2	2985	7.13E-04	5.63E-03	6.65E-03	1.21E-03	6.45E-07
TK-37	306487	6185695	28.2	785	1.87E-04	1.48E-03	1.75E-03	3.18E-04	8.21E-08
TK-38	306536	6185752	28.2	530	1.27E-04	1.00E-03	1.18E-03	2.15E-04	5.55E-08
TK-39	306536	6185750	28.2	753	1.80E-04	1.42E-03	1.68E-03	3.05E-04	1.63E-07

Appendix C WINDROSES FOR WOLLONGONG AIRPORT

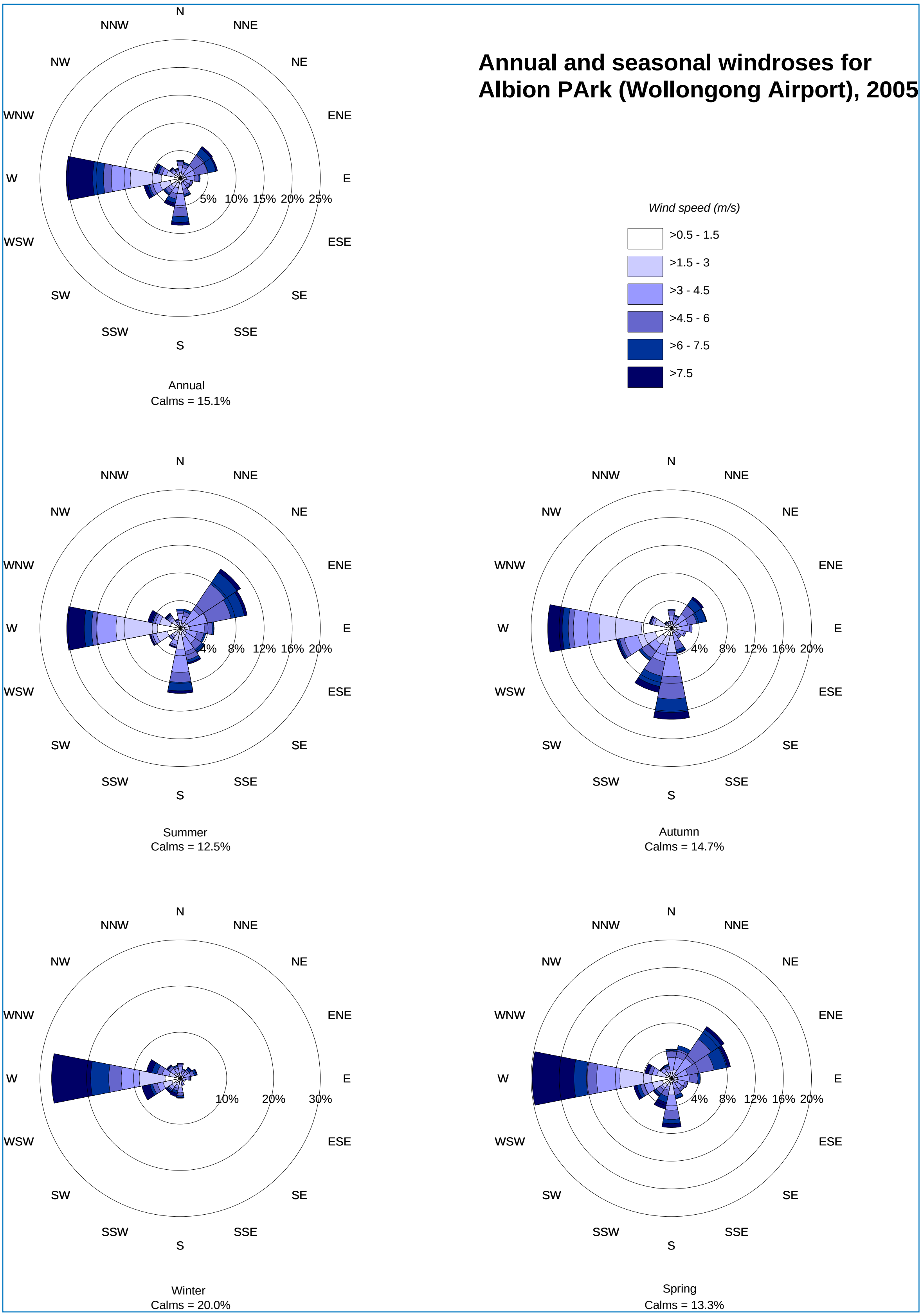

Figure C.1: Annual and Seasonal Windroses for 2005

