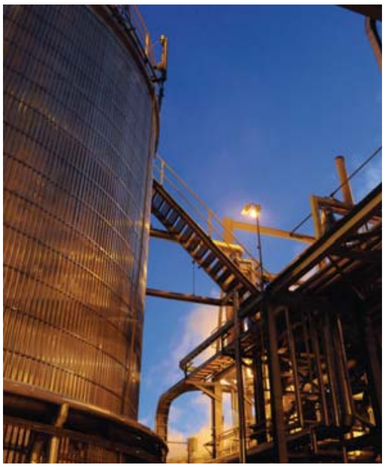
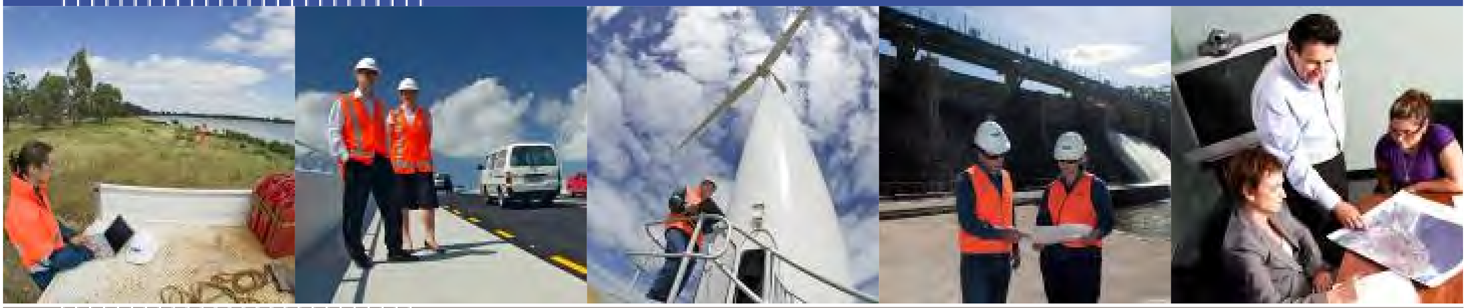
  

Appendix E

Air Quality Impact Assessment Report

URS
DYNO Dyno Nobel
Incitec Pivot
SouthernCross International

Incitec Pivot Limited



APPENDIX E

Air Quality Impact Assessment for Proposed Ammonium Nitrate Facility, Kooragang Island

24/08/2012

Prepared for

Incitec Pivot Limited

Heron Rd, Kooragang Island, New South Wales

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Abbreviations

Abbreviation	Description
AN	Ammonium Nitrate
ANSOL	Ammonium Nitrate in Solution
Approved Methods	The Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales
AQIA	Air Quality Impact Assessment
BAT	Best Available Techniques
DEC	NSW Department of Environment and Conservation
DGRs	Director General Requirements
EIS	Environmental Impact Statement
HP	High Pressure
IPL	Incitec Pivot Limited
KI	Kooragang Island
ktpa	Kilotonnes per annum
LP	Low Pressure
MPa	Megapascals
Mt	Mega-tonne
NA	Nitric Acid
Nm^3	Normal cubic metre (i.e. at conditions of 1 atmosphere and 0℃)
NH_3	Ammonia
NSCR	Non Selective Catalytic Reduction
NSW	New South Wales
NO	Nitric oxide
N_2O	Nitrous oxide
NO_2	Nitrogen dioxide
OEH	NSW Office of Environment and Heritage
Orica	Orica Australia Pty Ltd
PM	Particulate Matter
$PM_{2.5}$	Particulate matter 2.5 microns and smaller
PM_{10}	Particulate matter 10 microns and smaller
ppmv	Parts per million by volume
ppmvd	Parts per million by volume, at dry conditions (i.e. excluding moisture)
ppbv	Parts per billion by volume
SCR	Selective Catalytic Reduction
TAPM	The Air Pollution Model
TGAN	Technical Grade (solid) Ammonium Nitrate
tpd	Tonnes per day
tph	Tonnes per hour
TSP	Total Suspended Particulates

Executive Summary

URS Australia Pty Ltd (URS) was commissioned by Incitec Pivot Limited (IPL) to undertake an Air Quality Impact Assessment (AQIA) for the proposed ammonium nitrate facility (the Project) to be located on land within IPL's existing property at Kooragang Island, Newcastle, in New South Wales (the Project Site). This assessment has been performed in accordance with (DEC, 2005) Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (the Approved Methods).

Based on a review of the proposed operations, emissive processes were identified for consideration in the AQIA. These primarily included Nitric Acid (NA) manufacture, and Technical Grade Ammonium Nitrate (TGAN) manufacture. Key pollutants associated with these processes were identified as Oxides of Nitrogen (NO_x), Particulate Matter (as PM_{10}), and ammonia.

URS conducted a review of proposed plant items, as well as engineering estimates of emissions to air. From this, a summary of proposed emission controls was prepared, which was used for comparison against Best Available Techniques (BAT) for emission control based on international references. This comparison identified that the processes and emission controls proposed by IPL as consistent with BAT, as defined in recent references (IPPC, 2007). A summary of proposed licence limits was also prepared and reviewed against NSW regulatory emission limits. The proposed limits were found to comply with the relevant regulatory limits. From this information, an air emissions inventory was also prepared, identifying operational source parameters and emission rates of key pollutants for subsequent use in atmospheric dispersion modelling. Annualised emissions were also estimated, and compared to National Pollutant Inventory totals for the Newcastle local government area, of which the Project was estimated to emit an additional 1.5% and 1.1% of NO_x and PM_{10} (respectively).

A review of the existing environment and air quality was conducted, arriving at a set of pollutant concentrations suitable for incorporation as background data for the cumulative assessment of existing and Project related pollutant levels. A meteorological dataset was prepared, comprising a 10 x 10 km region surrounding the Project Site. This involved sourcing meteorological records from a range of Office of the Environment and Heritage (OEH) and other Automatic Weather Stations (AWS) and assimilating the data into the CSIRO's TAPM prognostic meteorological model. TAPM generated upper air files along with actual surface observations were incorporated into the Calmet meteorological pre-processor for Calpuff, an OEH approved dispersion model, which is recommended for use in coastal locations such as that of the Project.

The meteorological dataset was incorporated into the Calpuff dispersion model, and the influence of Project emissions were quantitatively assessed against OEH impact assessment criteria contained in the Approved Methods. Dispersion modelling was performed for normal operation, as well as infrequent events such as plant startup and ammonia flaring. An investigation of potential cumulative impacts from the approved/proposed Orica Kooragang Island ammonium nitrate facility expansion project was also undertaken.

Given the high anticipated operating duty of the Project (>95%), operational emissions were considered to be of key importance. Dispersion modelling predicted a peak incremental 1 hour all NO_x as NO_2 concentration of 53 µg/m³, which was confined to a small area to the west of the Project Site. Peak incremental 1 hour NO_2 impacts were estimated to be less than 30 µg/m³ at all non-industrial locations, with a maximum of 27.8 µg/m³ predicted at Stockton. In the context of peak background levels (which were estimated at 84 µg/m³), this peak cumulative prediction of 112 µg/m³ was found to be below the OEH NO_2 criterion of 246 µg/m³. Operational PM_{10} and ammonia predictions were also found to be minor, and within OEH impact assessment criteria, with peak incremental concentrations

constituting approximately 1% and 4% of the relevant criteria, respectively. Modelling predictions for non-routine operations and cumulative operation with the proposed (adjacent) Orica upgrade were found to be more elevated, yet within criteria, despite being based on conservative statistics and assessment methodologies.

Based on the information reviewed and the assessment performed the potential for the Project to result in adverse air quality impacts is considered to be low.

Introduction

1.1 Introduction

URS Australia Pty Ltd (URS) has been commissioned by Incitec Pivot Limited (IPL) to undertake an Air Quality Impact Assessment (AQIA) for the proposed ammonium nitrate facility (the Project). The Project is to be located on IPL's existing property at Kooragang Island. This lot of land (the 'Lot') is situated at 39 Heron Road, Kooragang Island within the Port of Newcastle, approximately 3 kilometres (km) north from the Newcastle CBD, NSW. The Lot is legally described as Lot 3 on DP1117013 and is 36.8 hectares (ha) in size. Within the Lot is an area (the 'Project Site') which includes the existing operations of Incitec Pivot Fertilizers, as well as a section of mainly vacant land on which the Project is proposed to be situated. The physical boundary of Lot and Project Site are shown in **Figure 1-1**.

Figure 1-1 Aerial view of Lot boundary (blue) and Project Site boundary (red)

Aerial image sourced from Nearmap 2011

1 Introduction

The Project consists of a 350 kilo tonne per annum (ktpa) ammonium nitrate manufacturing facility incorporating:

- A 30,000 tonne anhydrous ammonia storage area;
- A 280,000 tonne per annum nitric acid[1] plant;
- A 350,000 tonne per annum 100% ammonium nitrate plant;
- Bulk storage of 5,000 tonnes of technical grade ammonium nitrate;
- Bagging facility for technical grade ammonium nitrate including storage of 6,000 tonnes; and
- Auxiliary infrastructure and utilities.

The Project does not include ammonia manufacture, as ammonia would be imported to the Project Site. The Project Site will operate 24 hours per day, 7 days per week. IPL anticipate that the proposed facility will have a life of 25+ years.

1.2 Assessment Scope

The Director General's Environmental Assessment Requirements (DGRs) for the environmental assessment of the Project outlines that the:

"Environment Impact Statement (EIS) must address:.. …Air Quality and Odour, including:

- *An assessment of all pollutants from all sources during construction and operation, and from road, rail and sea transport, including any potential volatile organic compounds, particulates, odour, NOx, N_2O, and NH_3;*
- *Details of all control measures including NO_x and N_2O abatement, and start-up venting controls for NO_x and NH_3 for the Nitric Acid Plant; and*
- *Cumulative impacts of the proposal in relation to approved and existing and approved developments the area."*

To satisfy the DGRs, and facilitate the consideration of the Project approval in the context of air quality issues, the AQIA has included the following:

- A review of proposed activities and production processes;
- Identification of emission sources and key pollutants;
- A review of regulatory criteria including emission limits and impact assessment criteria;
- Benchmarking of proposed emission controls against Best Available Techniques (BAT), and a comparison of proposed emission limits against regulatory emission limits;
- A review of existing environment including climate, meteorology and existing air quality;
- Preparation of an air emissions inventory for the Project;
- Atmospheric dispersion modelling of Project emissions; and
- Comparison of predicted impacts against relevant impact assessment criteria.

[1] In this report, NA denotes Nitric Acid on a 100% basis.

Site Operations

2.1 Existing Operations

The existing fertiliser storage, bagging and distribution operation on the Project Site would be retained, with the Project being located on unused land on the centre and east of the Lot. The Project Site is currently used as a primary distribution centre (PDC) by IPL. The Project Site currently receives and stores solid fertilisers, before blending, bagging and dispatching both bulk and bagged fertiliser. The existing operation currently handles approximately 155 ktpa and dispatches this material in both 25 kilogram (kg) bags and Flexible Intermediate Bulk Containers (FIBC).

Bulk operations are performed in two interconnected bulk sheds that are approximately 18 m high and which are located in the north west of the Lot. Bagging operations are performed in a dedicated bagging shed on the Project Site. Extensive conveyor systems exist for both bulk shed and bagging operations to transport materials around the Project Site. Within the bulk sheds, bulk tippers are located that discharge product into bulk storage bays. From the storage bays, product is loaded with front-end loaders via hoppers into blending units. The load out building on the Project Site is approximately 10 m high and has access to the road to allow product to be prepared for removal from the Project Site via road transport.

In addition to fertiliser, the PDC stores, handles and dispatches approximately 20 ktpa of sulphuric acid (via road tanker) for industrial chemical users, and 20 ktpa of ammonium nitrate. Bulk sulphuric acid is imported by ship, unloaded at Kooragang Island berth and transferred by pipeline into three large storage tanks located on the Project Site.

2.2 Project – Construction Phase

The construction phase is expected to last approximately 28 months, and would be anticipated to start in the first quarter of 2013. For the purposes of this assessment, the construction phase has been divided into four stages. A description of each stage follows.

Stage 1 - Project Site preparation

During this stage the eastern part of the Lot would be prepared for construction. Where required, land would be graded and if necessary certain vegetation and waste would be removed from the Lot. Construction laydown areas, the internal road system, storage and stockpile locations, construction offices, as well as other construction related equipment and facilities and structures would be established. This stage is expected to last approximately six months.

Stage 2 - Civil and structural works

During this Stage the civil and structural work for the Project would be completed in order to prepare the Project Site for the delivery of various modules. These works would involve excavations, dewatering (if required), stockpiling of soils and other ground preparation activities. Other activities that would be completed during this stage include:

- Piling and foundations;
- Installation of key utilities;
- Preparation of concrete slabs;
- Construction of the stormwater system and internal road network;
- Erection of steel structures, other buildings and structures (e.g. load out areas, storage area, pipeline gantries, workshops, control buildings etc.); and

- Preparation of bunded areas.

This stage is expected to last approximately 15 months; from month 7 to month 21. This stage would overlap with stages 3 and 4.

Stage 3 - Module Erection and General Activities

During this stage various pre-constructed Project components would be shipped to Newcastle Harbour before being transferred to barges at the Western Basin berths. Once on the Project Site, the various modules would be fixed to the appropriate structures and joined to other Project components. This construction stage is expected to last approximately 18 months; from month 9 to month 26.

Stage 4 - Commissioning

During this stage a number of pre-commissioning and commissioning activities would be completed, including testing and initial startup of the nitric acid and ammonium nitrate plants. This stage is expected to last approximately 11 months from; month 18 to month 28.

2.3 Project - Operational Phase

2.3.1 Ammonium Nitrate Production Overview

The proposed ammonium nitrate manufacture consists of a range of processes, which produce and consume a range of intermediate constituents. Within this assessment, the abbreviations in **Table 2-1** have been used to denote some of these substances.

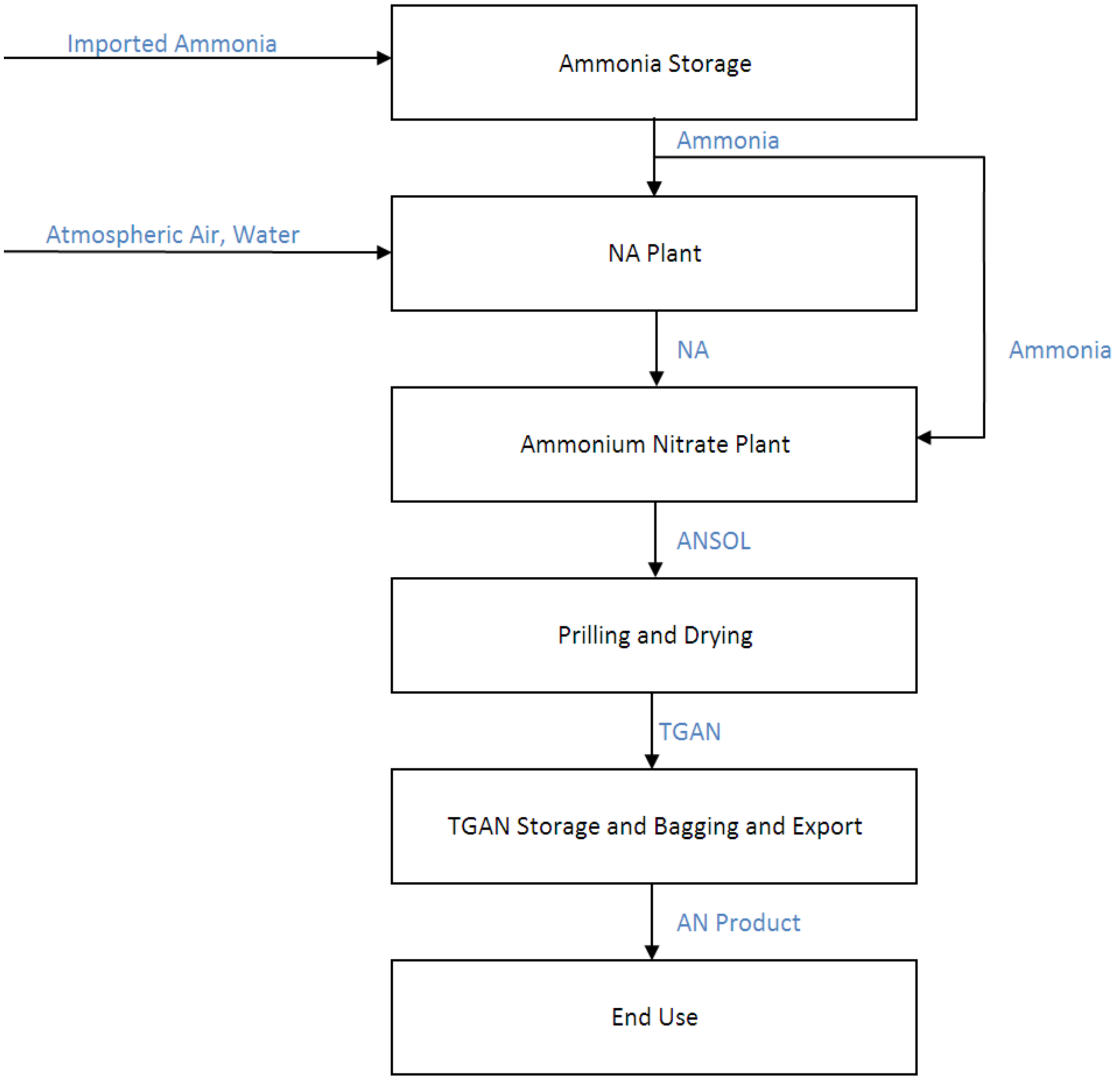
Table 2-1 Abbreviations used for ammonium nitrate products and process intermediates

Abbreviation	Description
AN	Ammonium Nitrate
ANSOL	Ammonium Nitrate in Solution
NA	Nitric Acid
TGAN	Technical Grade (solid) Ammonium Nitrate

Figure 2-1 provides a simplified[2] overview of the TGAN production process. Ammonia is brought to the Project Site, either by ship, or road tanker, and stored for use. Some of this ammonia is mixed with air and reacted to produce NA. This NA is neutralised with ammonia to produce ANSOL which is then concentrated. Droplets of ANSOL are then dispensed into a tower containing a counter current air flow. As the mixture falls, it is dried into small solid pellets (prills). These prills are further dried, then subsequently despatched in bulk to Hunter Valley mining customers, or bagged and exported to end users.

[2] Diagram has been simplified to show an overview of the process. Energy inputs, waste streams and intermediate storage have been excluded.

Figure 2-1 Simplified process flow diagram for AN production process



2.3.2 Ammonia Import and Storage

IPL do not propose to produce ammonia at the facility, rather anhydrous liquid ammonia would be imported to Project Site either by ship or by road tankers. Deliveries by ship would take place at a new berth constructed by Newcastle Ports Corporation, to be located between the existing Kooragang Island berths K2 and K3. Shipments would range between approximately 15 kilo tonne (kt) and 23 kt, with total ship imports constituting approximately 160 ktpa. IPL anticipate approximately 8 ship movements per year, with a ship present at Berth for approximately 36 hours per import event.

Ammonia would be unloaded at the Kooragang Island berth and transported to the Project Site via pipeline. Ammonia is currently imported and exported from the Kooragang Island berth.

IPL also propose to deliver approximately 20 ktpa of ammonia to the Project Site by road tanker. This ammonia would be brought from IPL operations in Queensland. Approximately 20 ktpa would be distributed in road tankers from the Project Site to external IPL fertiliser business operations.

Given that ammonia is a gas at ambient temperatures, liquid storage requires cooling to compensate for heat that is conducted through tank insulation, and thus minimise ammonia vaporization. In addition, during ammonia import operations, boil-off gas is produced as heat from piping infrastructure is taken up by the ammonia stream. IPL propose to accommodate for these effects through the use of refrigeration units. These refrigeration units would be configured in parallel, and supplied with backup power in order to accommodate electricity network outages.

A single refrigeration unit would be operational during routine storage operations, whilst a second refrigeration unit would be brought on line to supplement cooling requirements during ammonia import operations. The use of parallel units with backup power minimises risks of a refrigeration failure, in which a stream of boil off ammonia would be produced. In this unlikely event, ammonia boil off would be vented to an ammonia flare, located at the south of the Project Site. Natural gas would be used as pilot fuel and would also be used to assist ammonia combustion during a flaring event.

IPL anticipate that ammonia flaring events would very infrequent, occurring less than once in 10 years, with a typical event lasting for approximately 12 hours.

2.3.3 Nitric Acid Production

The proposed NA Plant is based on the Espindesa high efficiency dual pressure technology. Although higher in capital cost than the mono pressure process, the dual pressure process has a higher ammonia conversion efficiency, lower catalyst consumption and longer catalyst life.

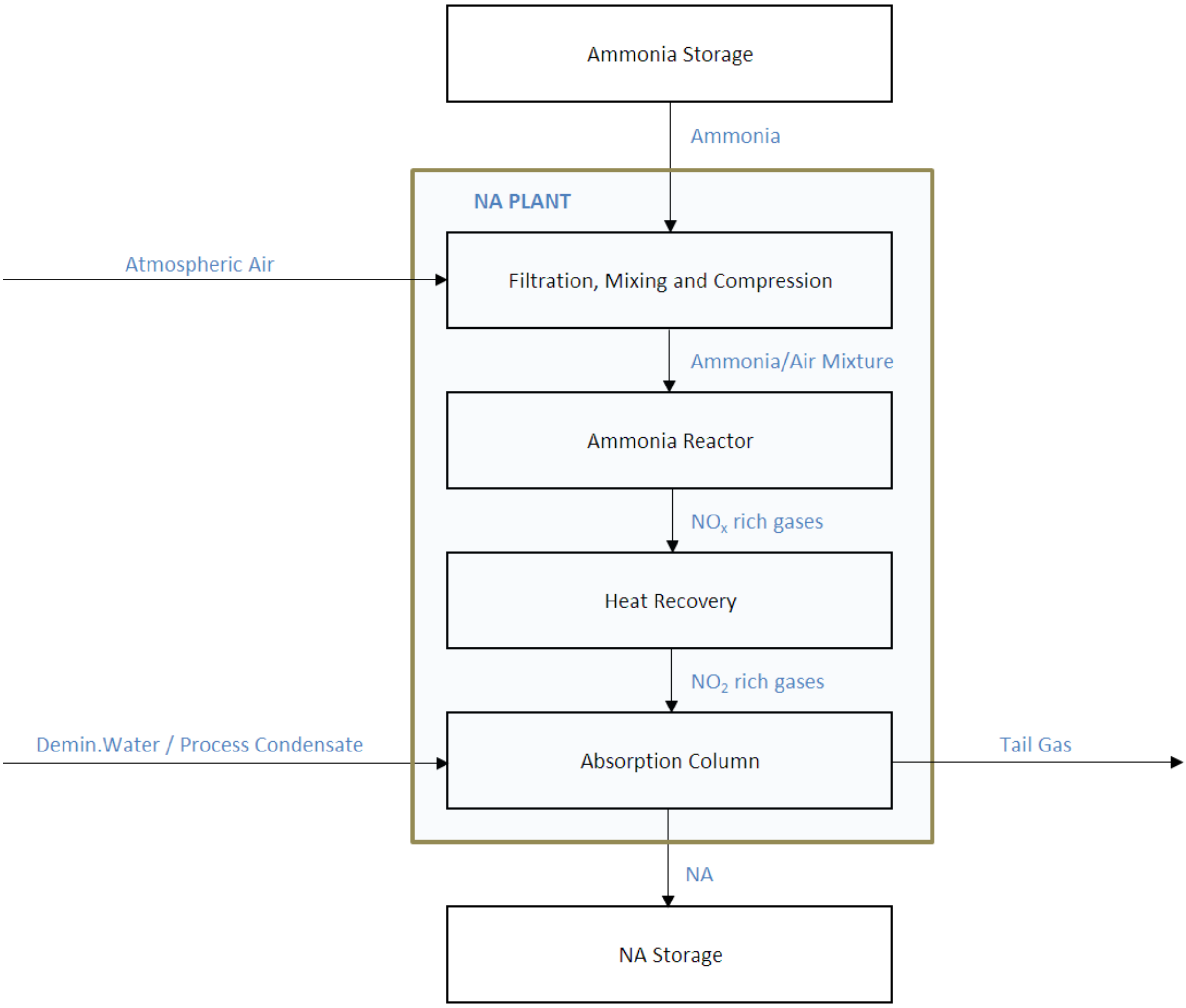
The NA plant has a nominal NA production capacity of 760 tonnes per day (tpd), producing up to 280 ktpa[3] when running at 100% capacity. The NA plant would operate on the basis of continuous manufacture with an input of ammonia and an output of NA.

Figure 2-2 provides an overview of the NA process, whilst the following sections provide a detailed description of the NA production process.

[3] NA plant capacities are based on 100% concentration whereas NA storage capacities based on solution concentration of less than 100% (normally 60%).

2 Site Operations

Figure 2-2 NA process overview



Feedstock Preparation

The ammonia feedstock is sourced as a liquid from ammonia storage at -33^{0}C. Liquid ammonia is filtered and vaporised using chilled water and superheated with steam to prevent any liquid carryover. The ammonia vapour is fed to a mixer where it is combined with filtered-preheated air in a ratio of approximately 10:1 (ammonia to air).

Ammonia Oxidation

The ammonia-air mixture is pressurised to approximately 0.4 MPa, and directed into an ammonia reactor, where it is reacted on a platinum/rhodium alloy catalyst. Nitric oxide (NO) and water are formed in this process according to the desired reaction (Equation 1):

Equation 1: $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

Simultaneously, nitrous oxide (N_2O), nitrogen and water are also formed.

Equation 2: $4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$

Equation 3: $2NH_3 + 2O_2 \rightarrow N_2O + 3H_2O$

The oxidation reactor includes several catalysts which work by lowering the activation energy required for a desired reaction. In this case the platinum-rhodium gauze promotes the reaction described in **Equation 1**. The other reactions, described within **Equation 2** and **Equation 3**, are undesirable; however still occur to some extent within the process.

The hot reaction gases are then cooled down to approximately 50-55°C by passing through a series of heat exchangers. During this process, the nitric oxide (NO) in the hot reaction gases is oxidised to nitrogen dioxide (NO_2) as the gases are cooled:

Equation 4: $$2NO + O_2 \rightarrow 2NO_2$$

As part of this process a weak NA (30%) would be formed by the reaction of nitrogen dioxide and condensed water.

NO_2 Absorption

The resultant NO_2 rich gas stream is compressed to approximately 1.0 MPa, and directed to an aqueous absorption column. Weak NA (condensed from the post-oxidation cooling) and demineralised water are also injected into this column. NO_2 is absorbed to form NA in accordance with:

Equation 5: $$3NO_2 + H_2O \rightarrow 2HNO_3 + 2NO$$

The NA produced in the absorber contains dissolved nitrogen oxides which are physically stripped off and returned to the absorber using bleaching air. The acid is transferred from the bottom of the absorber to a NA storage tank, whilst excess (tail) gas from the process is directed to a heat exchanger.

Cooling is provided to the absorber, as this promotes the formation of NO_2, a favourable reactant (as in **Equation 5**), whilst also reducing NO_x levels in the tail gas to less than 500 parts per million by volume (ppmv).

Nitric acid (60%) is to be stored in an atmospheric nitric acid storage facility with a capacity of circa 3,000 tonnes. The tank vent is to be fitted with a simple gravity water scrubber design.

2.3.4 Ammonium Nitrate Production

The proposed AN plant is based on the Espindesa ammonium nitrate process technology. The plant has a nominal production capacity of 1060 tpd[4] (350 ktpa) AN, and would consist of two main parts:

- **AN Liquor Plant –** where the AN would be produced in a neutralisation process and concentrated in an evaporation process to produce ANSOL; and
- **TGAN Prill Plant –** where approximately 80% of ANSOL would be turned into prill.

The AN plant would be located directly north of the NA plant. The AN Liquor Plant would occupy a footprint of approximately 27 m x 27 m, whilst the TGAN Prill Plant would occupy a footprint of approximately 40 m x 36 m. The majority of the components within both plants would be less than 25 m in height from the ground. The exception would be the Prill Tower which would be approximately 61 m in height from the ground and have a base of 12 m x 12 m.

[4] AN plant capacities are based on 100% concentration whereas AN storage capacities based on solution concentration of less than 100% (normally 88%)

2 Site Operations

The plant would work on the basis of continuous manufacture with inputs of ammonia and NA and an output of ANSOL and TGAN. A description of the AN process through the various components of the plant is provided below.

Neutralisation

Liquid ammonia would be pumped from the ammonia storage tank where it would be vaporised in the Ammonia Evaporator, passed through an ammonia liquid – vapour separator to remove any liquid droplets and then superheated in the in the ammonia reheater. This vapour would then be fed into the Neutralisation Reactor alongside a commensurate flow of NA.

In the Neutralisation Reactor, ammonia and nitric acid would be reacted together to form ANSOL as shown in **Equation 6**.

Equation 6: $$NH_3 + HNO_3 \rightarrow NH_4NO_3$$

The AN solution would then be concentrated and directed to either the TGAN prill plant or ANSOL storage.

Prilling and Drying

The prilling process allows the ANSOL to form into solid porous spheres which can be safely transported and used in the mining process. An additive is mixed with the concentrated ANSOL to assist crystallisation. The ANSOL / Additive mixture would then be passed through a number of spray nozzles. As the mixture falls, the counter current flow of air up through the Prilling Tower would cool and solidify the droplets into AN prill.

The warm air stream leaving the top of the Prill Tower would be scrubbed with weak AN solution to remove entrained AN dust, ANSOL and any free ammonia. The scrubber would also cool the air stream allowing greater volumes of air to be recycled into the base of the Prill Tower, thereby further reducing the emissions.

The balance of air from the scrubber would pass through a second stage of scrubbing, before being discharged via the vent stack. The second stage scrubber would consist of a primary venturi scrubbing and secondary packed column scrubbing to ensure maximum scrubbing efficiency. The two stages of scrubbing would eliminate the majority of pollutants in the discharged air.

The prills would be taken by conveyor to a series of drums that would cool and dry the prills. The heat in the prill would be removed by the Fluidised Bed Cooler by means of a number of fans. The counter-current air flow in the pre-drying and drying drums would allow any remaining water to be evaporated before progressively drying and hardening the product. The air leaving the drums would be would be sent to the venturi scrubber and then the Dryer Air Scrubber to reduce air emissions. Once scrubbed the air would then be sent to the AN Stack.

After cooling, the prills would be sent to the Coating Drum to be coated with an anti-caking additive and transferred by enclosed conveyors to the bulk store.

2.3.5 Product Distribution and Storage

TGAN Prill Storage and Distribution

The bulk store would have storage capacity for approximately 5,000 t of TGAN. A load out system would load the TGAN into bulk tippers for dispatch to IPL's Warkworth facility and customers in the Hunter Valley.

TGAN would also be transferred by conveyor to a bagging plant, where it would be loaded into one tonne bulk bags for export and domestic sale. The bags would be stored in shipping containers for export and an existing bag store for domestic sale.

Waste ANSOL Handling

Waste ANSOL that cannot be recycled into the process would be stored in a 145 t tank before being concentrated to approximately 70% for fertiliser sales. ANSOL waste from a number of processes would be stored in Waste Weak ANSOL Tanks before being pumped to the ANSOL Concentrator Column. The ANSOL waste would be concentrated in the column by heating the solution to 90^0C using a heat exchanger and introducing ambient air to the base of the column from the Stripping Air Blower. The process of evaporation and water absorption by the air concentrates the waste ANSOL. When the concentration reaches 70% the solution would be pumped to the Concentrated Waste ANSOL Tank. Before leaving the column the air would be scrubbed with fresh weak ANSOL and process water.

The Concentrated Waste ANSOL would be stored in this tank until being sent to a separate load out facility with a specific loading arm to load the tankers.

2.3.6 Process Heat (Auxiliary Boiler)

During operation, heat from exothermic reactions will provide adequate heat to generate the process heat (steam) for the plant. During plant startup, HP steam is required to operate the NA compressor. In addition, LP steam will be required to provide supplementary heat to a range of processes. IPL propose to provide this steam through the operation of a (natural) gas-fired package boiler. The boiler would be approximately 40 tph capacity, occupy a footprint of 10 m x 20 m, and be approximately 4 m high.

The boiler will also be used to provide steam to generate power via the NA compressor electrical generator unit.

Emissions to Air

3.1 Project Emission Sources

The Project involves a range of plant components that produce gaseous waste streams. URS has reviewed engineering documentation for the Project, including a gas effluent summary for the proposed infrastructure. Based on this review, the following air emission points were identified as being of potential significance:

- NA plant stack;
- NA storage tank vent;
- AN plant scrubber stack;
- Auxiliary boiler stack;
- Ammonia storage flare;
- AN bagging plant dust extraction; and
- Waste ANSOL concentrator.

Table 3-1 shows emission sources, and the respective processes from which each effluent gas stream is generated.

Table 3-1 Emissions to air

Emission Source	Generation Process
NA plant stack	Tail gas from aqueous absorption of NO_x gases.
NA storage tank vents	Displacement of NO_x gases from NA storage tank headspace.
AN plant scrubber	Moisture-laden exhaust stream from AN prilling and drying.
Auxiliary boiler	Exhaust stream from natural gas combustion.
Ammonia storage flare (standby)	Exhaust stream from natural gas combustion.
Ammonia storage flare (operation)	Exhaust stream from (natural gas-assisted) ammonia combustion.
AN bagging plant dust extraction	Exhaust stream from material handling operation.
Waste ANSOL concentrator	Moisture-laden exhaust stream from ANSOL concentration.

3.2 Offsite Emissions

IPL anticipate that ammonia import operations will require approximately 8 deliveries per year, with ships being at berth for a total duration of 36 hours at berth per import event. The Newcastle ports website notes that Newcastle port currently handles around 3,000 ship movements per year[5]. In the context of existing shipping operations emissions from infrequent shipping imports are considered negligible, and have been excluded from quantitative assessment.

3.3 Key Pollutants

Key pollutants have been identified based on engineering documentation, as well as a review of a proposed production processes. This review incorporated information available in emission estimation, process, and emission control manuals including the following:

[5] http://www.newportcorp.com.au/site/index.cfm?display=111636 (accessed 23/05/12)

- (NPI, 1999) *National Pollutant Inventory Emission Estimation Technique Manual For Explosives Manufacturing,* National Pollutant Inventory, Department of Environment and Heritage, August 1999;
- (USEPA, 1995) AP 42, Fifth Edition Compilation of Air Pollutant Emission Factors, Section 8.0 Inorganic Chemical Manufacturing., Volume 1: Stationary Point and Area Sources;
- (AWMA, 1992) *Air Pollution Engineering Manual*, Edited by Buonicore A J, and Davis W T, Published by the Air & Waste Management Association, 1992;
- (IPPC, 2007) *Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilisers,* European Commission, August 2007;
- (EFMA, 2000) *Best Available Techniques for Pollution Prevention and Control in the European Fertilizer Industry Booklet No. 6 of 8: Production of Ammonium Nitrate and Calcium Ammonium Nitrate*, European Fertilizer Manufacturers' Association, 2000.

Table 3-2 shows identified emission sources, and key pollutants by source.

Table 3-2 Pollutant types by emission source

Emission Source	Pollutant		
	NOx	Ammonia	Particulate Matter (as PM10)
NA plant	✓	✓	
NA storage tank vent	✓		
AN plant scrubber		✓	✓
Auxiliary boiler	✓		
Ammonia storage flare	✓	✓	✓
AN bagging plant dust extraction			✓
Waste ANSOL concentrator		✓	✓
TGAN Bulk Load Out Facility			✓

PM_{10} is considered the most relevant particulate class of emissions from the plant, where the use of wet scrubbers on key emission sources will capture the vast majority of particles greater than 10 microns in aerodynamic diameter.

It is also noted that the DGR's have requested the assessment of N_2O emissions. URS have not identified Australian standards relevant to local ambient air quality. URS notes that the Texas Commission on Environmental Quality has a 1 hour guideline value of 4,500 µg/m^3 (TCEQ, 2012). Given the magnitude[6] of the emissions of N_2O it is extremely unlikely that this guideline will be exceeded. Therefore N_2O emissions have been addressed in the greenhouse gas assessment conducted as part of this EA.

Given the minor scale of the proposed boiler, emissions such as carbon monoxide, sulphur dioxide and Hazardous Air Pollutants (HAPs) have not been assessed. It is also noted that Ammonia constitutes the key odorous pollutant associated with the Project, and has been used as a surrogate for the assessment of potential odour impacts.

[6] N_2O is expected to be released from the NA Plant at concentrations similar to NO_x (i.e. $NO+NO_2$), hence would be expected at a similar ratio in ambient air downwind of the NA Plant.

3.4 Regulatory Framework

There are three main types of regulatory criteria relevant to air emissions associated with the Project. These are:

- **Emission Standards** – which specify maximum allowable in-stack pollutant concentrations specified for particular industrial activities and plant types;
- **Air Impact Assessment Criteria** – ambient criteria designed for use in air dispersion modelling and air quality impact assessments for new or modified emission sources; and
- **Ambient Air Quality Standards** – regional standards against which ambient air quality monitoring results may be assessed.

A combination of Emission Standards and Air Impact Assessment Criteria are typically used to evaluate the expected impact of air emissions on local air quality, and the effectiveness of plant design with any associated mitigation measures. The wider objective of these criteria is to ensure that the resulting local and regional ambient air quality meets the relevant Ambient Air Quality Standards.

3.4.1 Emission Standards

The *Protection of the Environment Operations (Clean Air) Regulation 2010* (POEO) sets emission limits for air impurities from stationary plant and equipment. The current standards, as relevant to the Project are presented in **Table 3-3**. These limits are based on levels that are achievable through the application of reasonably available technology and good environmental practices.

Table 3-3 Emission standards relevant to the proposal, sourced from Schedule 3, Protection of the Environment Operations (Clean Air) Regulation 2010

Activity or Plant	Applicable Source	Air Impurity	Group 6 Standard of Concentration*
Acid Production	NA Stack	NO_x as NO_2	350 mg/m^3
		Smoke	Ringelmann 1 or 20% opacity
Any crushing, grinding, separating or materials handling activity	AN Plant Scrubber, Bagging Scrubber	Solid Particles	20 mg/m^3
Any boiler operating on gas	Boiler	NO_x as NO_2	350 mg/m^3 (3% O_2)
Any Flare	Ammonia Flare	Visible Emissions	No visible emission other than for a period of no more than 5 minutes in any 2 hours.

Note: An activity is designated to "Group 6" if it commenced to be carried on, or to operate, on or after 1 September 2005, as a result of an environment protection licence granted under the Protection of the Environment Operations Act 1997 pursuant to an application made on or after 1 September 2005. *Concentrations apply at reference conditions: dry, 273K, 101.3 kPa.

It is noted that these limits do not apply during:

- A start-up period—that is, while the plant is being brought up to normal operation following a period of inactivity; and
- A shutdown period—that is, while the plant is being taken out of service from normal operation to inactivity.

A comparison of proposed emission limits to those listed in **Table 3-3** is provided in **Section 4.3**.

3.4.2 Air Impact Assessment Criteria

In August 2005, OEH (NSW EPA) released the *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW*. This document specifies impact assessment criteria for a range of air pollutants. The impact assessment criteria for those pollutants associated with the Project are shown in **Table 3-4**.

Table 3-4 OEH impact assessment criteria

Substance	Averaging Period	Impact Assessment Criteria	
		(ppmv)	(µg/m³)
NO_2	1 hour	0.12	246
	Annual	0.03	62
Ammonia[1]	1 hour	0.46	330
Particulate Matter as PM_{10}	24 hour	-	50
	Annual	-	30

[1] In the Approved Methods, where a compound has both toxic and odorous properties, the lower criterion has been adopted, e.g. if a compound is determined to be toxic at levels below which it is determined to be odorous (as is the case for Ammonia), the endorsed criterion is based on toxicity. Hence this criterion is considered protective against odour impacts associated with ammonia emissions from the Project.

3.4.3 Ambient Air Quality Criteria

Ambient air quality criteria are provided in National Environmental Protection Measure (Ambient Air Quality) NEPC (1998). The guidelines contained in NEPC (1998) are designed for use in assessing regional air quality and are not intended for use as Project Site boundary or atmospheric dispersion modelling criteria, hence Project emissions have not been assessed directly against these guidelines. It should be noted, however, that the maximum concentrations for NO_2 and PM_{10}, are identical to the DEC (2005) criteria.

3.5 Background Information on Key Pollutants

3.5.1 Oxides of Nitrogen (NO_x)

Oxides of nitrogen (NO_X) are the sum of nitric oxide (NO) and nitrogen dioxide (NO_2). In combustion sources the primary mechanism for NO_X formation is termed "thermal NO_X". This occurs in the combustion zone, where high temperatures allow the dissociation of atmospheric nitrogen (N_2), after which the nitrogen may combine with excess oxygen. Generally, the NO_x emissions from a combustion source comprise approximately 90% NO and 10% NO_2 at the source. In addition, emissions from NA production comprise approximately 50% NO and 50% NO_2 at the source.

In the atmosphere NO and NO_2 are linked in a circular reaction with oxidants such as ozone, which generate NO_2 from NO and sunlight which breaks NO_2 down to NO. Due to this reaction sequence, the exact amount of NO and NO_2 within emissions is often unknown, and consequently the sum emission of both species (i.e. NO_x) is quoted. The ambient concentration of NO_2 near to a NO_X source is dependent on the amount of oxidant and sunlight at the time.

In ambient concentrations usually found within the atmosphere, NO has no impact on either human health or the environment. Conversely, it is known that "*exposures of NO_2 in the range of 1.5 ppm can cause small, statistically significant effects on airway responsiveness in healthy individuals. In studies* *with asthmatics, short term exposure to NO_2 as been associated with increased airway reactivity following exposures to 0.2 ppm to 0.3 ppm NO_2 for 30 minutes to 2 hours"* (NEPM, 2010). At present, the maximum short term exposure is set within NSW at 246 µg/m^3 (120 ppb). The long term effects of NO_2 are less well known although some evidence suggests poor lung function of inhabitants of areas with high NO_2 concentrations. To address the potential long term effects of NO_2, an annual average limit of 62 µg/m^3 has been set by OEH.

3.5.2 Ammonia

Ammonia is a naturally occurring colourless gas with a distinct and sharp odour. Ammonia dissolves in water to form aqueous ammonia (i.e. ammonia solution). In this form most of the ammonia changes to ammonium ions (NH_4^+) which are not gaseous, and have no odour. Ammonium ions contained within solution can alter their state back to their non-ionic form, thus resulting in ammonia gas being formed. Ammonium compounds, such as ammonium salts can also exist.

Ammonia is an important compound for organic life (i.e. plants and animals). It is found naturally in soil, water and air is a source of nitrogen for plants and animals. As a result ammonia tends not to last very long in the environment and is rapidly taken up by microorganisms. Ammonia exists naturally in the air at levels between 1 and 5 parts per billion (ppbv) (ATSDR, 2004a). Ammonia is also commonly found in household cleaning products and fertilizers.

At elevated concentrations, ammonia is considered as an air pollutant due to its corrosive nature. The toxic effects associated with ammonia are restricted to the area of direct contact (i.e. skin, eyes, respiratory tract etc.). Ammonia exposure typically occurs through the inhalation of ammonia gas and can cause irritation (i.e. coughing) and burns.

Short term health effects associated with ammonia are apparent in the form of irritation to exposure areas and burns. ATSDR (2004b) suggest that "*Exposures to levels exceeding 50 ppm result in immediate irritation to the nose and throat; however, tolerance appears to develop with repeated exposure".* Additionally ATSDR (2004b) sets an inhalation Minimal Risk Level (MRL) as follows *"An MRL of 1.7 ppm has been derived for acute-duration inhalation exposure (14 days or less) to ammonia. This MRL is based on a lowest-observed-adverse-effect level (LOAEL) of 50 ppm for mild irritation to the eyes, nose, and throat in humans exposed to ammonia as a gas for 2 hours".*

As identified in **Table 3-4**, the 1 hour average impact assessment criterion for Ammonia is 0.46 ppmv (330 µg/m^3).

3.5.3 Particulate Matter

Major natural sources of background particulate levels include forest fires, pollen and wind-blown dust from exposed areas. Anthropogenic sources include stationary and mobile combustion sources, road dust, agriculture, mining, major fires and emissions from industrial processes. Background levels vary widely depending on location, meteorology and proximity of major sources. Particulate matter is generally divided into three broad fractions:

- Total Suspended Particulate Matter (TSP);
- Particulate Matter of less than 10 µm in aerodynamic diameter (PM_{10}); and
- Particulate Matter of less than 2.5 µm in aerodynamic diameter ($PM_{2.5}$).

3 Emissions to Air

$PM_{2.5}$ is a sub-class of PM_{10}, which in itself is a sub-category of TSP. Whilst in definition, TSP includes the smaller size fractions, it is generically used to describe the larger fraction (between 10 µm and 30 µm diameter) that, because of its aerodynamic diameter and density, falls more rapidly from the air than smaller fractions. Given sufficient time, however, PM_{10} will also settle out of suspension in the atmosphere. The size of TSP means that the majority of this material will not enter the human body thorough inhalation, as it is stopped by the cilia in the nose and throat. Impacts of TSP are primarily limited nuisance effects, and may only affect health via annoyance reactions.

PM_{10} is acknowledged as a pollutant of concern due to its ability to be inhaled into the lungs. PM_{10} has been considered as part of this assessment, where emission control devices will filter out the majority of particulate matter that is greater than 10 µm in aerodynamic diameter.

There is currently no state regulatory criterion for $PM_{2.5}$. Whilst the Ambient Air NEPM does provide an Advisory Standard of 25 $\mu g/m^3$, further data collection and research is currently underway prior to a regulatory criteria being issued.

Emission Control Review

4.1 Proposed Emission Controls

The Project infrastructure will incorporate a range of emission control measures, such that pollution is minimised, and regulatory emission limits are either met or surpassed. Detail of these measures is provided within the following sections.

4.1.1 NA Plant Stack

The aqueous absorption of NO_2 produces a gas stream containing traces of NO_x (tail gas). The proposed NA plant minimises NO_x emissions from tail gas through the following means:

- Optimisation of the absorption stage such that initial NO_x concentrations in the tail gas are reduced to below 500 ppmv; and
- Treatment of the tail gas through Selective Catalytic Reduction (SCR) to further reduce NO_x concentrations by approximately 90%.
- Installation of a tail gas heater such that the SCR is at operational temperature during startup of the NA plant.

SCR is a gas treatment process that is used to preferentially reduce NO_x concentrations through reactions with ammonia and oxygen, producing nitrogen and water (vapour), in accordance with the reactions shown in **Equation 7** through **Equation 11**:

Equation 7: $$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$

Equation 8: $$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$$

Equation 9: $$6NO + 4NH_3 \rightarrow 5N_2 + 6H_2O$$

Equation 10: $$6NO_2 + 8NH_3 \rightarrow 7N_2 + 12H_2O$$

Equation 11: $$NO_2 + NO + 2NH_3 \rightarrow 2N_2 + 3H_2O$$

These reactions are promoted using a catalyst, typically at temperatures between 200℃ - 400℃ where lower temperatures may render the catalyst ineffective, and higher temperatures may damage the catalyst. Careful control of reaction stoichiometry is required to prevent excess ammonia being emitted to atmosphere (ammonia slip), whilst also providing sufficient quantities for NO_x reductions to be achieved. IPL anticipate ammonia slip of less than 5 ppmv.

IPL anticipate that the NA plant will typically achieve NO_x exhaust concentrations of 30-40 ppmv, with an upper limit of 75 ppmv during normal operation. Due to dynamic changes in system parameters during NA plant startup, IPL expect that NO_x levels would be higher during this time. Whilst the tail gas heater will ensure that the SCR is operational, IPL expect NO_x levels in exhaust of up to 200 ppmv within the 30 minute startup period. Startup is anticipated to occur approximately 3-4 times per year.

4.1.2 NA Storage Tank Vents

The NA tank vent will be fitted with a simple gravity fed water column scrubber. These act to reduce breathing emissions (due to minor changes in atmospheric and/or tank pressure), whilst also reducing NO_x gases in the flow when tank headspace relief is required.

4.1.3 AN Plant

The proposed AN plant minimises emissions from the prill tower through the following means:

- Recycling of air to minimise the quantity of the waste stream. This includes:
  - Recycling a portion of prilling air into the base of the prill tower; and
  - Recycling of air from the fluidized bed cooler into the dryer drums.
- Wet scrubbing of the waste stream using firstly, an AN liquor solution in a venturi scrubber, and secondly, process condensate in a packed tower scrubber with the AN (scrubbing) solution recycled into the AN plant.