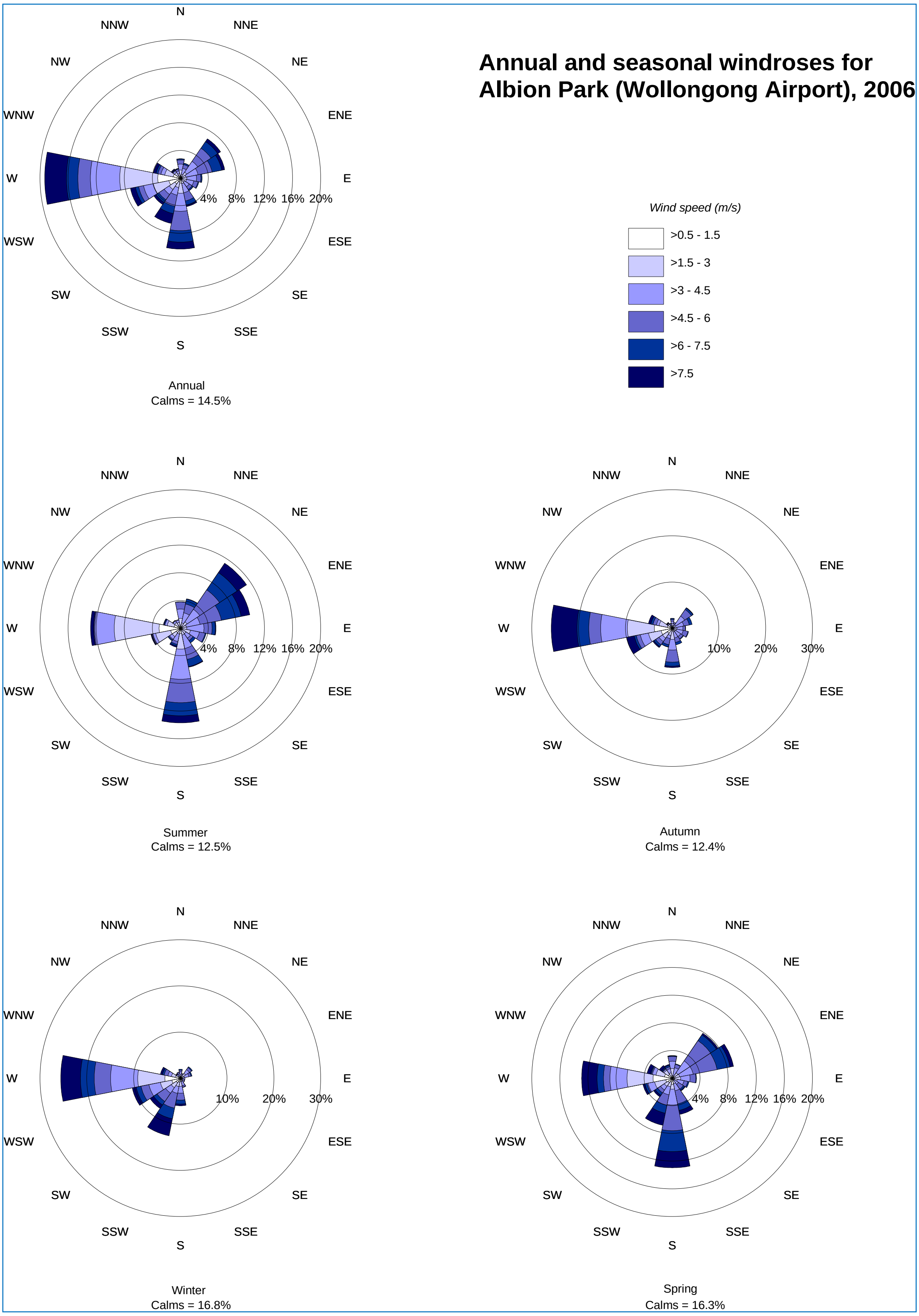

Figure C.2: Annual and Seasonal Windroses for 2006

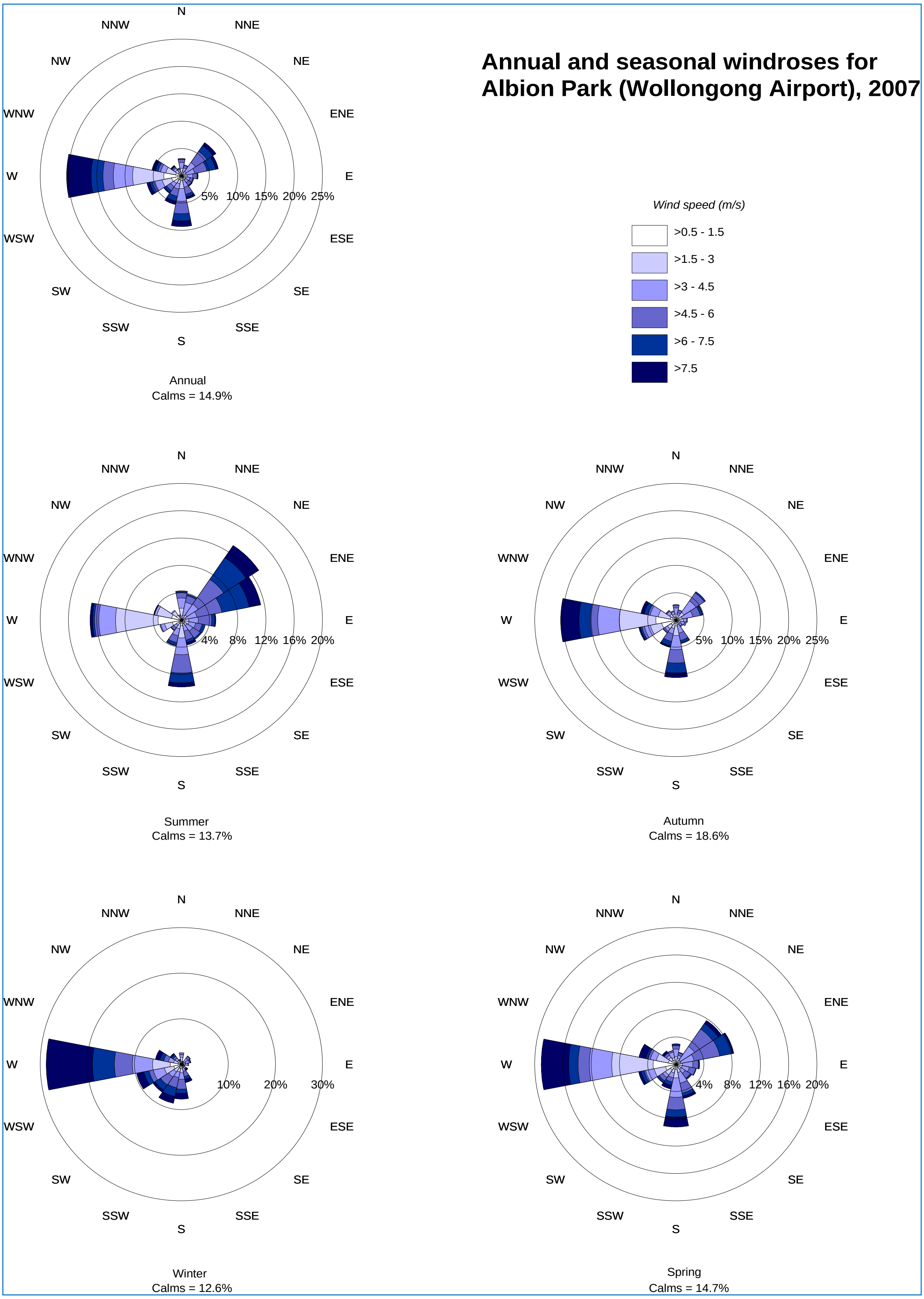

Figure C.3: Annual and Seasonal Windroses for 2007

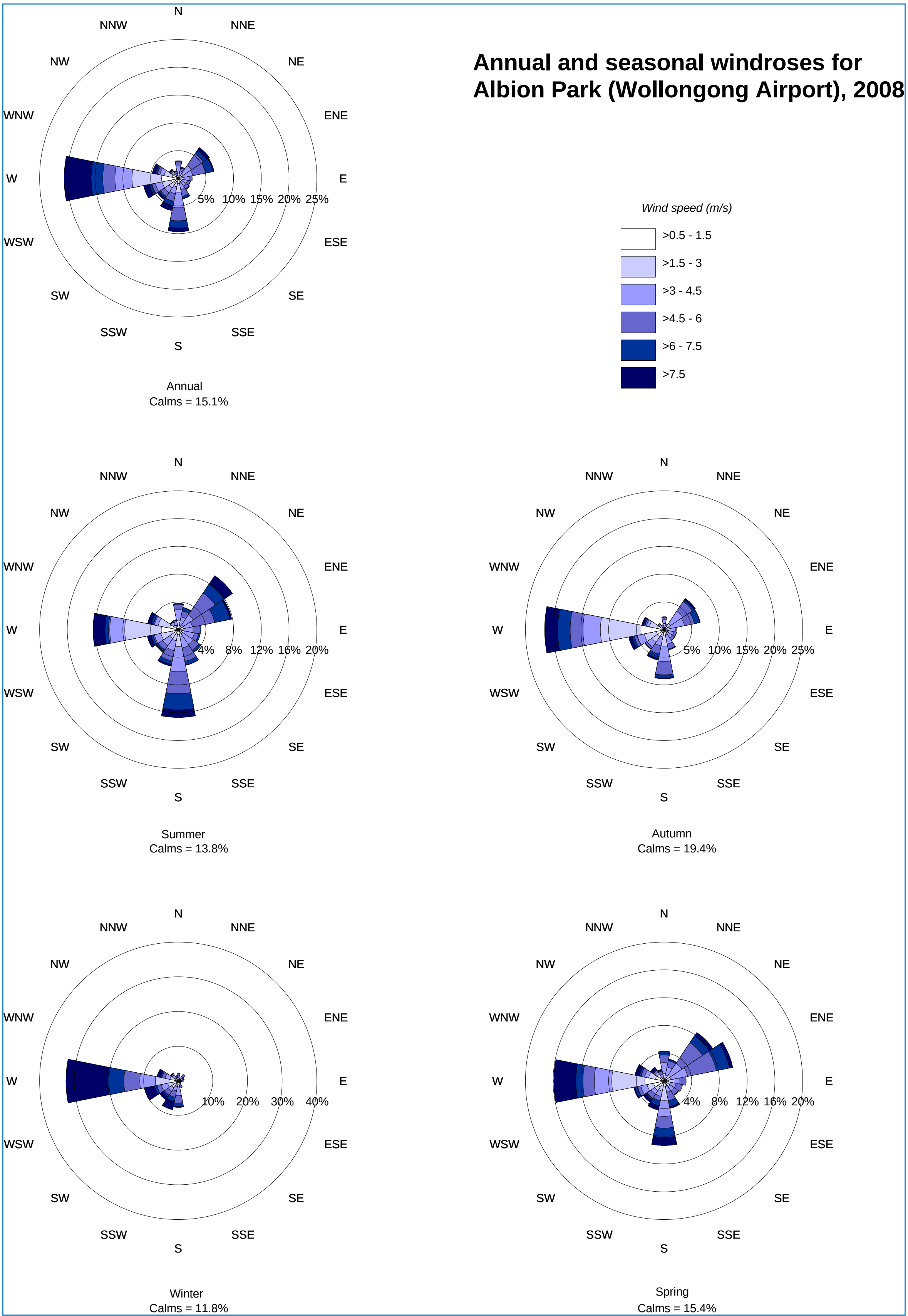

Figure C.4: Annual and Seasonal Windroses for 2008

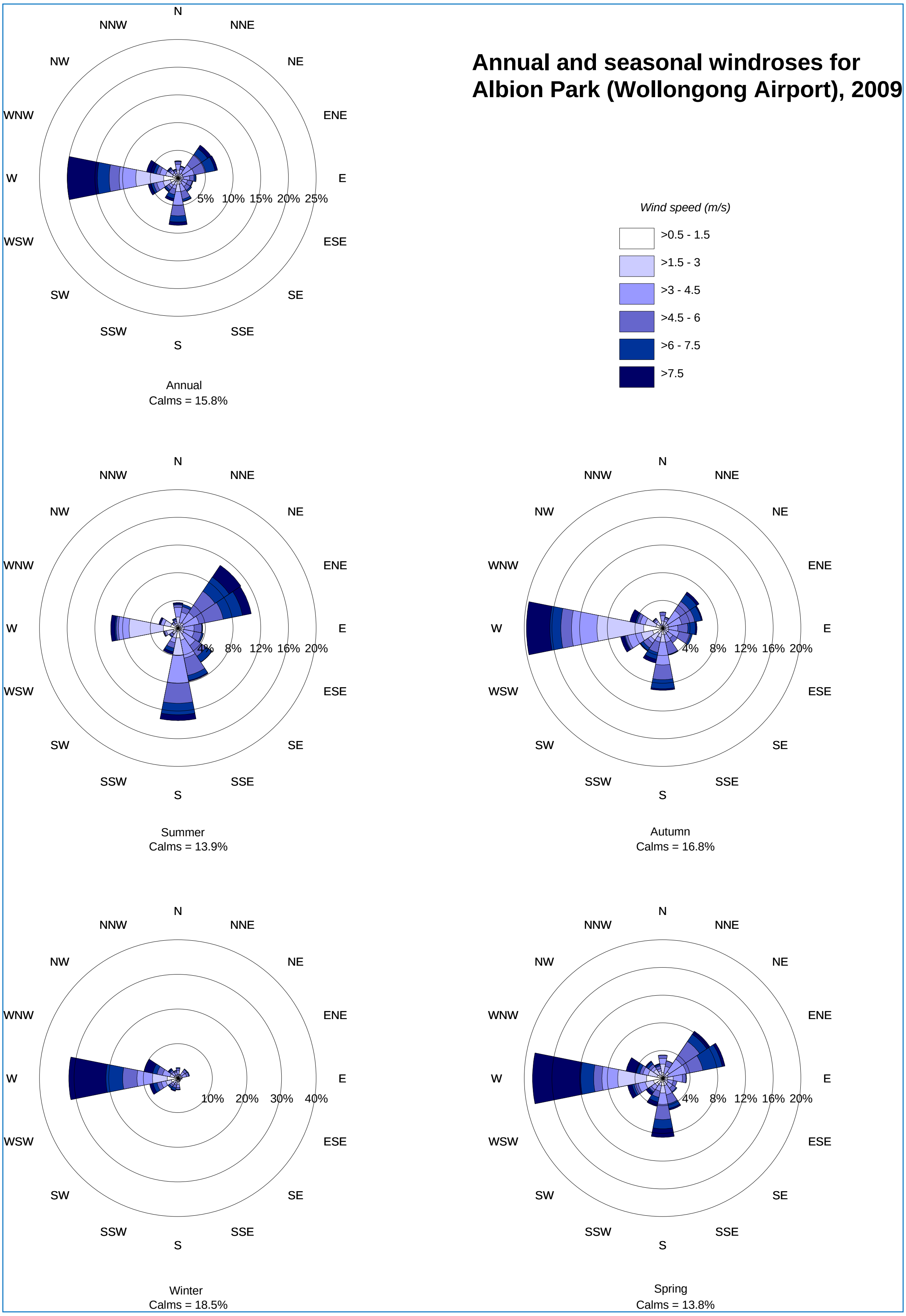

Figure C.5: Annual and Seasonal Windroses for 2009

Appendix D METEOROLOGY MODELS

D.1 TAPM

The Air Pollution Model, or TAPM, is a three dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. A detailed description of the TAPM model and its performance is provided elsewhere. The Technical Paper by **Hurley (2008)** describes details of the model equations, parameterisations, and numerical methods. A summary of some verification studies using TAPM is also given in **Hurley *et al*. (2008).**

TAPM solves the fundamental fluid dynamics and scalar transport equations to predict meteorology and (optionally) pollutant concentrations. It consists of coupled prognostic meteorological and air pollution concentration components. The model predicts airflow important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analyses.

Upper air data were generated over the study region using TAPM. It is noted that observed surface meteorological data nudged with TAPM in generating upper air data. CALMET was set up to use the TAPM generated upper air data as an initial guess field which is then adjusted to the observations in the final guess filed.

The TAPM-generated data and observed surface meteorological data were then entered into the CALMET diagnostic meteorological model, which is discussed below.

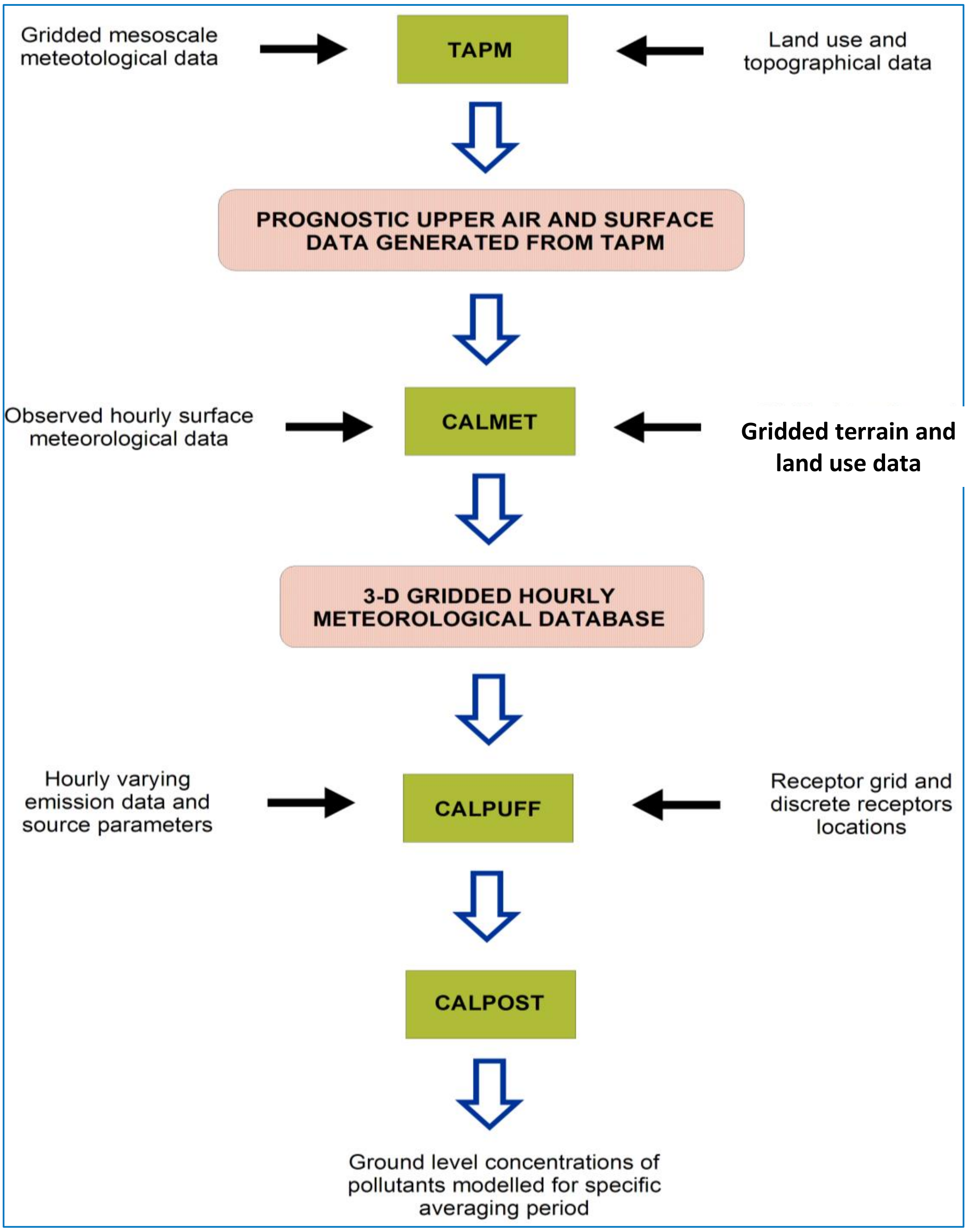

Figure D.1: Modelling Methodology utilised in this Study

D.2 CALMET

CALMET is a meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the three-dimensional meteorological fields that are used in the CALPUFF dispersion model.

The hourly TAPM-generated data and observed data for the period of analysis were used as input to the CALMET pre-processor to create a fine resolution, three-dimensional meteorological field for input into the dispersion model. CALMET uses the meteorological inputs in combination with land use and geophysical information for the modelling domain to predict girded meteorological fields for the region.

Hourly surface meteorological data from Wollongong Airport and Bellambi monitoring stations were used for the modelling year (2009). These data were the closest available data, approximately 12 km away. To use these observed data for the generation of meteorological data files a large computational grid domain is required. A coarse resolution would then be needed which may result in neglecting local terrain effects.

To overcome this problem, CALMET was run in two stages. The first stage was to run the model over a large domain (25 km by 25 km) with a coarse resolution (500 m) using the observations from Wollongong Airport and Bellambi monitoring sites combined with terrain data from Shuttle Terrain Mission dataset (100m resolution) and upper air data from TAPM output. The second stage involved using the output from stage one as input for CALMET over a much smaller domain (15 km by 15 km) and finer resolution (150 m). This fine resolution then captures any effects due to local terrain.