As a result of this treatment, exhaust gases will contain less than 20 mg/m^3 of particulate matter (273K, 1 Atm), with operational levels typically ranging between 4-7 mg/m^3.

4.1.4 Auxiliary Boiler

IPL propose to use a package boiler with a Dry Low NO_x combustion arrangement, such that NO_x emissions are reduced below 75 ppmv, which equates to 150 mg/m^3 NO_x as NO_2 at the reference conditions of 3.5%O_2, dry, 1 Atm).

4.1.5 Ammonia storage flare

The ammonia storage flare is itself an emission control device, in that it is used to control ammonia emissions in the event of a refrigeration failure. During standby, the flare will remain in a ready state by combusting approximately 20 kg of natural gas per hour, in conjunction with a minor quantity of inert gases that accumulate in the storage tank.

During emergency flaring operation (a less than 1 in 10 year event), a peak design ammonia flow of 4 t/hr will be sent to the flare. The flare designers have indicated that the flare will provide an ammonia destruction efficiency in excess of 98% (Woods, 2012).

4.1.6 AN bagging Plant

Emissions from bagging operations will be managed through the capture and filtration of dust that is produced through the associated material transfer operations. Given the minor scale of this source, it is not envisaged that it will be licenced. In-stack concentrations have been estimated at less than 20mg/m^3 (273K, 1 Atm).

4.2 Benchmarking of Emission Controls against Best Available Techniques

URS conducted a review of air emission levels from the Project against Best Available Technology (BAT) as defined in (IPPC, 2007) *Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilisers.*

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This document represents a comprehensive reference for production processes relating to AN manufacture, and provides specific recommendations with regard to BAT air emissions control for a range of industrial processes relating to inorganic chemical production. The following sections provide a review of Project emission sources in the context of IPPC (2007), as well as a review of NO_x levels from NA production in Australia.

4.2.1 NA Production

IPPC (2007) contains NO_x emission levels from an extensive list of reference plants. **Table 4-1** provides a summary of these data, sorted by control technology, process type, the date the emission control was installed, and the NO_x emission level. **Figure 4-1** provides a visual representation of these data.

Table 4-1 NO_x emission levels in NA Plant tail gas from IPPC (2007)

Type	Process(1)	Plant Capacity (ktpa)	Date Control Commissioned	Emission Level (ppmv)
Combined	M/H	300	2003	5
NSCR	H/H	N/A	N/A	75
		400	N/A	100
		305	N/A	150-180
SCR	N/A	N/A	N/A	70
		80	1991	**100**
		90	1992	**100**
		80	1976	165
		180	1986	**170**
		80	1979/1980	200
		60	1979	**200**
		60	1982	**200**
		65	1982	**200**
		100	1982	**200**
		110	1983	**200**
		110	1983	**200**
		130	1985	**200**
		130	1987	**200**
		160	1987	**200**
		180	1988	**200**
		180	1990	**200**
		325	1990	**200**
		240	1985	**300**
		140	1982	**500**
		330	1982	**500**
	L/M	180	N/A	90
		73	N/A	100
		390	1975/1977	**150**
		180	-	155-160

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Type	Process(1)	Plant Capacity (ktpa)	Date Control Commissioned	Emission Level (ppmv)
	M/H	235	N/A	70
		300		90
		680		**100**
	M/M	210	N/A	75
		200	N/A	150-180
		65		200
		255		200
		75		240
N/A	H/H	120	N/A	50
	M/H	380		50
		720		80-90
		500		170
		730		180
		395		170-200
		270		190-200
		245		200
		585		200

Notes: **Bold text** shown to indicate values shown as It is assumed that “<” emissions are reflective of emission levels that would be suitable for licencing, whilst other values reflect operational or generally achievable emission levels. NSCR: Non-Selective Catalytic Reduction. N/A: Not Available, i.e not provided in IPPC (2007). (1)Process Type letters denote ammonia oxidation and NO_2 absorption stage pressures (respectively), which comprises combination of Low (L): <1.7 Bar, Medium (M): 1.7-6.5 Bar, High (H): 1.7-6.5 Bar.

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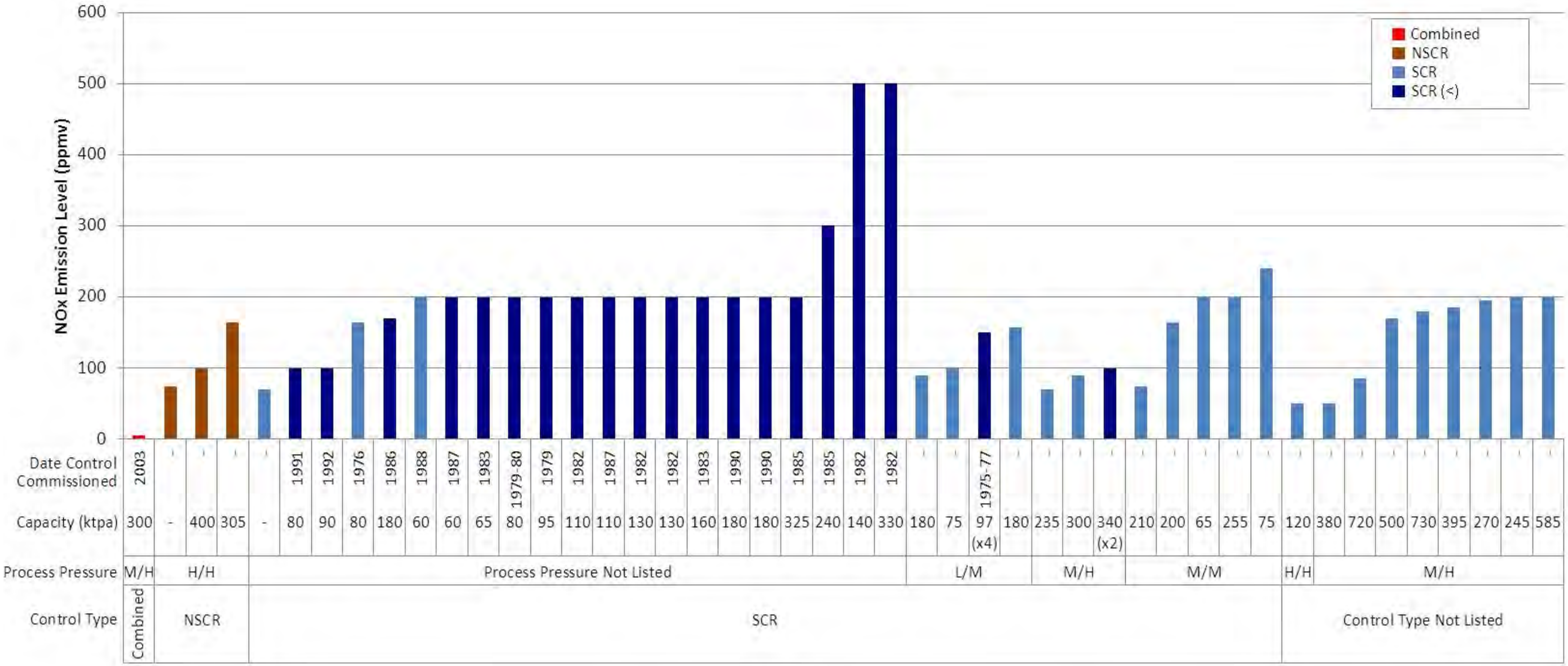
Figure 4-1 Comparison of NO_x emission levels from NA manufacture (IPPC, 2007)



Notes: Where a range is given in **Table 4 1**, an average value has been shown. It is assumed that "<" emissions are reflective of emission levels that would be suitable for licencing, whilst other values reflect operational or generally achievable emission levels. NSCR: Non-Selective Catalytic Reduction. Process type letters denote ammonia oxidation and NO_2 absorption stage pressures (respectively), which comprises combination of Low (L): <1.7 Bar, Medium (M): 1.7-6.5 Bar, High (H): 1.7-6.5 Bar.

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Consistency with BAT for NA Production

With regard to BAT for NA production, IPPC (2007) provides the following recommendations:

*"BAT is to reduce emissions of NO_x and to achieve the emission levels given in..***(Table 4-2)***..by applying one or a combination of the following techniques:*

- *Optimisation of the absorption stage;*
- *Combined NO_x and N_2O abatement in tail gases;*
- *SCR;*
- *Addition of H_2O_2 to the last absorption stage.*

BAT is to reduce emissions during startup and shutdown conditions."

The Project is consistent with the recommendations from IPPC (2007) in the use of BAT given the following:

- Optimisation of absorption stage to produce tail gas with the use of SCR;
- Use of SCR;
- Use of a tail gas heater to maintain operation of the SCR through startup.

As can be seen in **Table 4-2**, the Project is also consistent with BAT NO_x emission levels as listed in IPPC (2007).

Table 4-2 Comparison of IPL proposed NOx emission levels with IPPC (2007) BAT

	NO_x Emission Level (ppmv)	
Emission Source	**IPPC (2007) BAT**	**IPL Proposed**
New plants	5 - 75	30-40 (typical) 75 (licence limit)
Existing plants	5 - 90*	N/A
NH_3 slip from SCR	<5	<5

Notes: N/A: Not Applicable. *can be up to 150 ppmv, where safety aspects due to deposits of AN restrict the effect of SCR or with addition of H_2O_2 instead of applying SCR.

Review Against Existing and Proposed Plants within Australia

A brief review was conducted for emission levels within Australian NA plants. The following documents were included in this review:

- (GHD, 2006) *Dyno Nobel Moranbah Ammonium Nitrate Project, Air Quality Assessment*, GHD August 2006;
- (ERM, 2009) *Technical Ammonium Nitrate Plant – Air Quality Assessment*, Environmental Resources Management Australia, December 2009;
- (ENSR, 2009) *Air Quality Impact Assessment – Kooragang Island NSW*, ENSR Australia Pty Ltd, April 2009;
- (GHD, 2010) *Dampier Nitrogen Pty Ltd, Report for Ammonium Nitrate Project - Air Quality Assessment*, GHD September 2010; and
- (Environ, 2011) *Kwinana Ammonium Nitrate Expansion – Air Dispersion Modelling Report*, Environ Australia Pty Ltd, March 2011.

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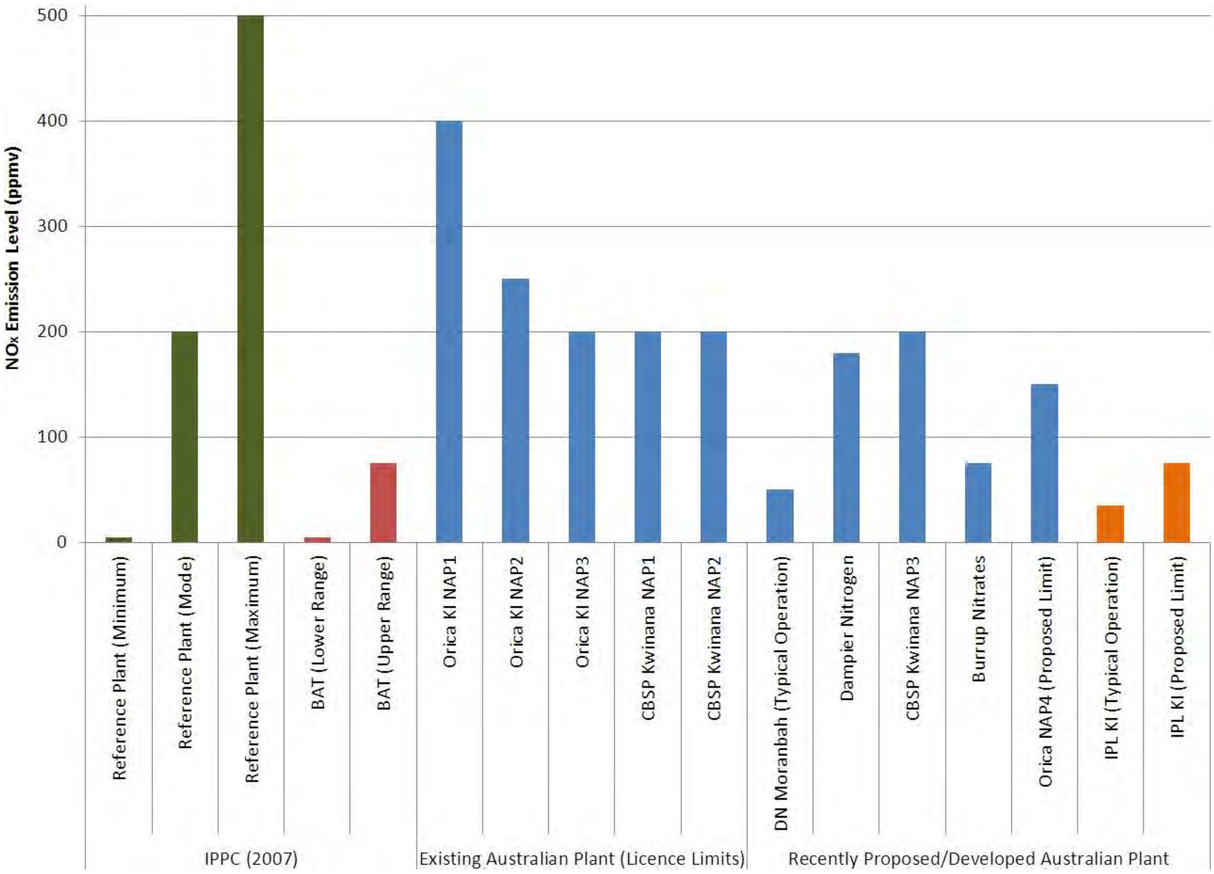
These documents provide examples of emission levels from existing and proposed NA plants. **Table 4-3** provides a summary of these data. A range of emission levels from IPPC (2007) are also provided for context. **Figure 4-2** provides a visual representation of these data.

Table 4-3 Review against IPPC references as well as existing and proposed plants within Australia

Class	Plant	NO_x Emission Level (ppmv)	Source
IPPC Reference	Reference Plant - Minimum	5	IPPC (2007)
	Reference Plant - Mode	200	
	Reference Plant - Maximum	500	
	BAT - Lower Range	5	
	BAT - Upper Range	75	
Existing Australian Plant (Licence Limits)	Orica KI NAP1	400	ENSR (2009)
	Orica KI NAP2	250	
	Orica KI NAP3	200	
	CBSP Kwinana NAP1	200	Environ (2011)
	CBSP Kwinana NAP2	200	
Recently Proposed/Developed Australian Plant	Dyno Nobel Moranbah (Typical Operation)	50	GHD (2006)
	Dampier Nitrogen	180	GHD (2010)
	CBSP Kwinana NAP3	200	Environ (2011)
	Burrup Nitrates	75	ERM (2009)
	Orica NAP4 (Proposed Limit)	150	ENSR (2009)
	IPL KI (Typical Operation)	35	IPL
	IPL KI (Proposed Limit)	75	

Figure 4-2 Review of Project NO_x emission levels against IPPC references as well as existing and proposed plants within Australia



4.2.2 AN Production

IPPC (2007) does not provide BAT recommendations with regard to AN production, stating: *"Because of an insufficient data basis, no conclusions could be drawn for emissions to air from neutralisation, evaporation, granulation, prilling, drying, cooling and conditioning."*

It does however detail a summary of reference levels for ammonia and particulate matter emissions from ammonium nitrate prilling, drying and associated processes. **Table 4-4, Figure 4-3** and **Figure 4-4** provide a summary of these emission levels[7].

[7] Reference levels for granulation, concentration, and insoluble processes have been excluded.

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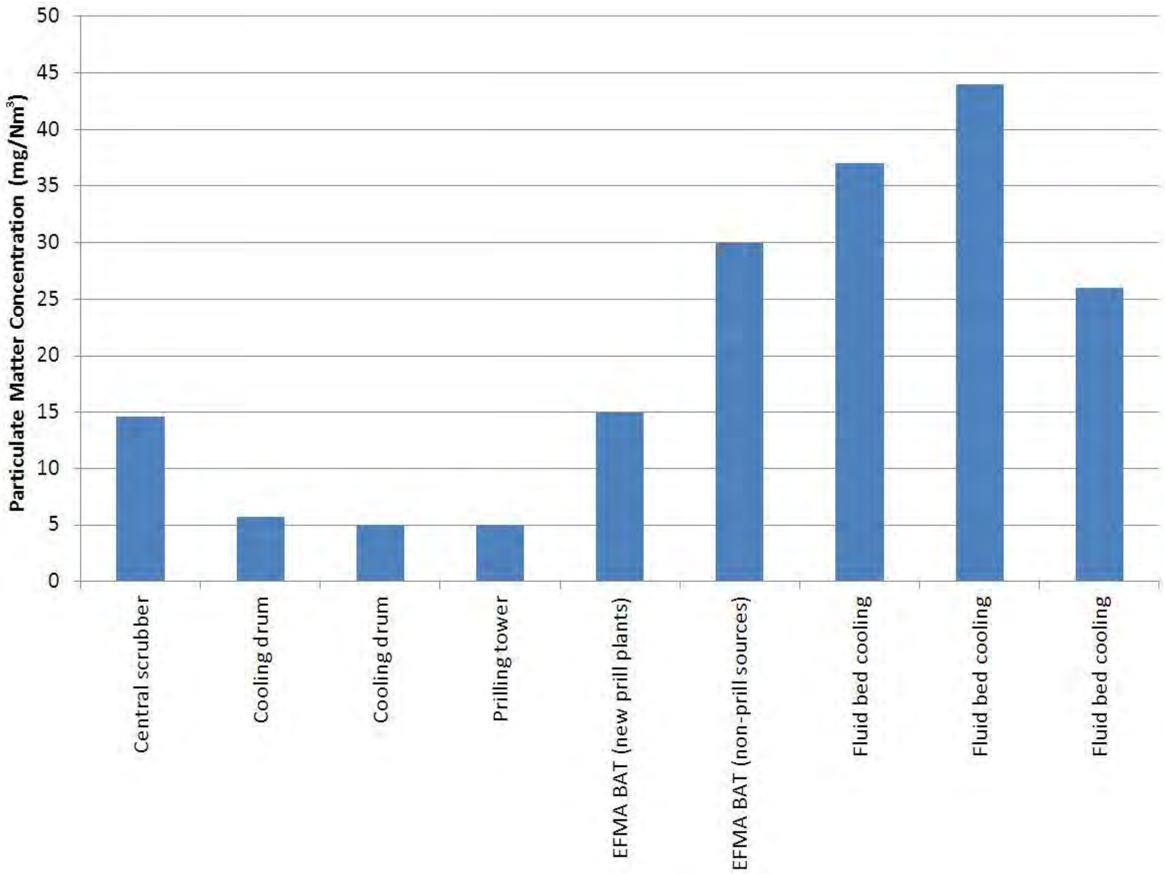
Table 4-4 Particulate matter and ammonia emission levels from AN production at various plants (IPPC, 2007)

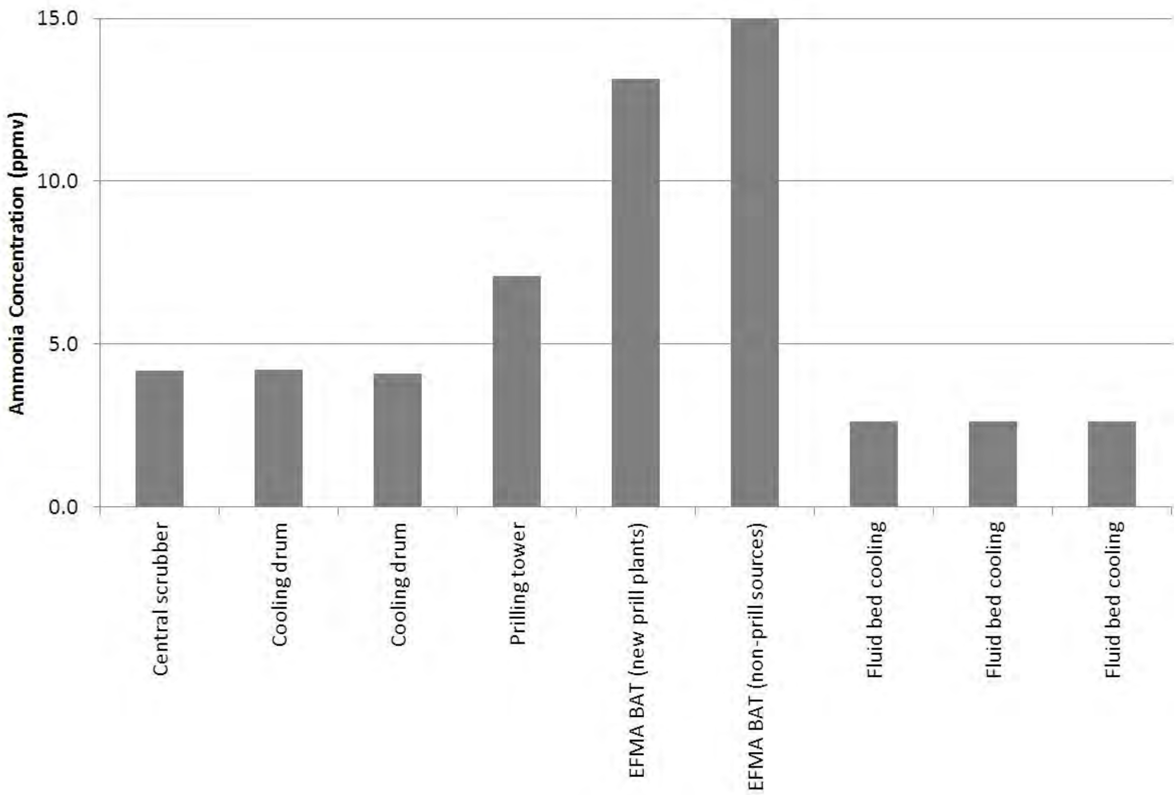
Emission Source	Particulate Matter (mg/m^3)	Ammonia (ppmv)
Central scrubber	14.5-14.8	0.5-0.6
Cooling drum	5-6.5	3.6-4.8
Cooling drum	5	4.0-4.2
Prilling tower	5	5.6-8.6
EFMA BAT (new prill plants)	15	13
EFMA BAT (non-prill sources)	30	66
Fluid bed cooling	37	3
Fluid bed cooling	44	3
Fluid bed cooling	26	3

Figure 4-3 Comparison of particulate matter emission levels from AN manufacture (IPPC, 2007)



4 Emission Control Review

Figure 4-4 Comparison of ammonia emission levels from AN manufacture (IPPC, 2007)



The "EFMA BAT" references listed in **Table 4-4** refer to (EFMA, 2000) *Best Available Techniques for Pollution Prevention and Control in the European Fertilizer Industry Booklet No. 6 of 8: Production of Ammonium Nitrate and Calcium Ammonium Nitrate*, European Fertilizer Manufacturers' Association, 2000. **Table 4-5** shows a comparison of proposed particulate matter and ammonia emission levels with BAT as defined in EFMA (2000).

Table 4-5 Comparison of IPL proposed AN emission levels with EFMA (2000) BAT

Emission Source	EFMA (2000) BAT	IPL Proposed
Particulate Matter		
AN Prill Towers	15 mg/Nm^3	<20 mg/Nm^3
Other Individual Emission Points	30 mg/Nm^3	
Ammonia		
AN Prill Towers	10 mg/Nm^3 (13 ppmv)	<3.8 mg/Nm^3 (<5 ppmv)
Other Individual Emission Points	50 mg/Nm^3 (66 ppmv)	

As can be seen in **Table 4-5**, IPLs proposed sources are consisted with BAT as defined in EFMA (2000), with the upper limit of particulate emission levels within the range of BAT values provided, and ammonia levels well within the provided BAT values. It is noted that the AN scrubber stack handles air from the prill tower and other processes (i.e. drying/screening and cooling).

4.3 Proposed Emission Limits

During the operational phase of the Project, emissions will be monitored to ensure that emission controls are operating effectively, and that equipment is compliant with statutory limits implemented for the purposes of environmental protection. **Table 4-6** shows proposed emission limits for the Project, with comparison against the relevant POEO limits.

Table 4-6 Proposed emission limits with comparison to the POEO (clean air) regulation 2010.

Point	Parameter	Proposed Limit(1) (273K, 1atm, dry)	POEO Limit(1) (273K, 1atm, dry)	Proposed Monitoring Frequency	Proposed Monitoring Method
NA Plant Stack	NO_x as NO_2	154 mg/m^3	350 mg/m^3	Continuous	CEM-2
	Smoke	Ringelmann 1 or 20% opacity	Ringelmann 1 or 20% opacity	NA	NA
AN Plant Scrubber	Solid Particles	20 mg/m^3	20 mg/m^3	Yearly	TM-15
Auxiliary Boiler	NO_x as NO_2	150 mg/m^3 (3.5%O_2)	350 mg/m^3 (3%O_2)	Yearly	TM-11
Ammonia Flare	Visible Emissions	No visible emission other than for a period of no more than 5 minutes in any 2 hours.	No visible emission other than for a period of no more than 5 minutes in any 2 hours.	NA	NA

Notes: (1) Limits exclude startup and shutdown periods. (NA) – Routine monitoring not proposed.

Existing Environment

5.1 Climate

Climate data was obtained for one of the closest Bureau of Meteorology (BoM) weather stations located at Williamtown RAAF air base. A summary of the parameters recorded between 1942 and 2012 is presented in **Table 5-1**.

The mean daily maximum temperature is approximately 28°C during summer and 18°C during winter. Sub-zero temperatures have been recorded between May and August. The area receives moderate to high rainfall having a mean annual rainfall of 1126.6 mm over an average of 138 rain days per year.

5.2 Meteorology

A range of meteorological data has been sourced for the purposes of dispersion modelling. A discussion of meteorological data used in this assessment is presented in **Appendix B**. **Figure 5-1** shows a wind rose generated by the Calmet meteorological model for the Project Site. Winds are typical of the region with dominant north westerly winds as influenced by the broader topography of the Hunter Valley (and synoptic trends for the region), as well as a high proportion of winds from the south eastern quadrant.

Figure 5-1 Calmet Generated Wind Rose for the Project Site (2005)

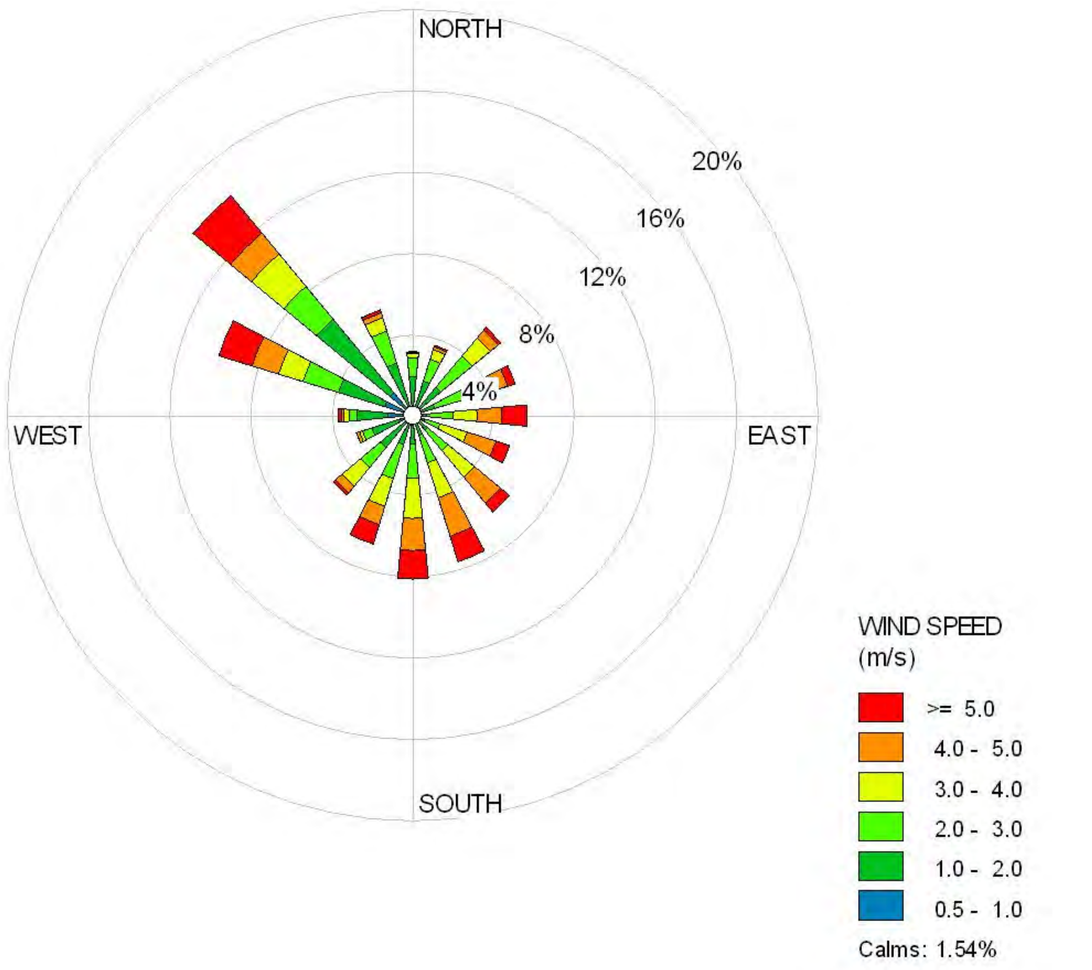


Table 5-1 Summary of climatic data from Williamtown RAAF (Station 061078), Bureau of Meteorology

Statistic	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Start Year	End Year
Mean maximum temperature (Degrees C)	28.0	27.6	26.2	23.6	20.3	17.7	17.0	18.6	21.3	23.6	25.5	27.2	23.0	1942	2012
Highest temperature (Degrees C)	44.4	42.9	40.7	37.0	29.6	26.6	27.8	30.1	26.0	39.4	43.2	42.8	44.4	1942	2012
Lowest maximum temperature (Degrees C)	18.1	19.1	18.1	15.2	11.8	10.7	9.2	10.4	10.9	14.4	14.1	17.4	9.2	1942	2012
Lowest temperature (Degrees C)	9.4	9.6	8.6	2.1	-0.6	-1.8	-3.9	-1.9	0.4	3.0	5.1	7.9	-3.9	1942	2012
Mean rainfall (mm)	96.3	121.0	119.9	107.4	115.1	122.3	73.5	75.5	60.5	74.8	82.3	79.7	1126.6	1942	2012
Highest rainfall (mm)	327.3	599.6	398.5	361.2	410.2	414.2	190.4	427.5	179.2	237.5	241.4	238.0	1793.7	1942	2012
Lowest rainfall (mm)	2.2	5.6	2.2	4.4	2.3	14.6	0.0	0.0	0.4	1.0	6.8	14.2	541.0	1942	2012
Highest daily rainfall (mm)	153.0	276.0	148.8	129.0	95.0	147.0	72.9	100..8	122.9	106.0	100.0	99.4	276.0	1942	2012
Mean number of days of rain	12.0	12.0	12.9	11.5	12.6	12.4	10.3	10.2	9.6	11.7	11.8	11.1	138.1	1942	2012
Mean daily solar exposure (MJ/m^2)	24.1	21.5	18.7	14.5	10.9	9.4	10.3	13.9	17.5	20.5	22.7	24.4	17.4	1990	2012
Mean number of clear days	7.3	5.7	7.5	8.4	8.8	8.9	11.3	12.2	11.0	8.3	6.7	7.1	103.2	1942	2010
Mean number of cloudy days	12.0	12.0	11.3	10.0	11.4	10.8	9.1	7.9	8.3	11.5	11.2	11.8	127.3	1942	2010
Mean 9 am temperature (Degrees C)	23.0	22.5	21.2	18.2	14.3	11.6	10.5	12.2	15.7	18.8	20.5	22.2	17.6	1942	2010
Mean 9 am relative humidity (%)	72	76	77	76	79	80	77	71	66	64	66	68	73	1942	2010
Mean 9 am wind speed (km/hr)	11.9	10.6	10.2	11.4	13.7	15.9	16.4	16.8	15.3	14.4	14.4	12.9	13.7	1942	2010
Mean 3 pm temperature (Degrees C)	26.5	26.1	24.9	22.5	19.3	16.8	16.2	17.6	20.0	21.9	23.8	25.6	21.8	1942	2010
Mean 3 pm relative humidity (%)	59	62	61	59	60	60	55	50	50	54	55	56	57	1942	2010
Mean 3 pm wind speed (km/hr)	21.9	20.6	18.9	17.2	15.8	17.5	18.7	20.9	22.0	22.5	23.5	23.5	20.2	1942	2010

5.3 Existing Air Quality

The existing air quality has been reviewed in order to establish general trends in pollutants and identify appropriate background values for use in the assessment. This section provides detail of this review including:

- A review of available monitoring data;
- A review of NO_2 and PM_{10} levels and trends; and
- A summary of background levels incorporated into this assessment.

5.3.1 Nitrogen Dioxide

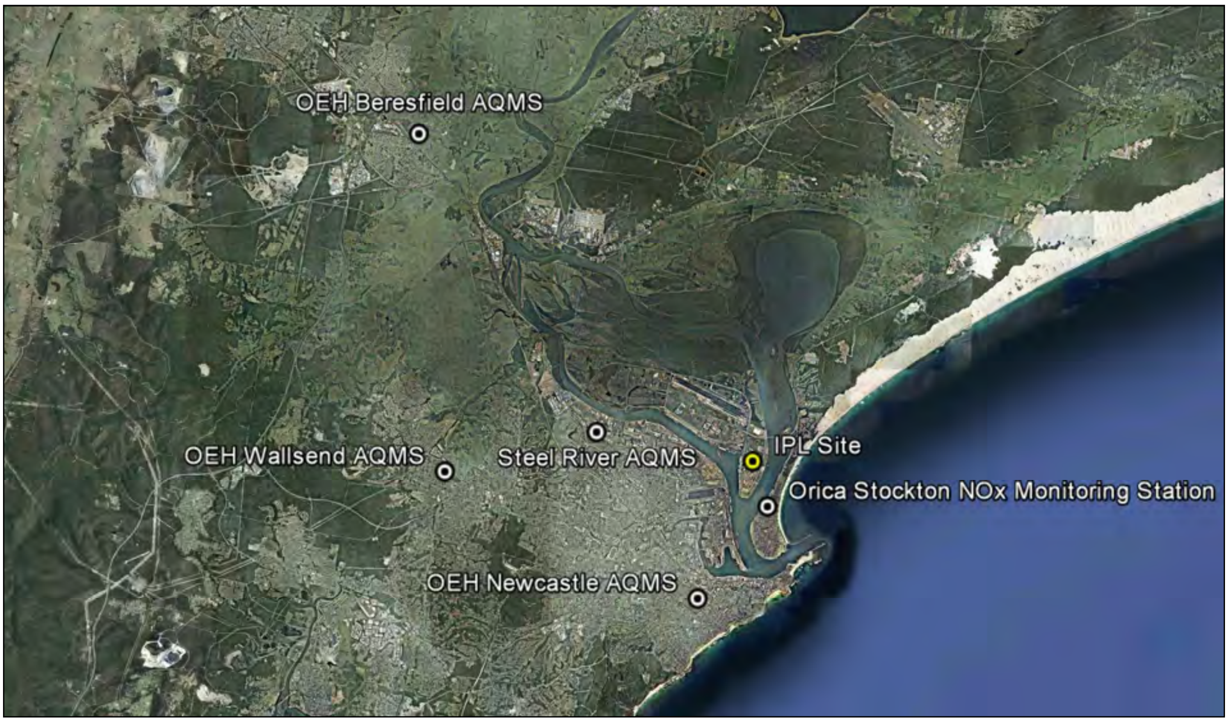
Data Sources

URS conducted a review of available NOx monitoring data as detailed in (OEH, 2012) *Lower Hunter Ambient Air Quality Review of Available Data*, NSW Office of Environment and Heritage, April 2012. The following NO_2 monitoring sites were identified:

- OEH Beresfield;
- OEH Wallsend;
- OEH Newcastle
- Steel River; and
- Orica Stockton.

Figure 5-2 shows and aerial view of Air Quality Monitoring Stations (AQMS) relative to the Project Site.

Figure 5-2 Aerial view of Newcastle showing NO_2 AQMS sites



(Image sourced from Google Earth Pro)

5 Existing Environment

URS sourced monitoring data from the Orica Stockton monitoring site, as well as from the OEH AQMS sites, as provided in OEH (2012), OEH (2011) and the OEH website[8]. Data from the Steel River site were not sourced due to potential influences from sources within the immediate vicinity of the monitoring site[9].

Orica Stockton NO_2 Monitoring Data

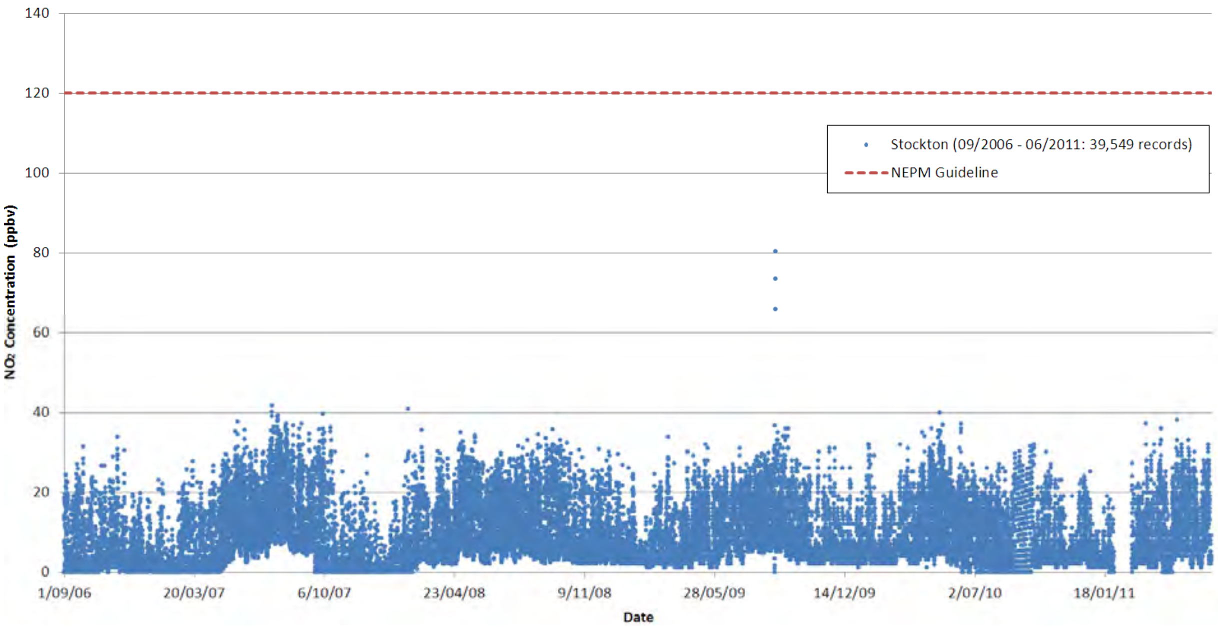
The Orica Stockton monitoring site is located on Roxburgh St, within the residential area of Stockton. The monitor records a continuous datalog of ambient NO, NO_2, and NO_x levels, which Orica use for the purposes of their community air monitoring program. The Orica KI site is located approximately 1 km north west of the monitoring site, hence the monitoring location is downwind of prevailing winds at KI. In this respect, the monitor is considered to be appropriately located to capture the impact of existing emissions from the Orica KI site.

Orica provided IPL with a compilation of monitoring records that extended from mid-2006 to mid-2011[10]. This consisted of approximately 60 files, some consisting of 10 minute data, and others of hourly averaged data. URS compiled these data into a single dataset of hourly records in accordance with the following procedures:

- 10 minute records were compiled into hourly clock averages;
- Hours with missing (10 minute) records were excluded;
- Negative values (a characteristic of the instrument) were corrected to zero[11]; and
- All of the files were compiled into a single dataset.

Figure 5-3 provides a visual representation of this dataset.

Figure 5-3 Orica Stockton 1 hour average NO_2 monitoring records (09/2006-06/2011)



[8] http://www.environment.nsw.gov.au/AQMS/search.htm (accessed 28/05/12)
[9] The monitoring site is now located within approximately 10m from a small car park, and near to a main thoroughfare of the Steel river industrial park. Environ (2012) provides a summary of this monitoring which includes erratic data that was dismissed within the report;
[10] It is understood that this was the same dataset provided to OEH for the preparation of OEH (2012);
[11] A maximum negative NO_2 record of -4 ppb was reported in the five years of monitoring data;

5 Existing Environment

As can be seen in **Figure 5-3**, there is little inter-annual variability in the Stockton data, with peak annual 1 hour NO_2 levels measured at around 40 ppbv. This is with the exception of a single event in 2009, when three consecutive hourly records of 80, 66, and 73 ppbv were recorded. Given that levels during this event were approximately twice as high as the next highest of (approximately) 40,000 records, they were considered anomalous in nature, and excluded. The exact source of these elevated results was not investigated, but could be the result of any of a range of influences. It is noted that the monitor is located at a suburban property, and that these elevated results occurred on a Saturday night between 7pm and 10pm, which would be consistent with the typical time of use of an outdoor combustion source such as a barbeque or outdoor space heater.

Table 5-2 shows a summary of these results (excluding the anomalous data, for the reason discussed above).

Table 5-2 Summary of Orica Stockton NO_2 monitoring results (ppbv)

Year	Concentration		% Complete
	1 hour Average	Annual Average	
2006*	33.8	4.4	31.8%
2007	41.7	8.0	93.9%
2008	40.8	9.4	94.8%
2009	36.6	8.6	95.2%
2010	39.9	8.2	95.5%
2011*	38.0	8.4**	40.1%

*Mass based concentrations calculated based on conversion at 0°C, 1 atm. **Data completion limited by the chronological extent of the dataset.

OEH NO_2 Monitoring Data

OEH monitoring data were sourced in the form of annual average and Maxima from the OEH website. **Table 5-3** shows these data. As can be seen in these data, maximum 1 hour average NO_2 levels are typically around 40 ppbv across all stations.

Table 5-3 Summary of OEH NO_2 monitoring results (ppbv)

	Maximum 1 hour Average			Annual Average		
Year	Newcastle	Wallsend	Beresfield	Newcastle	Wallsend	Beresfield
1993	67	76	N/A	10	9	N/A
1994	48	70	45	NA	9	10
1995	57	49	70	11	10	9
1996	44	44	N/A	N/A	N/A	N/A
1997	58	48	56	N/A	N/A	10
1998	35	39	40	8	8	9
1999	34	49	42	9	9	9
2000	54	44	50	9	8	10
2001	44	40	46	9	9	10
2002	43	47	50	9	N/A	10
2003	39	50	40	8	8	9
2004	44	41	44	9	8	9
2005	41	38	38	9	8	9
2006	42	37	36	8	9	10
2007	32	35	33	N/A	8	9
2008	33	31	31	7	7	8
2009	43	40	36	8	8	6
2010	38	38	32	8	9	7
2011	38	37	42	7	8	9

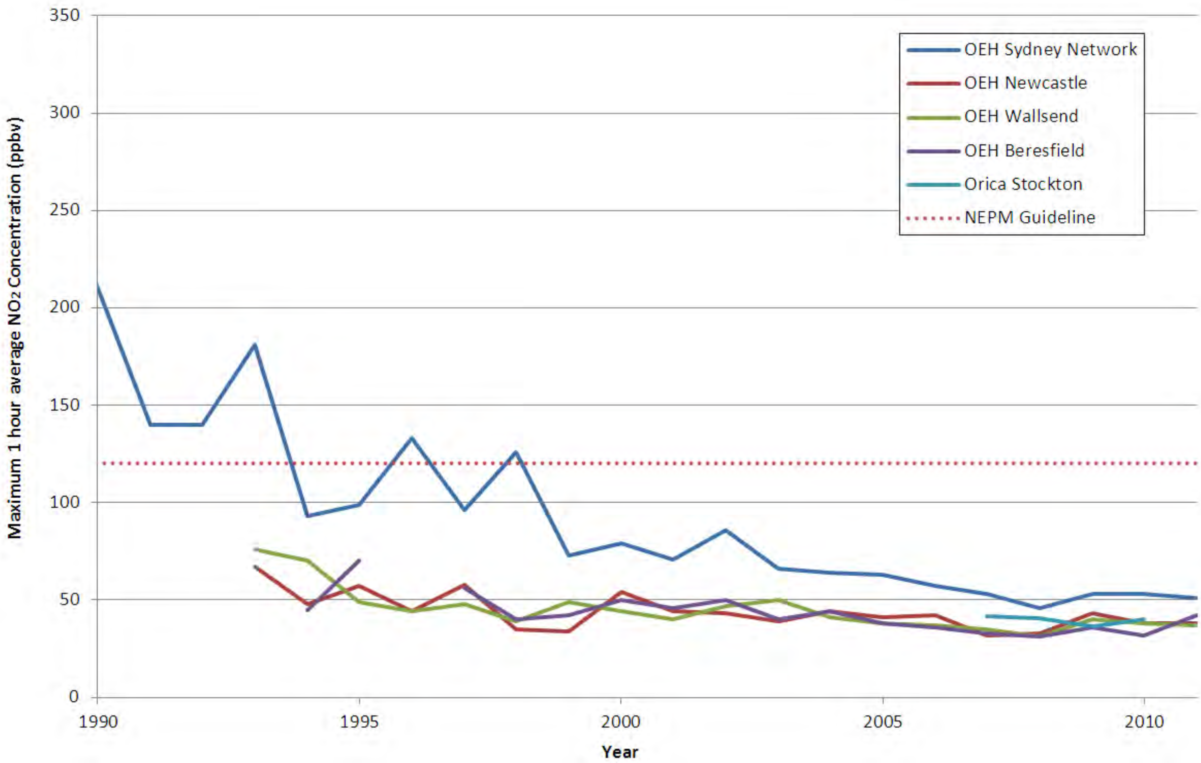
Note: N/A – Not Available.

Peak Annual 1 hour NO_2 Concentrations

Peak NO_2 levels have reduced significantly in recent decades, with the current NEPM guideline being consistently achieved at all monitoring locations in NSW. This is a contrast to levels in the 1980's, where peak annual 1 hour concentrations averaged around 250 ppbv[12] between years. It is expected that these improvements are due to progress in emission regulations in conjunction with technological advances, including the introduction of catalytic converters on motor vehicles, and the reduction of emission limits on industrial sources.

Figure 5-4 shows long-term peak annual 1 hour NO_2 Trends. The peak Sydney monitoring network result has also been shown in order to provide context to levels prior to the commissioning of the Newcastle (NO_x) monitoring network in the early 90's.

Figure 5-4 Long-Term peak annual 1 hour NO_2 trends*



Notes: *2006 and 2011 Orica maxima excluded due to low data completion. Sydney data compiled from OEH (2011) and NEHF (1997).

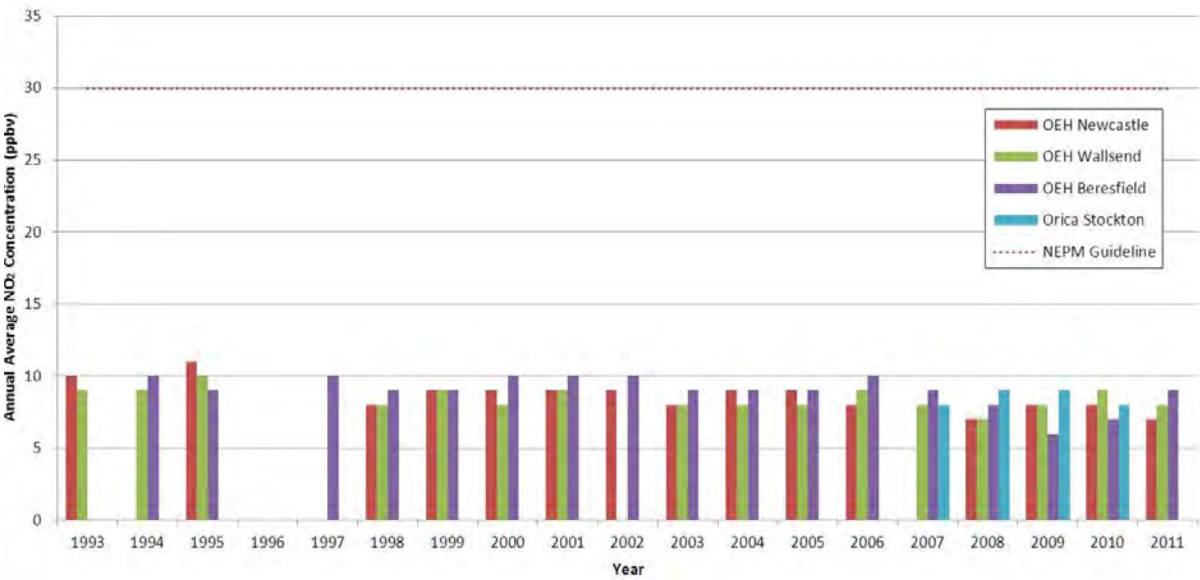
As can be seen in **Figure 5-4**, peak annual 1 hour NO_2 concentrations in Newcastle are fairly consistent between different locations, and different years, with a gentle downward trend evident over the period since monitoring began.

[12] Average excludes 1980 and 1985 (due to missing records).

Annual Average NO_2 Concentrations

Figure 5-5 shows annual NO_2 Trends. In a manner similar to 1 hour records, the annual average concentrations in Newcastle are fairly consistent between different locations, and different years, with a slight downward trend evident over the period since monitoring began.

Figure 5-5 Long-term annual average NO_2 trends*



Notes: *2006 and 2011 Orica maxima excluded from trend analysis due to low data completion.

NO_2/NO_x Ratios

To better establish local NO_X and NO_2 concentrations, further analysis of data from Beresfield (2005) and Stockton (2006 – 2011) has also been undertaken. These data are shown in **Figures 5-6 and 5-7**. The data shows that NO_2 concentrations at the locations were measured at concentrations below 40 ppbv (81 µg/m^3) for the majority of the sampling period, (as consistent with data provided in **Figure 5-3)**, the ratio of NO_x and NO_2 concentrations varies, with peak NO_2 concentrations occurring at NO_2/NO_x ratios ranging between 0.2 and 0.9.

5 Existing Environment

Figure 5-6 Beresfield 2005 NO_x monitoring data showing NO_2/NOx ratios

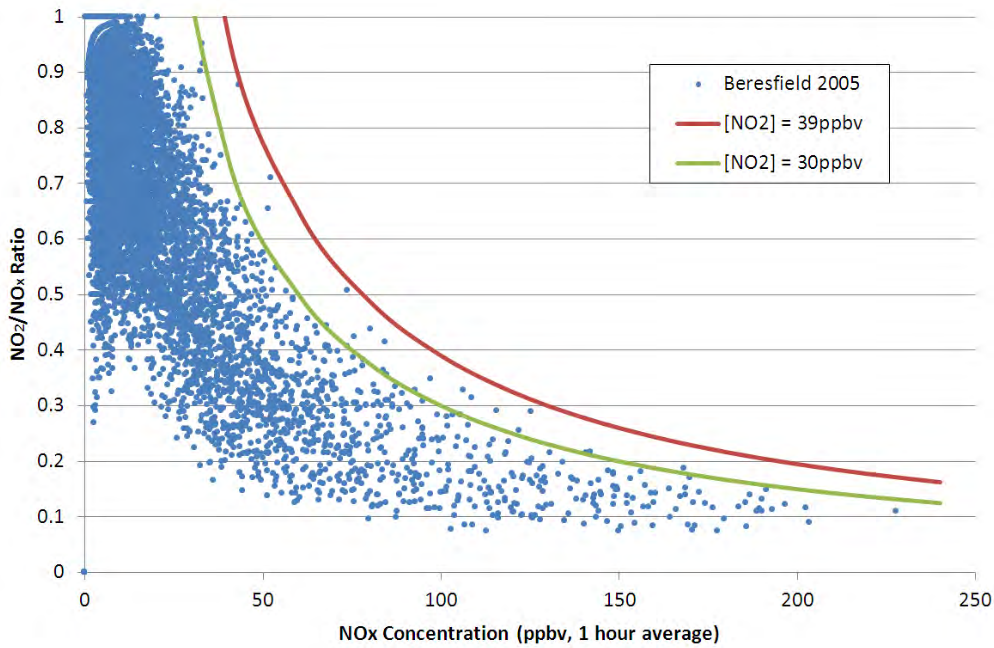
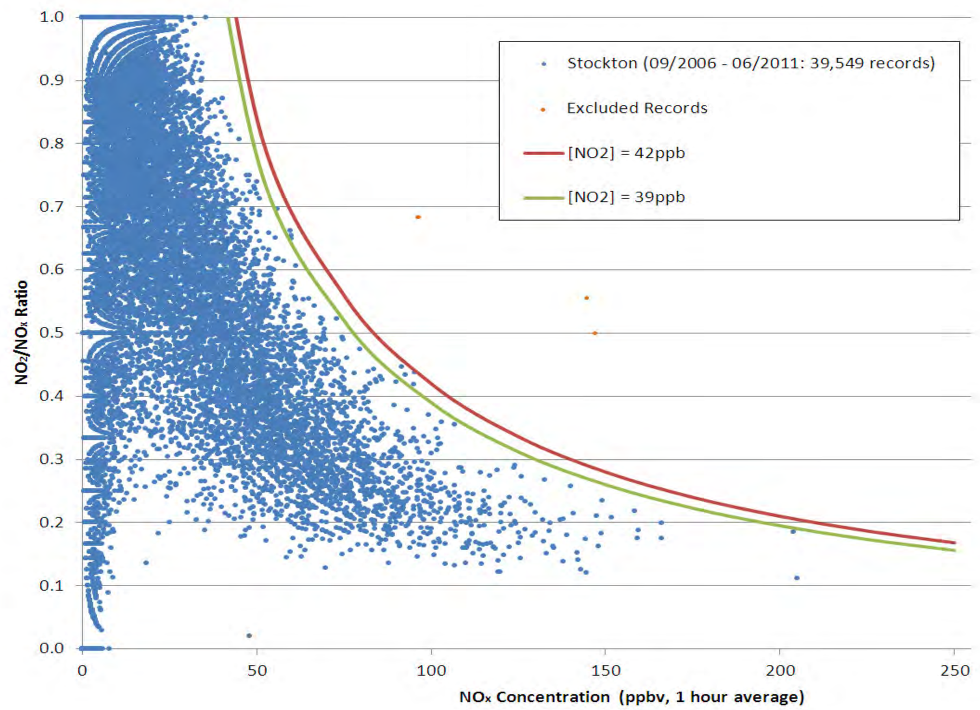


Figure 5-7 Orica Stockton 2006-2011 NO_x monitoring data showing NO_2/NOx ratios



Adopted Background NO_2 Concentrations

The Stockton monitoring peaks were found to be consistent with other measured values in the Newcastle region. To remain consistent with the meteorological modelling year of 2005, the assessment has adopted the background NO_2 concentration as being 41 ppbv, which is the maximum 1 hour value from Newcastle (2005). This value is slightly higher than the maximum measured value at Beresfield and Wallsend in 2005 (38 ppbv), and near to the 5 year maximum measured in Stockton (42 ppbv).

For the representation of annual average background NO_2 concentrations, the 2005 background concentrations from Newcastle and Beresfield were reviewed (8 and 9 ppbv respectively), with Beresfield adopted for inclusion in the assessment.

5.3.2 Particulate Matter (as PM_{10})

Data Sources

A review of available PM_{10} monitoring data conducted, as detailed in (OEH, 2012). The following monitoring sites were identified:

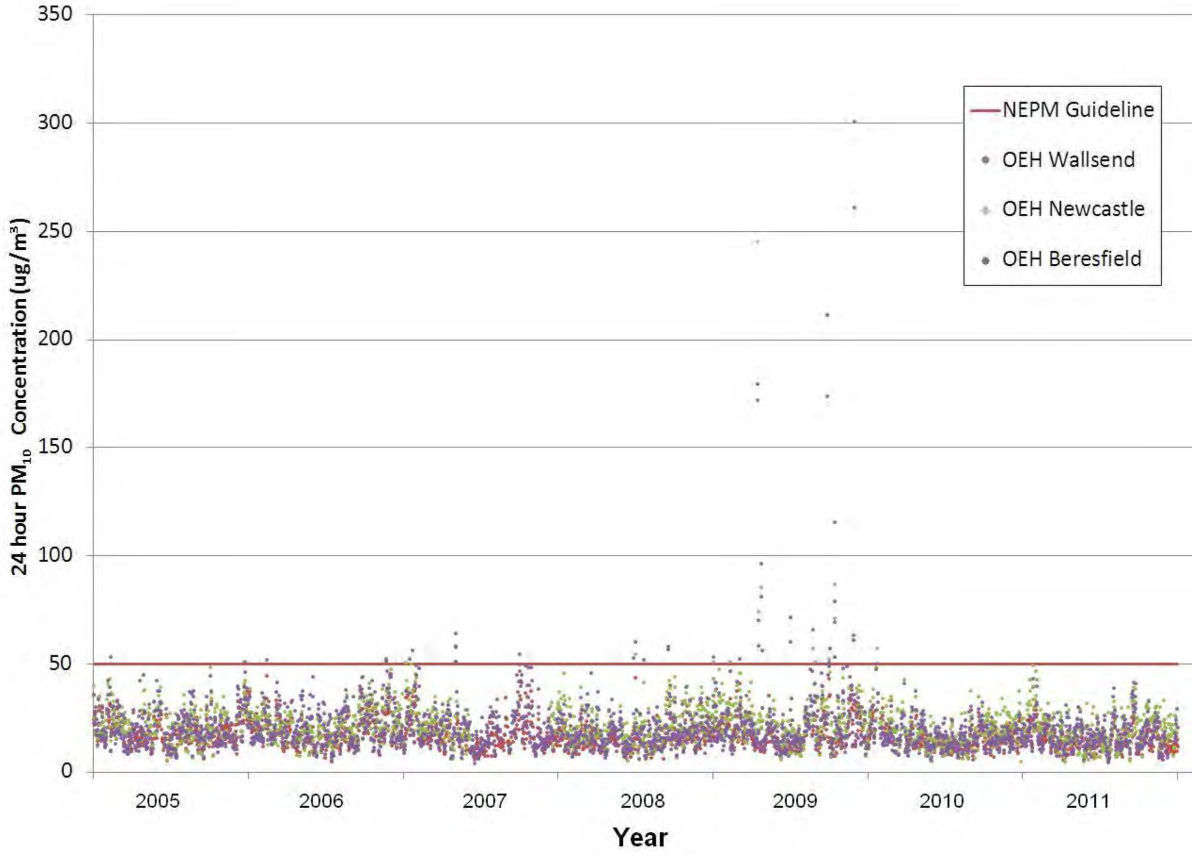
- OEH Beresfield;
- OEH Wallsend; and
- OEH Newcastle

A range of industry monitoring stations are also detailed in OEH (2012) however this monitoring is limited to 1 in every 6 days.

24 Hour Average Data

Figure 5-8 show 6 years of PM_{10} data at the OEH Wallsend, Newcastle and Beresfield monitoring locations. As can be seen in the data, the NEPM guideline is regularly exceeded, and there is a wide scatter in the data, with exceedances occurring across a range of years. The majority of these exceedances are associated with events such as dust storms and bushfires. In particular, during 2009 dust storms which were generated in central Australia frequently moved across NSW and out to sea, causing elevated dust levels across the state on a range of different months of the year.

Figure 5-8 Summary of OEH 24 hour PM_{10} data (2005-2011)



Note: peak 2009 values (of around 2000-2400 µg/m³) have been excluded to improve ease of viewing.

OEH 2005 data were sourced from the OEH website[13] and compiled into the data shown in **Table 5-4**.

Table 5-4 Summary of OEH PM_{10} monitoring for 2005 – 24 hour average (µg/m³)

Statistic	Beresfield	Newcastle	Wallsend
Maximum	53.1	48.3	50.7
99th Percentile	44.3	41.7	36.1
98th Percentile	41.1	39.3	34.7
95th Percentile	37	35.7	30.7
90th Percentile	31.7	31.8	27.1
75th Percentile	25.2	26.4	21.6
50th Percentile	18.6	20.9	16.8
Annual Average	20.3	21.7	18.2

13 http://www.environment.nsw.gov.au/AQMS/search.htm (accessed May, 2012)

Adopted Background PM_{10} Concentrations

Section 11.2 of the Approved Methods provides a detailed a methodology for the incorporation of elevated background concentrations into air quality assessments. This includes the sourcing of background data for a period that is concurrent with the meteorological dataset, with contemporaneous analysis of predicted impacts and existing background levels for each day of the meteorological dataset. The intent of this approach is understood to be to assess whether a proposal's impacts are likely to coincide with elevated background concentrations (as dictated by variability in both emissions and meteorological patterns), and ultimately to establish a proposal's emissions are likely to generate additional exceedances of impact assessment criteria. Given the frequent and random nature of dust events, coupled with uncertainties in dust measurement and the minor scale of particulate emissions from the project, in the case of this assessment, contemporaneous assessment is not able to be able to undertaken in a robust and meaningful manner as intended by the Approved Methods. Hence the approach has been simplified, in that a 90th percentile background concentration has been incorporated as being present at all times. This simplified approach allows the consideration of Project impacts in the context of existing background levels.

Newcastle data has been used to represent background levels for both the 90th percentile 24 hour, and annual average statistics.

5.4 Summary of Adopted Background Concentrations

The concentrations listed in **Table 5-5** have been incorporated into this assessment for the purpose of estimating cumulative concentrations.

Table 5-5 Summary of background pollutant concentrations

Substance	Averaging Period	Monitoring Source	Background Concentration ppbv *(µg/m³)*	DECCW Criteria ppbv *(µg/m³)*
NO_2	1 hour	Newcastle	41 *(84)*	120 *(246)*
	Annual	Beresfield	9.1 (*18.7*)	30 *(62*)
PM_{10}	24 hour	Beresfield	*(31.7)*	*(50)*
	Annual	Newcastle	*(21.7)*	*(30)*
Ammonia	1 hour	N/A	N/A	460 *(330*)

Notes:
N/A - Not Applicable.
The *Approved Methods* stipulate that the incremental impact be evaluated.
Bracketed italic figures represent µg/m^3.

6

Emissions Inventory

6.1 Point Source Emissions

Point source emissions have been estimated based on information provided by IPL. **Table 6-1** provides a summary of these data, including emission parameters and emission rates. Flare emissions have been calculated in accordance with the methodology outlined in **Appendix A**.

Table 6-1 Summary of point source emission parameters

	Parameter	NA Stack			AN Scrubber	Auxiliary Boiler		Bagging Unit Filter	ANSOL Concentrator	NH_3 Storage Flare	
	Source Parameters										
1	Easting (m) MGA94	385796			385796	385723		385932	385890	385648	
2	Northing (m) MGA94	6360071			6360074	6360022		6360150	6360109	6359921	
3	Stack height (m)	68			65	25		5	19	37.1	46.3
		T0-30	**T30-60**	**Operation**	**Operation**	**Plant Startup**	**Operation**	**Operation**	**Operation**	**Standby**	**Operation**
	Flow Parameters										
4	Exit temperature (℃)	45	145	145	50	170	170	25	65	550	750
5	Exit temperature (K)	318	418	418	323	443	443	298	338	823	1023
6	Flow (Nm^3/hr)	70,000	80,000	110,000	214,172	46,669	20,324	61	47,241	N/A	N/A
7	Flow (Nm^3/s)	19.4	22.2	30.6	59.5	13.0	5.6	0.02	13.12	N/A	N/A
8	Flow (Am^3/s)	22.6	34.0	46.8	70.4	21.0	9.2	0.02	16.25	N/A	N/A
9	Stack tip diameter (m)	1.50	1.50	1.50	2.20	1.20	1.20	0.05	1.2	0.46	2.0
10	Exit Velocity (m/s)	12.8	19.3	26.5	18.5	18.6	8.1	9.4	14.4	5.0	20.0
11	Moisture content	0.50%	0.32%	0.32%	8.8%	11.0%	11.0%	3.1%	2.0%	N/A	N/A
12	Mol. Weight (gas phase, g/mol)	NA	NA	28.08	28.05	27.7	27.7	28.19	25.66	N/A	N/A
	Pollutant Parameters										
13	NO_x as NO_2 (mg/Nm^3)	511	154	154	N/A	134	134	N/A	NA	N/A	N/A
14	NO_x as NO_2 (mg/Nm^3,dry)	513	154	154	N/A	150	150	N/A	NA	N/A	N/A
15	NO_x as NO_2 (ppmv)	249	75	75	N/A	65	65	N/A	NA	N/A	N/A
16	NO_x as NO_2 (ppmvd)	250	75	75	N/A	73	73	N/A	NA	N/A	N/A
17	NO_x as NO_2 (g/s)	9.93	3.41	4.69	N/A	1.7	0.75	N/A	NA	0.01	8.49
18	Ammonia (mg/Nm^3)	3.79	3.79	3.79	5	N/A	N/A	N/A	5	N/A	N/A
19	Ammonia (mg/Nm^3,dry)	3.80	3.80	3.80	5	N/A	N/A	N/A	5	N/A	N/A
20	Ammonia (ppmv)	5.0	5.0	5.0	6.6	N/A	N/A	N/A	7	N/A	N/A
21	Ammonia (ppmvd)	5.0	5.0	5.0	7.2	N/A	N/A	N/A	7	N/A	N/A
22	Ammonia (g/s)	0.07	0.08	0.12	0.30	N/A	N/A	N/A	0.07	N/A	22.2
23	PM (mg/Nm^3)	N/A	N/A	N/A	18.24	N/A	N/A	19.38	19.6	N/A	N/A
24	PM (mg/Nm^3,dry)	N/A	N/A	N/A	20	N/A	N/A	20	20	N/A	N/A
25	PM (g/s)	N/A	N/A	N/A	1.1	0.01	0.002	0.0003	0.26	0.001	0.066

Notes:

T0-30 and T0-60 denote the first and second 30 minute periods during NA startup.

ppmvd: parts per million, volumetric, dry

Boiler conditions “Operation” and “Startup” refer to NA plant status.

N/A: Not Applicable

Am^3 refers to “Actual” flow, i.e. as stack conditions.

Nm^3 denotes Normal conditions of 273K and 1 Atmosphere.

Flare height, diameter and velocity reflect virtual source parameters as calculated in **Appendix A**.

PM: Particulate Matter

Boiler PM emissions based on the USEPA (1998) PM emission factor, in conjunction with gas consumption of 3185 and 1274kg/hr.

6.2 Fugitive Sources

Dust emissions associated with cooling, screening, and bagging of prills have been incorporated into the dispersion model through the AN plant and bagging scrubber point sources, as detailed in **Table 6-1**. Given the enclosure of transport conveyors and bulk storage areas, emissions from these sources (to the external environment) are considered negligible. Given the use of sealed roads, and speed limits on the Lot, trucking emissions are considered minor, and have also been excluded.

Fugitive processes that were identified as potentially emissive include the following:

- Existing fertiliser bulk load out; and
- Proposed TGAN bulk load out.

IPL has informed URS that once TGAN prills have been screened and coated, that load out emissions are unlikely to be of significance. However, to ensure that this estimation is conservative, an allowance for these emissions has been incorporated into the assessment.

Existing Fertiliser Bulk Load Out

The Project Site currently handles a throughput 155 ktpa of fertiliser products. Approximately 65% of this material is loaded into "bulk tipper" style trucks, for export from the Project Site. Emissions from this process have been estimated using the standard NPI load out emission equation[14], using the NPI (1999) *Emission Estimation Technique Manual for Concrete Batching and Concrete Manufacturing* emission factor of 0.0036 kg/t, which is recommended for material transfer operations involving dry material. It is noted that emission factors directly relevant to fertiliser manufacture were not identified in NPI manuals. NPI (1999) suggests a reduction of 70% for partial enclosure (2 or 3 walls) of a load out area. Whilst IPL's existing bulk load out area is enclosed on two sides, as a conservative measure, this reduction has been ignored. **Table 6-2** provides detail of the emission estimate for the existing bulk load out.

Table 6-2 Estimate of PM_{10} emissions from existing fertiliser bulk load out

Parameter	Value	Units
Existing fertiliser plant throughput	155	ktpa
Fertiliser quantity exported through bulk load out	65%	-
	101	ktpa
	504	tpd[(1)]
	63	tph[(2)]
PM_{10} Emission Factor	0.0036[(3)]	kg/t
PM_{10} Emissions	0.227[(3)]	kg/hr
	0.063[(3)]	g/s

Notes: [(1)] Assuming peak daily deliveries are 175% of long-term average rates. [(2)] Assuming deliveries occur over 8 hours per day. [(3)]NPI (1999) suggests a reduction of 70% for partial enclosure (2 or 3 walls) of the load out area. Whilst the load out is enclosed on two sides, as a conservative measure, this reduction has been ignored.

Proposed TGAN Bulk Load Out

The proposed AN production capacity for the Project Site is 350 ktpa. Approximately 20% of this will be sold in solution, with a large proportion of the remaining material estimated to be exported in bulk, through the load out facility on the Project Site. Emissions from this process have been estimated using the same approach as for the existing fertiliser load out. As a conservative measure, it has been

[14] This emission factor was understood to be initially developed for mining emission estimates, however is widely applied to a range of material handling operations.

assumed that all TGAN will be exported through the TGAN bulk load out, rather than the proposed combination of pre-bagged[15] and bulk TGAN export. **Table 6-3** provides detail of the TGAN bulk load out estimate.

Table 6-3 Estimate of PM_{10} emissions from proposed TGAN bulk load out

Parameter	Value	Units
AN exported	350	ktpa
TGAN Quantity exported through bulk load out	100%	-
	280	ktpa
	1400[(1)]	tpd
	175[(2)]	tph
PM_{10} Emission Factor	0.0072[(3)]	kg/t
PM_{10} Emissions	0.630[(3)]	kg/hr
	0.18[(3)]	g/s

Notes: [(1)] Assuming peak daily deliveries are 175% of long-term average rates.. [(2)] Assuming deliveries occur over 8 hours per day. [(3)]NPI (1999) suggests a reduction of 70% for partial enclosure (2 or 3 walls) of the load out area. Whilst the load out is enclosed on two sides, as a conservative measure, this reduction has been ignored.

Nitric Acid Storage

Peak NO_2 emission rates were estimated based on information provided by the manufacturers. Details of these estimates are provided in **Table 6-4**.

Table 6-4 Estimates of peak NA storage emissions

Parameter	NA Plant Startup Tank	Peak NA Transfer	Units
NO_x concentration	<100	<200	mg/Nm^3
Peak flow rate	40	350	Nm^3/h
Peak emission rate	<0.002	<0.01	g/s

It is noted that these estimates represent peak emission rates, and that the emissions are intermittent in nature. For example, startup tank emissions would occur approximately 3-4 occasions per year. In addition, during steady state operation (>95% of the time), NA production and consumption rates will be similar, hence tank venting emissions would be well below the estimates[16].in **Table 6-4** during operation. Given the minor scale of these emissions[17] and their infrequent nature, they have been considered negligible, hence excluded from further assessment.

6.3 Annualised Project Emissions

Basic emission estimates have been performed in order to provide context on the scale of emissions from the Project emissions relative to existing sources within the region, as well as the relative scale of each proposed emission source associated with the Project. The following sections provide detail of emission estimates for NO_x and PM_{10}.

[15] Emissions from the export of bagged TGAN would be negligible in the context of this assessment.
[16] Steady state NA production rates would displace approximately 23 m^3/hr when the AN plant is offline.
[17] Startup tank and NA transfer emission rates are estimated at <0.02% and <0.2% of startup and operational emissions (respectively).

6.3.1 NO_x Emissions

Hourly NO_x emissions were estimated based on the emission estimation detailed in the previous section, with assumptions to correct for operation within proposed licence limits where relevant. These emissions were then multiplied out by the hours per year which they are anticipated to occur. **Table 6-5** shows a breakdown of this estimate by source, with percentage contribution shown in the right hand column.

Table 6-5 Estimate of annualised Project emissions - NO_x

Emission Source	Occurrence	Hours/Year	NO_x Emissions		
			(kg/hr)	(tpa)	% Contribution
Boiler (Operation)(1)	350 days/year	8400	2.0	17	20%
NA Plant (Operation)(2)	350 days/year	8400	7.9	66	79%
Boiler (Startup) (1)	4 x 3 hour periods/year	12	4.7	0.1	0.1%
NA Plant (Startup)(3)	4 x 1 hour periods	4	16.3	0.1	0.1%
Ammonia Flare (Standby)	Continuous	8760	0.03	0.2	0.3%
Total	**N/A**	**N/A**	**N/A**	**84**	**100%**

Notes: (1) Boiler emissions estimated assuming emission levels equal to 75% of licence limits. (2) NA plant operational emissions estimated assuming an average operational emission level of 35ppm. (3) NA plant startup emissions estimated assuming a 30 minute average startup emission level of 75% of 250ppm, and operation at 35ppm for the remainder of the hour. N/A - Not Applicable.

Total NO_x emissions are estimated at approximately 84 tpa, with operational emissions from the auxiliary boiler and NA plant representing key emission sources (constituting approximately 79% and 20% of total emissions respectively). Startup emissions were estimated to constitute approximately 0.2% of total emissions.

6.3.2 PM_{10} Emissions

Hourly PM_{10} emissions were estimated based on the emission estimation detailed in the previous section, assuming that all point source emissions occur at licence limits. These emissions were then multiplied out by the hours per year during which they are anticipated to occur, whilst fugitive emissions (from bulk load out operations) were based on annualised quantities. **Table 6-6** shows a breakdown of this estimate by source, with percentage contribution shown in the right hand column.

Table 6-6 Estimate of annualised Project emissions – PM_{10}

Emission Source	Occurrence	Hours/Year	PM_{10} Emissions		
			(kg/hr)	(tpa)	% Contribution
Boiler (Operation)	350 days/year	8400	0.01	0.1	0.4%
Boiler (Startup)	4 X 3 hour periods/year	12	0.02	0.0002	0.0%
AN Plant	350 days/year	8400	1.37	11.5	91%
Ammonia Flare (Standby)	8760	8760	0.003	0.03	0.2%
Bagging Unit Filter	~50% operation	4380	0.001	0.004	0.0%
ANSOL Concentrator	1 hour per month	12	0.7	0.008	0.1%
TGAN Bulk Load Out	280 ktpa/annum(1)	N/A	N/A	1.0	8%
Total	**N/A**	**N/A**	**N/A**	**12.6**	**100%**

Notes: N/A - Not Applicable. (1) This estimate conservatively assumes that all TGAN is exported through the TGAN bulk load out facility, that all point sources operate at licence limits, and the exclusion of the 70% emission reduction suggested in NPI (1999) for the partial enclosure of bulk load out operations.

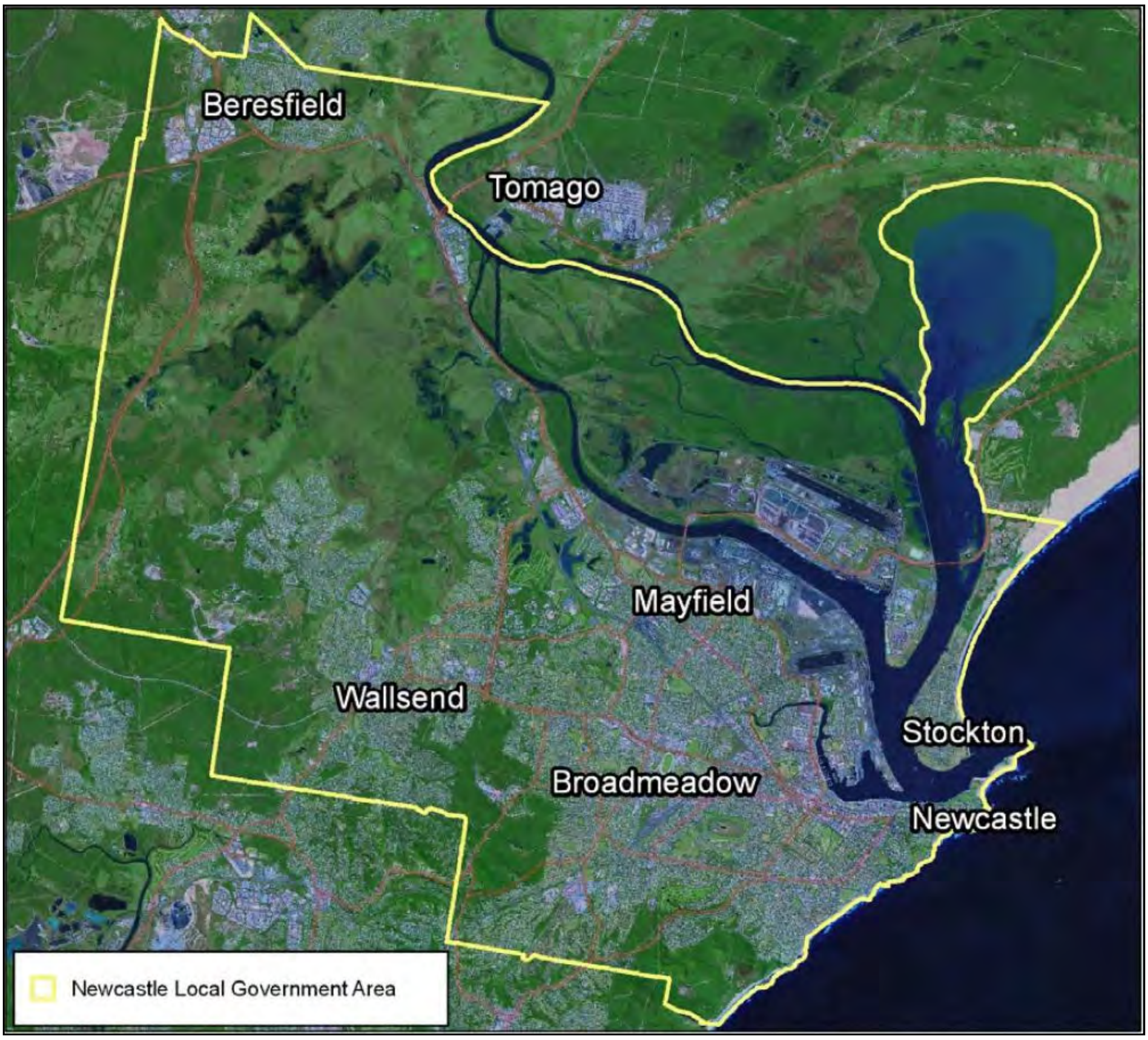
Total PM_{10} emissions were estimated at approximately 12.6 tpa, with operational emissions from the AN plant constituting key emission sources (approximately 91% of total emissions).

6.4 Comparison to National Pollutant Inventory Emissions

In order to compare the scale of emissions from the Project to those currently emitted in the Newcastle region, an estimation of regional emission sources was required. The National Pollutant Inventory (NPI) consists of a wide ranging emissions database that details industrial and domestic emissions across a wide range of pollutants on an annual basis. Facility operators report industrial emissions, whilst diffuse emissions from households and other sources like motor vehicles are estimated by government agencies.

The NPI database was accessed to obtain a breakdown of NO_x and PM_{10} emissions within the Newcastle Local Government Area (LGA). **Figure 6-1** shows an aerial image of the Newcastle LGA sourced from OEH (2012). As can be seen, the boundary includes areas around Newcastle Harbour, extending up to Beresfield. Tomago is not included in the Newcastle LGA.

Figure 6-1 Aerial image showing Newcastle LGA



Note: image sourced from OEH (2012).

6.4.1 Newcastle LGA 2010/2011 NO_x Emissions

The NPI was accessed to provide a breakdown of NO_x sources within the Newcastle LGA[18] for the 2010/2011 reporting year. **Table 6-7** provides a summary of this breakdown.

Table 6-7 Breakdown of NO_x emission sources within the Newcastle LGA

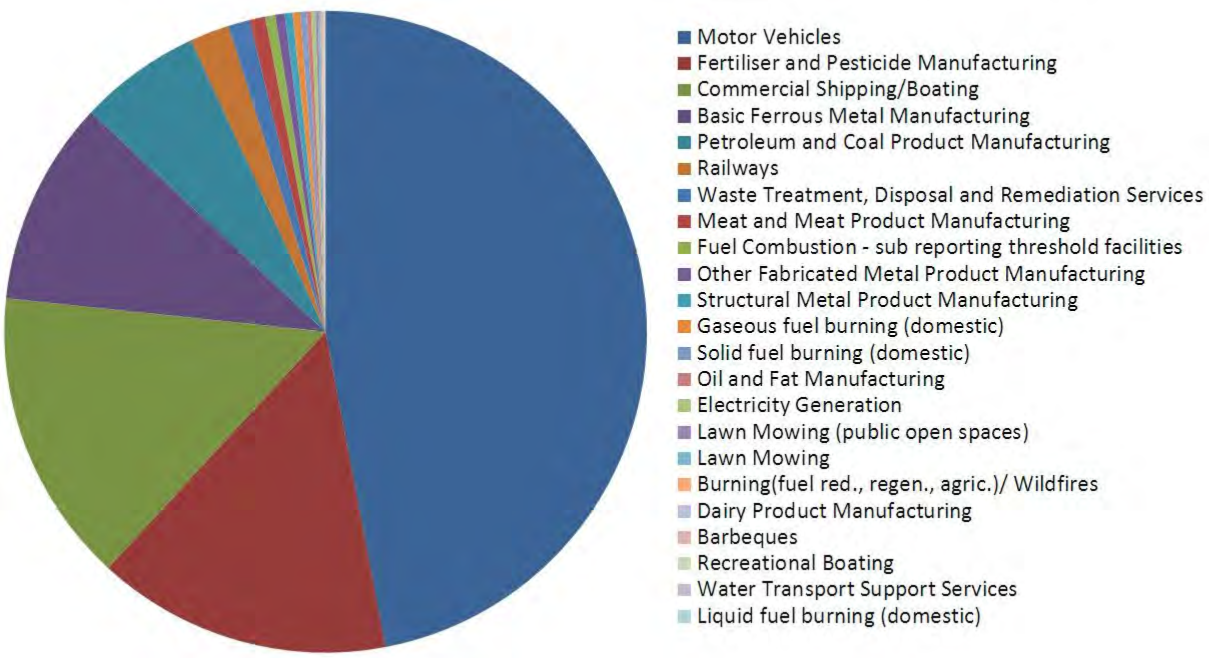
Category	NO_x Emissions (tpa, 2010/2011)	% Contribution
Motor Vehicles	2,600	47%
Fertiliser and Pesticide Manufacturing	820	15%
Commercial Shipping/Boating	820	15%
Basic Ferrous Metal Manufacturing	570	10%
Petroleum and Coal Product Manufacturing	340	6.1%
Railways	110	2.0%
Waste Treatment, Disposal and Remediation Services	60	1.1%
Meat and Meat Product Manufacturing	44	0.8%
Fuel Combustion - sub reporting threshold facilities	28	0.5%
Other Fabricated Metal Product Manufacturing	26	0.5%
Structural Metal Product Manufacturing	22	0.4%
Gaseous fuel burning (domestic)	21	0.4%
Solid fuel burning (domestic)	17	0.3%
Oil and Fat Manufacturing	13	0.2%
Electricity Generation	12	0.2%
Lawn Mowing (public open spaces)	7.3	0.1%
Lawn Mowing	6.4	0.1%
Burning(fuel red., regen., agric.)/ Wildfires	4.6	0.1%
Dairy Product Manufacturing	2.7	0.05%
Barbeques	2.2	0.04%
Recreational Boating	1.7	0.03%
Water Transport Support Services	1.7	0.03%
Liquid fuel burning (domestic)	0.92	0.02%
Total	**5,531**	**100%**

18 http://www.npi.gov.au/npidata/action/load/emission-by-source-result/criteria/year/2011/destination/ALL/lga/49/substance/69/source-type/ALL/subthreshold-data/Yes/substance-name/Oxides%2Bof%2BNitrogen

6 Emissions Inventory

Figure 6-2 provides a visual representation of the relative contribution of each emission class.

Figure 6-2 Breakdown of NO_x emission sources within the Newcastle LGA



6.4.2 Newcastle LGA 2010/2011 PM_{10} Emissions

The NPI was accessed to provide a breakdown of PM_{10} sources within the Newcastle LGA[19]. **Table 6-8** shows a summary of this breakdown.

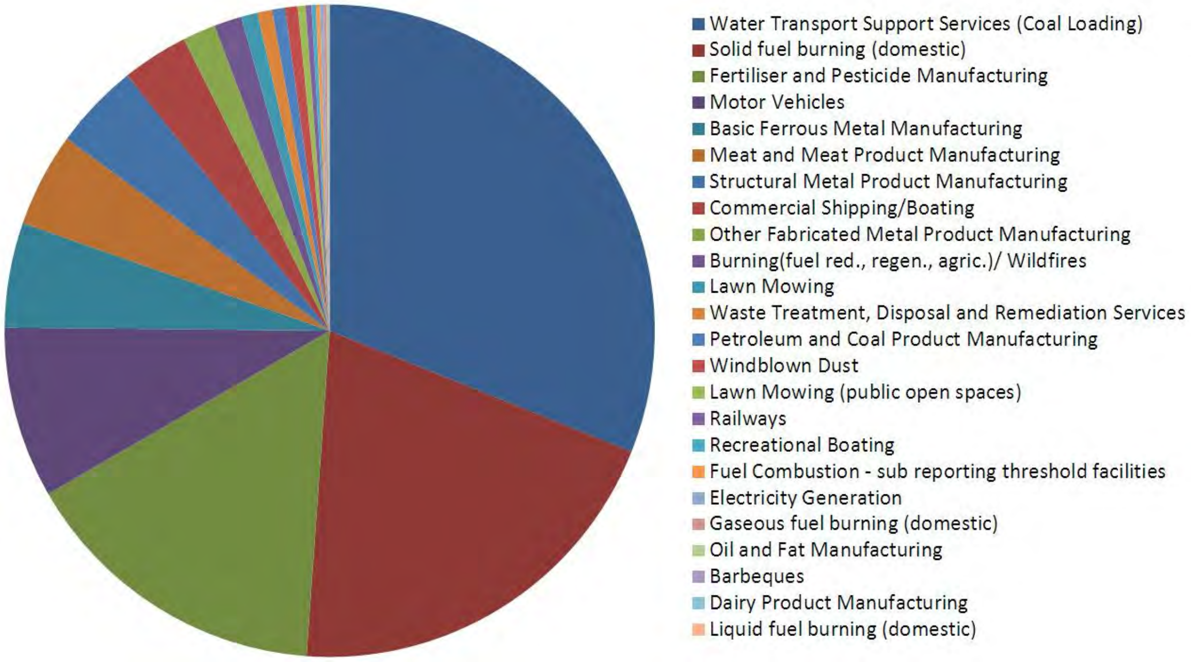
Table 6-8 Breakdown of PM_{10} emission sources within the Newcastle LGA

Category	NO_x Emissions (tpa, 2010/2011)	% Contribution
Water Transport Support Services (Coal Loading)	340	31%
Solid fuel burning (domestic)	220	20%
Fertiliser and Pesticide Manufacturing	170	16%
Motor Vehicles	93	8.5%
Basic Ferrous Metal Manufacturing	57	5.2%
Meat and Meat Product Manufacturing	51	4.7%
Structural Metal Product Manufacturing	47	4.3%
Commercial Shipping/Boating	36	3.3%
Other Fabricated Metal Product Manufacturing	18	1.6%
Burning(fuel red., regen., agric.)/ Wildfires	15	1.4%
Lawn Mowing	9	0.8%
Waste Treatment, Disposal and Remediation Services	8	0.7%
Petroleum and Coal Product Manufacturing	7	0.6%
Windblown Dust	6.9	0.6%
Lawn Mowing (public open spaces)	4.2	0.4%
Railways	3.3	0.3%
Recreational Boating	2.3	0.2%
Fuel Combustion - sub reporting threshold facilities	2.2	0.2%
Electricity Generation	1.9	0.2%
Gaseous fuel burning (domestic)	1.7	0.2%
Oil and Fat Manufacturing	1	0.1%
Barbeques	0.39	0.04%
Dairy Product Manufacturing	0.19	0.02%
Liquid fuel burning (domestic)	0.02	0.002%
Total	**1,095**	**100%**

[19] http://www.npi.gov.au/npidata/action/load/emission-by-source-result/criteria/year/2011/destination/ALL/lga/49/substance/70/source-type/ALL/subthreshold-data/Yes/substance-name/Particulate%2BMatter%2B10.0%2Bum

Figure 6-3 provides a visual representation of the relative contribution of each emission class.

Figure 6-3 Breakdown of PM_{10} emission sources within the Newcastle LGA



6.4.3 Comparison of Project Emissions to Newcastle LGA 2010/2011

Table 6-9 provides a comparison of Project emissions with the NPI Newcastle LGA 2010/2011 data. As can be seen, NO_x emissions constitute approximately 1.5% of total reported emissions, and approximately 2.9% of total emissions excluding motor vehicles (the key non-industrial NO_x source). In addition, PM_{10} emissions were estimated to be approximately 1.1% of total emissions for Newcastle LGA.

Table 6-9 Comparison of Project emissions to NPI 2010/2011 data for Newcastle LGA

Category	LGA Emissions (tpa)	Project Contribution (tpa)	Project Contribution (%)
NO_x			
All sources	5,531	84	1.5%
All sources (excl. Motor Vehicles)	2,931	84	2.9%
PM_{10}			
All sources	1095	13	1.2%
All sources (excl. Motor Vehicles)	1002	13	1.3%

Assessment Methodology

This section provides detail of the methodologies employed in the assessment, including dispersion model selection, modelling configurations and assessment scenarios.

7.1 Dispersion Model

Three dispersion models are generally endorsed by OEH for use in air quality impact assessment. These are AUSPLUME, TAPM and Calpuff.

Given the coastal location of the Project, and the presence of elevated sources, coastal fumigation is considered to be of potential importance. The height of the atmospheric boundary layer is driven by turbulence, which is generated either mechanically (through fluid motion over rough obstacles) or convectively (through heating of the earth's surface). Given the low surface roughness of water, and the ability of the water to absorb and distribute incident solar radiation, levels of convective and mechanical turbulence over sea are lower than on land, hence daytime overwater boundary layer heights can be far lower than those over land. During onshore wind flows, as emissions from elevated sources (present above the boundary layer) travel inland, they can be consumed into a growing Thermal Internal Boundary Layer (TIBL), where the strong convective mixing can act to bring emissions to the ground, a phenomenon referred to as "coastal fumigation". Given the absence of horizontally varying meteorology, AUSPLUME is unable to treat this effect, whilst Calpuff can provide a more realistic representation of spatial variations in meteorological conditions in coastal locations. For this reason, DEC (2005) does not approve the use of AUSPLUME for use in coastal situations.

7.1.1 Plume Behaviour

The Project consists of a range of air emissions sources, which vary from non-buoyant to mildly buoyant in nature, and are emitted at moderate to high velocities. The main emission sources (the NA plant and AN scrubber stack are constitute elevated sources, which are elevated at around 70 m above ground level, and lightly buoyant, with a heat release of approximately 3 and 1.2 MW (respectively). It is considered that the dispersion of emissions from the Project will be driven by surrounding meteorology, and mechanical turbulence induced by structures on the Lot. It is likely that these plumes will merge under a range of meteorological conditions. Given the low quantity of heat release, enhancement of plume rise is likely to be minor, hence plume merging effects have been omitted. For the proposed sources, this is considered mildly conservative.

7.1.2 Model Selection

The Calpuff dispersion model has been selected for this assessment for the following reasons:

- The ability to address variations in meteorology with changing land use (water/land) including coastal fumigation; and
- The ability to treat causality, and mixing of emissions from consecutive hours (of interest given that the plant startup sequence extends over several hours).

7.2 Model Configuration

7.2.1 Modelling Domain and Receptor Locations

Dispersion modelling has been performed on a 10 X 10 km modelling domain. This domain is considered inclusive of key receptor locations and of an adequate range to capture peak ground level impacts. The grid consists of 101 X 101 gridded receptors, at 100 m resolution, equating to a total of 10,201 gridded receptors. In addition, two rows of receptors (34 in total) have been added: one along the Fern Bay to Stockton shoreline, and another along the residential/industrial boundary at Mayfield. Whilst it is noted that elevated impacts may originate beyond these lines, these receptors have been included for screening purposes. **Figure 7-1** shows an aerial view of Calpuff modelling domain showing the Project Site location, nearby suburbs and receptor locations.

Figure 7-1 Aerial view of Calpuff modelling domain showing the Project Site, nearby suburbs and receptors

7.2.2 Building Wake Effects

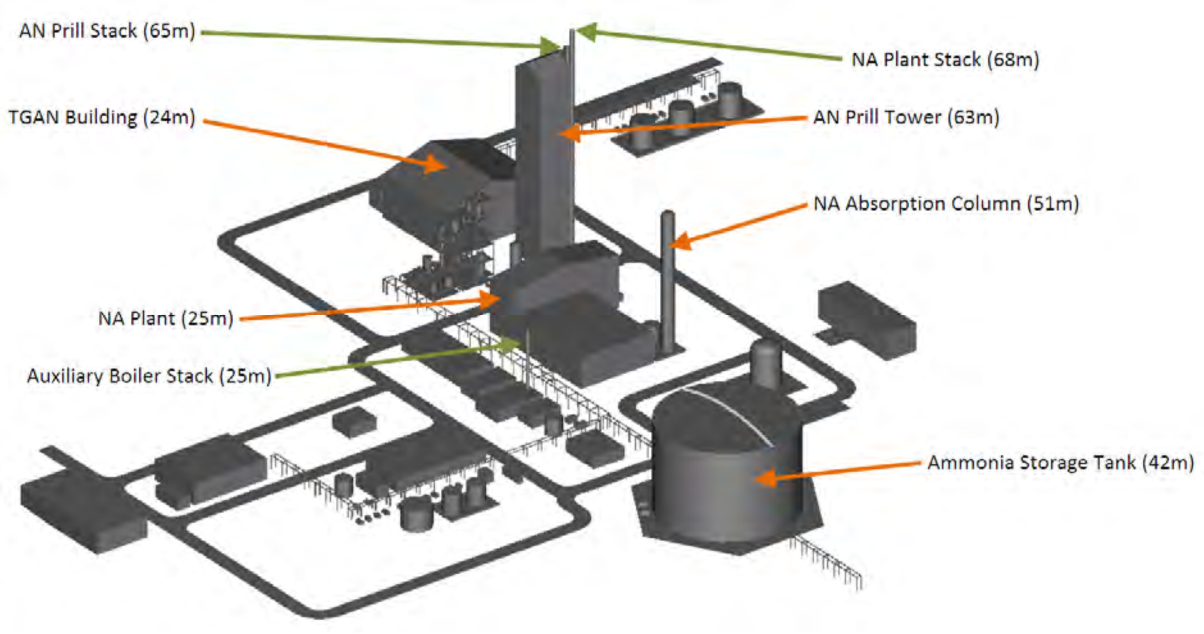
As air passes over building structures, aerodynamic wakes are produced. In these wakes strong turbulence, and downward mixing can occur. Emissions from point sources located near to these wakes can be drawn downward, and recirculated within the lee of the wake, producing locally elevated concentrations, and reducing the extent of plume rise at a distance downwind. This effect is known as building downwash.

Site plans were reviewed in order to assess the potential significance of building downwash on the dispersion of emissions from the proposed sources. Specifically, point sources were screened for potential location within building wakes, where wakes were assumed to:

- Extend 5L from the leeward edge of a structure, where L is the lesser of projected structure width or height); and
- Extend to a height of 2.5 times the height of the structure.

Figure 7-2 shows an isometric view of point sources and building structures. It should be noted that the prill tower structure is not proposed to be clad, rather the extent of the steel lattice framework is shown. Given that air will flow through this framework (and around the cylindrical prill tower), the use of the outer dimensions in the consideration of building downwash effects is considered conservative.

Figure 7-2 Isometric view of plant structure envelopes showing heights of point sources and structures



The following structures were identified as potentially significant with regard to building downwash:

- TGAN building (24 m high);
- AN Prill Tower (63 m high);
- Ammonia storage tank (42 m high); and
- NA plant (25 m high).

These buildings were entered into the Building Profile Input Program (BPIP) along with source parameters, and wind direction-dependent building downwash parameters were defined for each point source. Bagging scrubber emissions were assumed to be completely wake effected, hence were represented as a ground level volume source.

7.2.3 Fugitive Source Parameters

All sources have been modelled using the point source emission parameters detailed in **Section 6**. This is with the exception of the bagging scrubber, and the bulk load out emission sources, which have been modelled as volume sources as detailed in **Table 7-1**.

Table 7-1 Volume source emission parameters

Vent Emission Parameter	Bagging Scrubber	Existing Bulk Load Out	TGAN Bulk Load Out	Units
Easting	385.932	385.800	385.896	kmE MGA94
Northing	6360.150	6360.225	6360.195	kmN MGA94
Height (above ground level)	3	3	3	m
Initial σ_y /σ_z	2.8/1.4	2.8/1.4	2.8/1.4	m

7.2.4 Emission Source Locations

Figure 7-3 shows an aerial view of the Project Site, overlaid with the location of each emission source. The boundary of the Project Site is shown in red.

7 Assessment Methodology

Figure 7-3 Aerial view of the Project Site, showing the location of each emission source

Aerial image sourced from Nearmap 2011

7.2.5 Summary of Model Settings

Detailed presentation and analysis of the TAPM and Calmet meteorological modelling is included in **Appendix B** and summary of the input parameters is provided below. In addition, the TAPM list file and Calmet/Calpuff input files are provided in **Appendix C**.