A summary of the data and parameters used as part of the meteorological component of this study are shown in **Table D.1**.

Table D.1: Meteorological Parameters used for this Study

TAMP (v 3.0)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grids point	25 x 25 x 25
Year of analysis	2009
Centre of analysis	34° 28' S, 150° 52' E
CALMET (v 6.212)	
Outer domain	
Meteorological grid domain	25 km x 25 km
Meteorological grid resolution	0.5 km
Fine Domain	
Meteorological grid domain	15 km x 15 km
Meteorological grid resolution	0.15 km
Surface meteorological stations	BoM Wollongong Airport and Bellambi Wind speed Wind direction Temperature Relative humidity Pressure Cloud cover TAPM* Missing data
Upper air meteorological stations	Data extracted from TAPM

*If no data is available for any hour at all BOM stations, data extracted from TAPM were used for that particular hour

Appendix E GREENHOUSE GAS CALCULATIONS

Fuel Consumption – Diesel

An estimate of the type (and period of use) of equipment involving diesel consumption was provided by TQ Holdings Australia. The total diesel accounted for within the data is equal to diesel used for transport, stationary and non-combustion purposes was estimated using the information provided.

Diesel consumed on-site is used in the following activities:

- Safety (diesel fire pump)
- Internal transport
- Equipment for general operations use (cranes).

Greenhouse gas emissions from diesel consumption were estimated using the following equation:

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1000}$$

Where:

E_{ij}	=	Emissions of GHG from diesel combustion	(t CO_2-e)[1]
Q_i	=	Quantity of fuel	(GJ)[2]
EC_i	=	Energy content of fuel	(GJ/kL)[3]
EF_{ijoxec}	=	Emission factor (Scope 1) for diesel combustion	(kg CO_2-e/GJ)[4]

[1] t $CO_{2\text{-}e}$ = tonnes of carbon dioxide equivalent
[2] GJ = giga joules
[3] GJ/kL = gigajoules per kilolitre
[4] kg CO_2-e/GJ = kilograms of carbon dioxide equivalents per gigajoule

Scope 1 fuel consumption emissions have been calculated using the energy content and emission factors from Table 4 of the National Greenhouse Accounts (NGA) Factors 2014 (**DoE, 2014**) and are presented in **Table D.1**.

Table E.1: Diesel (for stationary purposes) GHG Emission Factors – Scope 1

Fuel type	Energy Content (GJ/kL)	Emission factor (kg $CO_{2\text{-}e}$/GJ)		
		CO_2	CH_4	N_20
Diesel Oil	38.6	69.2	0.2	0.5

Source: Table 4 (DoE, 2014).

The estimated annual GHG emissions from diesel usage are presented in **Table D.2**.

Table E.2: Estimated $CO_{2\text{-}e}$ (tonnes) for Diesel Consumption

Stage	Diesel Consumption (kL)	Annual Emissions (t CO_2-e) Scope 1
1	26	69
2	40	108
3	58	154

Fuel Consumption - Electricity

GHG emissions from electricity usage were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

where:

E_{CO2-e}	=	Emissions of GHG from electricity usage	(tCO_2-e/annum)
Q	=	Estimated electricity usage	(kWh/annum)[1]
EF	=	Emission factor (Scope 2 or Scope 3) for electricity usage	($kgCO_2$-e/kWh)[2]

[1] kWh/annum = kilowatt hours per annum
[2] $kgCO_2$-e/kWh = kilograms of carbon dioxide equivalents per kilowatt hour

The quantity of electricity used each year was provided by TQ Holdings Australia, as presented in **Table D.3**.

Table E.3: Estimated CO_{2-e} (tonnes) for Electricity Consumption

Stage	Electricity Consumption (kWh)	Annual Emissions (t CO_2-e) Scope 2
1	3,687,525	3,171
2 (Stage 1 inclusive)	5,527,017	4,753
3 (Stages 1 and 2 inclusive)	6,487,858	5,580

Scope 2 emissions have been calculated using an emission factor of 0.86 kg CO_2-e/kWh for New South Wales and Australian Capital Territory as sourced from Table 41 of the National Greenhouse Accounts (NGA) Factors 2014 (**DoE, 2014**).

The estimated annual and Project total GHG emissions from electricity usage are presented in **Table E.3.**