TAPM (Meteorological Model)

TAPM Version 4.0.3 was configured in accordance with the following:

- 5 modelling grids (at 28.6, 10.4, 3.8 1.4 and 0.5 km resolution), 51 x 51 grid points, with 25 vertical levels;
- Grid centre coordinates: 151º44'30''E, 32º51'30''S, (MGA94: 382260 mE, 6363717 mN);
- Assimilation of meteorological data (configured to affect the two lowest vertical levels, i.e. 10 and 25 m) from:
  - OEH Beresfield Automatic Weather Station (AWS);
  - OEH Newcastle (AWS);
  - BoM Nobby's Head (AWS);
  - Hunter Development Corporation Steel River (AWS);
  - OEH Wallsend (AWS); and
  - BoM Williamtown (AWS).
- Data exported at assimilation sites as surface and upper air files for incorporation into Calmet. TAPM surface wind (assimilation) results were overwritten with actual wind observations when records were available.

Calmet (Meteorological pre-processor for Calpuff)

Calmet V6.333 was configured as detailed below:

- Two nested grids with outer grid results used as initial guess field:
  - Outer: 43 x 43 grid points at 500 m resolution, Grid origin: 371.75 kmE 6352.75 kmN MGA, Zone 56 (South)
  - Inner: 101 x 101 grid points at 100 m resolution, Grid origin: 379.95 kmE 6354.95 kmN MGA, Zone 56 (South)
- Terrain information sourced from the USGS 3 second (~90 m) terrain database;
- Land use data manually generated from aerial photography;
- Cell face levels at 0, 20, 30, 50, 100, 150, 250, 300, 400, 600, 1000, 1500, 2500 mAGL;
- Temperature from surface and upper air stations;
- Diagnostic wind module used with:
  - No Surface wind extrapolation;
  - Horizontally and vertically varying winds with divergence minimisation. Froude number adjustment and slope flows incorporated with a radius of influence (TERRAD) of 2 km; and
  - No calculation of kinematic effects;
  - R1 = 3km, R2 = 5 km; and
  - R1MAX = R2MAX = R3MAX = 10 km.

Calpuff (Dispersion Module)

Calpuff V6.42 was configured as detailed below:

- 101 x 101 gridded receptors at 100 m resolution;
- Inversion strength computed from temperature gradients ;
- Transitional plume rise modelled;
- Stack tip downwash included;
- Briggs rise for point sources not subject to downwash;
- Partial plume penetration of elevated inversions was used;
- Terrain effects were incorporated using the partial plume adjustment method;
- ISC urban wind speed profile was used; and
- Pasquill Gifford dispersion coefficients were used; and
- Particle deposition effects have been ignored.

7.3 Modelling of Particulate Matter (as PM_{10})

Within this assessment, it has been assumed that all particulate matter from point sources will be emitted in the form of PM_{10}. In addition, particulate matter has been modelled as a tracer gas, which means that it has been assumed that particles will not deposit out of the atmosphere. This is considered to be a conservative approach for the estimation of PM_{10} levels.

7.4 NO_2/NO_x Conversion Calculations

For the purposes of this assessment, oxides of nitrogen (NO_x) consist of the sum of nitrogen dioxide (NO_2), and Nitric Oxide (NO). In the atmosphere NO_x emissions interact with oxidants such as tropospheric ozone to form a circular reaction series between NO and NO_2.

In air quality impact assessment, the emission rates of oxides of nitrogen from industrial sources are typically calculated as "NO_X as NO_2". This terminology infers that the emissions reflect the quantity of NO_x atoms emitted, assuming (regardless of the actual amount of NO present) that all NO_x exists in the form of NO_2. This means that predicted ground NO_x concentrations can be scaled directly by an assumed NO_2/NO_x ratio, in order to arrive at a ground level concentration for NO_2.

The *Approved Methods* propose three methods for assessing NO_2 impacts, which are listed in order of increasing complexity. A summary of the methods is discussed below:

- **Method 1**: 100% Conversion of NO to NO_2. This method assumes all NO_x emissions are emitted as NO_2 and that the highest recorded background NO_2 level is constant;
- **Method 2**: NO to NO_2 conversion limited by ambient ozone concentration (OLM). This method presumes all available ambient ozone (O_3) will react with NO to form NO_2; and
- **Method 3**: NO to NO_2 conversion using empirical relationship. (The Janssen Method). In the paper "*A Classification of NO Oxidation Rates in Power Plant Plumes Based on Atmospheric Conditions*", Janssen et al. (1988).

For most industrial sources, NO_2 will typically only make up a small proportion (~10%) of the total NO_x at the point of discharge, and the NO_2/NO_x ratio will increase as the plume travels downwind and NO in the plume is oxidised by ozone to form additional NO_2. The NA plant constitutes the key NO_x source in this assessment, for which NO_2 will typically make up approximately 50% total NO_X at the point of discharge. **Table 7-2** shows typical NO_2/NOx ratios for the sources considered in this assessment.

Table 7-2 Typical source NO_2/NO_x ratios for proposed emission sources

Source	Typical In-Stack NO_2/NO_x Ratio
NA plant stack (operation)	0.5*
NA plant stack (startup)	0.7*
Auxiliary boiler stack	0.1
Ammonia storage flare (standby)	0.1

Note: *Source: (IPPC, 2007)

The standard OLM assumes in-stack NO_2/NO_x ratio of 10% (i.e. the 0.1 in **Equation 12**):

Equation 12

$$[NO_{2p}] = \min\left(\left(0.1 \times [NO_{Xp}] + \frac{46}{48}[O_{3m}]\right) or \left([NO_{Xp}]\right)\right)$$

Where:

$[NO_{2,p}]$ = predicted NO_2 concentration (µg/m³)

$[NO_{x,p}]$ = predicted NO_x concentration (µg/m³)

$[O_{3,m}]$ = measured Ozone concentration (µg/m³)

Where the OLM is used, the 0.1 value, as presented in **Equation 12**, would need to be changed to between 0.5 and 0.7 to reflect the in-stack NO_x ratio. If using average ozone concentrations (e.g. 30ppbv / 65 µg/m³)[20], the OLM would only begin to offer refinement of the NO_x ratio beyond predicted NO_x (as NO_2) impacts above 130 µg/m³, hence would not offer refinement for this assessment. Hence a modified OLM would offer little refinement beyond Method 1, and Method 3 is considered inappropriate, as it represents an empirical relationship derived from a source with an in-stack NO_x ratio of approximately 10%.

Hence in this assessment it has conservatively been assumed that all Project emitted NO_x exists in the form of NO_2.

7.5 Assessment of Emissions During Construction

Based on the review of activities detailed in **Section 2.2**, and the industrial nature of the Project Site and immediate surroundings, the potential for adverse air quality impacts to arise from construction operations is considered to be low, with dust generation considered to be of a moderate emissions potential, and manageable through the implementation of appropriate mitigation and management programs.

As part of the construction phase of the Project, IPL propose to implement a Construction Environmental Management Plan (CEMP), which will include details of measures to be implemented to ensure that construction emissions from the Project Site are managed. On this basis, construction activities have been excluded from quantitative assessment.

.[20] A typical Ozone concentrations for Newcastle, as shown in OEH (2012),

7.6 Assessment of Operational Emissions

The Project involves a range of process, not all of which occur simultaneously.

Table 7-3 provides frequency and duration of routine and infrequent operations.

Table 7-3 Duration and frequency of routine and infrequent operations

Emission Source	Duration	Frequency
Routine Operations		
NA plant stack (operational conditions)	Continuous	>95% of the year
AN plant scrubber		
Auxiliary boiler (operational conditions)		
AN bagging plant dust extraction		
Ammonia storage flare (standby)		~100% of the year
TGAN load out	Intermittent	Throughout the year
Existing fertiliser load out		
Non-Routine Operations		
NA plant stack (startup conditions)	~30 minutes	~3 – 4 times per year
Auxiliary boiler (plant startup conditions)	~3 hours	~3 – 4 times per year
Waste ANSOL concentrator	~ 1 hour	~ Monthly
Ammonia storage flare (operation)	~12 hours	< once in 10 years

The sources listed in **Table 7-3** have been collated into three emission scenarios. These are:

- Plant startup;
- Steady state operation; and
- Ammonia flaring.

Table 7-4 identifies active emission sources by emissions scenario.

Table 7-4 Active emission sources by emissions scenario

Emission Source	Modelling Scenario		
	NA Plant Startup	Plant Operation	Flaring
NA plant	✓	✓	
AN plant scrubber	✓	✓	
Auxiliary boiler	✓	✓	
Ammonia storage flare (standby)	✓	✓	
Ammonia storage flare (operation)			✓
AN bagging plant dust extraction	✓	✓	
Waste ANSOL concentrator		✓*	
Existing bulk load out		✓**	
TGAN bulk load out		✓**	

Notes: *Modelled each day at 12 pm for a single hour. ** Modelled continuously each day between the hours of 8am and 4pm.

Operational Emissions

The operational emissions scenario has assumed that all sources in **Table 7-4** operate continuously through the year, with the exception of the bulk load out points which have been assumed to operate continuously each day between the hours of 8am and 4pm, and the waste ANSOL concentrator which has been modelled as operating each and every day at 12 pm for a single hour.

NO_x Emissions from Plant Startup

NA Plant startup is anticipated to occur approximately 3-4 times per year. A startup event consists of a sequence of operations, beginning with the priming of the boiler, then the initiation of NA plant flows and introduction of heat and reactant (ammonia). At this stage, the reaction parameters are transient, and NO_x emission levels are elevated. After approximately 30 minutes, the NO_x levels are expected to reduce to below 75ppmv, and the plant ramps up to full operational flow.

This has been represented in the dispersion model through the use of a variable emissions file, allowing the effect of accumulation of emissions from the various processes to be investigated. The variable emissions file comprised the following:

- The boiler is run at the plant startup condition (100% flow) for 2 hours;
- The NA plant starts up over a 30 minute period (70,000 Nm^3/hr / 250 ppmv NO_x);
- The plant gradually increases flow over the next 30 minutes; (80,000 Nm^3/hr / 75 ppmv NO_x);
- The plant continues under normal operation for 10 hours (110,000 Nm^3/hr / 75 ppmv NO_x);

The variable emissions file consisted of 13 hours of emissions, which were cycled every 23 hours. This means that within the year modelled, a total of 381 startup events were modelled (approximately two orders of magnitude higher than anticipated), and that a range of diurnal and seasonal meteorological conditions are assessed.

Table 7-5 shows the startup sequence that was incorporated into the dispersion model.

Table 7-5 Modelled startup sequence

Hour	NA Stack (T0-30)	NA Stack (T30-60)	NA Stack (Operation)	Boiler (Startup)	Boiler (Operation)	Ammonia Flare (Standby)
1				✓		✓
2				✓		✓
3(1)	✓(2)	✓(2)		✓		✓
4			✓		✓	✓
5			✓		✓	✓
6			✓		✓	✓
7			✓		✓	✓
8			✓		✓	✓
9			✓		✓	✓
10			✓		✓	✓
11			✓		✓	✓
12			✓		✓	✓
13			✓		✓	✓

Notes: (1)Shaded row reflects hour in which startup is simulated to occur. (2)Emission rate weighted to reflect 30 minute duration.

Flaring

Flaring has been assumed to take place independently of other plant operations as IPL expect that NA and AN plants would be shutdown. IPL consider this scenario to be unlikely and occur less than once in 10 years.

7.6.1 Emissions from Other Approved Developments in the Region

URS conducted a brief review of the NSW Department of Planning and Infrastructure (DP&I) website in order to identify other approved developments that would have significant potential for cumulative air quality impacts with the Project. URS identified the Orica Ammonium Nitrate Facility Upgrade as detailed in ENSR (2009), as having significant potential to produce cumulative impacts with the Project, primarily due to:

- Co-location of the IPL and Orica facilities;
- Similarities in production processes, and pollutant classes;
- Similarities in emission characteristics (elevated point sources with moderate buoyancy).

For these reasons, a quantitative representation of the approved emission sources has been incorporated into this assessment. URS reviewed the AQIA for the Project, and noted the following proposed alterations to the Orica facility:

- Addition of a Pre-Reformer Furnace (PRF) to the ammonia plant;
- Modifications to the boiler emissions (BS);
- Addition of a fourth NA plant (NAP4);
- A reduction in NO_x emissions from the existing reformer stack from 14.2g/s to 10.86 g/s; and
- Addition of a third ammonium nitrate plant (ANP3).

This cumulative assessment has been limited to NO_2, on the basis that it is the key pollutant of interest with respect to potential cumulative impacts from proposed sources, with proposed particulate emissions primarily limited to those ANP3, for which PM_{10} emissions were estimated at 0.32 g/s. It is also noted that NO_2 emissions from existing Orica operations have been excluded from this modelling on the basis that they have been captured in the background monitoring data collected at Stockton. This data includes approximately 40,000 hourly NO_2 records at a location that is aligned downwind of the Orica facility (in accordance with prevailing winds for the region), and where highest impacts from the Orica facility were predicted to occur (ENSR, 2009).

As appropriate to the representation of emissions from third party sources, some refinements were made to the Orica data in order to provide a more realistic estimate of emissions. These included:

- Assumed constant operation at 75% of licence limits; and
- A NO_2/NO_x ratio of 30% applied to gas combustion sources (this allows for uptake of ozone under ambient conditions[21].

Table 7-6 provides a summary of this representation.

[21] Nitric acid plant emissions have been modelled as 100% NO_x as NO_2

7 Assessment Methodology

Table 7-6 Modelled emissions from Orica upgrade emission sources

Parameter	Proposed Source			Units
	Revised Boiler	Pre-Reformer Furnace	NA Plant	
Flow	8.33	5.28	26.67	Nm^3/s
NO_x Concentration)[1]	1000	350	307.5	mg/Nm^3
Assumed Fraction of EPL	0.35[2]	0.75	0.75	-
Assumed NO_2/NO_x ratio	30%	30%	100%	-
Emission Rate	**0.875**	**0.42**	**6.15**	g/s

Note: [1]NO_x as NO_2 [2]As was assumed in ENSR (2009).

For simplicity, the reduction in reformer emissions and existing boiler emissions were ignored. Stack and building downwash parameters were modelled as detailed in ENSR (2009).

8

Results

This section provides the results of the dispersion modelling, with comparison against OEH impact assessment criteria. Results have been presented both in tabulated form, and as contour isopleths. NO_2 results have been presented in accordance with the Approved Methods, which specify assessment against the peak (100th percentile) results, with addition to peak background concentrations. Whilst this may be sufficient to demonstrate compliance with assessment criteria, consideration should be given to model assumptions when considering reported pollutant levels outside of the assessment framework provided in the Approved Methods.

8.1 Plant Operation

8.1.1 Nitrogen Dioxide (NO_2)

Table 8-1 shows detail of model predictions for NO_2, with comparison against impact assessment criteria, with inclusion of the background concentrations detailed in **Section 5.4**. As can be seen, peak model predictions are low relative to criteria. When added to existing background levels, peak model predictions are within OEH impact assessment criteria.

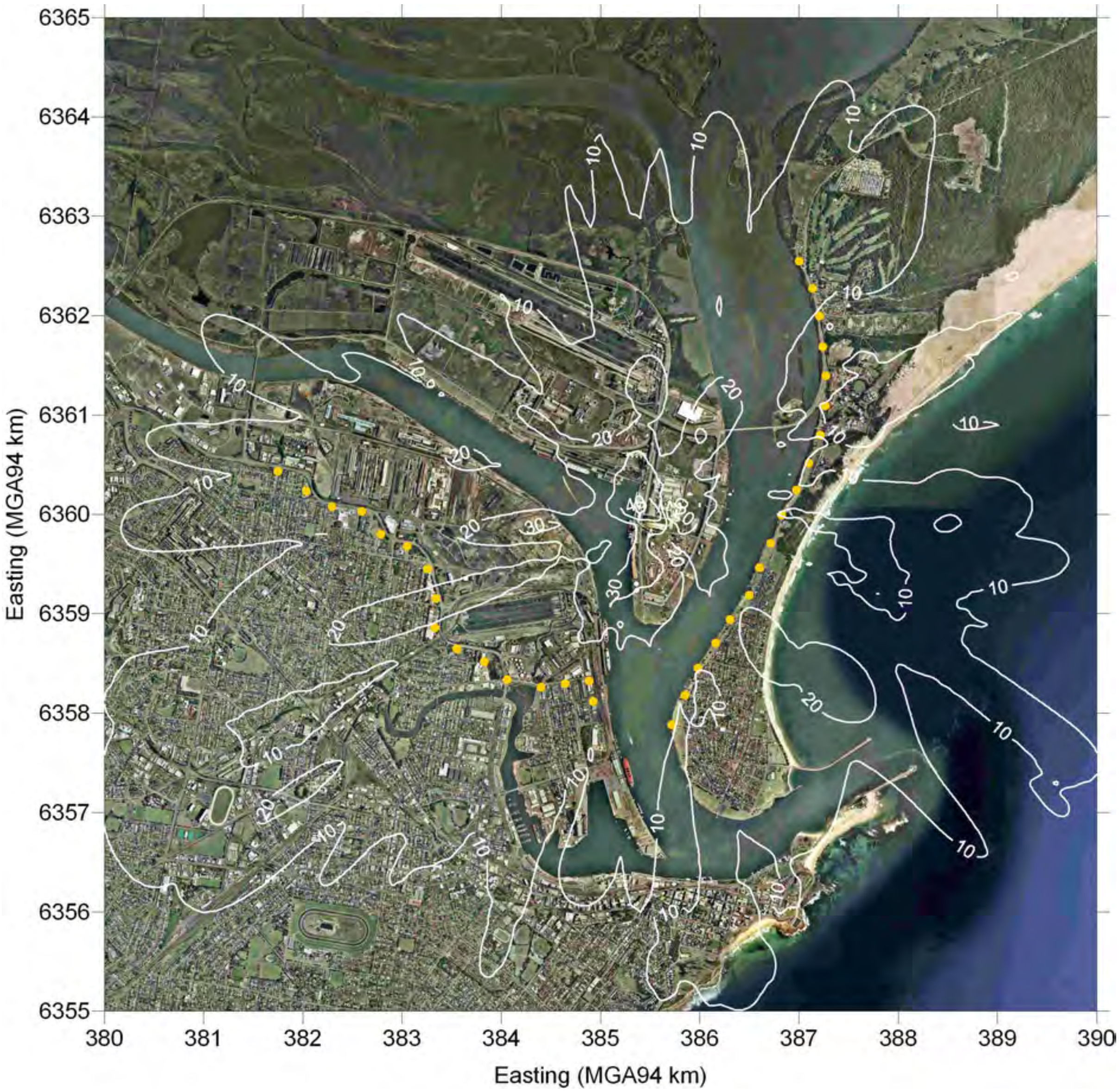
Table 8-1 Dispersion model results: NO_2 (All NO_x as NO_2) - Plant Operation (µg/m³)

Category	Receptor	1 hr Average	Annual Average
Incremental Impact	Max Discrete	25	0.4
	Max Gridded	53	1.5
Background	-	*84*	*18.7*
Cumulative Impact	Max Discrete	109	19.1
	Max Gridded	137	20.2
Criteria	-	*246*	*62*

Figure 8-1 shows the spatial variation of peak 1 hour average model predictions. A review of the location of the 20 most affected gridded receptors identified peak areas as being confined to the (closest) 30 µg/m³ contour area immediately to the south west and west of the Lot. Peak concentrations at these 20 grid points ranged between 34 µg/m³ and (the peak grid point) 53 µg/m³, implying that outside of this area peak, maximum concentrations were all less than 34 µg/m³. Indeed, predicted peak 1 hour NO_2 impacts were estimated to be less than 30 µg/m³ at all non-industrial locations, with a maximum prediction at Stockton of 27.8 µg/m³.

8 Results

Figure 8-1 Predicted maximum incremental 1 hour NO_2 (All NO_x as NO_2) - Plant Operation (µg/m³)

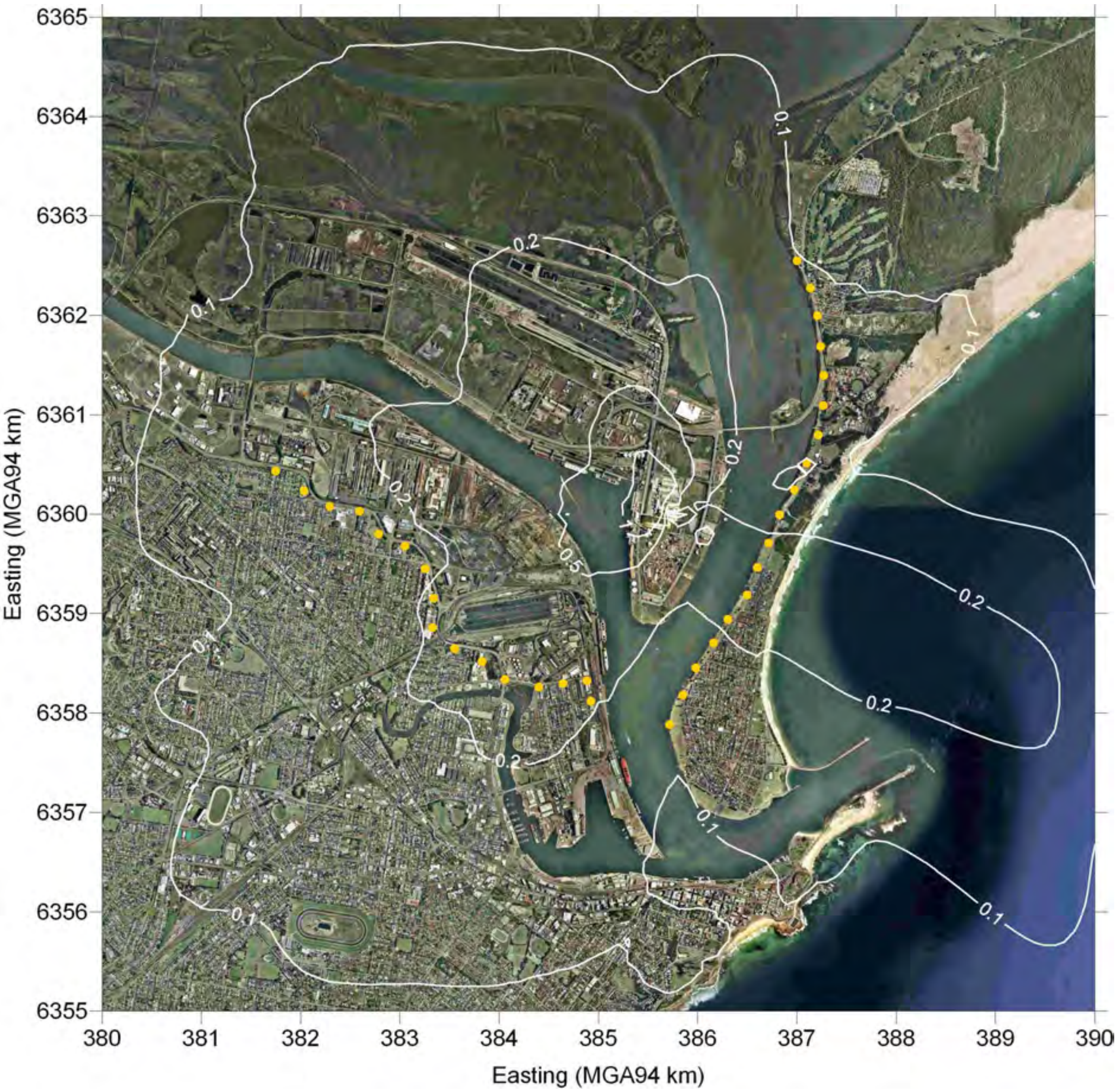


(Image sourced from Google Earth Pro)

● Discrete Receptor

Figure 8-2 shows the spatial variation in annual average NO_2 predictions.

Figure 8-2 Predicted incremental annual average NO_2 (All NO_x as NO_2) - Plant Operation (µg/m³)



(Image sourced from Google Earth Pro)

● Discrete Receptor

8.1.2 Particulate Matter (as PM_{10})

Table 8-2 shows detail of model predictions for PM_{10}, with comparison against impact assessment criteria. As can be seen in these data, peak model predictions are low relative to criteria and when added to existing background levels, are within OEH impact assessment criteria.

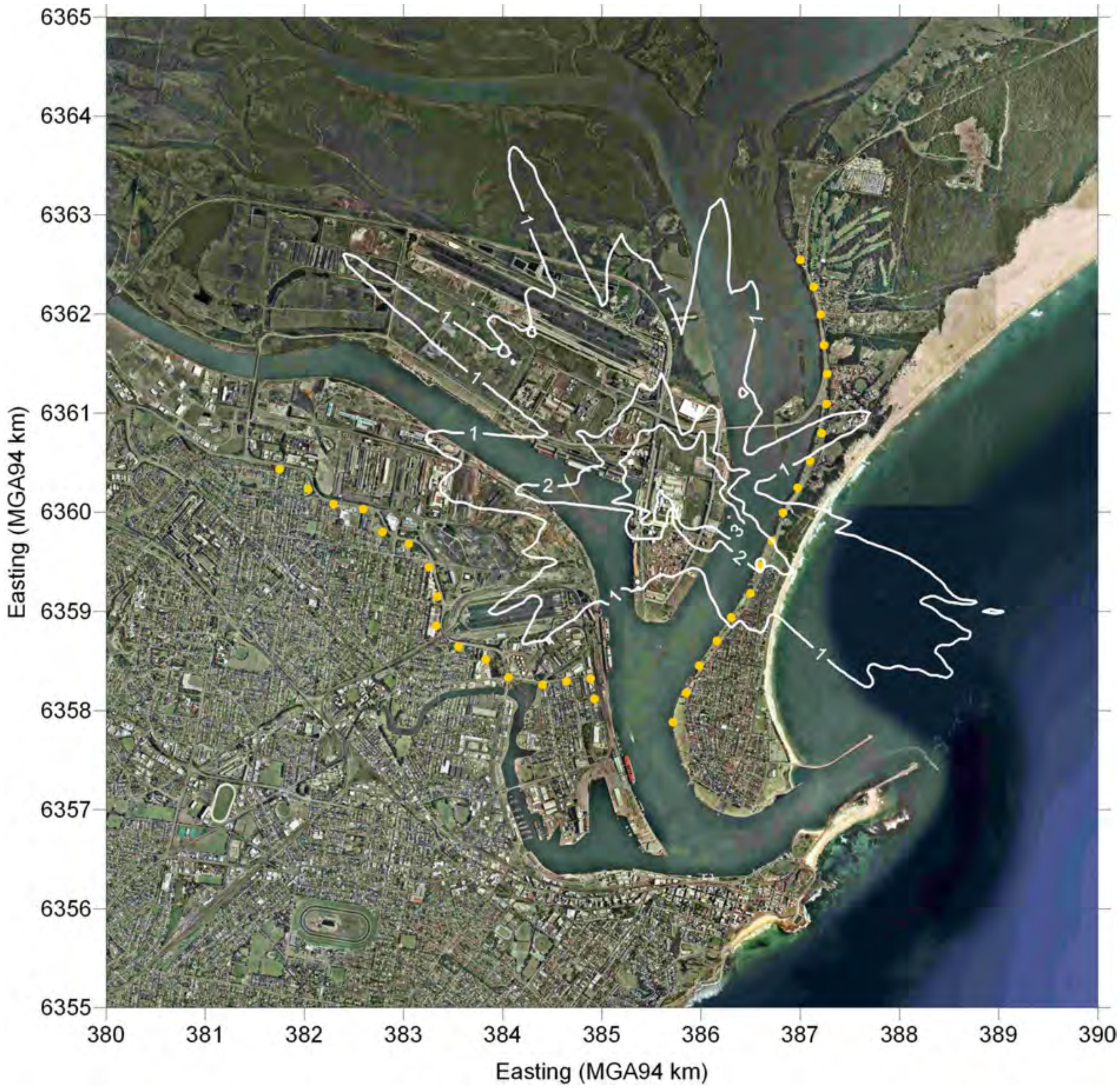
Table 8-2 Dispersion model results: PM_{10} - Plant Operation (µg/m³)

Category	Receptor	24 hr Average	Annual Average
Incremental Impact	Max Discrete	2.0	0.2
	Max Gridded	11.9	0.9
Background	-	*31.7*	*21.7*
Cumulative Impact	Max Discrete	33.7	21.9
	Max Gridded	43.6	22.6
Criteria	-	*50*	*30*

8 Results

Figure 8-3 shows the annual average PM_{10} predictions from Project operation. Concentrations greater than 3 µg/m³ are primarily confined to areas directly around the Project Site.

Figure 8-3 Peak incremental 24 hour PM_{10} predictions - Plant Operation (µg/m³)

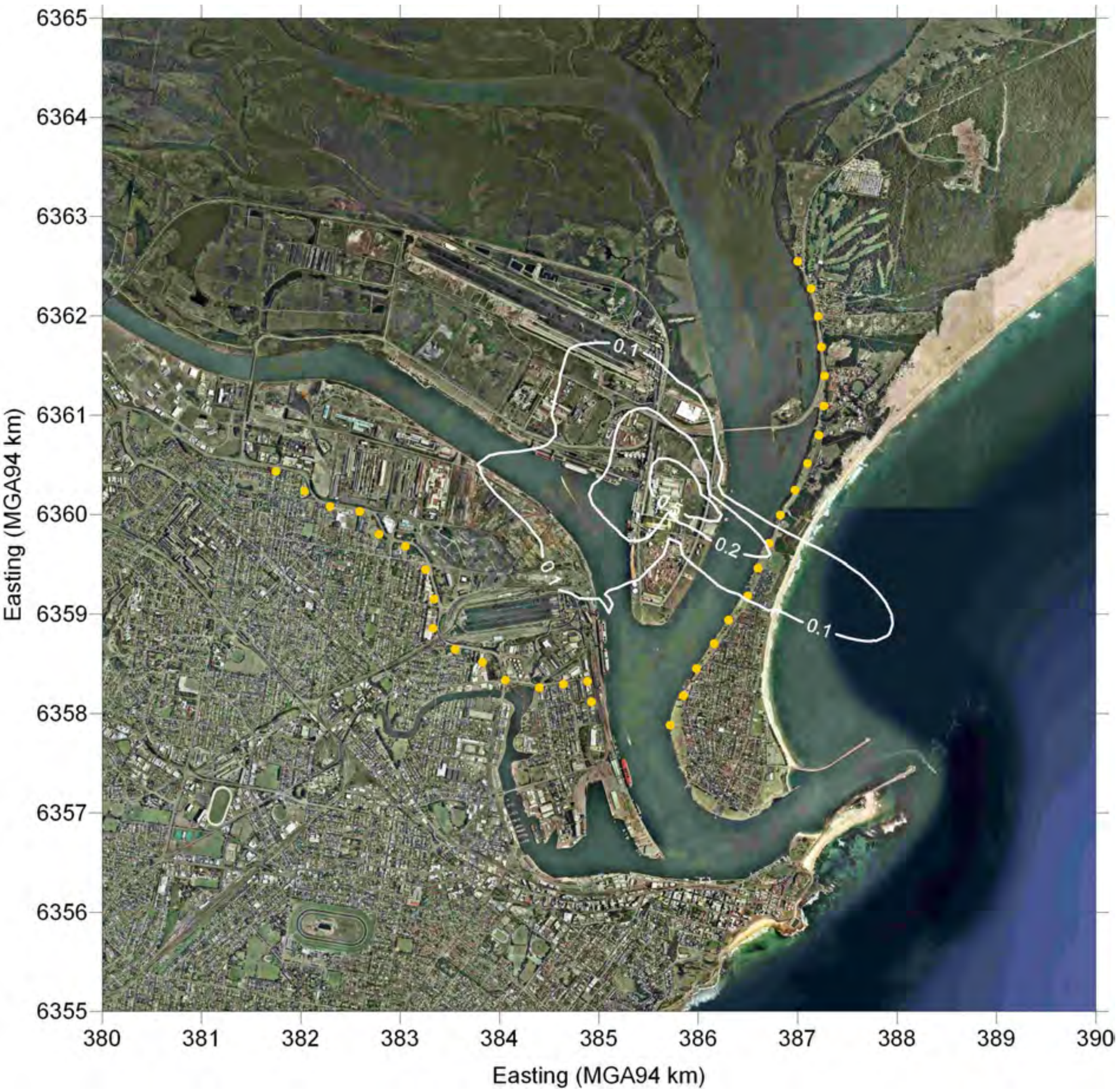


(Image sourced from Google Earth Pro)

● Discrete Receptor

Figure 8-4 shows annual average PM_{10} predictions from Project operation. The influence of predominant winds is seen through the extension of the 0.1 µg/m³ to the south east of the Lot, whilst predictions greater than 0.2 µg/m³ are confined to areas directly around the Lot.

Figure 8-4 Annual average incremental PM_{10} predictions - Plant Operation (µg/m³)



(Image sourced from Google Earth Pro)

Discrete Receptor

8.1.3 Ammonia

Table 8-3 provides detail of model predictions for Ammonia, with comparison against impact assessment criteria. As can be seen, peak model predictions within OEH impact assessment criteria. In accordance with the Approved Methods, this criterion is applied based on impacts of the pollutant source alone (i.e. emissions from the Project Site).

Table 8-3 Dispersion model results: PM_{10} - Plant Operation (µg/m³)

Category	Receptor	1 hr Average
Predicted Impact	Max Discrete	1.2
	Max Gridded	2.5
Criterion	-	*330*

8.2 Non-Routine Emissions

This section provides the results of the dispersion modelling of non-routine operations, with comparison against OEH impact assessment criteria. Results have been presented both in tabulated form, and as contour isopleths. Despite the infrequent nature of these events, 100th percentile NO_2 results and 99.9th percentile ammonia results have been presented. An awareness of the proposed frequency of these events should be maintained when reviewing these results.

In addition, given the short duration and infrequent nature of these events, criteria with averaging periods greater than 1 hour have not been presented.

8.2.1 Nitrogen Dioxide

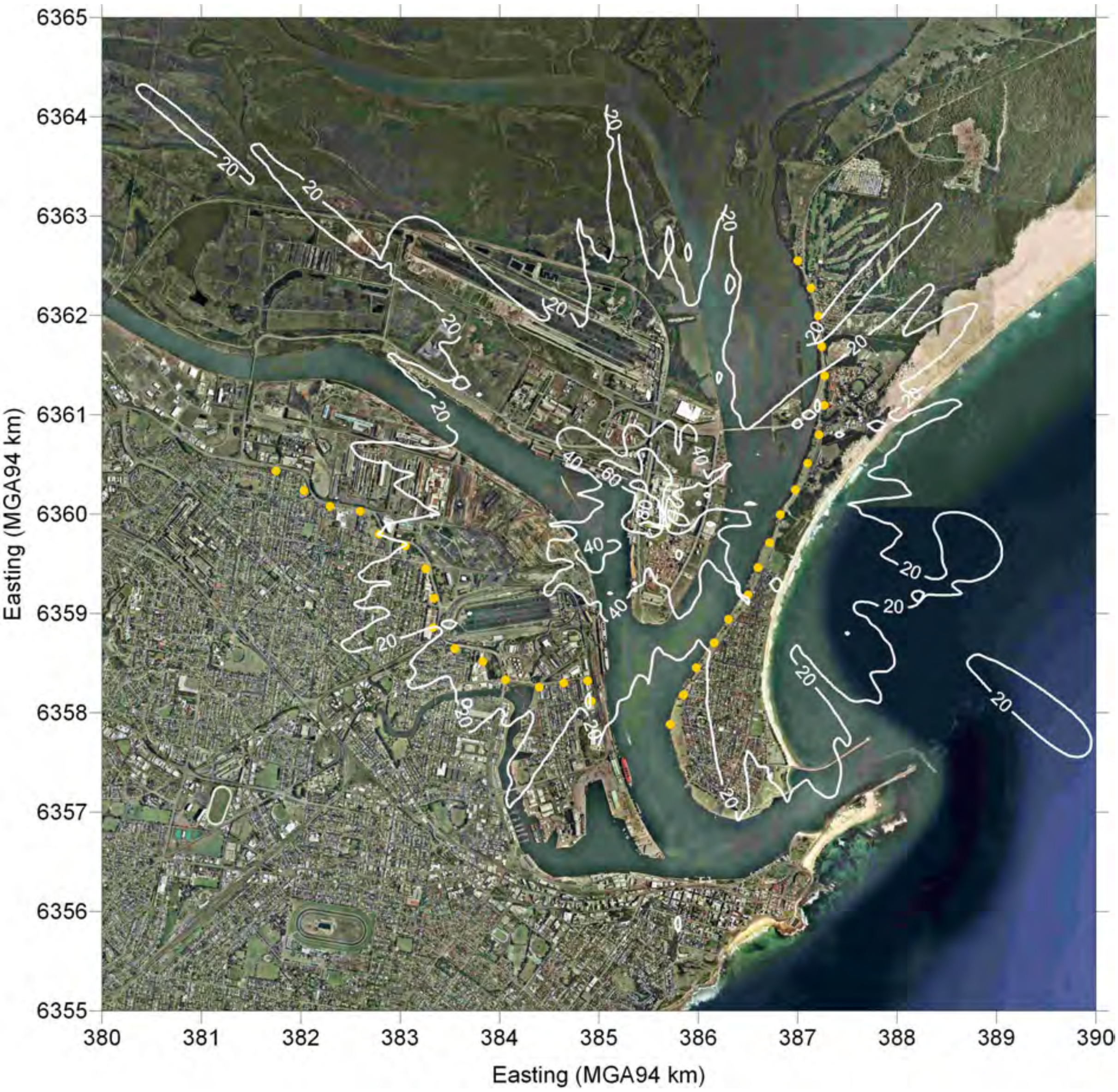
Table 8-4 shows peak NO_2 predictions for NA plant startup, and Flaring events. As can be seen in these data, when added to existing background levels, peak model predictions are within OEH impact assessment criteria.

Table 8-4 Dispersion model results: NO_2 (All NO_x as NO_2) – Non-Routine Operations (µg/m³)

Category	Receptor	NA Startup	Flaring
Incremental Impact	Max Discrete	40	47
	Max Gridded	94	137
Background	-	*84*	*84*
Cumulative Impact	Max Discrete	124	131
	Max Gridded	178	221
Criteria	-	*246*	*246*

Figure 8-5 shows predicted maximum incremental 1 hour NO_2 for plant startup conditions. Predicted incremental concentrations in excess of 60 µg/m³ are confined to areas directly around the Project Site.

Figure 8-5 Predicted maximum Incremental 1 hour NO_2 (All NO_x as NO_2) – NA Plant Startup (µg/m³)



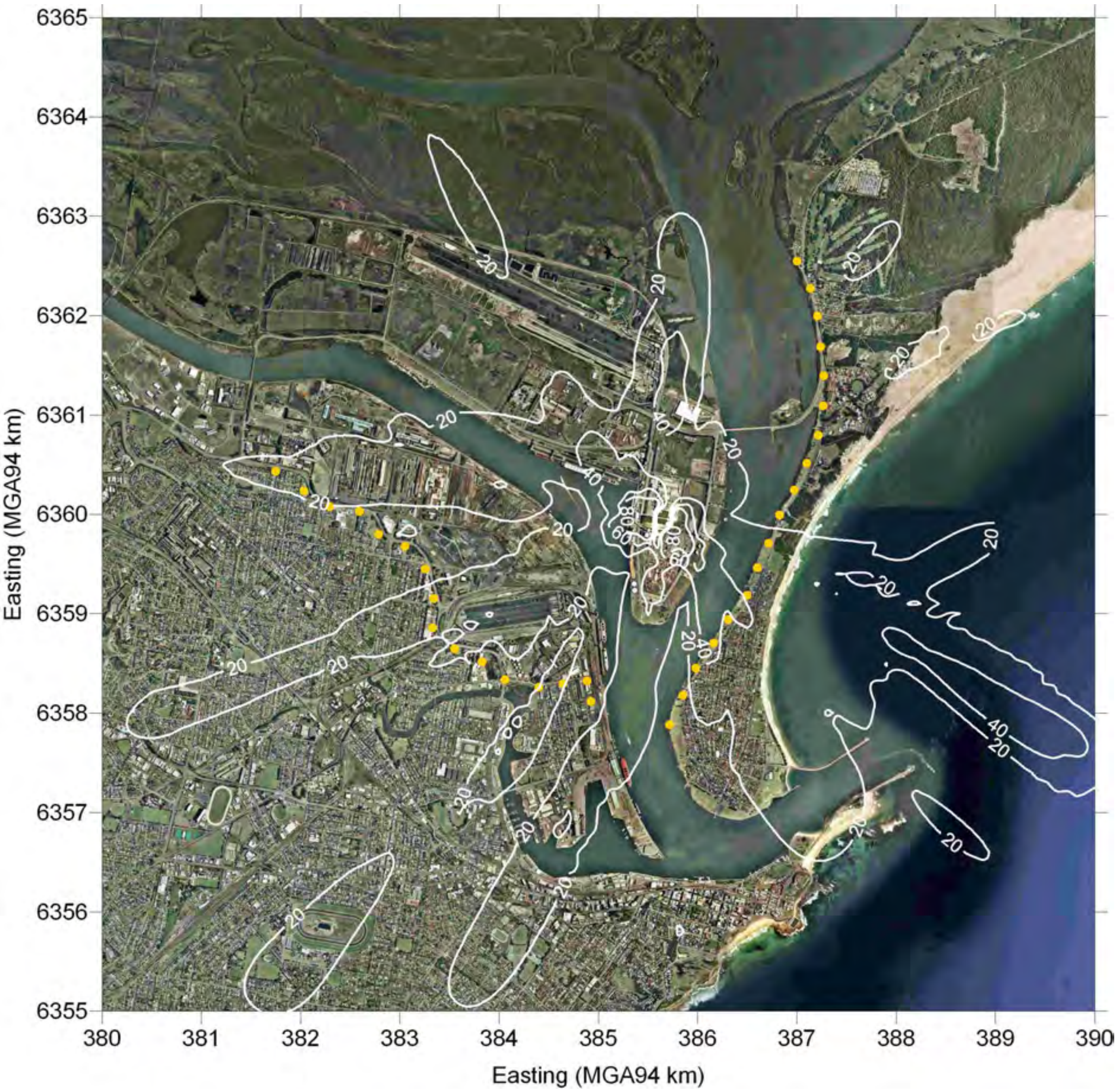
(Image sourced from Google Earth Pro)

Discrete Receptor

8 Results

Figure 8-6 shows predicted maximum incremental 1 hour NO_2 for flaring conditions. Predicted incremental concentrations in excess of 60 µg/m³ are confined to areas directly around the Project Site.

Figure 8-6 Predicted maximum Incremental 1 hour NO_2 (All NO_x as NO_2) - Flaring (µg/m³)



(Image sourced from Google Earth Pro)

Discrete Receptor

8.2.2 Ammonia

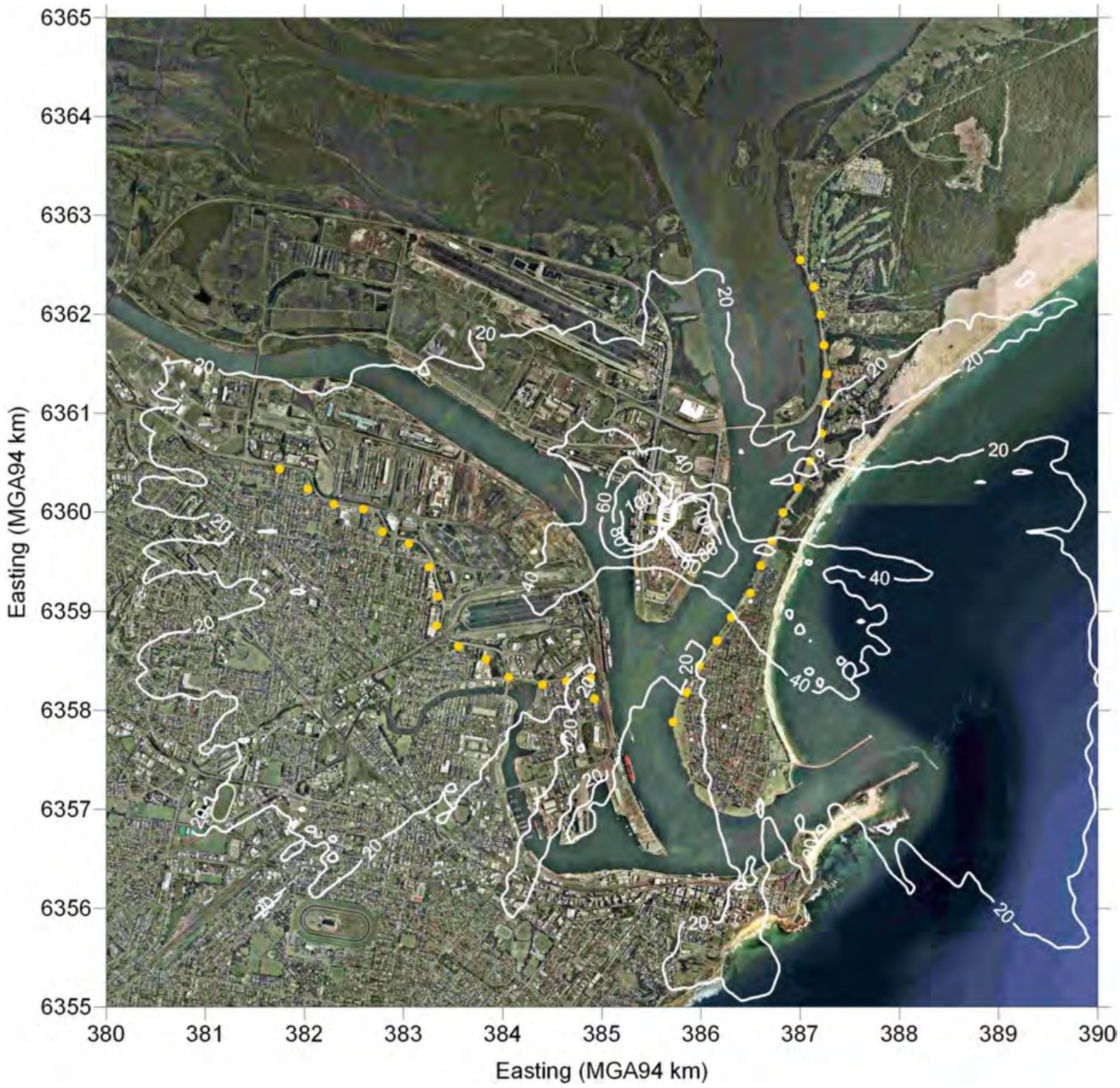
Table 8-5 and **Figure 8-7** show the predicted ammonia concentrations associated with a flaring event. This result is within the OEH impact assessment criterion. Given the rarity of flaring events (~1 in 10 years), the use of a 99.9th percentile result in conjunction with the OEH criterion is considered highly conservative.

Table 8-5 Predicted 99.9th percentile 1 hour ammonia – Flaring (µg/m³)

Category	Receptor	Flaring
Incremental Impact	Max Discrete	52
	Max Gridded	262
Criterion	-	*330*

8 Results

Figure 8-7 Predicted 99.9th percentile 1 hour ammonia – Flaring (µg/m³)



(Image sourced from Google Earth Pro)

● Discrete Receptor

8.3 Cumulative Assessment of Proposed Orica and IPL Sources

This scenario presents the cumulative impact of Project emissions, and emissions sources proposed as part of the proposed upgrade to the Orica site adjacent to the Project Site. This has been performed in order to provide consideration for potential coincident impacts from emission sources on Orica and IPL facilities that do not exist at present, and have not been captured in ambient monitoring performed to date. This cumulative assessment has been limited to NO_2, on the basis that it is the key pollutant of interest with respect to potential cumulative impacts from proposed sources. **Table 8-6** provides a summary of the results of this analysis.

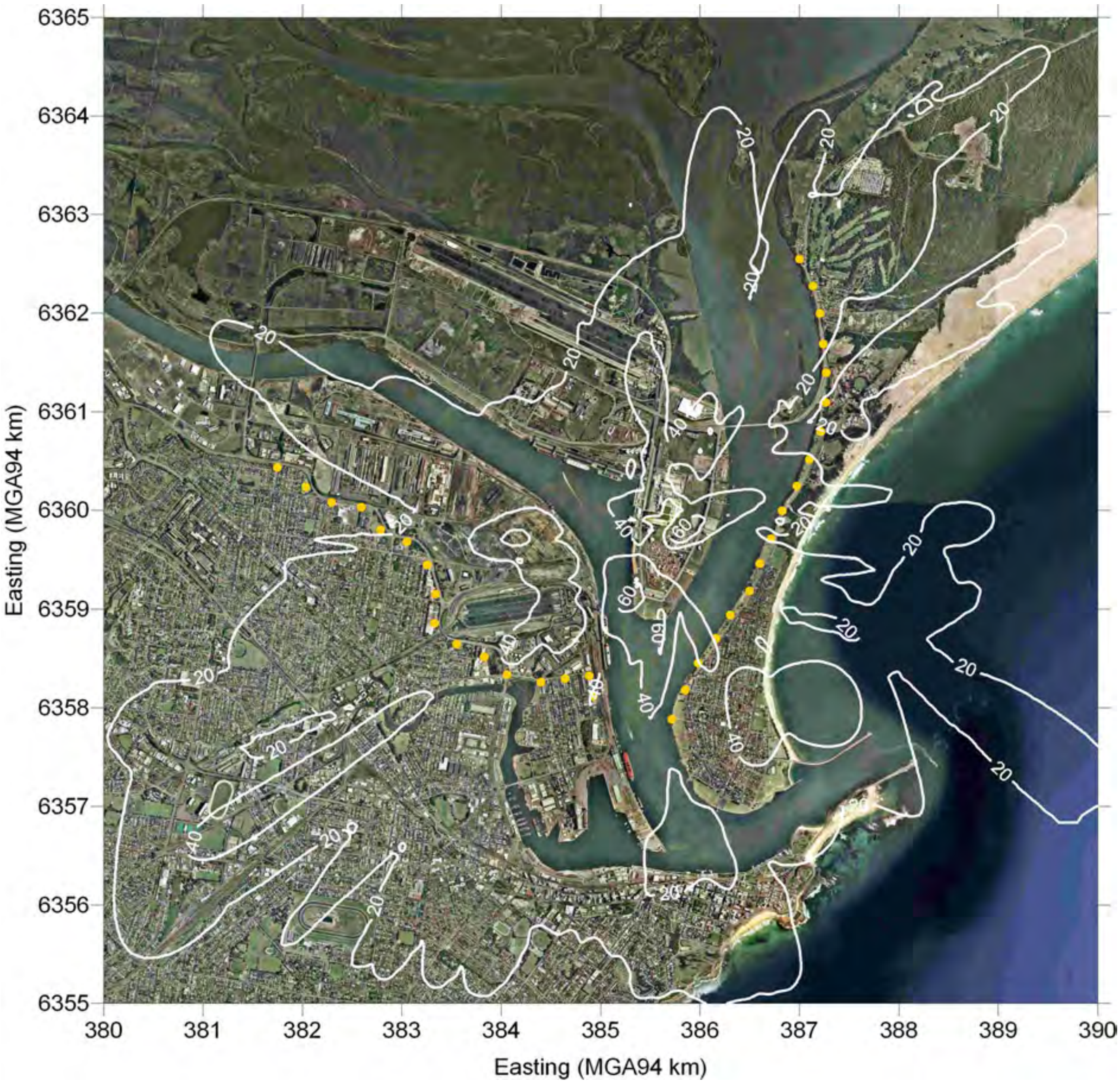
Table 8-6 Predicted cumulative NO_2 –Orica and IPL KI (µg/m³)

		NA Plant Startup	Plant Operation	
Category	Receptor	1 hour Max	1 hour Max	Annual
Incremental Impact[1]	Max Discrete	41	41	0.7
	Max Gridded	108	71	3.0
Background	-	*84*	*84*	*18.7*
Cumulative Impact	Max Discrete	125	125	19
	Max Gridded	192	155	22
Criteria	-	*246*	*246*	*62*

Note[(1)]: In this instance, "incremental" refers to the incremental impact from the Project and Orica upgrade sources combined.

Figure 8-8 shows the predicted cumulative incremental NO_2 predictions for operation of the Orica upgrade and the IPL Project. All sources have been modelled as all NO_x as NO_2, excluding the NO_x emissions from gas combustion on the Orica site, which have assumed an ambient ratio of 30%.

Figure 8-8 Predicted maximum incremental 1 hour NO_2 – Orica and IPL KI operation (µg/m³)



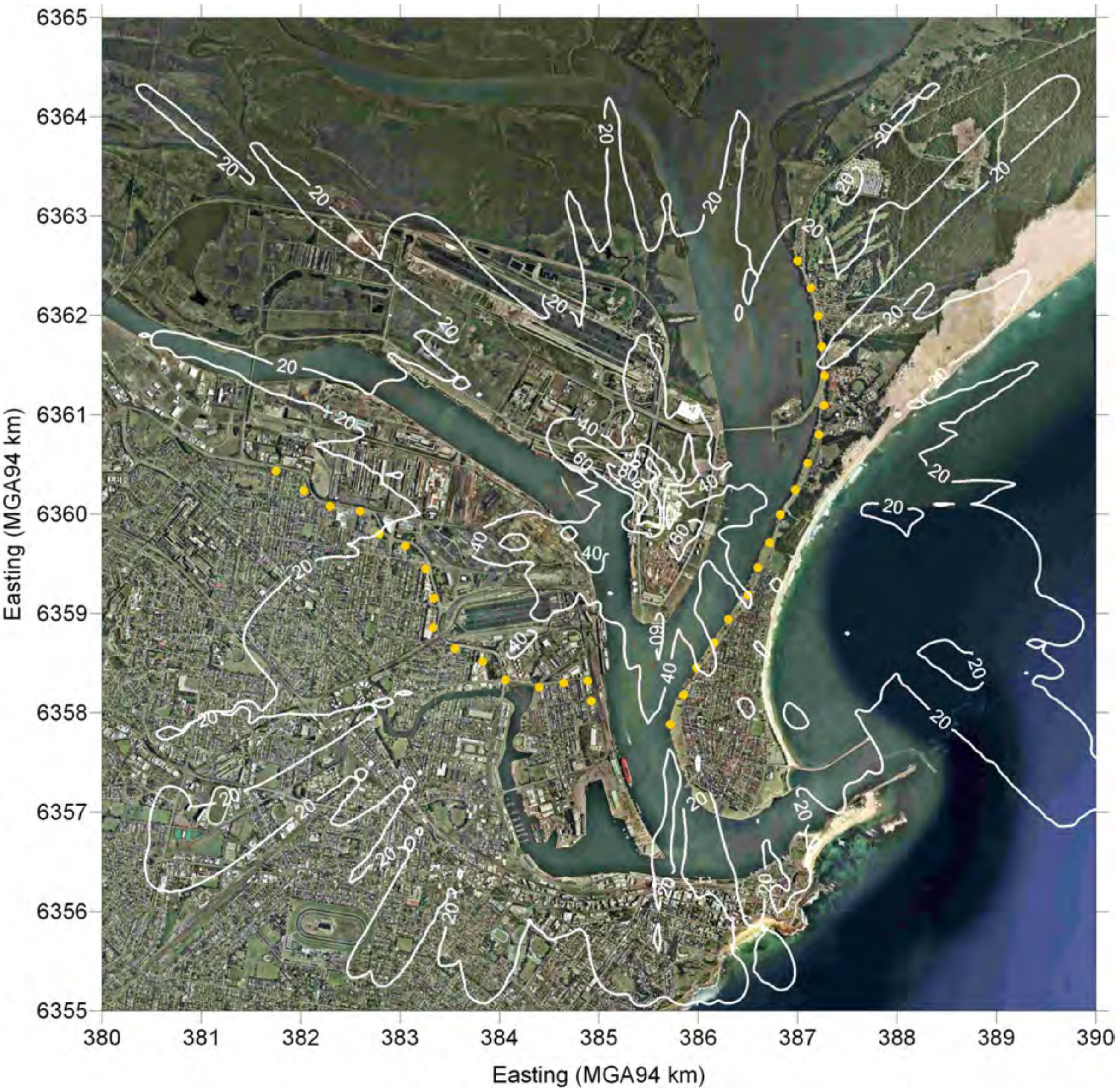
(Image sourced from Google Earth Pro)

Discrete Receptor

8 Results

Figure 8-9 shows incremental NO_2 predictions for operation of the Orica upgrade and startup of the IPL Project. All sources have been modelled as all NO_x as NO_2, excluding the NO_x emissions from gas combustion on the Orica site, which have assumed an ambient ratio of 30%.

Figure 8-9 Predicted maximum incremental 1 hour NO_2 – Orica operation and IPL KI startup (µg/m³)



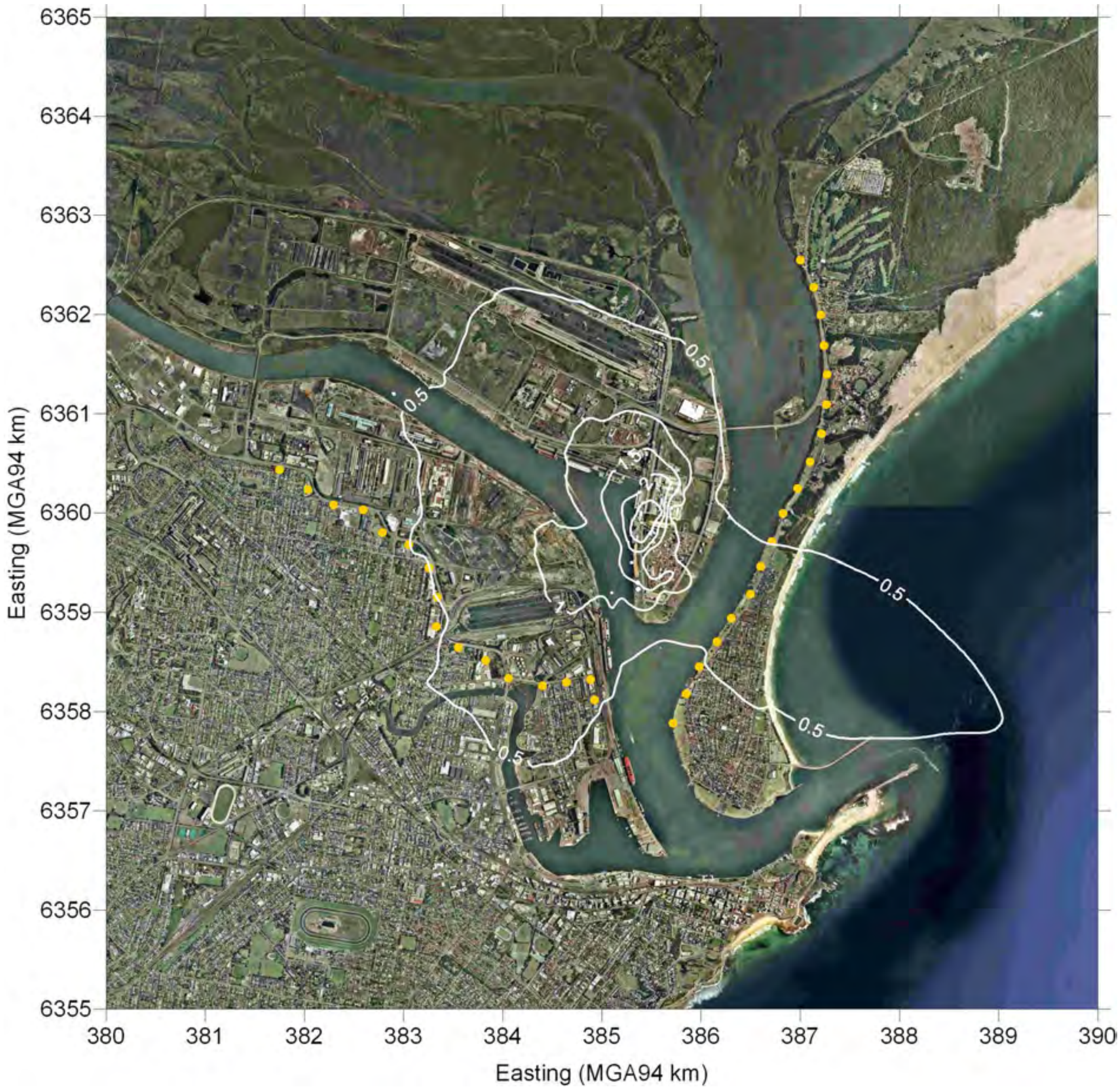
(Image sourced from Google Earth Pro)

● Discrete Receptor

8 Results

Figure 8-10 shows annual average NO_2 predictions from operation of the Orica upgrade, and the IPL Project.

Figure 8-10 Predicted incremental annual average NO_2 –Orica and IPL KI operation (µg/m³)



(Image sourced from Google Earth Pro)

Discrete Receptor

9 Conclusions

The potential air quality impact of the Project has been assessed through a review of proposed emissions, and assessment using the Calpuff dispersion modelling package.

Dispersion modelling predicted a peak incremental impact 1 hour all NO_x as NO_2 concentration of 53 µg/m³, which was confined to a small area to the west of the Project Site. Peak 1 hour NO_2 impacts were estimated to be less than 30 µg/m³ at all non-industrial locations, with a maximum of 27.8 µg/m³ predicted at Stockton. In the context of peak background levels (which were estimated at 84 µg/m³, this peak cumulative prediction of 112 µg/m³ was found to be well below the OEH NO_2 criterion of 246 µg/m³. Operational PM_{10} and ammonia predictions have also been found to be minor, and within OEH impact assessment criteria, with peak incremental concentrations constituting approximately 1% and 4% of the relevant criteria. Modelling predictions for non-routine operations were found to be more elevated, yet within criteria, despite being based on conservative statistics and assessment methodologies. Hence, based on the information reviewed and the assessment performed the potential for the Project to result in adverse air quality impacts is considered to be low.

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A

Appendix A Flare Calculations

URS

Appendix A - Flare Calculations

A.1 Flare Calculation Methodology

As the flame of a flare extends beyond the flare structure, the structural geometry cannot be used to define the point source. Instead, an equivalent representation must be made in order to provide appropriate initial conditions for the dispersion model.

Buoyancy flux is considered to be the key parameter relevant to plume dispersion from flare sources. The derivation of the virtual stack representation has been performed by assuming generally representative source temperatures and exit velocities, and then back calculating the plume diameter (for a plane at the end of the flame) such that the net buoyancy flux reflects the total quantity of thermal energy that is advected into the plume. This is equal to the enthalpy of combustion, minus the radiative heat loss from the flare. This approach is consistent with the methodology provided in Beychok (2005)[22].

The virtual source height is defined by the point at which combustion is complete, which is determined by the end of the flame. This involves the calculation of the flame length in accordance with the API[23] methodology (**Equation 1**):

(**Equation 1**)
$$H_{equiv} = H_{actual} + 0.006 Q_c^{0.478}$$

The plume diameter at the virtual source height is equal to:

(**Equation 2**)
$$D_{equiv} = \sqrt{\frac{F_b}{\left(\frac{gV(T_s - T_a)}{4T_s}\right)}}$$

Where buoyancy flux is equal to:

(**Equation 3**)
$$F_b = 2.58 \times 10^{-6} Q_p$$

Where:

H_{equiv}	=	Equivalent height of the flare, (ft);
H_{actual}	=	Height of the flare structure from the ground, (ft);
Q_c	=	Flared gas heat release, (Btu/hr);
D_{equiv}	=	Equivalent diameter of the flare, (m);
F_b	=	Buoyancy Flux, (m^4/s^3);
G	=	Gravitational acceleration, (m/s^2);
V	=	Assumed exit velocity, (m/s);
T_s	=	Assumed source temperature;
T_a	=	Assumed ambient temperature (293K);
Q_p	=	Heat advected to plume (Btu/hr);

[22] Beychok, M - *Fundamentals of Stack Gas Dispersion* Fourth Edition, 2005
[23] American Petroleum Institute - *Guide for pressure relief and depressuring systems*, API RP 521, First Edition, September 1969

Appendix A - Flare Calculations

A.2 Standby Flare Calculation

PARAMETER	VALUE	UNITS
Natural gas flow	20	kg/hr
Calorific value	51.4	MJ/kg (HHV)
	46.3	MJ/kg (LHV)
Energy Release	926	MJ/hr
	8.8E+05	BTU/hr
	0.257	MW
	25%	Radiative heat loss
Sensible heat release	695	MJ/hr
	6.58E+05	BTU/hr
	0.19	MW
Flame Length	1.1	m(2)
Flare Base Height	36	m
Virtual source height	37.1	m
Buoyancy Flux	1.70	m^4/s^3
Plume averaged velocity	5	m/s
Plume averaged Temperature	823	K
Effective source diameter	0.46	m
NO_x Emissions	0.068	lb/MMBTU(1)
	3.08E-05	g/BTU
	0.008	g/s
PM Emissions	7.45E-03	lb/MMBTU(2)
	3.38E-06	g/BTU
	0.0008	g/s

(1) US EPA AP42, Section 13.5: Industrial Flares (Oxides of Nitrogen: Table 13.5-1)
(2) US EPA AP42, Section 1.4: Natural Gas Combustion (PM-Total: Table 1.4-2)

A.3 Operational Flare Calculation

PARAMETER	VALUE	UNITS
Natural gas combusted	30	kg/hr
Natural gas calorific value	51.4	MJ/kg (HHV)
	46.3	MJ/kg (LHV)
Energy release	1389	MJ/hr
Ammonia Flow	4000	kg/hr
Ammonia combustion efficiency	98%	-
Ammonia combusted	3920	kg/hr
Ammonia calorific value	22.5	MJ/kg (HHV)
	18.6	MJ/kg (LHV)
Energy release	72912	MJ/hr
Total Energy release	74301	MJ/hr
	7.0E+07	BTU/hr
	20.6	MW
Flame Length	10.3	m
Flare Base Height	36.0	m
Virtual source height	46.3	m
Radiative heat loss	25%	-
Sensible heat release	55726	MJ/hr
	5.28E+07	BTU/hr
	15.48	MW
Buoyancy Flux	136.28	m^4/s^3
Plume averaged velocity	20	m/s
Plume averaged Temperature	1023	K
Effective source diameter	1.97	m
Thermal NO_x	0.068	lb/MMBTU(1)
	3.08E-05	g/BTU
	0.6	g/s
Fuel NO_x	8.88E-01	lb/MMBTU(2)
	4.03E-04	g/BTU
	7.88	g/s
Total NO_x	**8.5**	g/s
PM	7.45E-03	lb/MMBTU(3)
	3.38E-06	g/BTU
	0.066	g/s
Ammonia emissions	80	kg/hr
	22.2	g/s

(1) US EPA AP42, Section 13.5: Industrial Flares (Oxides of Nitrogen: Table 13.5-1)

(2) Flare Study Phase I Report, Steve Sterner, Santa Barbara County Air Pollution Control District
Table A-3 (Equation in section IV) www.sbcapcd.org/eng/dl/other/flarestudyphase1.pdf

(3) US EPA AP42, Section 1.4: Natural Gas Combustion (PM-Total: Table 1.4-2)

Appendix B Meteorological Data Discussion

Appendix B - Meteorological Data Discussion

B.1 Overview

The dispersion of pollutants in the atmosphere is driven by meteorology. Likewise, dispersion models rely on meteorological data as a fundamental input for the estimation of pollutant concentrations near to emission sources. For this reason, meteorological data is required to be representative of the region in which an assessment is conducted. This assessment has incorporated a site specific meteorological dataset, prepared using a wide range of input data. This Appendix provides a summary of the methodology that was followed in the preparation of the meteorological data, and an analysis of the results.

B.2 Available Meteorological Records

URS conducted a review of available meteorological data in the region, including that identified in PAEHolmes (2011), *Review of Meteorology in the Newcastle Inner City & Port neighbourhood*, as prepared for OEH. The following Automatic Weather Stations (AWS) were identified as potentially suitable for incorporation into the study on the basis that the quality of station siting, instrumentation and quality, as well as proximity to the region surrounding the Project Site.

- OEH Beresfield;
- OEH Newcastle;
- OEH Wallsend;
- BoM Nobby's Head;
- BoM Williamtown;
- Port Waratah Coal Services (PWCS) Kooragang Island; and
- Hunter Development Corporation (HDC) Steel River.

In addition, URS identified BoM Williamtown as a source of upper air data, with daily balloon soundings being collected each day at approximately 9am (local standard time).

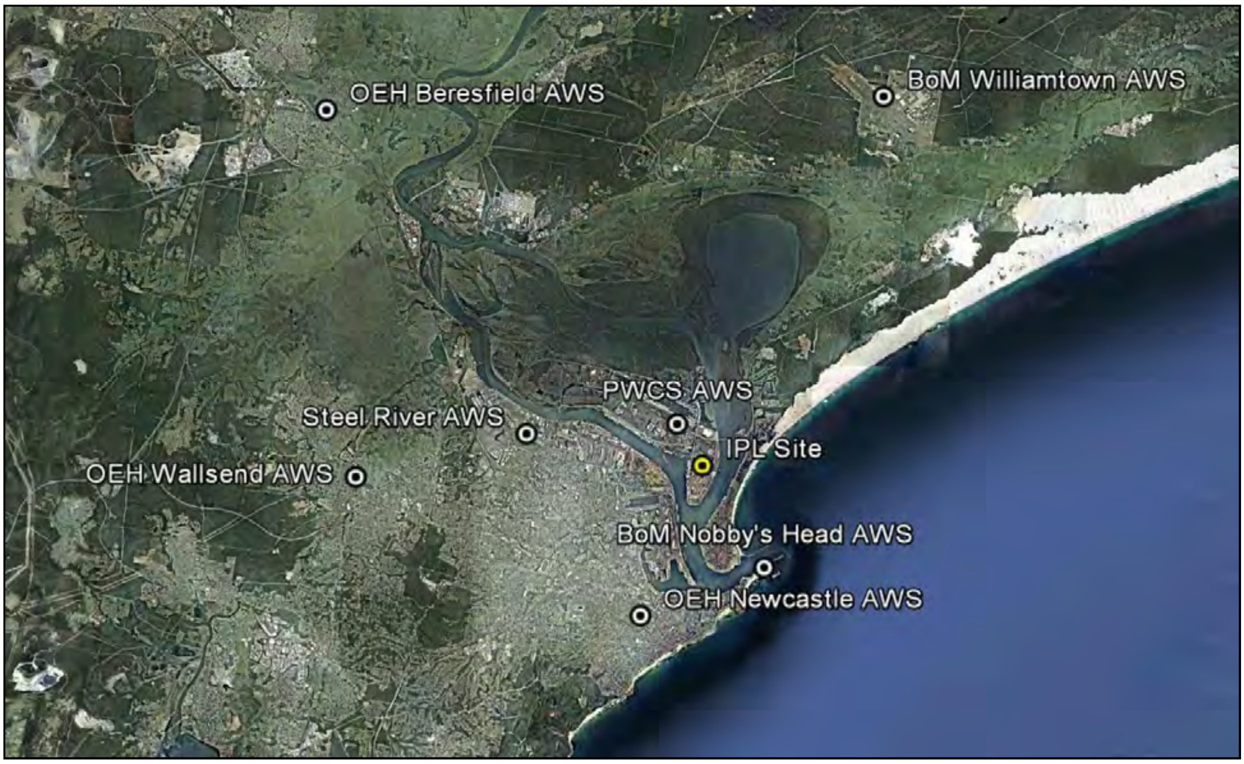
Table B-1 shows coordinates and bearings of each AWS relative to the Project Site, whilst **Figure B-1** shows the locations of each AWS relative to the Project Site.

Table B-1 AWS Locations and bearings relative to the Project Site

Station		Location (MGA94, Zone 56)		Location Relative to Project Site	
Location	Operator	Easting	Northing	Distance (km)	Bearing
Beresfield	OEH	374 629	6370 450	15	NW
Newcastle	OEH	384 034	6355 663	4.8	SSW
Nobby's Head	BoM	387 654	6357 119	3.5	SE
PWCS	PWCS	385 046	6361 312	1.4	NW
Steel River	HDC	380 626	6360 969	5.3	WNW
Wallsend	OEH	375 624	6359 641	10	W
Williamtown	BoM	390 999	6371 039	12	NNE

Appendix B - Meteorological Data Discussion

Figure B-1 Aerial image showing AWS locations relative to the Project Site



(Image sourced from Google Earth Pro)

B.3 Selection of Assessment Year

The year of meteorology used for dispersion modelling has been established through a consideration of both data availability, and inter-annual variability. This assessment provides detail of these considerations.

B.3.1 Data Availability

An objective is to select a year for which high quality meteorological records are available, with the greatest quantity of data available. The extension of surface wind readings (taken at 10 m above ground level) requires appropriately sited and operated AWS, where turbulence from nearby obstructions restricts the ability of surface measurements to reflect conditions in the atmospheric layers immediately above. Due to the construction of buildings in 2005, immediately to the west of the Steel River AWS, readings after 2005 have been excluded. **Table B-2** provides a summary of data availability.

Table B-2 Summary of data availability

Site	2005	2006	2007	2008	2009	2010
Beresfield	84.9%	100%	64%	69%	42%	95%
Newcastle	98.7%	42%	42%	64%	98%	81%
PWCS	83.0%	99%	79%	96%	79%	99%
Nobby's Head	92.0%	57.7%	97.6	99.6%	99.4%	98.4%
Steel River	98.0%	N/A	N/A	N/A	N/A	N/A
Wallsend	91.0%	96%	81%	71%	39%	97%
Williamtown	94.9%	99%	99%	99%	99%	91%
Average	*92%*	*71%*	*66%*	*71%*	*65%*	*80%*
Average (Exc. Steel River)	*NA*	*82%*	*77%*	*83%*	*76%*	*94%*

Notes: Shaded values indicate data completeness of less than 80%. Values to 1 decimal place have been calculated from raw data. Values to 0 decimal places have been sourced from PAEHolmes (2011). N/A: Data excluded – AWS siting impeded by the construction of buildings adjacent to the AWS.

B.3.2 Inter-Annual Variability

The dispersion modelling utilises a full year of meteorology which equates to 8,760 hourly meteorological records. Whilst this period encompasses diurnal and seasonal cycles, given the use a single year, a review of longer term meteorological patterns is required to ensures that inter-annual variability is adequately represented in the assessment.

For this purpose, URS reviewed 5 years of wind records from Williamtown (2005-2009), with comparison of the following:

- Annual averaged wind speed;
- Frequency of calm conditions;
- Annual wind roses;
- Wind speed frequency distributions; and
- Wind direction frequency distributions.

Appendix B - Meteorological Data Discussion

Table B-3 presents a summary of wind conditions at the Williamtown AWS for the period 2005-2009, including average wind speed, percentage calm conditions (<0.5 m/s). Percentage completeness is also provided.

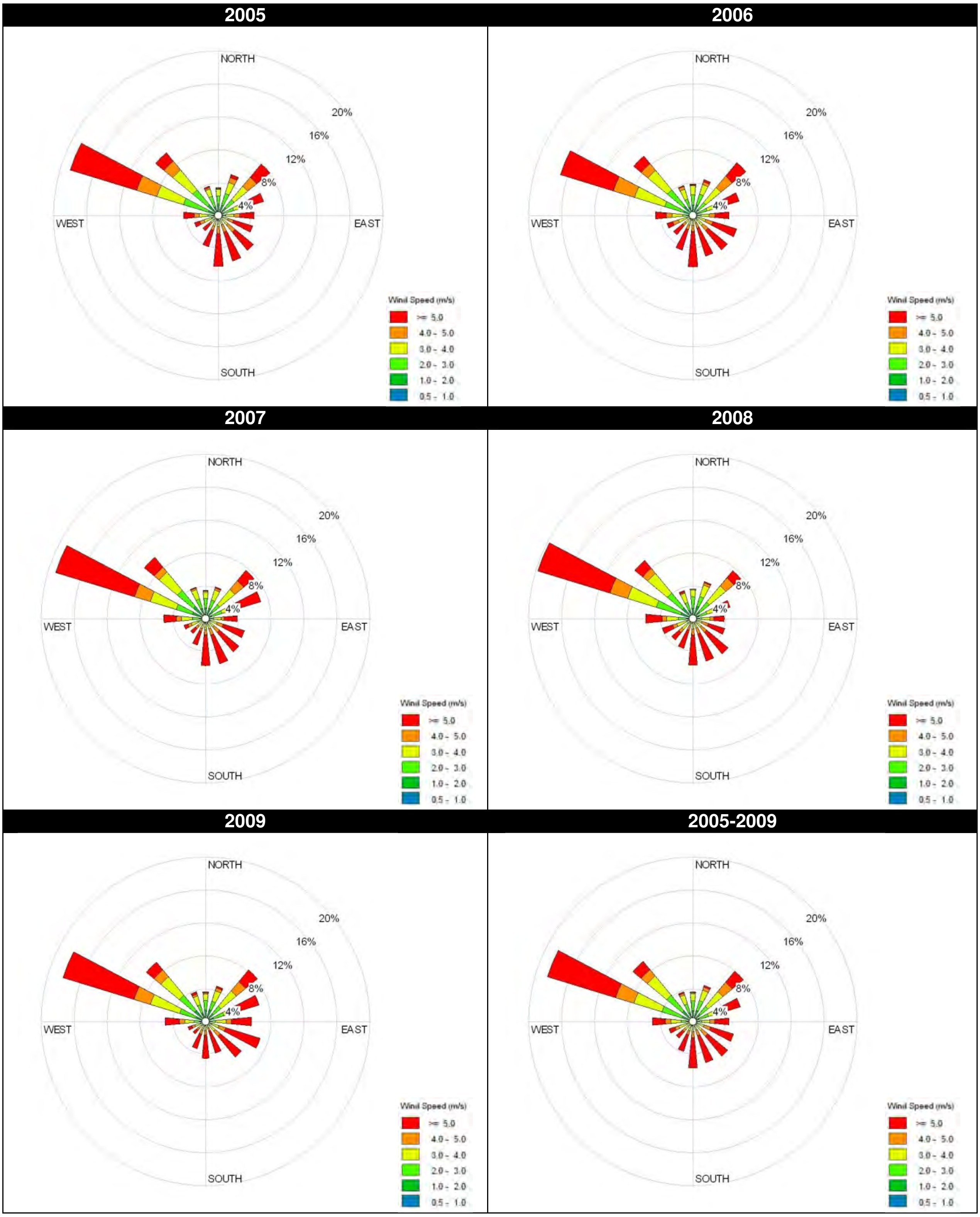
Table B-3 Summary of wind conditions at the BoM Williamtown AWS for the Period 2005-2009

Period	Average Wind Speed	% Calms	% Complete
2005	4.26	4.6	95
2006	4.22	4.6	99
2007	4.23	5.5	99
2008	4.18	5.0	100
2009	4.27	5.8	99
2005-2009	**4.23**	**5.0**	**98**

Figure B-2 provides wind roses, whilst **Figure B-3 and B-4** provide wind speed and wind direction frequency distributions for the 5 years reviewed.

Appendix B - Meteorological Data Discussion

Figure B-2 Wind roses for the BoM Williamtown AWS for the period 2005-2009



Appendix B - Meteorological Data Discussion

Figure B-3 Wind direction frequency distribution for BoM Williamtown AWS (2005-2009)

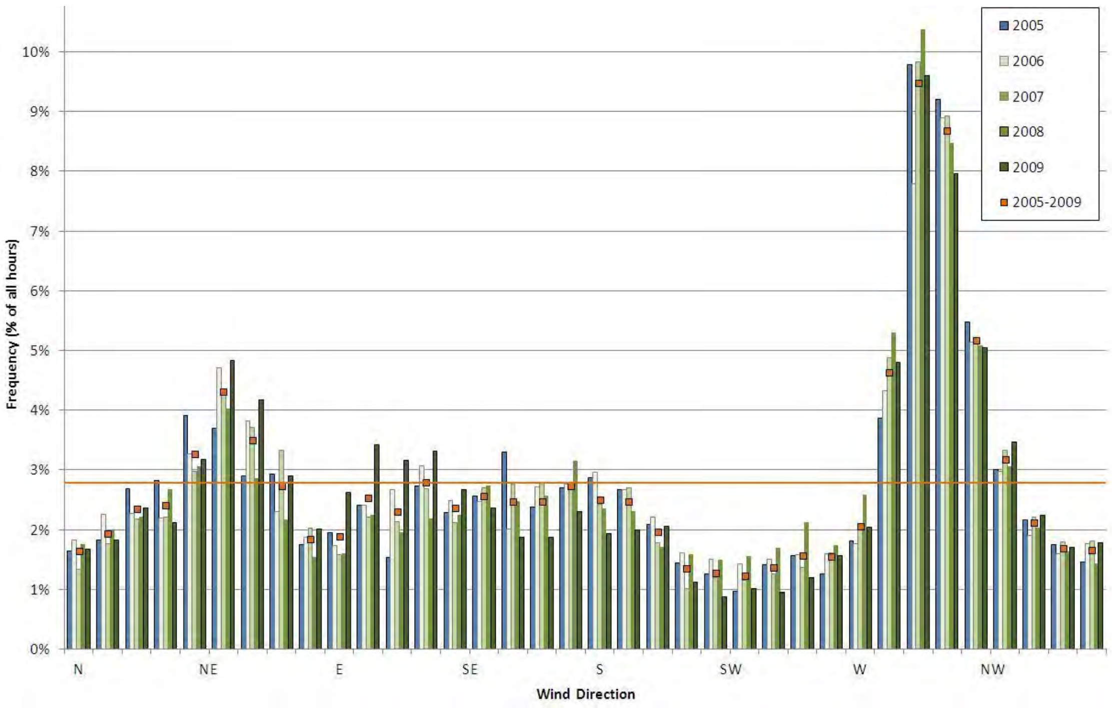
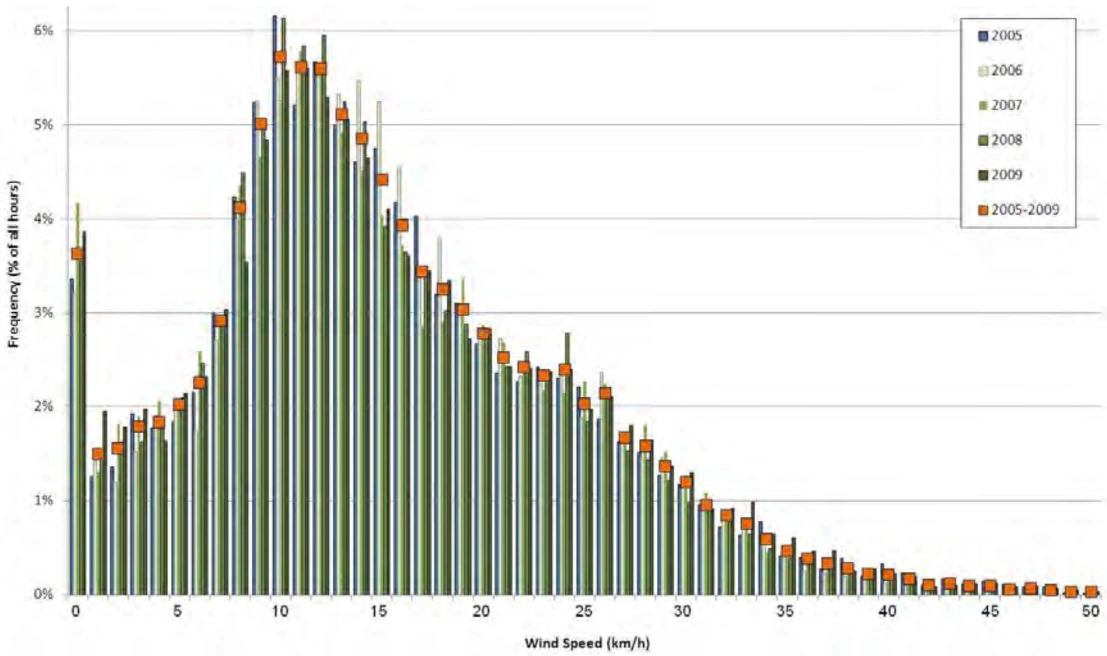


Figure B-4 Wind speed frequency distribution for BoM Williamtown AWS (2005-2009)



B.3.3 Selected Year

Based on the data reviewed, 2005 has been selected as the year for assessment on the basis of:

- The high data availability (especially of OEH stations and the availability of Steel River data);
- The consistency of 2005 wind records in this year with the 5 years of data reviewed.

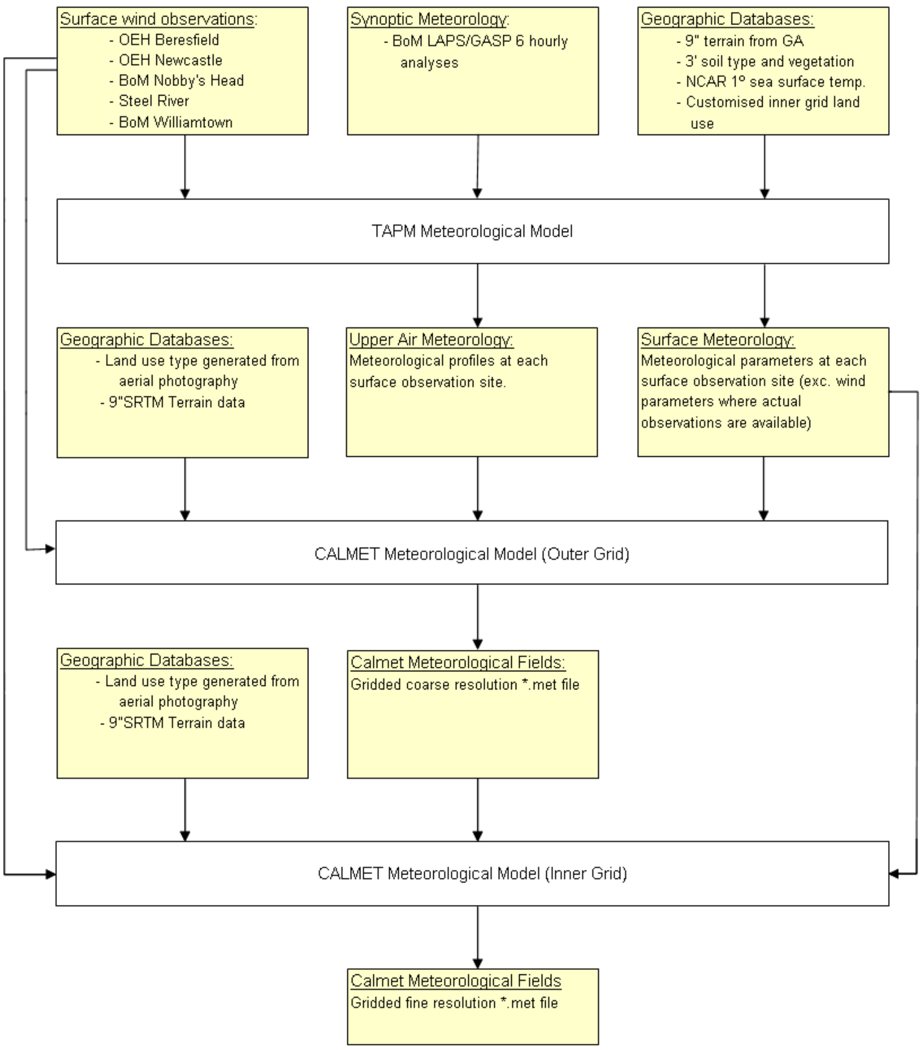
B.4 Meteorological Modelling Methodology

The methodology for the preparation of the meteorological dataset has been based upon the requirements of the meteorological pre-process for the selected dispersion model (Calmet), with the following objectives:

- The incorporation real meteorological records from well sited AWS; and
- The avoidance of assimilation boundaries, as generated by the combination of conflicting data sources.

In addition, the guidance documented in *Generic Guidance and Optimum Model Settings for the CALPUFF Modeling System for Inclusion into the Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia* (TRC, 2011) has been reviewed, and incorporated into this methodology where consistent with the priorities listed above. It is noted that given the wealth of surface wind data available in the region, that the TRC(2011) recommendation of complete reliance on synoptic model outputs has not been adopted. **Figure B-5** shows an overview of the meteorological modelling process adopted for this assessment.

Figure B-5 Overview of the meteorological modelling process.



Appendix B - Meteorological Data Discussion

B.4.1 TAPM (Meteorological Model)

TAPM is a synoptic scale meteorological model developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). TAPM has been identified as a suitable model of choice to simulate meteorological fields in a number of situations[24]. TAPM is an incompressible, non-hydrostatic, primitive equation model with a terrain-following vertical co-ordinate for three-dimensional simulations. It includes parameterisations for cloud/rain micro-physical processes, turbulence closure, urban/vegetative canopy and soil, and radiative fluxes.

TAPM (Version 4), with the use of the input databases provided by CSIRO, was used to generate upper air meteorological files for each AWS.

The following TAPM settings and input files were used:

- 5 nested model grids (at 28.6, 10.4, 3.8 1.4 and 0.5km resolution[25]), 51 x 51 grid points, with 25 vertical levels;
- Grid centre coordinates: 151º44'30''E, 32º51'30''S, (MGA94: 382260 mE, 6363717 mN);
- Assimilation of meteorological data (configured to affect the two lowest vertical levels, i.e. 10 and 25m) from:
  - — OEH Beresfield Automatic Weather Station AWS, Radius of Influence (ROI): 9 km ;
  - — OEH Newcastle AWS), ROI: 2 km;
  - — BoM Nobby's Head AWS, ROI: 1.5 km;
  - — Steel River, ROI: 6 km;
  - — OEH Wallsend AWS, ROI: 6 km; and
  - — BoM Williamtown AWS, ROI: 10 km.

  Given that Nobby's head AWS is located on an exposed bluff with a base elevation of approximately 10m, the anemometer height has been increased to 15m, in order to provide some compensation for accelerations that occur as winds approach the mast.
- Data exported at assimilation sites as surface and upper air files for incorporation into Calmet. TAPM surface wind (assimilation) results were overwritten with actual wind observations when records were available.

B.4.2 Calmet (Meteorological pre-processor for Calpuff)

The outputs from TAPM, in conjunction with the hourly AWS wind records were incorporated into the Calmet model. Calmet V6.333 was configured as detailed below:

- Two nested grids with outer grid results used as initial guess field:
  - — Outer: 43 x 43 grid points at 500 m resolution, Grid origin: 371.75 kmE 6352.75 kmN MGA, Zone 56 (South)
  - — Inner: 101 x 101 grid points at 100 m resolution, Grid origin: 379.95 kmE 6354.95 kmN MGA, Zone 56 (South)
- Terrain information sourced from the USGS 3 second (~90 m) terrain database;
- Land use data manually generated from aerial photography;

[24] CSIRO (2005) *The Air Pollution Model (TAPM) Version 3. Part 2: Summary of Some Verification Studies. CSIRO Atmospheric Research Technical Paper 72*, 2005.

[25] These resolutions were selected to satisfy the following contraints: (1) Inclusion of all assimilation sites within the innermost grid (2) Recommended nesting ratios (3) Outer domain size limits (4) Inclusion of 5th modelling grid (as required to optimise assimilation).

Appendix B - Meteorological Data Discussion

- Cell face levels at 0, 20, 30, 50, 100, 150, 250, 300, 400, 600, 1000, 1500, 2500 mAGL;
- Temperature from surface and upper air stations;
- Diagnostic wind module used with:
  - No Surface wind extrapolation;
  - Horizontally and vertically varying winds with divergence minimisation. Froude number adjustment and slope flows incorporated with a radius of influence (TERRAD) of 2km; and
  - No calculation of kinematic effects;
  - R1 = 3km, R2 = 5 km; and

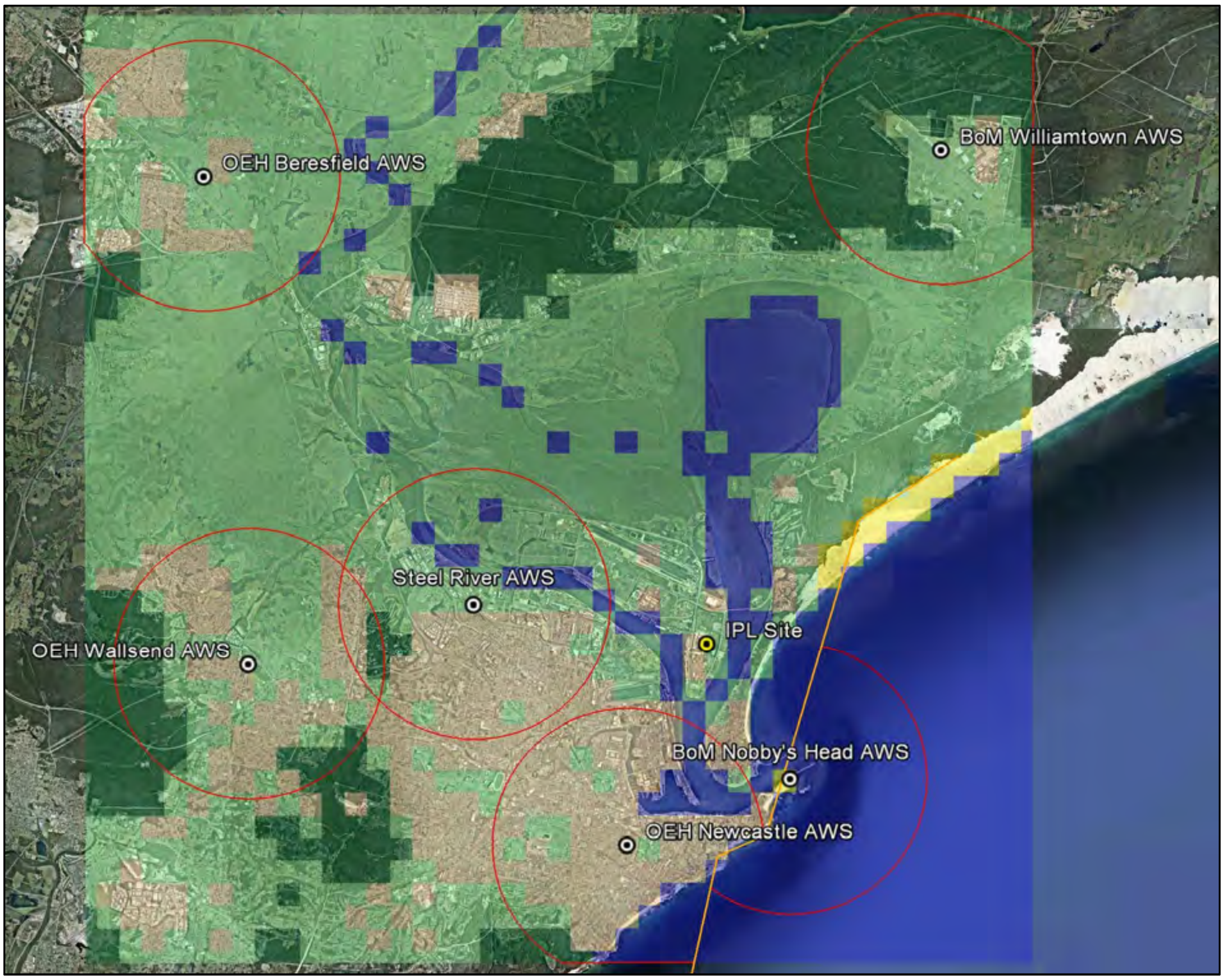
  R1MAX = R2MAX = R3MAX = 10km

  Given the exposed nature of Nobby's head, it is considered able to provide useful information on the wind over the ocean. Noting that it is located on a bluff, the anemometer height has been increased to 15m, in order to provide some compensation for accelerations that occur as winds approach the mast.

Appendix B - Meteorological Data Discussion

Figure B-6 and B-7 show the outer and inner Calmet modelling domains (respectively), overlaid with land use from the model outputs.

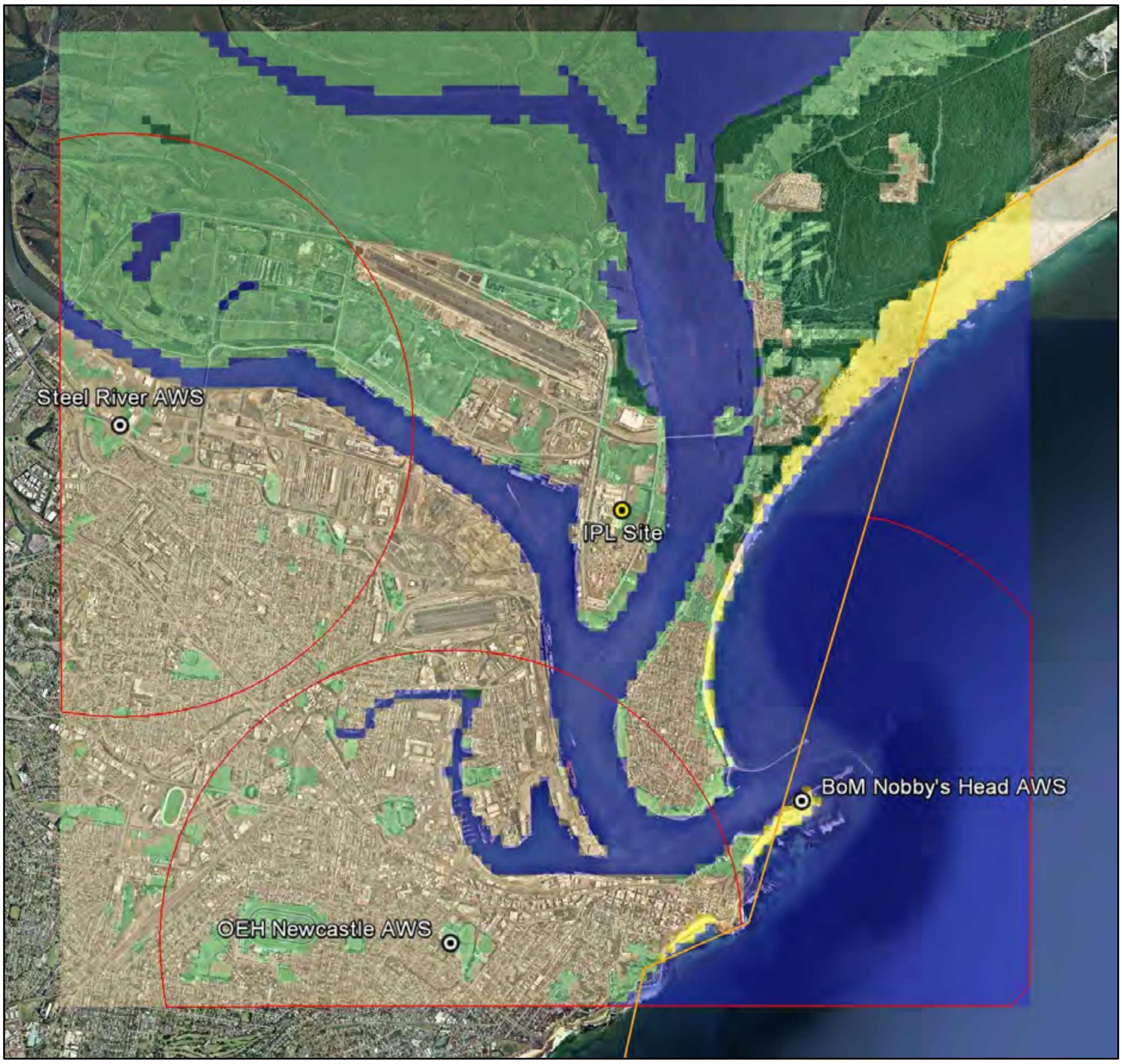
Figure B-6 Calmet outer grid domain showing land use (from Calmet output), and AWS locations with R1 values (red) and barrier (orange)



(Image sourced from Google Earth Pro)

Appendix B - Meteorological Data Discussion

Figure B-7 Calmet inner grid domain showing land use (from Calmet output), and AWS locations with R1 values (red) and barrier (orange)



(Image sourced from Google Earth Pro)

B.4.3 Excluded Data

Williamtown Upper Air Data

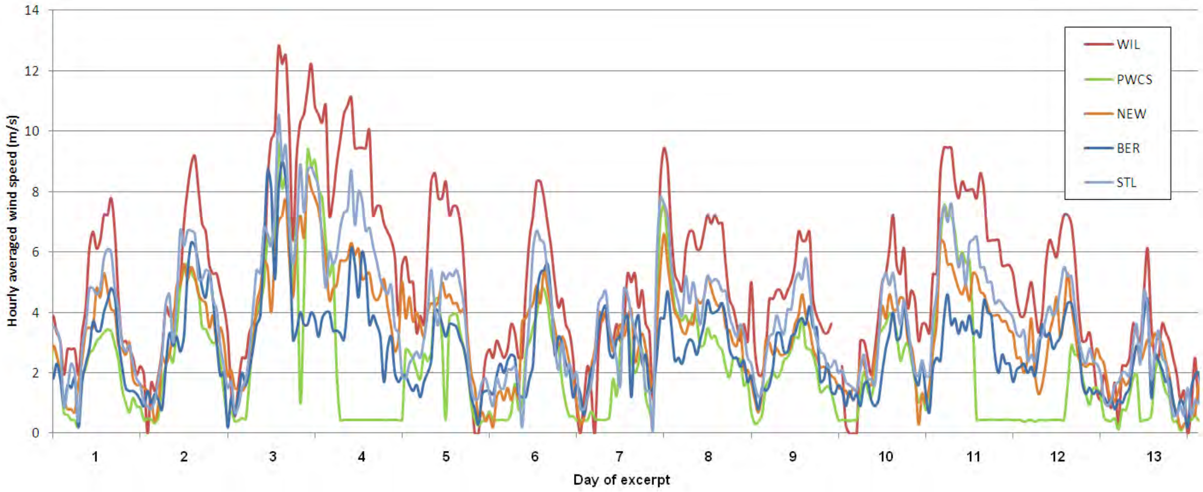
Williamtown upper air data has been excluded as it was not available at a frequency required by Calmet for incorporation into the generation of upper air fields, where a sounding is required at a minimum of every 14 hours.

Appendix B - Meteorological Data Discussion

PWCS Data

PWCS data was reviewed and excluded from the assessment due suspected inaccuracies in the measurement of wind during 2005. This was initially realised as a high presence of calm conditions, and was evident in the dataset through the presence of consecutive records of calm winds (0.45 m/s – the minimum 15 minute wind speed reported at the station) for periods extending from a few hours (possibly even single hours) to periods of up to 6 days. These data were interrogated against available records from the six other AWS listed in **Table B-1**. **Figure B-8** provides an example of this comparison starting on the 13th November 2005. Days 3, 4, 5, 7, 11-12 and 13 of the excerpt contain calm winds (at PWCS), during periods when high wind speeds were recorded elsewhere.

Figure B-8 - Comparison of 1 hour wind records



The PWCS data was filtered in order to remove blocks of calm conditions which persisted for more than 6 hours, and were recorded when wind speeds were significantly lower than other reviewed records (e.g. days 4 and 11-12 above). At this point it was noted that there were frequent instances of shorter blocks of calms during times at which wind speeds at other stations were elevated, and it was considered that the data could not be objectively filtered, in that there was a significant yet inconclusive prospect of instrument error in these meteorological records. Given these concerns, and the presence of this phenomenon at various points throughout the dataset, the PWCS data were excluded from the assessment.

Appendix B - Meteorological Data Discussion

B.5 Results

This section provides a summary and analysis of meteorological predictions that were developed for the dispersion modelling.

B.5.1 Winds

Figure B-8 provides a comparison of wind speed frequency distributions for AWS in the region, as well as Calmet predictions at the Project Site. The data shows a good agreement with nearby AWS, with wind speeds fitting between those observed at Newcastle and Steel River. Wind speeds at the Project Site fall well below wind observations at Williamtown and Nobby's head. It is noted that assimilation barriers have been used to limit the influence of Nobby's head to overwater areas.

Figure B-8 Wind speed frequency distributions – Calmet predictions at IPL Project Site vs Observations

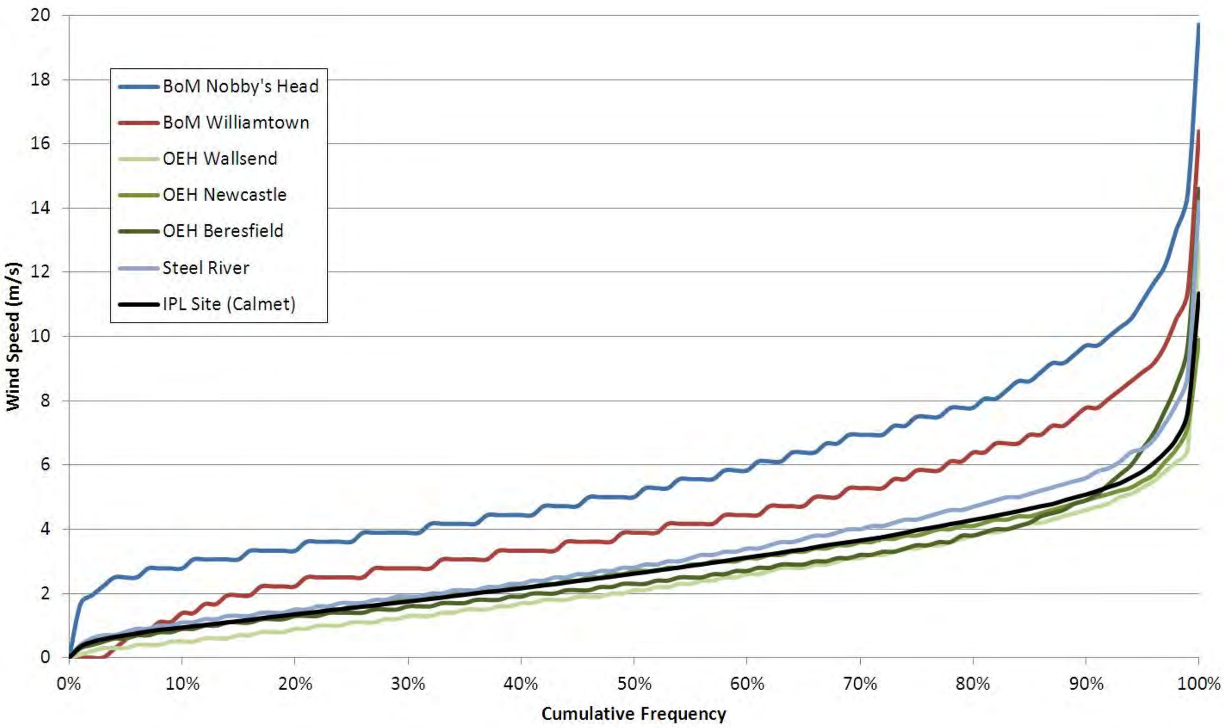
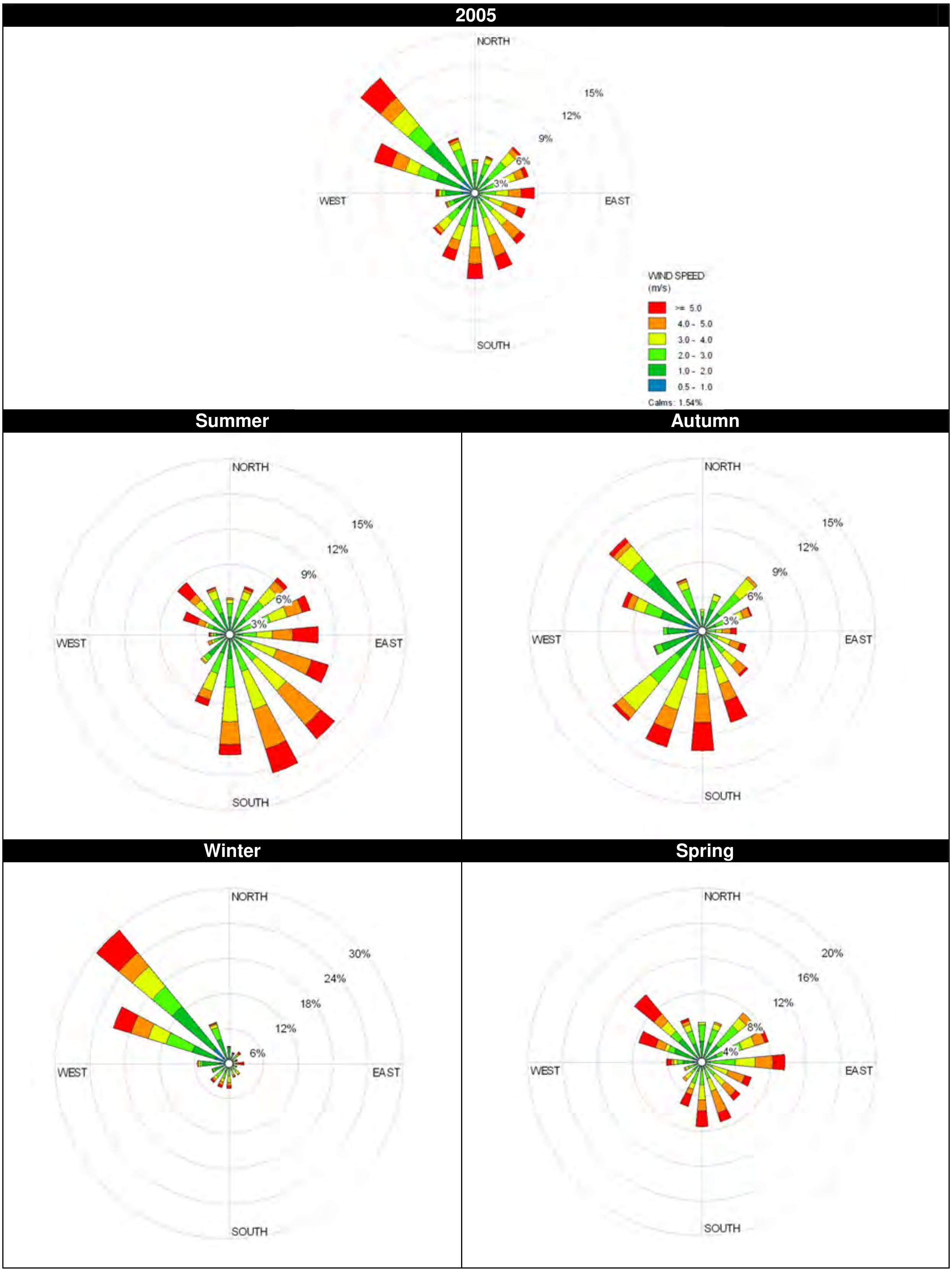


Figure B-9 provides wind roses for the Project Site, whilst full year wind roses for each observation site are attached to this Appendix.

Appendix B - Meteorological Data Discussion

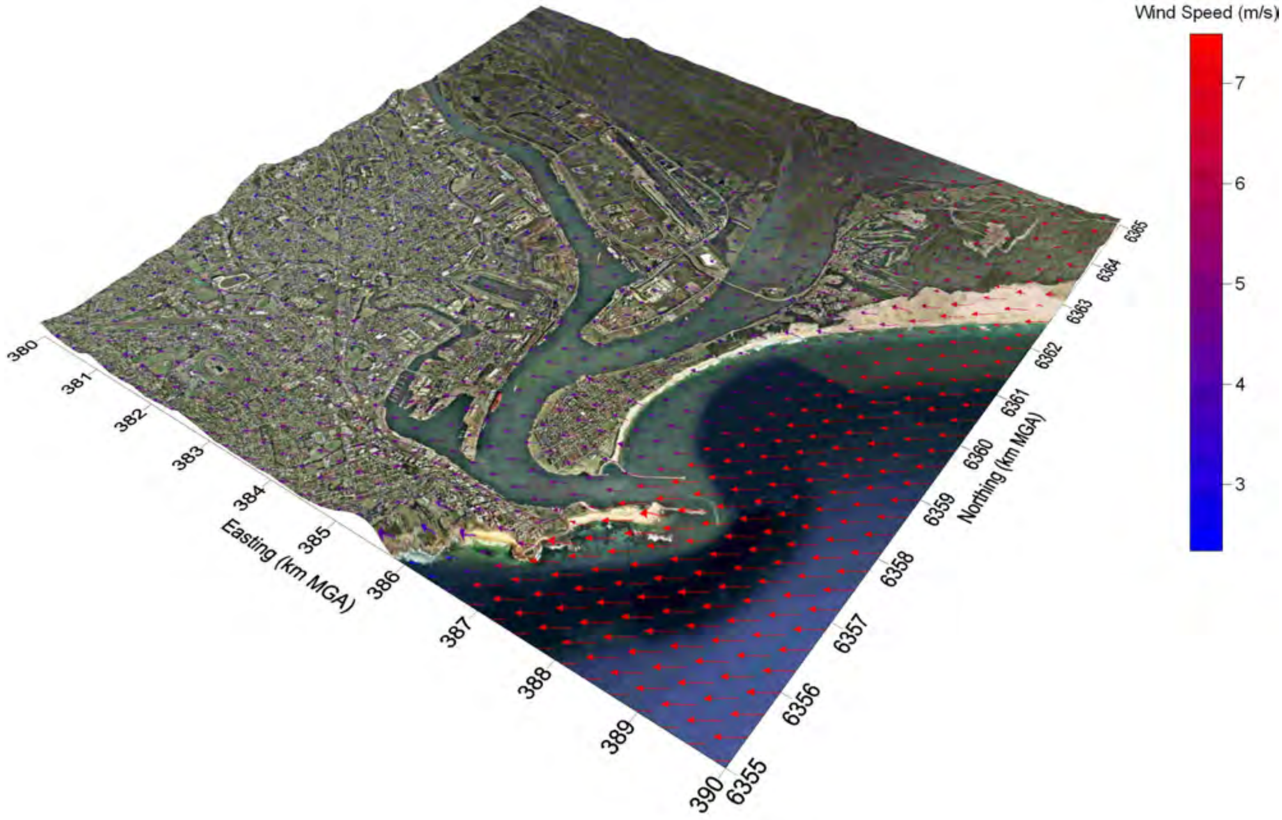
Figure B-9 Calmet predicted winds at Project Site



Appendix B - Meteorological Data Discussion

Figure B-10 shows an example of a Calmet generated vector wind field for the inner Calmet domain. Every third vector is shown.

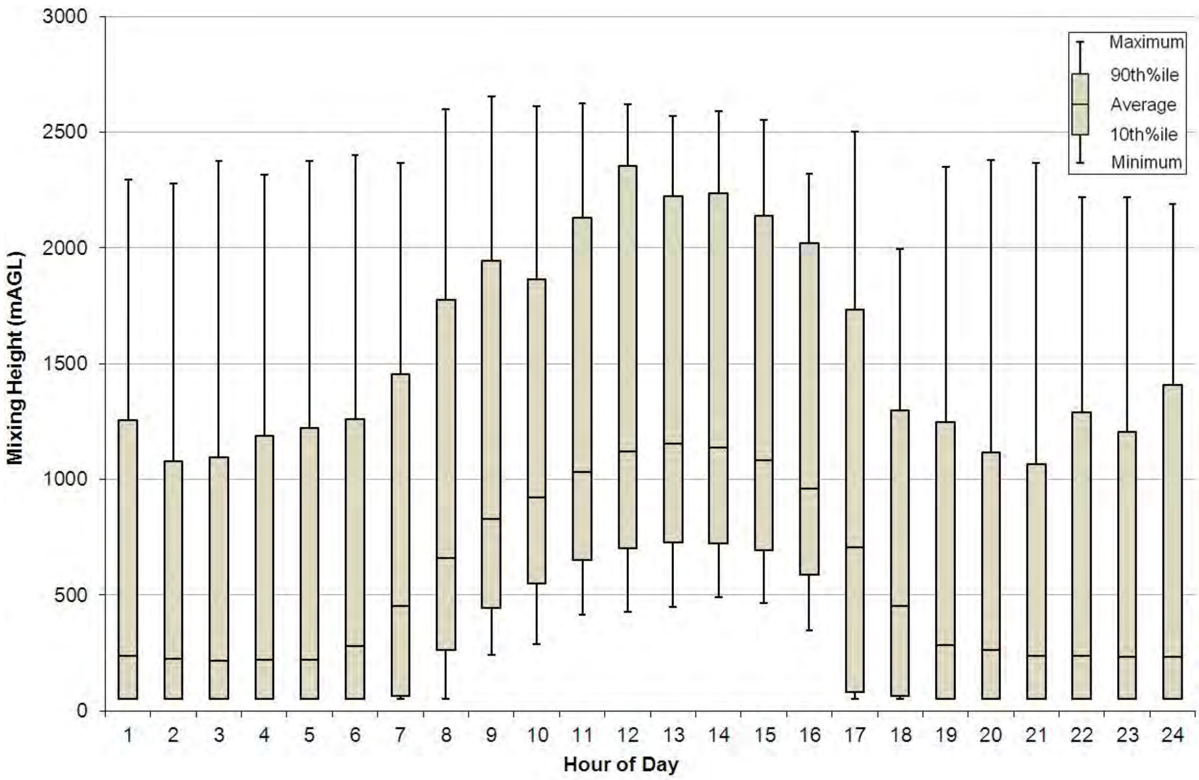
Figure B-10 Example of Calmet generated vector wind field for the inner Calmet domain



B.5.2 Mixing Height

Figure B-11 shows the mixing height against the hour of the day as generated by Calmet. The figure shows that the predicted mixing height increases with increasing solar radiation as a function of time of day. This is consistent with general atmospheric processes that show increased vertical mixing during the daytime associated with the heating of the land surface. Night time conditions are cooler, more stable and, as expected, winds are generally lighter thus vertical mixing is reduced leading to a lower mixing height.

Figure B-11 Mixing height at Project Site by hour of day



B.5.3 Stability Class

Stability class is used as an indicator of atmospheric turbulence for use in meteorological models. The class of atmospheric stability generally used in these types of assessments is based on the Pasquill-Gifford-Turner scheme where six categories are used (A to F) which represent atmospheric stability from extremely unstable to moderately stable conditions. The stability class of the atmosphere is based on three main characteristics, these being:

- Static stability (vertical temperature profile/structure);
- Convective turbulence (caused by radiative heating of the ground); and
- Mechanical turbulence (caused by surface roughness).

The Pasquill Gifford Stability classes are provided in **Table B-4**.

Appendix B - Meteorological Data Discussion

Table B-4 Modified Pasquill-Gifford stability classes (adapted from Turner, 1994[26])

Surface Wind Speed at 10m (m/s)	Insolation			Night-time cloud (Oktas)	
	Strong	Moderate	Slight	Thinly overcast of > 4/8 low cloud	< 3/8 Cloud
≤ 2	A	A-B	B	-	-
2 - 3	A-B	B	C	E	F
3 - 5	B	B-C	C	D	E
5 - 6	C	C-D	D	D	D
> 6	C	D	D	D	D

The Pasquill Gifford Stability Classes, shown in **Table B-5** shows moderately stable atmospheric conditions (Stability Class F) is the most prevalent Stability Class of the area, with the Extremely Unstable conditions (Stability Class A) being the least prevalent.

Table B-5 Calmet predicted Stability Class frequency (at Project Site)

Stability Class	Frequency
A (Extremely Unstable)	0.7%
B (Moderately Unstable)	12%
C (Slightly Unstable)	23%
D (neutral)	18%
E (Slightly Stable)	7.2%
F (Moderately Stable)	39%

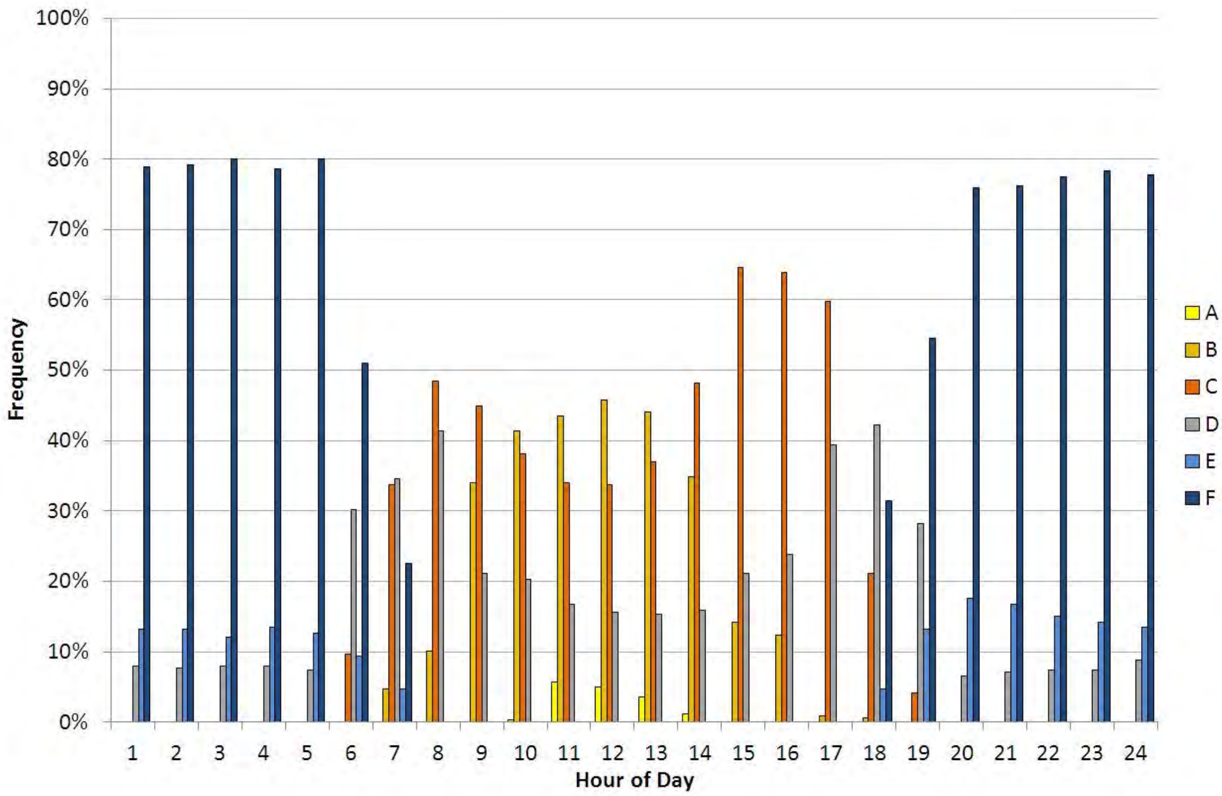
The F class prediction of 39% is considered elevated for a coastal region, and has been predicted as more prevalent than if the meteorological preparation was performed using traditional empirical (i.e. non-Calmet) methods. In a review of the frequency of cloud cover and high winds (conditions that prevent the accumulation of F-Class conditions), the TAPM frequencies were viewed to be similar to observations from BoM Williamtown. Hence the data were adopted for the assessment as being slightly conservative. It is also noted that this stability class frequency is consistent with other recent Calmet-based studies in the Newcastle area such as Environ (2012) and PAEHolmes (2011).

In addition to their frequency, Stability Classes have also been presented as a function of time of day, as shown in **Figure B-12**. As expected, there is a tendency for the unstable classes (Stability Classes A, B and C) to occur during daytime, whilst stable conditions (Stability Classes E and F) are shown to occur primarily during night time. This is consistent with the values contained in **Table B-4**.

Figure B-12 Calmet generated Stability Class vs hour of day (at Project Site)

[26] Turner B (1994) *Workbook of Atmospheric Dispersion Estimates: An Introduction to Dispersion Modelling.* 2nd Edition. CRC Press Inc.

Appendix B - Meteorological Data Discussion



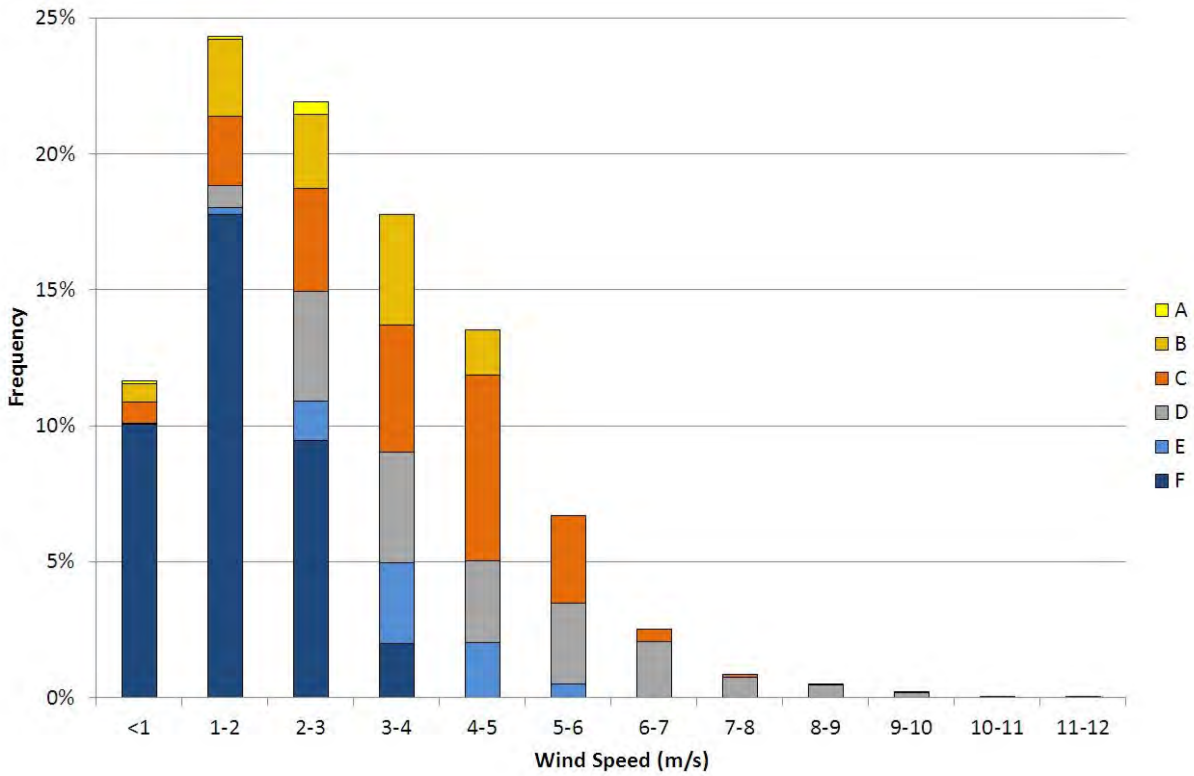
Stability Classes have been presented against wind speed, as shown in **Table B-6 and Figure B-13**. As expected, the highest wind speeds are associated with neutral stability classes (Stability Classes C and D). The more unstable conditions (Stability Classes A and B) are associated with lower wind speeds, and the more stable conditions (Stability Classes E and F) are also associated with lower wind speeds. These data are consistent with the values contained in **Table B-4.**

Table B-6 Calmet generated Stability Class vs wind speed (at Project Site)

	Wind Speed (m/s)												
Stability Class	**<1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**6-7**	**7-8**	**8-9**	**9-10**	**10-11**	**11-12**	**>12**
A	8	9	40	0	0	0	0	0	0	0	0	0	0
B	58	247	239	356	145	0	0	0	0	0	0	0	0
C	70	225	333	410	600	284	39	8	4	1	1	0	0
D	3	70	353	354	264	260	181	67	41	16	1	3	0
E	0	23	128	262	176	43	0	0	0	0	0	0	0
F	881	1,556	827	174	0	0	0	0	0	0	0	0	0
TOTAL	**1,020**	**2,130**	**1,920**	**1,556**	**1,185**	**587**	**220**	**75**	**45**	**17**	**2**	**3**	**0**

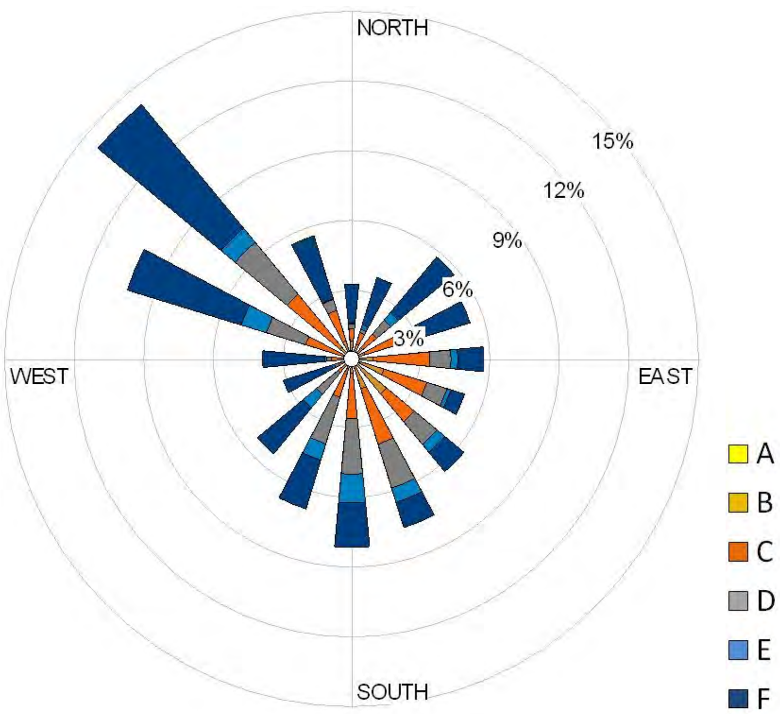
Appendix B - Meteorological Data Discussion

Figure B-13 Calmet generated Stability Class vs wind speed (at Project Site)



Stability Classes have been presented against wind direction, as shown in **Figure B-14**.

Figure B-14 Calmet generated Stability Class vs wind direction (at Project Site)



B.6 Conclusion

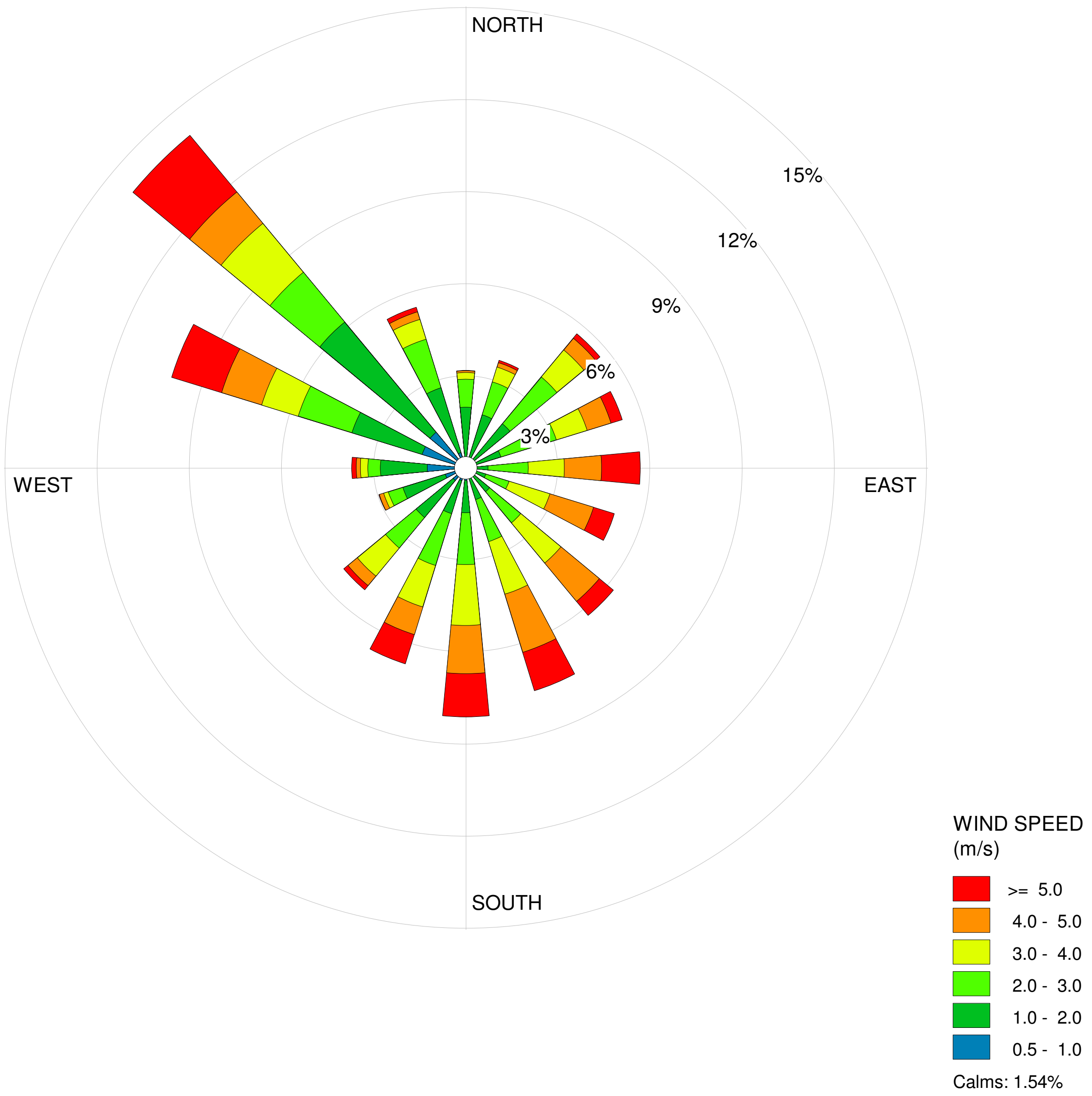
Where spatially variable meteorological fields are required, as is the case for the proposed IPL project at Kooragang Island, the predicted meteorological data used in the dispersion modelling is required to be representative of the surrounding area. Meteorological data from surrounding AWS (for the year 2005) were incorporated into the TAPM run, and reincorporated into Calmet along with TAPM upper air predictions. TAPM is a sophisticated, 3D meteorological model that has been validated and is considered appropriate for this purpose.

The assessment of the predicted meteorology at the Project Site was presented and was shown to be consistent with general atmospheric parameters. It is therefore considered that the meteorological data used is appropriate for use in the dispersion modelling.

Appendix B - Meteorological Data Discussion

Attachment A: Wind Roses for 2005

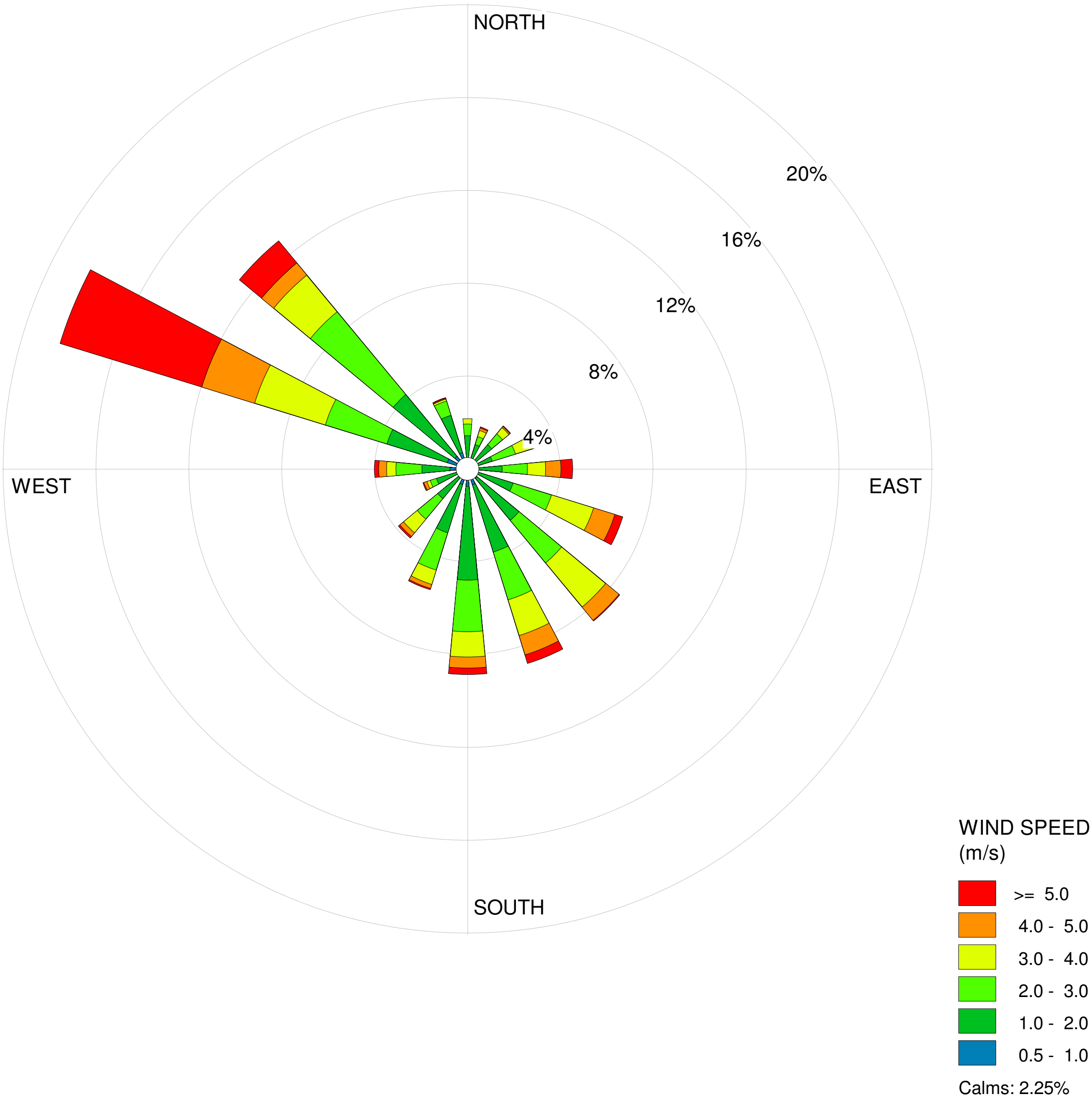
Calmet at IPL Site (2005)
Hourly Predictions of Wind Speed and Direction at 10m Elevation



COMMENTS: Wind direction shown as blowing from.	DATA PERIOD: Start Date: 1/01/2005 - 00:00 End Date: 31/12/2005 - 23:00	COMPANY: URS Australia Pty Ltd	
		PREPARED BY: JG	
	CALM WINDS: 1.54%	TOTAL COUNT: 8759 hrs.	
	AVG. WIND SPEED: 2.87 m/s	DATE: 14/06/2012	PROJECT NO.: 43177771

WRPLOT View - Lakes Environmental Software

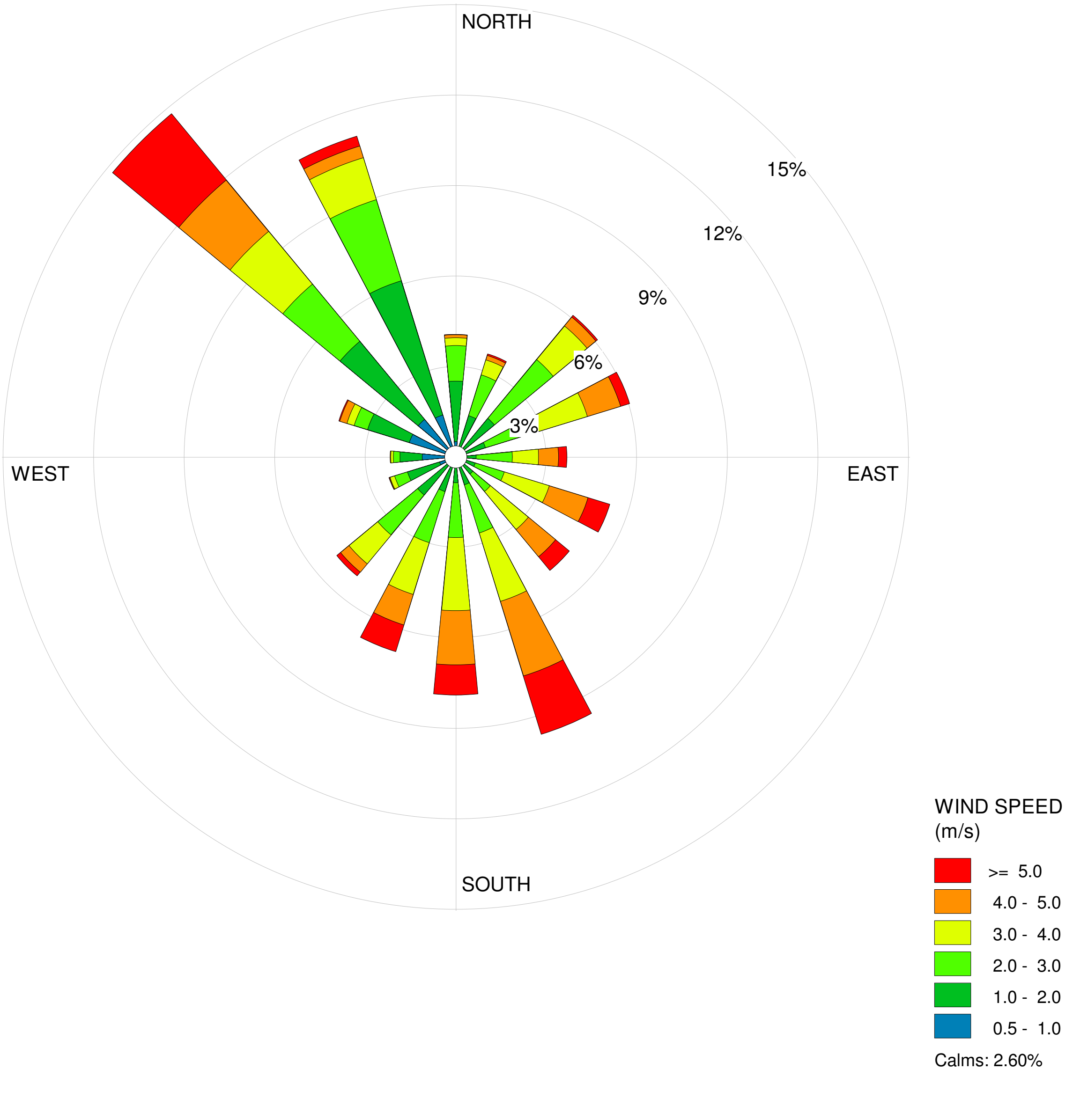
OEH Beresfield AWS (2005)
Hourly Records of Wind Speed and Direction at 10m Elevation



COMMENTS: Wind direction shown as blowing from.	DATA PERIOD: Start Date: 1/01/2005 - 00:00 End Date: 31/12/2005 - 23:00	COMPANY: URS Australia Pty Ltd	
		PREPARED BY: JG	URS
	CALM WINDS: 2.25%	TOTAL COUNT: 7437 hrs.	
	AVG. WIND SPEED: 2.70 m/s	DATE: 14/06/2012	PROJECT NO.: 43177771

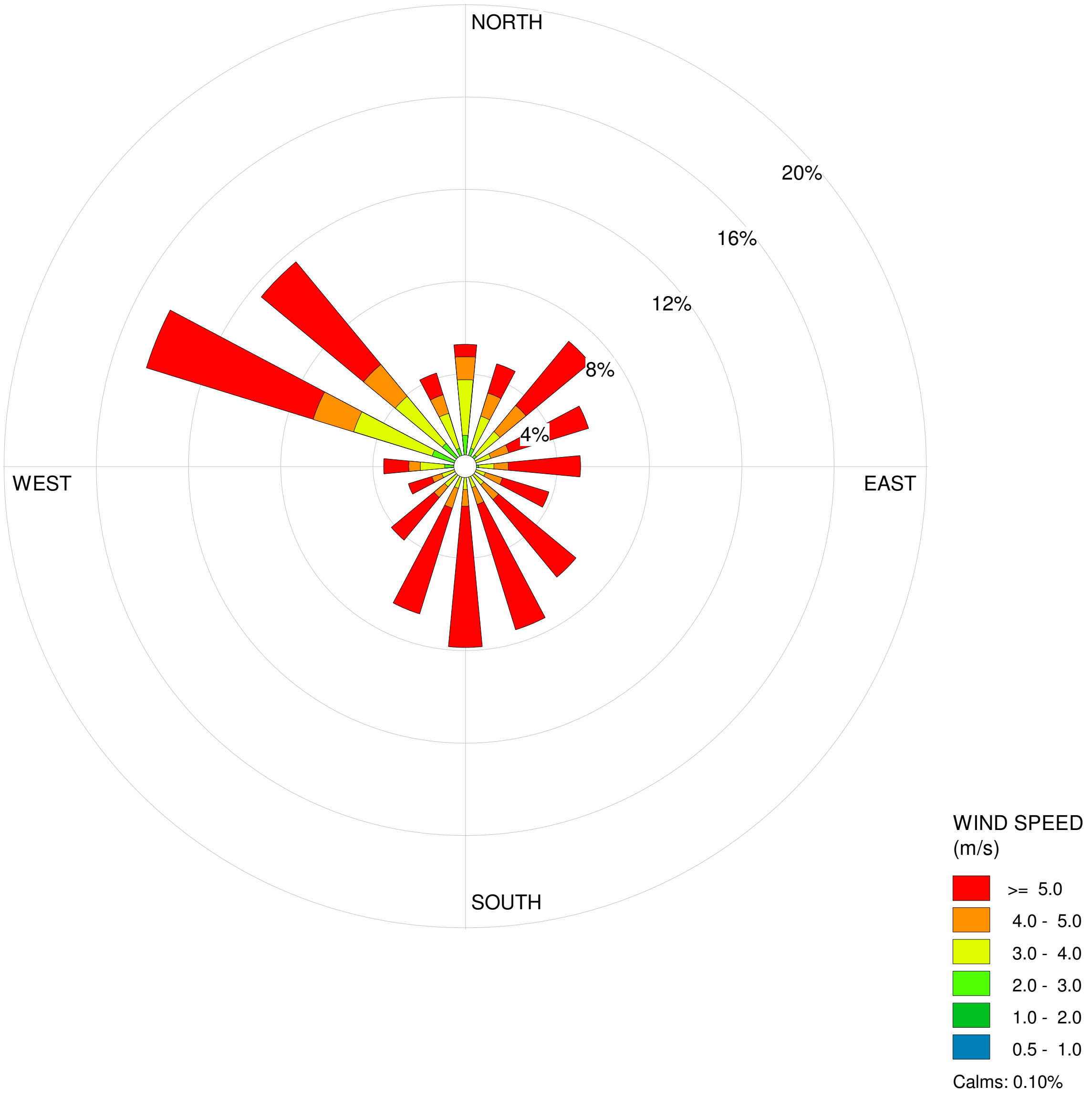
WRPLOT View - Lakes Environmental Software

OEH Newcastle AWS (2005)
Hourly Records of Wind Speed and Direction at 10m Elevation



COMMENTS:	DATA PERIOD:	COMPANY:	
Wind direction shown as blowing from.	Start Date: 1/01/2005 - 00:00 End Date: 31/12/2005 - 23:00	URS Australia Pty Ltd	
		PREPARED BY: JG	URS
	CALM WINDS: 2.60%	TOTAL COUNT: 8643 hrs.	
	AVG. WIND SPEED: 2.80 m/s	DATE: 14/06/2012	PROJECT NO.: 43177771

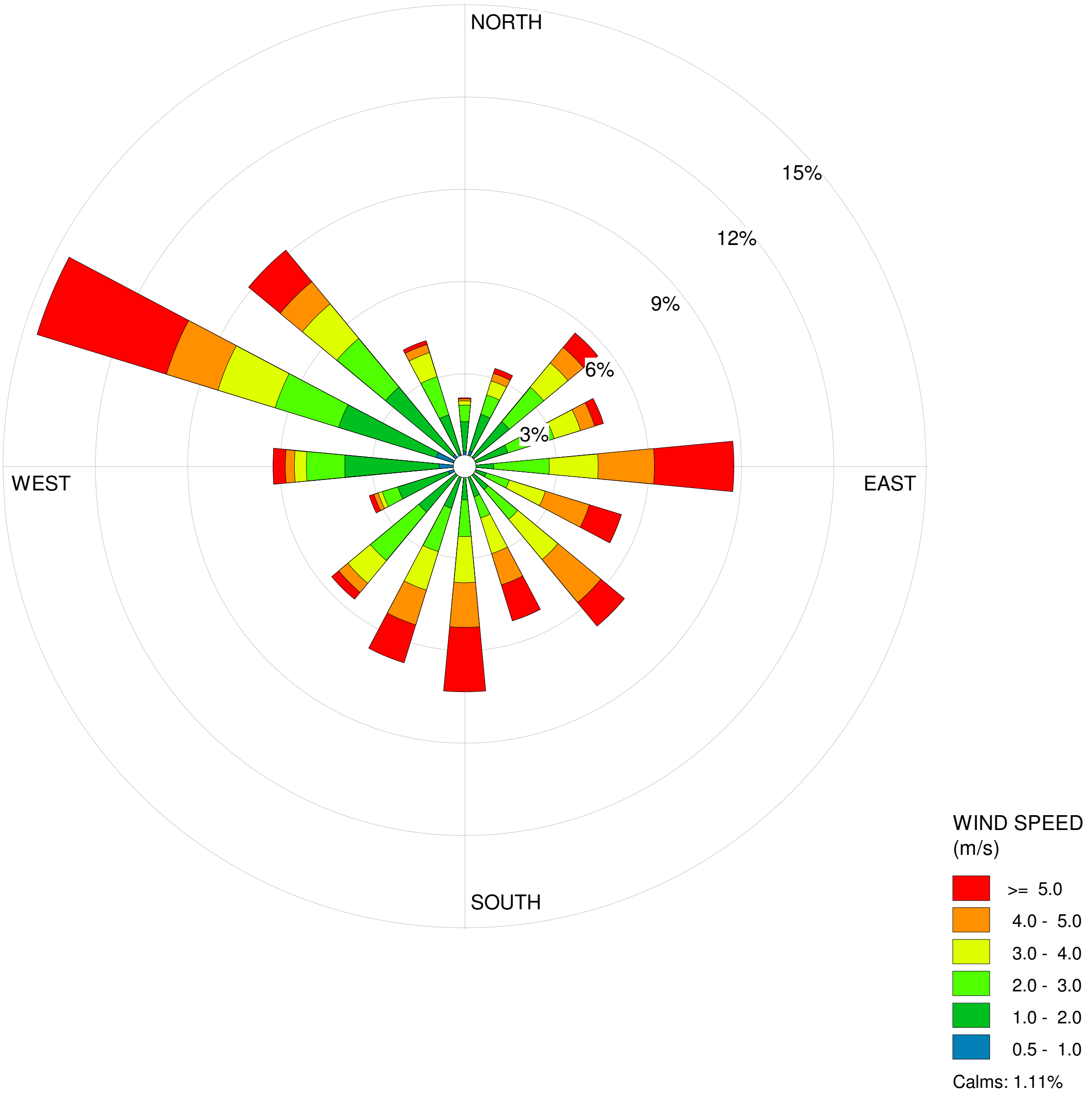
BoM Nobby's Head AWS (2005)
Hourly Records of Wind Speed and Direction at 10m Elevation



COMMENTS: Wind direction shown as blowing from.	DATA PERIOD: Start Date: 1/01/2005 - 00:00 End Date: 31/12/2005 - 23:00	COMPANY: URS Australia Pty Ltd	
		PREPARED BY: JG	URS
	CALM WINDS: 0.10%	TOTAL COUNT: 8060 hrs.	
	AVG. WIND SPEED: 5.79 m/s	DATE: 14/06/2012	PROJECT NO.: 43177771

WRPLOT View - Lakes Environmental Software

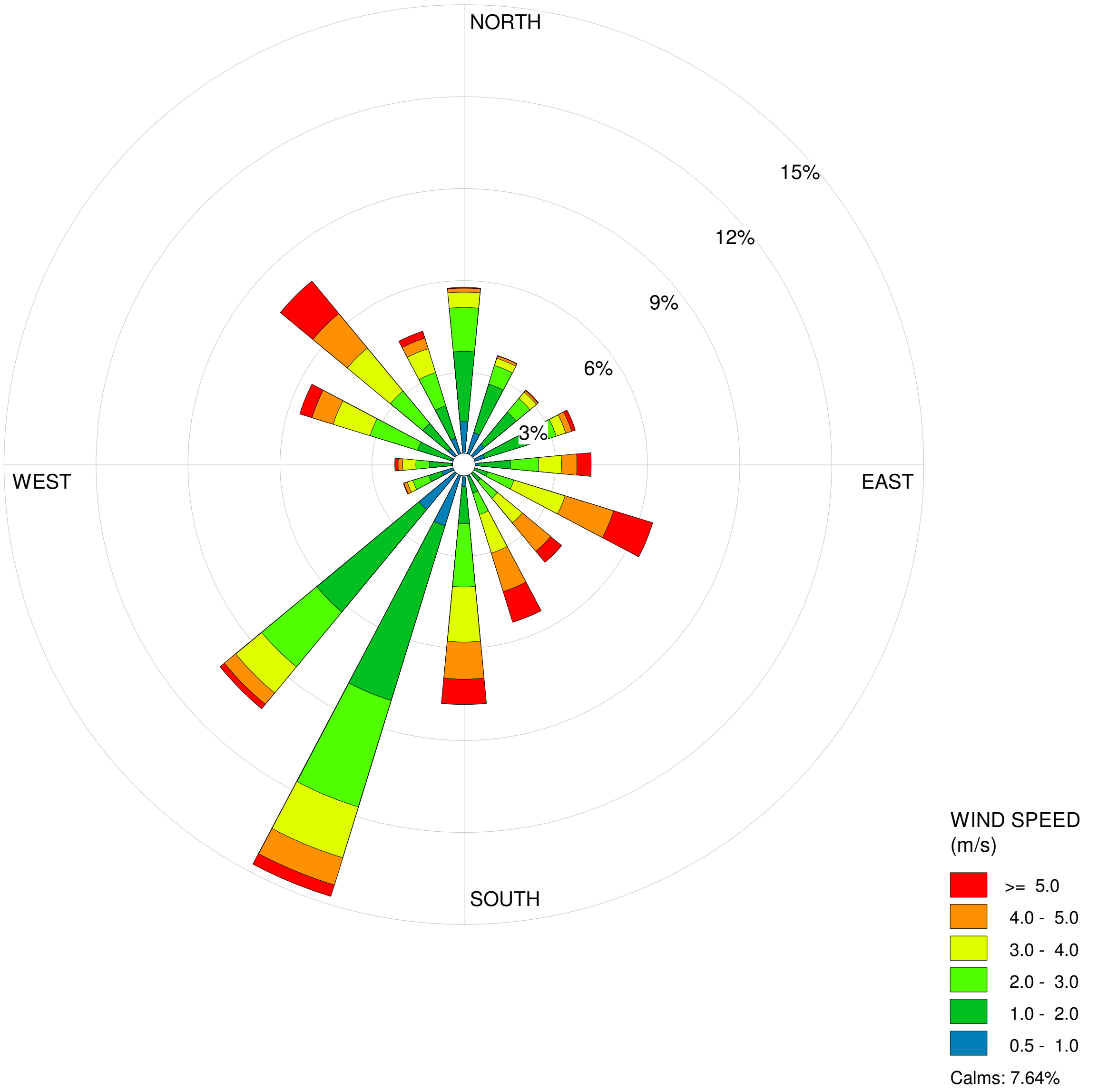
Steel River AWS (2005)
Hourly Records of Wind Speed and Direction at 10m Elevation



COMMENTS:	DATA PERIOD:	COMPANY:	
Wind direction shown as blowing from.	Start Date: 1/01/2005 - 00:00 End Date: 31/12/2005 - 23:00	URS Australia Pty Ltd	
		PREPARED BY: JG	URS
	CALM WINDS: 1.11%	TOTAL COUNT: 8582 hrs.	
	AVG. WIND SPEED: 3.17 m/s	DATE: 14/06/2012	PROJECT NO.: 43177771

WRPLOT View - Lakes Environmental Software

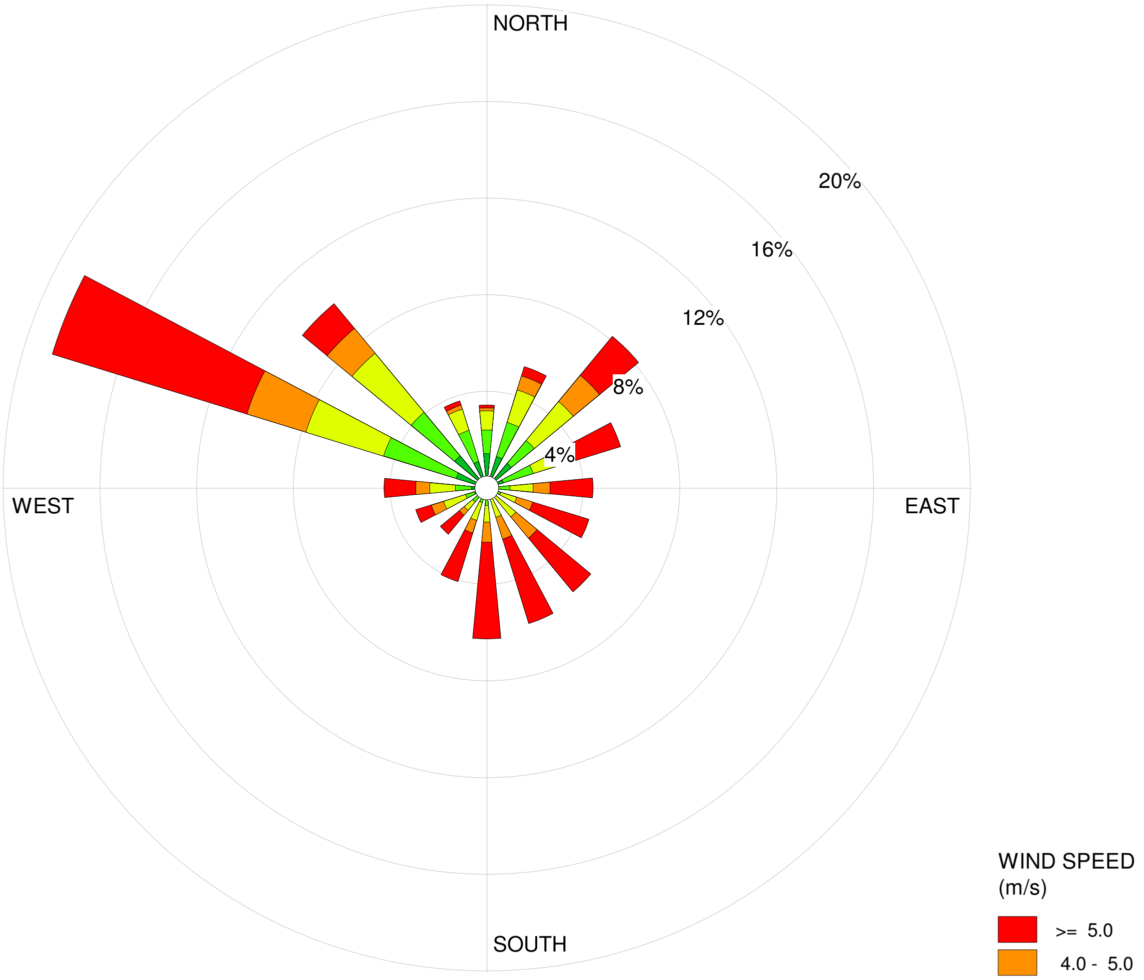
OEH Wallsend AWS (2005)
Hourly Records of Wind Speed and Direction at 10m Elevation



COMMENTS: Wind direction shown as blowing from.	DATA PERIOD: Start Date: 1/01/2005 - 00:00 End Date: 31/12/2005 - 23:00	COMPANY: URS Australia Pty Ltd	
		PREPARED BY: JG	URS
	CALM WINDS: 7.64%	TOTAL COUNT: 7974 hrs.	
	AVG. WIND SPEED: 2.34 m/s	DATE: 14/06/2012	PROJECT NO.: 43177771

WRPLOT View - Lakes Environmental Software

BoM Williamtown AWS (2005)
Hourly Records of Wind Speed and Direction at 10m Elevation



COMMENTS: Wind direction shown as blowing from.	DATA PERIOD: Start Date: 1/01/2005 - 00:00 End Date: 31/12/2005 - 23:00	COMPANY: URS Australia Pty Ltd	
		PREPARED BY: JG	
	CALM WINDS: 4.38%	TOTAL COUNT: 8312 hrs.	
	AVG. WIND SPEED: 4.26 m/s	DATE: 14/06/2012	PROJECT NO.: 43177771

WRPLOT View - Lakes Environmental Software

Appendix C Model List Files

```
|---------------------------------------|
| THE AIR POLLUTION MODEL (TAPM V4.0.3). |
| Copyright (C) CSIRO Australia.         |
| All Rights Reserved.                   |
|---------------------------------------|

----------------
RUN INFORMATION:
----------------
NUMBER OF GRIDS=            5
GRID CENTRE (longitude,latitude)=(   151.7417     ,  -32.85833     )
GRID CENTRE (cx,cy)=(      382260 ,     6363717 ) (m)
GRID DIMENSIONS (nx,ny,nz)=(          51 ,          51 ,          25 )
NUMBER OF VERTICAL LEVELS OUTPUT =          20
DATES (START,END)=(    20041229 ,    20060101 )
DATE FROM WHICH OUTPUT BEGINS =    20050101
LOCAL HOUR IS GMT+   10.10000
TIMESTEP SCALING FACTOR =   1.000000
VARY SYNOPTIC WITH 3-D SPACE AND TIME
V4 LAND SURFACE SCHEME
EXCLUDE NON-HYDROSTATIC EFFECTS
INCLUDE PROGNOSTIC RAIN EQUATION
EXCLUDE PROGNOSTIC SNOW EQUATION
TKE-EPS TURBULENCE (PROGNOSTIC TKE + EPS, EDMF)
POLLUTION : NONE

---------------------------------
START GRID          1 Newcastle_05_N1
GRID SPACING (delx,dely)=(       28600 ,       28600 ) (m)
NUMBER OF MET. DATA ASSIMILATION SITES=           6
INITIALISE
LARGE TIMESTEP =   300.0000
METEOROLOGICAL ADVECTION TIMESTEP =   150.0000     (s)
MET. DATA ASSIMILATION SITE VALUES:
 is   xsite    ysite    zsite    rsite    qsite  zlevels:
  1  387654. 6357119.      15.     1500.     1.00  1 to  2
  2  390999. 6371039.      10.    10000.     1.00  1 to  2
  3  375624. 6359641.      10.     6000.     1.00  1 to  2
  4  384034. 6355663.      10.     2000.     1.00  1 to  2
  5  374629. 6370450.      10.     9000.     1.00  1 to  2
  6  380626. 6360969.      10.     6000.     1.00  1 to  2
IN_MET_SITES
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IN_MET_SITES
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IN_MET_SITES
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IN_MET_SITES
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DATE=20041229,HOUR=12
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DATE=20041229,HOUR=13
IN_MET_SITES
DATE=20041229,HOUR=14
IN_MET_SITES
```



```
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DATE=20041229,HOUR=16
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IN_SYNOPTIC
DATE=20041229,HOUR=17
IN_MET_SITES
DATE=20041229,HOUR=18
IN_MET_SITES
DATE=20041229,HOUR=19
IN_MET_SITES
DATE=20041229,HOUR=20
IN_MET_SITES
DATE=20041229,HOUR=21
IN_MET_SITES
DATE=20041229,HOUR=22
IN_MET_SITES
IN_SYNOPTIC
DATE=20041229,HOUR=23
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DATE=20041229,HOUR=24
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DATE=20041230,HOUR= 2
IN_MET_SITES
DATE=20041230,HOUR= 3
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DATE=20041230,HOUR= 4
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IN_SYNOPTIC
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DATE=20041230,HOUR= 6
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DATE=20041230,HOUR= 7
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DATE=20041230,HOUR=23
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```

```
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DATE=20050101,HOUR= 7
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DATE=20050101,HOUR= 8
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DATE=20050101,HOUR= 9
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DATE=20050101,HOUR=10
```



```
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DATE=20050101,HOUR=12
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DATE=20050101,HOUR=13
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DATE=20050101,HOUR=14
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DATE=20050101,HOUR=15
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DATE=20050101,HOUR=16
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DATE=20050102,HOUR= 9
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DATE=20050102,HOUR=12
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DATE=20050102,HOUR=13
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DATE=20050102,HOUR=14
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DATE=20050102,HOUR=15
IN_MET_SITES
DATE=20050102,HOUR=16
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IN_SYNOPTIC
DATE=20050102,HOUR=17
IN_MET_SITES
DATE=20050102,HOUR=18
IN_MET_SITES
DATE=20050102,HOUR=19
IN_MET_SITES
```

```
CALMET.INP      2.1             Hour Start and End Times with Seconds


---------------- Run title (3 lines) ------------------------------------------
                    CALMET MODEL CONTROL FILE
                    --------------------------

-----------------------------------------------------------------------------
----

INPUT GROUP: 0 -- Input and Output File Names


Subgroup (a)
------------
Default Name  Type          File Name
------------  ----          ---------
GEO.DAT       input    ! GEODAT=C:\URS-DATA\NCMETOUT\NCMETOUT.GEO      !
SURF.DAT      input    ! SRFDAT=C:\URS-DATA\NCMETOUT\NEWC_05.SUR      !
CLOUD.DAT     input    * CLDDAT=            *
PRECIP.DAT    input    * PRCDAT=            *
WT.DAT        input    * WTDAT=             *

CALMET.LST    output   ! METLST=C:\URS-DATA\NCMETOUT\NCMETOUT.LST     !
CALMET.DAT    output   ! METDAT=C:\URS-DATA\NCMETOUT\NCMETOUT.MET    !
PACOUT.DAT    output   * PACDAT=            *

All file names will be converted to lower case if LCFILES = T
Otherwise, if LCFILES = F, file names will be converted to UPPER CASE
         T = lower case      ! LCFILES = F !
         F = UPPER CASE

NUMBER OF UPPER AIR & OVERWATER STATIONS:

    Number of upper air stations (NUSTA)  No default     ! NUSTA =  6  !
    Number of overwater met stations
                                 (NOWSTA) No default     ! NOWSTA =  0  !

NUMBER OF PROGNOSTIC and IGF-CALMET FILEs:

    Number of MM4/MM5/3D.DAT files
                                 (NM3D) No default       ! NM3D =  0  !

    Number of IGF-CALMET.DAT files
                                 (NIGF)   No default     ! NIGF =  0  !

                       !END!
-----------------------------------------------------------------------------
-----
Subgroup (b)
---------------------------------
Upper air files (one per station)
---------------------------------
Default Name  Type       File Name
------------  ----       ---------
UP1.DAT       input     1  ! UPDAT=C:\URS-DATA\NCMETOUT\BER.UP!    !END!
UP2.DAT       input     2  ! UPDAT=C:\URS-DATA\NCMETOUT\NEW.UP!    !END!
UP3.DAT       input     3  ! UPDAT=C:\URS-DATA\NCMETOUT\NOB.UP!    !END!
UP4.DAT       input     4  ! UPDAT=C:\URS-DATA\NCMETOUT\STL.UP!    !END!
UP5.DAT       input     5  ! UPDAT=C:\URS-DATA\NCMETOUT\WAL.UP!    !END!
UP6.DAT       input     6  ! UPDAT=C:\URS-DATA\NCMETOUT\WIL.UP!    !END!
-----------------------------------------------------------------------------
-----
Subgroup (c)
-----------------------------------------
Overwater station files (one per station)
-----------------------------------------
Default Name  Type       File Name
------------  ----       ---------
```



```
SEA1.DAT       input     1  * SEADAT=SEA_449.DAT *    *END*
-----------------------------------------------------------------------------
-----
Subgroup (d)
------------------------------------------------
MM4/MM5/3D.DAT files (consecutive or overlapping)
------------------------------------------------
Default Name  Type       File Name
------------  ----       ---------
MM51.DAT       input     1  * M3DDAT=LSP2003.DAT *    *END*
-----------------------------------------------------------------------------
-----
Subgroup (e)
-------------------------------------------------
IGF-CALMET.DAT files (consecutive or overlapping)
-------------------------------------------------
Default Name  Type       File Name
------------  ----       ---------
IGFn.DAT       input     1  * IGFDAT=CALMET0.DAT *    *END*
-----------------------------------------------------------------------------
-----
Subgroup (f)
----------------
Other file names
----------------

Default Name  Type       File Name
------------  ----       ---------
DIAG.DAT      input      * DIADAT=                  *
PROG.DAT      input      * PRGDAT=                  *

TEST.PRT      output     * TSTPRT=                  *
TEST.OUT      output     * TSTOUT=                  *
TEST.KIN      output     * TSTKIN=                  *
TEST.FRD      output     * TSTFRD=                  *
TEST.SLP      output     * TSTSLP=                  *
DCST.GRD      output     * DCSTGD=                  *

-----------------------------------------------------------------------------
-----
NOTES: (1) File/path names can be up to 70 characters in length
       (2) Subgroups (a) and (f) must have ONE 'END' (surrounded by
           delimiters) at the end of the group
       (3) Subgroups (b) through (e) are included ONLY if the corresponding
           number of files (NUSTA, NOWSTA, NM3D, NIGF) is not 0, and each
           must have
           an 'END' (surround by delimiters) at the end of EACH LINE

                         !END!


-----------------------------------------------------------------------------
----

INPUT GROUP: 1 -- General run control parameters
--------------

     Starting date:    Year   (IBYR)  --    No default   ! IBYR  =  2005  !
                       Month  (IBMO)  --    No default   ! IBMO  =  1  !
                       Day    (IBDY)  --    No default   ! IBDY  =  1  !
     Starting time:    Hour   (IBHR)  --    No default   ! IBHR  =  0  !
                       Second (IBSEC) --    No default   ! IBSEC =  0  !

     Ending date:      Year   (IEYR)  --    No default   ! IEYR  =  2006  !
                       Month  (IEMO)  --    No default   ! IEMO  =  1  !
                       Day    (IEDY)  --    No default   ! IEDY  =  1  !
     Ending time:      Hour   (IEHR)  --    No default   ! IEHR  =  0  !
                       Second (IESEC) --    No default   ! IESEC =  0  !

      UTC time zone        (ABTZ) -- No default       ! ABTZ= UTC+1000 !
         (character*8)
         PST = UTC-0800, MST = UTC-0700 , GMT = UTC-0000
```

```
         CST = UTC-0600, EST = UTC-0500

     Length of modeling time-step (seconds)
     Must divide evenly into 3600 (1 hour)
     (NSECDT)                        Default:3600     ! NSECDT =  3600  !
                                     Units: seconds

     Run type           (IRTYPE) -- Default: 1       ! IRTYPE=  1  !

        0 = Computes wind fields only
        1 = Computes wind fields and micrometeorological variables
            (u*, w*, L, zi, etc.)
        (IRTYPE must be 1 to run CALPUFF or CALGRID)

     Compute special data fields required
     by CALGRID (i.e., 3-D fields of W wind
     components and temperature)
     in additional to regular           Default: T    ! LCALGRD = T !
     fields ? (LCALGRD)
     (LCALGRD must be T to run CALGRID)

      Flag to stop run after
      SETUP phase (ITEST)            Default: 2       ! ITEST=  2   !
      (Used to allow checking
      of the model inputs, files, etc.)
      ITEST = 1 - STOPS program after SETUP phase
      ITEST = 2 - Continues with execution of
                  COMPUTATIONAL phase after SETUP


     Test options specified to see if
     they conform to regulatory
     values? (MREG)                  No Default       ! MREG =   0   !

        0 = NO checks are made
        1 = Technical options must conform to USEPA guidance
                  IMIXH    -1       Maul-Carson convective mixing height
                                    over land; OCD mixing height overwater
                  ICOARE   0        OCD deltaT method for overwater fluxes
                  THRESHL  0.0      Threshold buoyancy flux over land
                  needed
                                    to sustain convective mixing height
                                    growth
                  ISURFT   > 0      Pick one representative station, OR
                           -2       in NOOBS mode (ITPROG=2) average all
                                    surface prognostic temperatures to get
                                    a single representative surface temp.
                  IUPT     > 0      Pick one representative station, OR
                           -2       in NOOBS mode (ITPROG>0) average all
                           surface
                                    prognostic temperatures to get a single
                                    representative surface temp.
                  IZICRLX  0        Do NOT use convective mixing height
                                    relaxation to equilibrium value

!END!

----------------------------------------------------------------------------
----

INPUT GROUP: 2 -- Map Projection and Grid control parameters
--------------

     Projection for all (X,Y):
     -------------------------

     Map projection
     (PMAP)                     Default: UTM    ! PMAP = UTM  !

         UTM :  Universal Transverse Mercator
         TTM :  Tangential Transverse Mercator
         LCC :  Lambert Conformal Conic
```



```
         PS :  Polar Stereographic
         EM :  Equatorial Mercator
       LAZA :  Lambert Azimuthal Equal Area

     False Easting and Northing (km) at the projection origin
     (Used only if PMAP= TTM, LCC, or LAZA)
     (FEAST)                    Default=0.0     ! FEAST  = 0.000  !
     (FNORTH)                   Default=0.0     ! FNORTH = 0.000  !

     UTM zone (1 to 60)
     (Used only if PMAP=UTM)
     (IUTMZN)                   No Default      ! IUTMZN =  56   !

     Hemisphere for UTM projection?
     (Used only if PMAP=UTM)
     (UTMHEM)                   Default: N      ! UTMHEM = S  !
         N   :  Northern hemisphere projection
         S   :  Southern hemisphere projection

     Latitude and Longitude (decimal degrees) of projection origin
     (Used only if PMAP= TTM, LCC, PS, EM, or LAZA)
     (RLAT0)                    No Default      ! RLAT0 =  0N  !
     (RLON0)                    No Default      ! RLON0 =  0E  !

         TTM :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         LCC :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         PS  :  RLON0 identifies central (grid N/S) meridian of projection
                RLAT0 selected for convenience
         EM  :  RLON0 identifies central meridian of projection
                RLAT0 is REPLACED by 0.0N (Equator)
         LAZA:  RLON0 identifies longitude of tangent-point of mapping
         plane
                RLAT0 identifies latitude of tangent-point of mapping plane

     Matching parallel(s) of latitude (decimal degrees) for projection
     (Used only if PMAP= LCC or PS)
     (XLAT1)                    No Default      ! XLAT1 =  0N  !
     (XLAT2)                    No Default      ! XLAT2 =  0N  !

         LCC :  Projection cone slices through Earth's surface at XLAT1 and
         XLAT2
         PS  :  Projection plane slices through Earth at XLAT1
                (XLAT2 is not used)

     ----------
     Note:  Latitudes and longitudes should be positive, and include a
            letter N,S,E, or W indicating north or south latitude, and
            east or west longitude.  For example,
            35.9  N Latitude  =  35.9N
            118.7 E Longitude = 118.7E


     Datum-region
     ------------

     The Datum-Region for the coordinates is identified by a character
     string.  Many mapping products currently available use the model of
     the
     Earth known as the World Geodetic System 1984 (WGS-84).  Other local
     models may be in use, and their selection in CALMET will make its
     output
     consistent with local mapping products.  The list of Datum-Regions
     with
     official transformation parameters is provided by the National Imagery
     and
     Mapping Agency (NIMA).

     NIMA Datum - Regions(Examples)

     ----------------------------------------------------------------------
```

```
     --------
     WGS-84    WGS-84 Reference Ellipsoid and Geoid, Global coverage
     (WGS84)
     NAS-C     NORTH AMERICAN 1927 Clarke 1866 Spheroid, MEAN FOR CONUS
     (NAD27)
     NAR-C     NORTH AMERICAN 1983 GRS 80 Spheroid, MEAN FOR CONUS (NAD83)
     NWS-84    NWS 6370KM Radius, Sphere
     ESR-S     ESRI REFERENCE 6371KM Radius, Sphere

     Datum-region for output coordinates
     (DATUM)                  Default: WGS-84    ! DATUM = WGS-84  !


     Horizontal grid definition:
     ---------------------------

     Rectangular grid defined for projection PMAP,
     with X the Easting and Y the Northing coordinate

            No. X grid cells (NX)      No default     ! NX =   43  !
            No. Y grid cells (NY)      No default     ! NY =   43  !

     Grid spacing (DGRIDKM)            No default     ! DGRIDKM = 0.5 !
                                       Units: km

     Reference grid coordinate of
     SOUTHWEST corner of grid cell (1,1)

        X coordinate (XORIGKM)         No default     ! XORIGKM = 371.750 !
        Y coordinate (YORIGKM)         No default     ! YORIGKM = 6352.750
        !
                                       Units: km


     Vertical grid definition:
     -------------------------

        No. of vertical layers (NZ)    No default     ! NZ =  12  !

        Cell face heights in arbitrary
        vertical grid (ZFACE(NZ+1))    No defaults
                                       Units: m
        ! ZFACE =
        0.,20.,30.,50.,100.,150.,250.,300.,400.,600.,1000.,1500.,2500. !

!END!

---------------------------------------------------------------------------
----

INPUT GROUP: 3 -- Output Options
--------------


    DISK OUTPUT OPTION

       Save met. fields in an unformatted
       output file ?            (LSAVE)  Default: T     ! LSAVE = T !
       (F = Do not save, T = Save)

       Type of unformatted output file:
       (IFORMO)                          Default: 1    ! IFORMO =  1  !

            1 = CALPUFF/CALGRID type file (CALMET.DAT)
            2 = MESOPUFF-II type file     (PACOUT.DAT)


    LINE PRINTER OUTPUT OPTIONS:

       Print met. fields ?  (LPRINT)     Default: F     ! LPRINT = T !
       (F = Do not print, T = Print)
```



```
       (NOTE: parameters below control which
              met. variables are printed)

       Print interval
       (IPRINF) in hours                  Default: 1     ! IPRINF =  1  !
       (Meteorological fields are printed
        every  1  hours)


       Specify which layers of U, V wind component
       to print (IUVOUT(NZ)) -- NOTE: NZ values must be entered
       (0=Do not print, 1=Print)
       (used only if LPRINT=T)        Defaults: NZ*0
       ! IUVOUT =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0
       !
       -----------------------


       Specify which levels of the W wind component to print
       (NOTE: W defined at TOP cell face --  12  values)
       (IWOUT(NZ)) -- NOTE: NZ values must be entered
       (0=Do not print, 1=Print)
       (used only if LPRINT=T & LCALGRD=T)
       -----------------------------------
                                           Defaults: NZ*0
        ! IWOUT =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0
        !


       Specify which levels of the 3-D temperature field to print
       (ITOUT(NZ)) -- NOTE: NZ values must be entered
       (0=Do not print, 1=Print)
       (used only if LPRINT=T & LCALGRD=T)
       -----------------------------------
                                           Defaults: NZ*0
        ! ITOUT =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0
        !

       Specify which meteorological fields
       to print
       (used only if LPRINT=T)            Defaults: 0 (all variables)
       -----------------------


         Variable           Print ?
                        (0 = do not print,
                         1 = print)
         --------       ------------------

      !  STABILITY  =          0           ! - PGT stability class
      !  USTAR      =          0           ! - Friction velocity
      !  MONIN      =          0           ! - Monin-Obukhov length
      !  MIXHT      =          0           ! - Mixing height
      !  WSTAR      =          0           ! - Convective velocity scale
      !  PRECIP     =          0           ! - Precipitation rate
      !  SENSHEAT   =          0           ! - Sensible heat flux
      !  CONVZI     =          0           ! - Convective mixing ht.


       Testing and debug print options for micrometeorological module

          Print input meteorological data and
          internal variables (LDB)        Default: F       ! LDB = F !
          (F = Do not print, T = print)
          (NOTE: this option produces large amounts of output)

          First time step for which debug data
          are printed (NN1)               Default: 1       ! NN1 =  1  !

          Last time step for which debug data
          are printed (NN2)               Default: 1       ! NN2 =  2  !
```

```
         Print distance to land
         internal variables (LDBCST)      Default: F       ! LDBCST = F !
         (F = Do not print, T = print)
         (Output in .GRD file DCST.GRD, defined in input group 0)

      Testing and debug print options for wind field module
      (all of the following print options control output to
       wind field module's output files: TEST.PRT, TEST.OUT,
       TEST.KIN, TEST.FRD, and TEST.SLP)

         Control variable for writing the test/debug
         wind fields to disk files (IOUTD)
         (0=Do not write, 1=write)        Default: 0       ! IOUTD =  0  !

         Number of levels, starting at the surface,
         to print (NZPRN2)                Default: 1       ! NZPRN2 =  1
         !

         Print the INTERPOLATED wind components ?
         (IPR0) (0=no, 1=yes)             Default: 0       !  IPR0 =  0  !

         Print the TERRAIN ADJUSTED surface wind
         components ?
         (IPR1) (0=no, 1=yes)             Default: 0       !  IPR1 =  0  !

         Print the SMOOTHED wind components and
         the INITIAL DIVERGENCE fields ?
         (IPR2) (0=no, 1=yes)             Default: 0       !  IPR2 =  0  !

         Print the FINAL wind speed and direction
         fields ?
         (IPR3) (0=no, 1=yes)             Default: 0       !  IPR3 =  0  !

         Print the FINAL DIVERGENCE fields ?
         (IPR4) (0=no, 1=yes)             Default: 0       !  IPR4 =  0  !

         Print the winds after KINEMATIC effects
         are added ?
         (IPR5) (0=no, 1=yes)             Default: 0       !  IPR5 =  0  !

         Print the winds after the FROUDE NUMBER
         adjustment is made ?
         (IPR6) (0=no, 1=yes)             Default: 0       !  IPR6 =  0  !

         Print the winds after SLOPE FLOWS
         are added ?
         (IPR7) (0=no, 1=yes)             Default: 0       !  IPR7 =  0  !

         Print the FINAL wind field components ?
         (IPR8) (0=no, 1=yes)             Default: 0       !  IPR8 =  0  !

!END!


---------------------------------------------------------------------------
----

INPUT GROUP: 4 -- Meteorological data options
--------------

    NO OBSERVATION MODE             (NOOBS)  Default: 0     ! NOOBS =  0
    !
          0 = Use surface, overwater, and upper air stations
          1 = Use surface and overwater stations (no upper air
          observations)
              Use MM4/MM5/3D.DAT for upper air data
          2 = No surface, overwater, or upper air observations
              Use MM4/MM5/3D.DAT for surface, overwater, and upper air data

    NUMBER OF SURFACE & PRECIP. METEOROLOGICAL STATIONS

       Number of surface stations   (NSSTA)  No default     ! NSSTA =  6  !
```



```
       Number of precipitation stations
       (NPSTA=-1: flag for use of MM5/3D.DAT precip data)
                                    (NPSTA)  No default     ! NPSTA =  0  !

    CLOUD DATA OPTIONS
       Gridded cloud fields:
                                   (ICLOUD)  Default: 0     ! ICLOUD =  0
                                   !
       ICLOUD = 0 - Gridded clouds not used
       ICLOUD = 1 - Gridded CLOUD.DAT generated as OUTPUT
       ICLOUD = 2 - Gridded CLOUD.DAT read as INPUT
       ICLOUD = 3 - Gridded cloud cover from Prognostic Rel. Humidity
                    at 850mb (Teixera)
       ICLOUD = 4 - Gridded cloud cover from Prognostic Rel. Humidity
                    at all levels (MM5toGrads algorithm)

    FILE FORMATS

       Surface meteorological data file format
                                   (IFORMS)  Default: 2     ! IFORMS =  2
                                   !
       (1 = unformatted (e.g., SMERGE output))
       (2 = formatted   (free-formatted user input))

       Precipitation data file format
                                   (IFORMP)  Default: 2     ! IFORMP =  2
                                   !
       (1 = unformatted (e.g., PMERGE output))
       (2 = formatted   (free-formatted user input))

       Cloud data file format
                                   (IFORMC)  Default: 2     ! IFORMC =  2
                                   !
       (1 = unformatted - CALMET unformatted output)
       (2 = formatted   - free-formatted CALMET output or user input)

!END!


---------------------------------------------------------------------------
----

INPUT GROUP: 5 -- Wind Field Options and Parameters
--------------


    WIND FIELD MODEL OPTIONS
       Model selection variable (IWFCOD)     Default: 1      ! IWFCOD =  1
       !
          0 = Objective analysis only
          1 = Diagnostic wind module

       Compute Froude number adjustment
       effects ? (IFRADJ)                    Default: 1      ! IFRADJ =  1
       !
       (0 = NO, 1 = YES)

       Compute kinematic effects ? (IKINE)   Default: 0      ! IKINE  =  0
       !
       (0 = NO, 1 = YES)

       Use O'Brien procedure for adjustment
       of the vertical velocity ? (IOBR)     Default: 0      ! IOBR =  0  !
       (0 = NO, 1 = YES)

       Compute slope flow effects ? (ISLOPE) Default: 1      ! ISLOPE  =  1
       !
       (0 = NO, 1 = YES)

       Extrapolate surface wind observations
       to upper layers ? (IEXTRP)            Default: -4     ! IEXTRP =  1
```

```
!
(1 = no extrapolation is done,
 2 = power law extrapolation used,
 3 = user input multiplicative factors
     for layers 2 - NZ used (see FEXTRP array)
 4 = similarity theory used
 -1, -2, -3, -4 = same as above except layer 1 data
     at upper air stations are ignored

Extrapolate surface winds even
if calm? (ICALM)                    Default: 0      ! ICALM  =  0
!
(0 = NO, 1 = YES)

Layer-dependent biases modifying the weights of
surface and upper air stations (BIAS(NZ))
  -1<=BIAS<=1
Negative BIAS reduces the weight of upper air stations
  (e.g. BIAS=-0.1 reduces the weight of upper air stations
by 10%; BIAS= -1, reduces their weight by 100 %)
Positive BIAS reduces the weight of surface stations
  (e.g. BIAS= 0.2 reduces the weight of surface stations
by 20%; BIAS=1 reduces their weight by 100%)
Zero BIAS leaves weights unchanged (1/R**2 interpolation)
Default: NZ*0
                        ! BIAS = -1 ,  1 ,  1 ,  1 ,  1 ,  1 ,  1 ,
                        1 ,  1 ,  1 ,  1 ,  1  !

Minimum distance from nearest upper air station
to surface station for which extrapolation
of surface winds at surface station will be allowed
(RMIN2: Set to -1 for IEXTRP = 4 or other situations
 where all surface stations should be extrapolated)
                                    Default: 4.     ! RMIN2 = 4.0
                                    !

Use gridded prognostic wind field model
output fields as input to the diagnostic
wind field model (IPROG)            Default: 0      ! IPROG =  0
!
(0 = No, [IWFCOD = 0 or 1]
 1 = Yes, use CSUMM prog. winds as Step 1 field, [IWFCOD = 0]
 2 = Yes, use CSUMM prog. winds as initial guess field [IWFCOD = 1]
 3 = Yes, use winds from MM4.DAT file as Step 1 field [IWFCOD = 0]
 4 = Yes, use winds from MM4.DAT file as initial guess field [IWFCOD
 = 1]
 5 = Yes, use winds from MM4.DAT file as observations [IWFCOD = 1]
 13 = Yes, use winds from MM5/3D.DAT file as Step 1 field [IWFCOD =
 0]
 14 = Yes, use winds from MM5/3D.DAT file as initial guess field
 [IWFCOD = 1]
 15 = Yes, use winds from MM5/3D.DAT file as observations [IWFCOD =
 1]

Timestep (seconds) of the prognostic
model input data   (ISTEPPGS)       Default: 3600   ! ISTEPPGS =
3600   !

Use coarse CALMET fields as initial guess fields (IGFMET)
(overwrites IGF based on prognostic wind fields if any)
                                    Default: 0      ! IGFMET =  0
                                    !
```

RADIUS OF INFLUENCE PARAMETERS

```
Use varying radius of influence     Default: F      ! LVARY =  F!
(if no stations are found within RMAX1,RMAX2,
 or RMAX3, then the closest station will be used)

Maximum radius of influence over land
in the surface layer (RMAX1)        No default      ! RMAX1 = 10.
!
```



```
                                      Units: km
Maximum radius of influence over land
aloft (RMAX2)                         No default      ! RMAX2 = 10.
!
                                      Units: km
Maximum radius of influence over water
(RMAX3)                               No default      ! RMAX3 = 10.
!
                                      Units: km
```

OTHER WIND FIELD INPUT PARAMETERS

```
Minimum radius of influence used in
the wind field interpolation (RMIN)   Default: 0.1    ! RMIN = 0.1 !
                                      Units: km
Radius of influence of terrain
features (TERRAD)                     No default      ! TERRAD = 2.
!

                                      Units: km
Relative weighting of the first
guess field and observations in the
SURFACE layer (R1)                    No default      ! R1 = 3. !
(R1 is the distance from an           Units: km
observational station at which the
observation and first guess field are
equally weighted)

Relative weighting of the first
guess field and observations in the
layers ALOFT (R2)                     No default      ! R2 = 5. !
(R2 is applied in the upper layers    Units: km
in the same manner as R1 is used in
the surface layer).

Relative weighting parameter of the
prognostic wind field data (RPROG)    No default      ! RPROG = 0. !
(Used only if IPROG = 1)              Units: km
------------------------

Maximum acceptable divergence in the
divergence minimization procedure
(DIVLIM)                              Default: 5.E-6  ! DIVLIM=
5.0E-06 !

Maximum number of iterations in the
divergence min. procedure (NITER)     Default: 50     ! NITER =  50
!

Number of passes in the smoothing
procedure (NSMTH(NZ))
NOTE: NZ values must be entered
     Default: 2,(mxnz-1)*4 ! NSMTH =
2 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4  !

Maximum number of stations used in
each layer for the interpolation of
data to a grid point (NINTR2(NZ))
NOTE: NZ values must be entered       Default: 99.    ! NINTR2 =
99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99  !

Critical Froude number (CRITFN)       Default: 1.0    ! CRITFN = 1.
!

Empirical factor controlling the
influence of kinematic effects
(ALPHA)                               Default: 0.1    ! ALPHA = 0.1
!

Multiplicative scaling factor for
extrapolation of surface observations
```

```
       to upper layers (FEXTR2(NZ))          Default: NZ*0.0
       ! FEXTR2 = 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0. !
       (Used only if IEXTRP = 3 or -3)


    BARRIER INFORMATION

       Number of barriers to interpolation
       of the wind fields (NBAR)             Default: 0       ! NBAR =  4  !

       Level (1 to NZ) up to which barriers
       apply (KBAR)                          Default: NZ      ! KBAR =  12
       !

       THE FOLLOWING 4 VARIABLES ARE INCLUDED
       ONLY IF NBAR > 0
       NOTE: NBAR values must be entered     No defaults
             for each variable               Units: km

          X coordinate of BEGINNING
          of each barrier (XBBAR(NBAR))      ! XBBAR = 385.117, 386.019,
          387.094, 389.162 !
          Y coordinate of BEGINNING
          of each barrier (YBBAR(NBAR))      ! YBBAR = 6351.313, 6355.391,
          6355.859, 6362.770 !

          X coordinate of ENDING
          of each barrier (XEBAR(NBAR))      ! XEBAR = 386.019, 387.094,
          389.162, 391.332 !
          Y coordinate of ENDING
          of each barrier (YEBAR(NBAR))      ! YEBAR = 6355.391, 6355.859,
          6362.770, 6364.149 !


    DIAGNOSTIC MODULE DATA INPUT OPTIONS

       Surface temperature (IDIOPT1)         Default: 0       ! IDIOPT1 =  0
       !
          0 = Compute internally from
              hourly surface observations or prognostic fields
          1 = Read preprocessed values from
              a data file (DIAG.DAT)

          Surface met. station to use for
          the surface temperature (ISURFT)   Default: -1    ! ISURFT =  1
          !
          (Must be a value from 1 to NSSTA,
           or -1 to use 2-D spatially varying
              surface temperatures,
           or -2 to use a domain-average prognostic
              surface temperatures (only with ITPROG=2))
          (Used only if IDIOPT1 = 0)
          --------------------------

       Temperature lapse rate used in the    Default: 0     ! IDIOPT2 =  0
       !
          computation of terrain-induced
          circulations (IDIOPT2)
          0 = Compute internally from (at least) twice-daily
              upper air observations or prognostic fields
          1 = Read hourly preprocessed values
              from a data file (DIAG.DAT)

          Upper air station to use for
          the domain-scale lapse rate (IUPT) Default: -1    ! IUPT   =  1
          !
          (Must be a value from 1 to NUSTA,
           or -1 to use 2-D spatially varying lapse rate,
           or -2 to use a domain-average prognostic
              lapse rate (only with ITPROG>0))
          (Used only if IDIOPT2 = 0)
          --------------------------
```



```
          Depth through which the domain-scale
          lapse rate is computed (ZUPT)      Default: 200.  ! ZUPT = 200. !
          (Used only if IDIOPT2 = 0)         Units: meters
          --------------------------

       Initial Guess Field Winds
       (IDIOPT3)                             Default: 0     ! IDIOPT3 =  0
       !
          0 = Compute internally from
              observations or prognostic wind fields
          1 = Read hourly preprocessed domain-average wind values
              from a data file (DIAG.DAT)

          Upper air station to use for
          the initial guess winds (IUPWND)   Default: -1    ! IUPWND = -1
          !
          (Must be a value from -1 to NUSTA, with
          -1 indicating 3-D initial guess fields,
          and IUPWND>1 domain-scaled (i.e. constant) IGF)
          (Used only if IDIOPT3 = 0 and noobs=0)
          --------------------------------------

          Bottom and top of layer through
          which the domain-scale winds
          are computed
          (ZUPWND(1), ZUPWND(2))        Defaults: 1., 1000. ! ZUPWND= 1.,
          1000. !
          (Used only if IDIOPT3 = 0, NOOBS>0 and IUPWND>0)    Units: meters
          --------------------------

       Observed surface wind components
       for wind field module (IDIOPT4)  Default: 0     ! IDIOPT4 =  0  !
          0 = Read WS, WD from a surface
              data file (SURF.DAT)
          1 = Read hourly preprocessed U, V from
              a data file (DIAG.DAT)

       Observed upper air wind components
       for wind field module (IDIOPT5)  Default: 0     ! IDIOPT5 =  0  !
          0 = Read WS, WD from an upper
              air data file (UP1.DAT, UP2.DAT, etc.)
          1 = Read hourly preprocessed U, V from
              a data file (DIAG.DAT)

       LAKE BREEZE INFORMATION

          Use Lake Breeze Module  (LLBREZE)
                                           Default: F      ! LLBREZE = F !

           Number of lake breeze regions (NBOX)            ! NBOX =  0  !

        X Grid line 1 defining the region of interest
                                                        ! XG1 = 0. !
        X Grid line 2 defining the region of interest
                                                        ! XG2 = 0. !
        Y Grid line 1 defining the region of interest
                                                        ! YG1 = 0. !
        Y Grid line 2 defining the region of interest
                                                        ! YG2 = 0. !

         X Point defining the coastline (Straight line)
                   (XBCST)  (KM)   Default: none    ! XBCST = 0. !

         Y Point defining the coastline (Straight line)
                   (YBCST)  (KM)   Default: none    ! YBCST = 0. !

         X Point defining the coastline (Straight line)
                   (XECST)  (KM)   Default: none    ! XECST = 0. !

         Y Point defining the coastline (Straight line)
                   (YECST)  (KM)   Default: none    ! YECST = 0. !
```

```
      Number of stations in the region     Default: none ! NLB =  0 !
      (Surface stations + upper air stations)

      Station ID's  in the region   (METBXID(NLB))
      (Surface stations first, then upper air stations)
        ! METBXID =  0 !

!END!


--------------------------------------------------------------------------
----

INPUT GROUP: 6 -- Mixing Height, Temperature and Precipitation Parameters
--------------

    EMPIRICAL MIXING HEIGHT CONSTANTS

      Neutral, mechanical equation
      (CONSTB)                              Default: 1.41   ! CONSTB =
      1.41 !
      Convective mixing ht. equation
      (CONSTE)                              Default: 0.15   ! CONSTE =
      0.15 !
      Stable mixing ht. equation
      (CONSTN)                              Default: 2400.  ! CONSTN =
      2400.!
      Overwater mixing ht. equation
      (CONSTW)                              Default: 0.16   ! CONSTW =
      0.16 !
      Absolute value of Coriolis
      parameter (FCORIOL)                   Default: 1.E-4  ! FCORIOL =
      7.9E-05!
                                            Units: (1/s)

    SPATIAL AVERAGING OF MIXING HEIGHTS

      Conduct spatial averaging
      (IAVEZI)  (0=no, 1=yes)               Default: 1      ! IAVEZI =  1
      !

      Max. search radius in averaging
      process (MNMDAV)                      Default: 1      ! MNMDAV =  1
      !
                                            Units: Grid
                                                   cells
      Half-angle of upwind looking cone
      for averaging (HAFANG)                Default: 30.    ! HAFANG = 30.
      !
                                            Units: deg.
      Layer of winds used in upwind
      averaging (ILEVZI)                    Default: 1      ! ILEVZI =  1
      !
      (must be between 1 and NZ)


    CONVECTIVE MIXING HEIGHT OPTIONS:
      Method to compute the convective
      mixing height(IMIHXH)                 Default: 1      ! IMIXH =  1
      !
          1: Maul-Carson for land and water cells
         -1: Maul-Carson for land cells only -
             OCD mixing height overwater
          2: Batchvarova and Gryning for land and water cells
         -2: Batchvarova and Gryning for land cells only
             OCD mixing height overwater

      Threshold buoyancy flux required to
      sustain convective mixing height growth
      overland (THRESHL)                    Default: 0.0    ! THRESHL =
```



```
      0.05 !
      (expressed as a heat flux             units: W/m3
       per meter of boundary layer)


      Threshold buoyancy flux required to
      sustain convective mixing height growth
      overwater (THRESHW)                   Default: 0.05   ! THRESHW =
      0.05 !
      (expressed as a heat flux             units: W/m3
       per meter of boundary layer)


      Flag to allow relaxation of convective mixing height
      to equilibrium value when  0<QH<THRESHL (overland)
                             or  0<QH<THRESHW (overwater)
      (IZICRLX)                             Default: 1      ! IZICRLX =  1
      !
         0 : do NOT use convective mixing height relaxation
             to equilibrium value (treatment identical to CALMET v5.8)
         1 : use convective mixing height relaxation
             to equilibrium value


      Relaxation time of convective mixing height to
      equilibrium value when  0<QH<THRESHL (overland)
                          or  0<QH<THRESHW (overwater)
      (Used only if IZICRLX = 1 and  TZICRLX must be >= 1.)
      (TZICRLX)                             Default: 800.   ! TZICRLX =
      800. !
                                            Units: seconds


      Option for overwater lapse rates used
      in convective mixing height growth
      (ITWPROG)                             Default: 0      ! ITWPROG =  0
      !
      0 : use SEA.DAT lapse rates and deltaT (or assume neutral
          conditions if missing)
      1 : use prognostic lapse rates (only if IPROG>2)
          and SEA.DAT deltaT (or neutral if missing)
      2 : use prognostic lapse rates and prognostic delta T
          (only if iprog>12 and 3D.DAT version# 2.0 or higher)

      Land Use category ocean in 3D.DAT datasets
      (ILUOC3D)                             Default: 16     ! ILUOC3D =
      16  !
      Note: if 3D.DAT from MM5 version 3.0, iluoc3d = 16
            if MM4.DAT,           typically iluoc3d = 7


   OTHER MIXING HEIGHT VARIABLES

      Minimum potential temperature lapse
      rate in the stable layer above the
      current convective mixing ht.         Default: 0.001  ! DPTMIN =
      0.001 !
      (DPTMIN)                              Units: deg. K/m
      Depth of layer above current conv.
      mixing height through which lapse     Default: 200.   ! DZZI = 200.
      !
      rate is computed (DZZI)               Units: meters

      Minimum overland mixing height        Default:  50.   ! ZIMIN = 50.
      !
      (ZIMIN)                               Units: meters
      Maximum overland mixing height        Default: 3000.  ! ZIMAX =
      3000. !
      (ZIMAX)                               Units: meters
      Minimum overwater mixing height       Default:   50.  ! ZIMINW = 50.
      !
      (ZIMINW) -- (Not used if observed     Units: meters
```

```
      overwater mixing hts. are used)
      Maximum overwater mixing height       Default: 3000.  ! ZIMAXW =
      3000. !
      (ZIMAXW) -- (Not used if observed     Units: meters
      overwater mixing hts. are used)


   OVERWATER SURFACE FLUXES METHOD and PARAMETERS
         (ICOARE)                           Default: 10      ! ICOARE =
         10   !
          0: original deltaT method (OCD)
         10: COARE with no wave parameterization (jwave=0, Charnock)
         11: COARE with wave option jwave=1 (Oost et al.)
             and default wave properties
        -11: COARE with wave option jwave=1 (Oost et al.)
             and observed wave properties (must be in SEA.DAT files)
         12: COARE with wave option 2 (Taylor and Yelland)
              and default wave properties
        -12: COARE with wave option 2 (Taylor and Yelland)
             and observed wave properties (must be in SEA.DAT files)

         Note:  When ICOARE=0, similarity wind profile stability PSI
         functions
                based on Van Ulden and Holtslag (1985) are substituted for
                later formulations used with the COARE module, and
                temperatures
                used for surface layer parameters are obtained from either
                the
                nearest surface station temperature or prognostic model 2D
                temperatures (if ITPROG=2).


         Coastal/Shallow water length scale (DSHELF)
         (for modified z0 in shallow water)
         ( COARE fluxes only)
                                         Default : 0.        ! DSHELF = 0.
                                         !
                                         units: km

          COARE warm layer computation (IWARM)               ! IWARM =  0
          !
          1: on - 0: off (must be off if SST measured with
          IR radiometer)                 Default: 0

          COARE cool skin layer computation (ICOOL)          ! ICOOL =  0
          !
          1: on - 0: off (must be off if SST measured with
          IR radiometer)                 Default: 0

   RELATIVE HUMIDITY PARAMETERS

      3D relative humidity from observations or
      from prognostic data? (IRHPROG)       Default:0        ! IRHPROG =
      0   !

         0 = Use RH from SURF.DAT file
             (only if NOOBS = 0,1)
         1 = Use prognostic RH
             (only if NOOBS = 0,1,2)

   TEMPERATURE PARAMETERS

      3D temperature from observations or
      from prognostic data? (ITPROG)        Default:0        ! ITPROG =  0
      !

         0 = Use Surface and upper air stations
             (only if NOOBS = 0)
         1 = Use Surface stations (no upper air observations)
             Use MM5/3D.DAT for upper air data
             (only if NOOBS = 0,1)
         2 = No surface or upper air observations
```



```
             Use MM5/3D.DAT for surface and upper air data
             (only if NOOBS = 0,1,2)

      Interpolation type
      (1 = 1/R ; 2 = 1/R**2)                Default:1        ! IRAD =  1
      !

      Radius of influence for temperature
      interpolation (TRADKM)                Default: 500.    ! TRADKM =
      500. !
                                            Units: km

      Maximum Number of stations to include
      in temperature interpolation (NUMTS)  Default: 5       ! NUMTS = 5
      !

      Conduct spatial averaging of temp-
      eratures (IAVET)  (0=no, 1=yes)       Default: 1       ! IAVET =  1
      !
      (will use mixing ht MNMDAV,HAFANG
       so make sure they are correct)

      Default temperature gradient          Default: -.0098  ! TGDEFB =
      -0.0098 !
      below the mixing height over          Units: K/m
      water (TGDEFB)

      Default temperature gradient          Default: -.0045  ! TGDEFA =
      -0.0045 !
      above the mixing height over          Units: K/m
      water (TGDEFA)

      Beginning (JWAT1) and ending (JWAT2)
      land use categories for temperature                   ! JWAT1 =
      999  !
      interpolation over water -- Make                      ! JWAT2 =
      999  !
      bigger than largest land use to disable

   PRECIP INTERPOLATION PARAMETERS

      Method of interpolation (NFLAGP)      Default: 2      ! NFLAGP =  2
      !
       (1=1/R,2=1/R**2,3=EXP/R**2)
      Radius of Influence  (SIGMAP)         Default: 100.0  ! SIGMAP =
      100. !
       (0.0 => use half dist. btwn          Units: km
        nearest stns w & w/out
        precip when NFLAGP = 3)
      Minimum Precip. Rate Cutoff (CUTP)    Default: 0.01   ! CUTP = 0.01
      !
       (values < CUTP = 0.0 mm/hr)          Units: mm/hr
!END!


----------------------------------------------------------------------------
----

INPUT GROUP: 7 -- Surface meteorological station parameters
--------------

     SURFACE STATION VARIABLES
     (One record per station --  7  records in all)


             1     2
         Name   ID          X coord.   Y coord.   Time   Anem.
                             (km)       (km)      zone   Ht.(m)
      ----------------------------------------------------------
! SS1  ='BER'    10001      374.629    6370.450   -10    10  !
! SS2  ='NEW'    10002      384.034    6355.663   -10    10  !
! SS3  ='NOB'    10003      387.654    6357.119   -10    15  !
```

```
! SS4  ='STL'    10004       380.626     6360.969   -10    10  !
! SS5  ='WAL'    10005       375.624     6359.641   -10    10  !
! SS6  ='WIL'    10006       390.999     6371.039   -10    10  !
-------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)

      2
        Six digit integer for station ID

!END!


----------------------------------------------------------------------------
----

INPUT GROUP: 8 -- Upper air meteorological station parameters
--------------

     UPPER AIR STATION VARIABLES
     (One record per station --  7  records in all)

             1     2
         Name    ID      X coord.   Y coord.  Time zone
                           (km)       (km)
        ----------------------------------------------
! US1  ='BER'   20001    374.629   6370.450   -10  !
! US2  ='NEW'   20002    384.034   6355.663   -10  !
! US3  ='NOB'   20003    387.654   6357.119   -10  !
! US4  ='STL'   20004    380.626   6360.969   -10  !
! US5  ='WAL'   20005    375.624   6359.641   -10  !
! US6  ='WIL'   20006    390.999   6371.039   -10  !
-------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)

      2
        Five digit integer for station ID

!END!


----------------------------------------------------------------------------
----

INPUT GROUP: 9 -- Precipitation station parameters
--------------

     PRECIPITATION STATION VARIABLES
     (One record per station --  0  records in all)
     (NOT INCLUDED IF NPSTA = 0)

            1          2
         Name   Station    X coord.  Y coord.
                  Code       (km)      (km)
         ------------------------------------


-------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)

      2
        Six digit station code composed of state
        code (first 2 digits) and station ID (last
        4 digits)

!END!
```

```
CALMET.INP      2.1             Hour Start and End Times with Seconds


---------------- Run title (3 lines) ------------------------------------------

                    CALMET MODEL CONTROL FILE
                    --------------------------

-------------------------------------------------------------------------------

INPUT GROUP: 0 -- Input and Output File Names


Subgroup (a)
------------
Default Name  Type          File Name
------------  ----          ---------
GEO.DAT       input    ! GEODAT=C:\URS-DATA\NCMETIN\NCMETIN.GEO       !
SURF.DAT      input    ! SRFDAT=C:\URS-DATA\NCMETOUT\NEWC_05.SUR      !
CLOUD.DAT     input    * CLDDAT=             *
PRECIP.DAT    input    * PRCDAT=             *
WT.DAT        input    * WTDAT=              *

CALMET.LST    output   ! METLST=C:\URS-DATA\NCMETIN\NCMETIN.LST     !
CALMET.DAT    output   ! METDAT=C:\URS-DATA\NCMETIN\NCMETIN.MET    !
PACOUT.DAT    output   * PACDAT=             *

All file names will be converted to lower case if LCFILES = T
Otherwise, if LCFILES = F, file names will be converted to UPPER CASE
         T = lower case      ! LCFILES = F !
         F = UPPER CASE

NUMBER OF UPPER AIR & OVERWATER STATIONS:

    Number of upper air stations (NUSTA)  No default     ! NUSTA =  6  !
    Number of overwater met stations
                                 (NOWSTA) No default     ! NOWSTA =  0  !

NUMBER OF PROGNOSTIC and IGF-CALMET FILEs:

    Number of MM4/MM5/3D.DAT files
                                 (NM3D) No default       ! NM3D =  0  !

    Number of IGF-CALMET.DAT files
                                 (NIGF)   No default     ! NIGF =  1  !

                       !END!
-------------------------------------------------------------------------------
Subgroup (b)
---------------------------------
Upper air files (one per station)
---------------------------------
Default Name  Type       File Name
------------  ----       ---------
UP1.DAT       input     1  ! UPDAT=C:\URS-DATA\NCMETOUT\BER.UP!    !END!
UP2.DAT       input     2  ! UPDAT=C:\URS-DATA\NCMETOUT\NEW.UP!    !END!
UP3.DAT       input     3  ! UPDAT=C:\URS-DATA\NCMETOUT\NOB.UP!    !END!
UP4.DAT       input     4  ! UPDAT=C:\URS-DATA\NCMETOUT\STL.UP!    !END!
UP5.DAT       input     5  ! UPDAT=C:\URS-DATA\NCMETOUT\WAL.UP!    !END!
UP6.DAT       input     6  ! UPDAT=C:\URS-DATA\NCMETOUT\WIL.UP!    !END!
-------------------------------------------------------------------------------
Subgroup (c)
-----------------------------------------
Overwater station files (one per station)
-----------------------------------------
Default Name  Type       File Name
------------  ----       ---------
SEA1.DAT       input     1  * SEADAT=SEA_449.DAT *    *END*
```



```
-------------------------------------------------------------------------------
Subgroup (d)
------------------------------------------------
MM4/MM5/3D.DAT files (consecutive or overlapping)
------------------------------------------------
Default Name  Type       File Name
------------  ----       ---------
MM51.DAT       input     1  * M3DDAT=LSP2003.DAT *    *END*
-------------------------------------------------------------------------------
Subgroup (e)
-------------------------------------------------
IGF-CALMET.DAT files (consecutive or overlapping)
-------------------------------------------------
Default Name  Type       File Name
------------  ----       ---------
IGF1.DAT       input     1  ! IGFDAT=C:\URS-DATA\NCMETOUT\NCMETOUT.MET!
!END!
-------------------------------------------------------------------------------
Subgroup (f)
----------------
Other file names
----------------

Default Name  Type       File Name
------------  ----       ---------
DIAG.DAT      input      * DIADAT=                  *
PROG.DAT      input      * PRGDAT=                  *

TEST.PRT      output     * TSTPRT=                  *
TEST.OUT      output     * TSTOUT=                  *
TEST.KIN      output     * TSTKIN=                  *
TEST.FRD      output     * TSTFRD=                  *
TEST.SLP      output     * TSTSLP=                  *
DCST.GRD      output     * DCSTGD=                  *

-------------------------------------------------------------------------------
NOTES: (1) File/path names can be up to 70 characters in length
       (2) Subgroups (a) and (f) must have ONE 'END' (surrounded by
           delimiters) at the end of the group
       (3) Subgroups (b) through (e) are included ONLY if the corresponding
           number of files (NUSTA, NOWSTA, NM3D, NIGF) is not 0, and each
           must have
           an 'END' (surround by delimiters) at the end of EACH LINE

                         !END!


-------------------------------------------------------------------------------

INPUT GROUP: 1 -- General run control parameters
--------------

     Starting date:    Year   (IBYR)  --    No default   ! IBYR  =  2005  !
                       Month  (IBMO)  --    No default   ! IBMO  =  1  !
                       Day    (IBDY)  --    No default   ! IBDY  =  1  !
     Starting time:    Hour   (IBHR)  --    No default   ! IBHR  =  0  !
                       Second (IBSEC) --    No default   ! IBSEC =  0  !

     Ending date:      Year   (IEYR)  --    No default   ! IEYR  =  2006  !
                       Month  (IEMO)  --    No default   ! IEMO  =  1  !
                       Day    (IEDY)  --    No default   ! IEDY  =  1  !
     Ending time:      Hour   (IEHR)  --    No default   ! IEHR  =  0  !
                       Second (IESEC) --    No default   ! IESEC =  0  !

      UTC time zone         (ABTZ) -- No default       ! ABTZ= UTC+1000 !
         (character*8)
         PST = UTC-0800, MST = UTC-0700 , GMT = UTC-0000
         CST = UTC-0600, EST = UTC-0500
```

```
     Length of modeling time-step (seconds)
     Must divide evenly into 3600 (1 hour)
     (NSECDT)                        Default:3600     ! NSECDT =  3600  !
                                     Units: seconds

     Run type            (IRTYPE) -- Default: 1       ! IRTYPE=  1  !

        0 = Computes wind fields only
        1 = Computes wind fields and micrometeorological variables
            (u*, w*, L, zi, etc.)
        (IRTYPE must be 1 to run CALPUFF or CALGRID)

     Compute special data fields required
     by CALGRID (i.e., 3-D fields of W wind
     components and temperature)
     in additional to regular            Default: T    ! LCALGRD = T !
     fields ? (LCALGRD)
     (LCALGRD must be T to run CALGRID)

      Flag to stop run after
      SETUP phase (ITEST)             Default: 2       ! ITEST=  2   !
      (Used to allow checking
      of the model inputs, files, etc.)
      ITEST = 1 - STOPS program after SETUP phase
      ITEST = 2 - Continues with execution of
                  COMPUTATIONAL phase after SETUP


     Test options specified to see if
     they conform to regulatory
     values? (MREG)                   No Default       ! MREG =   0   !

        0 = NO checks are made
        1 = Technical options must conform to USEPA guidance
                  IMIXH    -1       Maul-Carson convective mixing height
                                    over land; OCD mixing height overwater
                  ICOARE   0        OCD deltaT method for overwater fluxes
                  THRESHL  0.0      Threshold buoyancy flux over land
                  needed
                                    to sustain convective mixing height
                                    growth
                  ISURFT   > 0      Pick one representative station, OR
                           -2       in NOOBS mode (ITPROG=2) average all
                                    surface prognostic temperatures to get
                                    a single representative surface temp.
                  IUPT     > 0      Pick one representative station, OR
                           -2       in NOOBS mode (ITPROG>0) average all
                           surface
                                    prognostic temperatures to get a single
                                    representative surface temp.
                  IZICRLX  0        Do NOT use convective mixing height
                                    relaxation to equilibrium value

!END!

---------------------------------------------------------------------------
----

INPUT GROUP: 2 -- Map Projection and Grid control parameters
--------------

     Projection for all (X,Y):
     -------------------------

     Map projection
     (PMAP)                     Default: UTM    ! PMAP = UTM  !

         UTM :  Universal Transverse Mercator
         TTM :  Tangential Transverse Mercator
         LCC :  Lambert Conformal Conic
          PS :  Polar Stereographic
          EM :  Equatorial Mercator
```



```
        LAZA :  Lambert Azimuthal Equal Area

     False Easting and Northing (km) at the projection origin
     (Used only if PMAP= TTM, LCC, or LAZA)
     (FEAST)                    Default=0.0     ! FEAST  = 0.000  !
     (FNORTH)                   Default=0.0     ! FNORTH = 0.000  !

     UTM zone (1 to 60)
     (Used only if PMAP=UTM)
     (IUTMZN)                   No Default      ! IUTMZN =  56   !

     Hemisphere for UTM projection?
     (Used only if PMAP=UTM)
     (UTMHEM)                   Default: N      ! UTMHEM = S  !
         N   :  Northern hemisphere projection
         S   :  Southern hemisphere projection

     Latitude and Longitude (decimal degrees) of projection origin
     (Used only if PMAP= TTM, LCC, PS, EM, or LAZA)
     (RLAT0)                    No Default      ! RLAT0 =  0N  !
     (RLON0)                    No Default      ! RLON0 =  0E  !

         TTM :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         LCC :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         PS  :  RLON0 identifies central (grid N/S) meridian of projection
                RLAT0 selected for convenience
         EM  :  RLON0 identifies central meridian of projection
                RLAT0 is REPLACED by 0.0N (Equator)
         LAZA:  RLON0 identifies longitude of tangent-point of mapping
         plane
                RLAT0 identifies latitude of tangent-point of mapping plane

     Matching parallel(s) of latitude (decimal degrees) for projection
     (Used only if PMAP= LCC or PS)
     (XLAT1)                    No Default      ! XLAT1 =  0N  !
     (XLAT2)                    No Default      ! XLAT2 =  0N  !

         LCC :  Projection cone slices through Earth's surface at XLAT1 and
         XLAT2
         PS  :  Projection plane slices through Earth at XLAT1
                (XLAT2 is not used)

     ----------
     Note:  Latitudes and longitudes should be positive, and include a
            letter N,S,E, or W indicating north or south latitude, and
            east or west longitude.  For example,
            35.9  N Latitude  =  35.9N
            118.7 E Longitude = 118.7E


     Datum-region
     ------------

     The Datum-Region for the coordinates is identified by a character
     string.  Many mapping products currently available use the model of
     the
     Earth known as the World Geodetic System 1984 (WGS-84).  Other local
     models may be in use, and their selection in CALMET will make its
     output
     consistent with local mapping products.  The list of Datum-Regions
     with
     official transformation parameters is provided by the National Imagery
     and
     Mapping Agency (NIMA).

     NIMA Datum - Regions(Examples)

     ----------------------------------------------------------------------
     --------
     WGS-84    WGS-84 Reference Ellipsoid and Geoid, Global coverage
     (WGS84)
```

```
     NAS-C     NORTH AMERICAN 1927 Clarke 1866 Spheroid, MEAN FOR CONUS
     (NAD27)
     NAR-C     NORTH AMERICAN 1983 GRS 80 Spheroid, MEAN FOR CONUS (NAD83)
     NWS-84    NWS 6370KM Radius, Sphere
     ESR-S     ESRI REFERENCE 6371KM Radius, Sphere

     Datum-region for output coordinates
     (DATUM)                   Default: WGS-84    ! DATUM = WGS-84  !


     Horizontal grid definition:
     ---------------------------

     Rectangular grid defined for projection PMAP,
     with X the Easting and Y the Northing coordinate

            No. X grid cells (NX)      No default     ! NX =   101  !
            No. Y grid cells (NY)      No default     ! NY =   101  !

     Grid spacing (DGRIDKM)            No default     ! DGRIDKM = 0.1 !
                                       Units: km

     Reference grid coordinate of
     SOUTHWEST corner of grid cell (1,1)

        X coordinate (XORIGKM)         No default     ! XORIGKM = 379.950 !
        Y coordinate (YORIGKM)         No default     ! YORIGKM = 6354.950
        !
                                       Units: km


     Vertical grid definition:
     -------------------------

        No. of vertical layers (NZ)    No default     ! NZ =  12  !

        Cell face heights in arbitrary
        vertical grid (ZFACE(NZ+1))    No defaults
                                       Units: m
        ! ZFACE =
        0.,20.,30.,50.,100.,150.,250.,300.,400.,600.,1000.,1500.,2500. !

!END!

---------------------------------------------------------------------------
----

INPUT GROUP: 3 -- Output Options
--------------


    DISK OUTPUT OPTION

       Save met. fields in an unformatted
       output file ?             (LSAVE)  Default: T     ! LSAVE = T !
       (F = Do not save, T = Save)

       Type of unformatted output file:
       (IFORMO)                           Default: 1    ! IFORMO =  1  !

            1 = CALPUFF/CALGRID type file (CALMET.DAT)
            2 = MESOPUFF-II type file     (PACOUT.DAT)


    LINE PRINTER OUTPUT OPTIONS:

       Print met. fields ?  (LPRINT)      Default: F     ! LPRINT = T !
       (F = Do not print, T = Print)
       (NOTE: parameters below control which
              met. variables are printed)

       Print interval
```



```
       (IPRINF) in hours                  Default: 1     ! IPRINF =  1  !
       (Meteorological fields are printed
        every  1  hours)


       Specify which layers of U, V wind component
       to print (IUVOUT(NZ)) -- NOTE: NZ values must be entered
       (0=Do not print, 1=Print)
       (used only if LPRINT=T)        Defaults: NZ*0
       ! IUVOUT =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0
       !
       -----------------------


       Specify which levels of the W wind component to print
       (NOTE: W defined at TOP cell face --  12  values)
       (IWOUT(NZ)) -- NOTE: NZ values must be entered
       (0=Do not print, 1=Print)
       (used only if LPRINT=T & LCALGRD=T)
       -----------------------------------
                                             Defaults: NZ*0
        ! IWOUT =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0
        !


       Specify which levels of the 3-D temperature field to print
       (ITOUT(NZ)) -- NOTE: NZ values must be entered
       (0=Do not print, 1=Print)
       (used only if LPRINT=T & LCALGRD=T)
       -----------------------------------
                                             Defaults: NZ*0
        ! ITOUT =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0
        !

       Specify which meteorological fields
       to print
       (used only if LPRINT=T)            Defaults: 0 (all variables)
       -----------------------


         Variable            Print ?
                        (0 = do not print,
                         1 = print)
         --------       ------------------

      !  STABILITY  =          0           ! - PGT stability class
      !  USTAR      =          0           ! - Friction velocity
      !  MONIN      =          0           ! - Monin-Obukhov length
      !  MIXHT      =          0           ! - Mixing height
      !  WSTAR      =          0           ! - Convective velocity scale
      !  PRECIP     =          0           ! - Precipitation rate
      !  SENSHEAT   =          0           ! - Sensible heat flux
      !  CONVZI     =          0           ! - Convective mixing ht.


       Testing and debug print options for micrometeorological module

          Print input meteorological data and
          internal variables (LDB)         Default: F       ! LDB = F !
          (F = Do not print, T = print)
          (NOTE: this option produces large amounts of output)

          First time step for which debug data
          are printed (NN1)                Default: 1       ! NN1 =  1  !

          Last time step for which debug data
          are printed (NN2)                Default: 1       ! NN2 =  2  !

          Print distance to land
          internal variables (LDBCST)      Default: F       ! LDBCST = F !
          (F = Do not print, T = print)
          (Output in .GRD file DCST.GRD, defined in input group 0)
```

```
       Testing and debug print options for wind field module
       (all of the following print options control output to
        wind field module's output files: TEST.PRT, TEST.OUT,
        TEST.KIN, TEST.FRD, and TEST.SLP)

          Control variable for writing the test/debug
          wind fields to disk files (IOUTD)
          (0=Do not write, 1=write)        Default: 0       ! IOUTD =  0  !

          Number of levels, starting at the surface,
          to print (NZPRN2)                Default: 1       ! NZPRN2 =  1
          !

          Print the INTERPOLATED wind components ?
          (IPR0) (0=no, 1=yes)             Default: 0       !  IPR0 =  0  !

          Print the TERRAIN ADJUSTED surface wind
          components ?
          (IPR1) (0=no, 1=yes)             Default: 0       !  IPR1 =  0  !

          Print the SMOOTHED wind components and
          the INITIAL DIVERGENCE fields ?
          (IPR2) (0=no, 1=yes)             Default: 0       !  IPR2 =  0  !

          Print the FINAL wind speed and direction
          fields ?
          (IPR3) (0=no, 1=yes)             Default: 0       !  IPR3 =  0  !

          Print the FINAL DIVERGENCE fields ?
          (IPR4) (0=no, 1=yes)             Default: 0       !  IPR4 =  0  !

          Print the winds after KINEMATIC effects
          are added ?
          (IPR5) (0=no, 1=yes)             Default: 0       !  IPR5 =  0  !

          Print the winds after the FROUDE NUMBER
          adjustment is made ?
          (IPR6) (0=no, 1=yes)             Default: 0       !  IPR6 =  0  !

          Print the winds after SLOPE FLOWS
          are added ?
          (IPR7) (0=no, 1=yes)             Default: 0       !  IPR7 =  0  !

          Print the FINAL wind field components ?
          (IPR8) (0=no, 1=yes)             Default: 0       !  IPR8 =  0  !

!END!

---------------------------------------------------------------------------
----

INPUT GROUP: 4 -- Meteorological data options
--------------

    NO OBSERVATION MODE             (NOOBS)  Default: 0     ! NOOBS =  0
    !
          0 = Use surface, overwater, and upper air stations
          1 = Use surface and overwater stations (no upper air
          observations)
              Use MM4/MM5/3D.DAT for upper air data
          2 = No surface, overwater, or upper air observations
              Use MM4/MM5/3D.DAT for surface, overwater, and upper air data

    NUMBER OF SURFACE & PRECIP. METEOROLOGICAL STATIONS

       Number of surface stations   (NSSTA)  No default     ! NSSTA =  6  !

       Number of precipitation stations
       (NPSTA=-1: flag for use of MM5/3D.DAT precip data)
                                    (NPSTA)  No default     ! NPSTA =  0  !

    CLOUD DATA OPTIONS
```



```
       Gridded cloud fields:
                                    (ICLOUD)  Default: 0     ! ICLOUD =  0
                                    !
       ICLOUD = 0 - Gridded clouds not used
       ICLOUD = 1 - Gridded CLOUD.DAT generated as OUTPUT
       ICLOUD = 2 - Gridded CLOUD.DAT read as INPUT
       ICLOUD = 3 - Gridded cloud cover from Prognostic Rel. Humidity
                    at 850mb (Teixera)
       ICLOUD = 4 - Gridded cloud cover from Prognostic Rel. Humidity
                    at all levels (MM5toGrads algorithm)

    FILE FORMATS

       Surface meteorological data file format
                                    (IFORMS)  Default: 2     ! IFORMS =  2
                                    !
       (1 = unformatted (e.g., SMERGE output))
       (2 = formatted   (free-formatted user input))

       Precipitation data file format
                                    (IFORMP)  Default: 2     ! IFORMP =  2
                                    !
       (1 = unformatted (e.g., PMERGE output))
       (2 = formatted   (free-formatted user input))

       Cloud data file format
                                    (IFORMC)  Default: 2     ! IFORMC =  2
                                    !
       (1 = unformatted - CALMET unformatted output)
       (2 = formatted   - free-formatted CALMET output or user input)

!END!

---------------------------------------------------------------------------
----

INPUT GROUP: 5 -- Wind Field Options and Parameters
--------------


    WIND FIELD MODEL OPTIONS
       Model selection variable (IWFCOD)     Default: 1      ! IWFCOD =  1
       !
          0 = Objective analysis only
          1 = Diagnostic wind module

       Compute Froude number adjustment
       effects ? (IFRADJ)                    Default: 1      ! IFRADJ =  1
       !
       (0 = NO, 1 = YES)

       Compute kinematic effects ? (IKINE)   Default: 0      ! IKINE  =  0
       !
       (0 = NO, 1 = YES)

       Use O'Brien procedure for adjustment
       of the vertical velocity ? (IOBR)     Default: 0      ! IOBR =  0  !
       (0 = NO, 1 = YES)

       Compute slope flow effects ? (ISLOPE) Default: 1      ! ISLOPE  =  1
       !
       (0 = NO, 1 = YES)

       Extrapolate surface wind observations
       to upper layers ? (IEXTRP)            Default: -4     ! IEXTRP =  1
       !
       (1 = no extrapolation is done,
        2 = power law extrapolation used,
        3 = user input multiplicative factors
            for layers 2 - NZ used (see FEXTRP array)
        4 = similarity theory used
        -1, -2, -3, -4 = same as above except layer 1 data
```

```
         at upper air stations are ignored

     Extrapolate surface winds even
     if calm? (ICALM)                    Default: 0      ! ICALM  =  0
     !
     (0 = NO, 1 = YES)

     Layer-dependent biases modifying the weights of
     surface and upper air stations (BIAS(NZ))
       -1<=BIAS<=1
     Negative BIAS reduces the weight of upper air stations
       (e.g. BIAS=-0.1 reduces the weight of upper air stations
     by 10%; BIAS= -1, reduces their weight by 100 %)
     Positive BIAS reduces the weight of surface stations
       (e.g. BIAS= 0.2 reduces the weight of surface stations
     by 20%; BIAS=1 reduces their weight by 100%)
     Zero BIAS leaves weights unchanged (1/R**2 interpolation)
     Default: NZ*0
                             ! BIAS = -1 ,  1 ,  1 ,  1 ,  1 ,  1 ,  1 ,
                             1 ,  1 ,  1 ,  1 ,  1  !

     Minimum distance from nearest upper air station
     to surface station for which extrapolation
     of surface winds at surface station will be allowed
     (RMIN2: Set to -1 for IEXTRP = 4 or other situations
      where all surface stations should be extrapolated)
                                         Default: 4.     ! RMIN2 = 4.0
                                         !

     Use gridded prognostic wind field model
     output fields as input to the diagnostic
     wind field model (IPROG)            Default: 0      ! IPROG =  0
     !
     (0 = No, [IWFCOD = 0 or 1]
      1 = Yes, use CSUMM prog. winds as Step 1 field, [IWFCOD = 0]
      2 = Yes, use CSUMM prog. winds as initial guess field [IWFCOD = 1]
      3 = Yes, use winds from MM4.DAT file as Step 1 field [IWFCOD = 0]
      4 = Yes, use winds from MM4.DAT file as initial guess field [IWFCOD
      = 1]
      5 = Yes, use winds from MM4.DAT file as observations [IWFCOD = 1]
      13 = Yes, use winds from MM5/3D.DAT file as Step 1 field [IWFCOD =
      0]
      14 = Yes, use winds from MM5/3D.DAT file as initial guess field
      [IWFCOD = 1]
      15 = Yes, use winds from MM5/3D.DAT file as observations [IWFCOD =
      1]

     Timestep (seconds) of the prognostic
     model input data   (ISTEPPGS)       Default: 3600   ! ISTEPPGS =
     3600   !

     Use coarse CALMET fields as initial guess fields (IGFMET)
     (overwrites IGF based on prognostic wind fields if any)
                                         Default: 0      ! IGFMET =  1
                                         !

  RADIUS OF INFLUENCE PARAMETERS

     Use varying radius of influence     Default: F      ! LVARY =  F!
     (if no stations are found within RMAX1,RMAX2,
      or RMAX3, then the closest station will be used)

     Maximum radius of influence over land
     in the surface layer (RMAX1)        No default      ! RMAX1 = 10.
     !
                                         Units: km
     Maximum radius of influence over land
     aloft (RMAX2)                       No default      ! RMAX2 = 10.
     !
                                         Units: km
     Maximum radius of influence over water
     (RMAX3)                             No default      ! RMAX3 = 10.
     !
```



```
                                         Units: km

  OTHER WIND FIELD INPUT PARAMETERS

     Minimum radius of influence used in
     the wind field interpolation (RMIN) Default: 0.1    ! RMIN = 0.1 !
                                         Units: km
     Radius of influence of terrain
     features (TERRAD)                   No default      ! TERRAD = 2.
     !

                                         Units: km
     Relative weighting of the first
     guess field and observations in the
     SURFACE layer (R1)                  No default      ! R1 = 3. !
     (R1 is the distance from an         Units: km
     observational station at which the
     observation and first guess field are
     equally weighted)

     Relative weighting of the first
     guess field and observations in the
     layers ALOFT (R2)                   No default      ! R2 = 5. !
     (R2 is applied in the upper layers  Units: km
     in the same manner as R1 is used in
     the surface layer).

     Relative weighting parameter of the
     prognostic wind field data (RPROG)  No default      ! RPROG = 0. !
     (Used only if IPROG = 1)            Units: km
     ------------------------

     Maximum acceptable divergence in the
     divergence minimization procedure
     (DIVLIM)                            Default: 5.E-6  ! DIVLIM=
     5.0E-06 !

     Maximum number of iterations in the
     divergence min. procedure (NITER)   Default: 50     ! NITER =  50
     !

     Number of passes in the smoothing
     procedure (NSMTH(NZ))
     NOTE: NZ values must be entered
          Default: 2,(mxnz-1)*4 ! NSMTH =
 2 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4  !

     Maximum number of stations used in
     each layer for the interpolation of
     data to a grid point (NINTR2(NZ))
     NOTE: NZ values must be entered     Default: 99.    ! NINTR2 =
 99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99  !

     Critical Froude number (CRITFN)     Default: 1.0    ! CRITFN = 1.
     !

     Empirical factor controlling the
     influence of kinematic effects
     (ALPHA)                             Default: 0.1    ! ALPHA = 0.1
     !

     Multiplicative scaling factor for
     extrapolation of surface observations
     to upper layers (FEXTR2(NZ))        Default: NZ*0.0
     ! FEXTR2 = 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0. !
     (Used only if IEXTRP = 3 or -3)


  BARRIER INFORMATION

     Number of barriers to interpolation
     of the wind fields (NBAR)           Default: 0      ! NBAR =  4  !
```

```
Level (1 to NZ) up to which barriers
apply (KBAR)                        Default: NZ     ! KBAR =  12
!

THE FOLLOWING 4 VARIABLES ARE INCLUDED
ONLY IF NBAR > 0
NOTE: NBAR values must be entered     No defaults
      for each variable               Units: km

   X coordinate of BEGINNING
   of each barrier (XBBAR(NBAR))      ! XBBAR = 385.117, 386.019,
   387.094, 389.162 !
   Y coordinate of BEGINNING
   of each barrier (YBBAR(NBAR))      ! YBBAR = 6351.313, 6355.391,
   6355.859, 6362.770 !

   X coordinate of ENDING
   of each barrier (XEBAR(NBAR))      ! XEBAR = 386.019, 387.094,
   389.162, 391.332 !
   Y coordinate of ENDING
   of each barrier (YEBAR(NBAR))      ! YEBAR = 6355.391, 6355.859,
   6362.770, 6364.149 !


DIAGNOSTIC MODULE DATA INPUT OPTIONS

   Surface temperature (IDIOPT1)        Default: 0      ! IDIOPT1 =  0
   !
      0 = Compute internally from
          hourly surface observations or prognostic fields
      1 = Read preprocessed values from
          a data file (DIAG.DAT)

      Surface met. station to use for
      the surface temperature (ISURFT)   Default: -1    ! ISURFT =  1
      !
      (Must be a value from 1 to NSSTA,
       or -1 to use 2-D spatially varying
          surface temperatures,
       or -2 to use a domain-average prognostic
          surface temperatures (only with ITPROG=2))
      (Used only if IDIOPT1 = 0)
      --------------------------

   Temperature lapse rate used in the    Default: 0     ! IDIOPT2 =  0
   !
      computation of terrain-induced
      circulations (IDIOPT2)
      0 = Compute internally from (at least) twice-daily
          upper air observations or prognostic fields
      1 = Read hourly preprocessed values
          from a data file (DIAG.DAT)

      Upper air station to use for
      the domain-scale lapse rate (IUPT) Default: -1    ! IUPT   =  1
      !
      (Must be a value from 1 to NUSTA,
       or -1 to use 2-D spatially varying lapse rate,
       or -2 to use a domain-average prognostic
          lapse rate (only with ITPROG>0))
      (Used only if IDIOPT2 = 0)
      --------------------------

      Depth through which the domain-scale
      lapse rate is computed (ZUPT)      Default: 200.  ! ZUPT = 200. !
      (Used only if IDIOPT2 = 0)         Units: meters
      --------------------------

   Initial Guess Field Winds
   (IDIOPT3)                             Default: 0     ! IDIOPT3 =  0
   !
      0 = Compute internally from
```



```
          observations or prognostic wind fields
      1 = Read hourly preprocessed domain-average wind values
          from a data file (DIAG.DAT)

      Upper air station to use for
      the initial guess winds (IUPWND)   Default: -1    ! IUPWND = -1
      !
      (Must be a value from -1 to NUSTA, with
      -1 indicating 3-D initial guess fields,
      and IUPWND>1 domain-scaled (i.e. constant) IGF)
      (Used only if IDIOPT3 = 0 and noobs=0)
      --------------------------------------

      Bottom and top of layer through
      which the domain-scale winds
      are computed
      (ZUPWND(1), ZUPWND(2))        Defaults: 1., 1000. ! ZUPWND= 1.,
      1000. !
      (Used only if IDIOPT3 = 0, NOOBS>0 and IUPWND>0)    Units: meters
      --------------------------

   Observed surface wind components
   for wind field module (IDIOPT4)  Default: 0     ! IDIOPT4 =  0  !
      0 = Read WS, WD from a surface
          data file (SURF.DAT)
      1 = Read hourly preprocessed U, V from
          a data file (DIAG.DAT)

   Observed upper air wind components
   for wind field module (IDIOPT5)  Default: 0     ! IDIOPT5 =  0  !
      0 = Read WS, WD from an upper
          air data file (UP1.DAT, UP2.DAT, etc.)
      1 = Read hourly preprocessed U, V from
          a data file (DIAG.DAT)

   LAKE BREEZE INFORMATION

      Use Lake Breeze Module  (LLBREZE)
                                     Default: F      ! LLBREZE = F !

       Number of lake breeze regions (NBOX)            ! NBOX =  0  !

    X Grid line 1 defining the region of interest
                                                    ! XG1 = 0. !
    X Grid line 2 defining the region of interest
                                                    ! XG2 = 0. !
    Y Grid line 1 defining the region of interest
                                                    ! YG1 = 0. !
    Y Grid line 2 defining the region of interest
                                                    ! YG2 = 0. !

     X Point defining the coastline (Straight line)
               (XBCST)  (KM)   Default: none    ! XBCST = 0. !

     Y Point defining the coastline (Straight line)
               (YBCST)  (KM)   Default: none    ! YBCST = 0. !

     X Point defining the coastline (Straight line)
               (XECST)  (KM)   Default: none    ! XECST = 0. !

     Y Point defining the coastline (Straight line)
               (YECST)  (KM)   Default: none    ! YECST = 0. !


   Number of stations in the region     Default: none ! NLB =  0 !
   (Surface stations + upper air stations)

   Station ID's  in the region   (METBXID(NLB))
   (Surface stations first, then upper air stations)
     ! METBXID =  0 !

!END!
```

```
-------------------------------------------------------------------------------
----
INPUT GROUP: 6 -- Mixing Height, Temperature and Precipitation Parameters
--------------

    EMPIRICAL MIXING HEIGHT CONSTANTS

       Neutral, mechanical equation
       (CONSTB)                             Default: 1.41   ! CONSTB =
       1.41 !
       Convective mixing ht. equation
       (CONSTE)                             Default: 0.15   ! CONSTE =
       0.15 !
       Stable mixing ht. equation
       (CONSTN)                             Default: 2400.  ! CONSTN =
       2400.!
       Overwater mixing ht. equation
       (CONSTW)                             Default: 0.16   ! CONSTW =
       0.16 !
       Absolute value of Coriolis
       parameter (FCORIOL)                  Default: 1.E-4  ! FCORIOL =
       7.9E-05!
                                            Units: (1/s)

    SPATIAL AVERAGING OF MIXING HEIGHTS

       Conduct spatial averaging
       (IAVEZI)  (0=no, 1=yes)              Default: 1      ! IAVEZI =  1
       !

       Max. search radius in averaging
       process (MNMDAV)                     Default: 1      ! MNMDAV =  1
       !
                                            Units: Grid
                                                   cells
       Half-angle of upwind looking cone
       for averaging (HAFANG)               Default: 30.    ! HAFANG = 30.
       !
                                            Units: deg.
       Layer of winds used in upwind
       averaging (ILEVZI)                   Default: 1      ! ILEVZI =  1
       !
       (must be between 1 and NZ)


    CONVECTIVE MIXING HEIGHT OPTIONS:
       Method to compute the convective
       mixing height(IMIHXH)                Default: 1      ! IMIXH =  1
       !
           1: Maul-Carson for land and water cells
          -1: Maul-Carson for land cells only -
              OCD mixing height overwater
           2: Batchvarova and Gryning for land and water cells
          -2: Batchvarova and Gryning for land cells only
              OCD mixing height overwater

       Threshold buoyancy flux required to
       sustain convective mixing height growth
       overland (THRESHL)                   Default: 0.0    ! THRESHL =
       0.05 !
       (expressed as a heat flux            units: W/m3
        per meter of boundary layer)


       Threshold buoyancy flux required to
       sustain convective mixing height growth
       overwater (THRESHW)                  Default: 0.05   ! THRESHW =
       0.05 !
       (expressed as a heat flux            units: W/m3
        per meter of boundary layer)
```



```
       Flag to allow relaxation of convective mixing height
       to equilibrium value when  0<QH<THRESHL (overland)
                               or  0<QH<THRESHW (overwater)
       (IZICRLX)                            Default: 1      ! IZICRLX =  1
       !
          0 : do NOT use convective mixing height relaxation
              to equilibrium value (treatment identical to CALMET v5.8)
          1 : use convective mixing height relaxation
              to equilibrium value


       Relaxation time of convective mixing height to
       equilibrium value when  0<QH<THRESHL (overland)
                            or  0<QH<THRESHW (overwater)
       (Used only if IZICRLX = 1 and  TZICRLX must be >= 1.)
       (TZICRLX)                            Default: 800.   ! TZICRLX =
       800. !
                                            Units: seconds


       Option for overwater lapse rates used
       in convective mixing height growth
       (ITWPROG)                            Default: 0      ! ITWPROG =  0
       !
       0 : use SEA.DAT lapse rates and deltaT (or assume neutral
           conditions if missing)
       1 : use prognostic lapse rates (only if IPROG>2)
           and SEA.DAT deltaT (or neutral if missing)
       2 : use prognostic lapse rates and prognostic delta T
           (only if iprog>12 and 3D.DAT version# 2.0 or higher)

       Land Use category ocean in 3D.DAT datasets
       (ILUOC3D)                            Default: 16     ! ILUOC3D =
       16  !
       Note: if 3D.DAT from MM5 version 3.0, iluoc3d = 16
             if MM4.DAT,           typically iluoc3d = 7


    OTHER MIXING HEIGHT VARIABLES

       Minimum potential temperature lapse
       rate in the stable layer above the
       current convective mixing ht.        Default: 0.001  ! DPTMIN =
       0.001 !
       (DPTMIN)                             Units: deg. K/m
       Depth of layer above current conv.
       mixing height through which lapse    Default: 200.   ! DZZI = 200.
       !
       rate is computed (DZZI)              Units: meters

       Minimum overland mixing height       Default:  50.   ! ZIMIN = 50.
       !
       (ZIMIN)                              Units: meters
       Maximum overland mixing height       Default: 3000.  ! ZIMAX =
       3000. !
       (ZIMAX)                              Units: meters
       Minimum overwater mixing height      Default:   50.  ! ZIMINW = 50.
       !
       (ZIMINW) -- (Not used if observed    Units: meters
       overwater mixing hts. are used)
       Maximum overwater mixing height      Default: 3000.  ! ZIMAXW =
       3000. !
       (ZIMAXW) -- (Not used if observed    Units: meters
       overwater mixing hts. are used)


    OVERWATER SURFACE FLUXES METHOD and PARAMETERS
          (ICOARE)                          Default: 10      ! ICOARE =
          10   !
           0: original deltaT method (OCD)
          10: COARE with no wave parameterization (jwave=0, Charnock)
          11: COARE with wave option jwave=1 (Oost et al.)
```

```
           and default wave properties
      -11: COARE with wave option jwave=1 (Oost et al.)
           and observed wave properties (must be in SEA.DAT files)
       12: COARE with wave option 2 (Taylor and Yelland)
            and default wave properties
      -12: COARE with wave option 2 (Taylor and Yelland)
           and observed wave properties (must be in SEA.DAT files)

       Note:  When ICOARE=0, similarity wind profile stability PSI
       functions
              based on Van Ulden and Holtslag (1985) are substituted for
              later formulations used with the COARE module, and
              temperatures
              used for surface layer parameters are obtained from either
              the
              nearest surface station temperature or prognostic model 2D
              temperatures (if ITPROG=2).


       Coastal/Shallow water length scale (DSHELF)
       (for modified z0 in shallow water)
       ( COARE fluxes only)
                                Default : 0.        ! DSHELF = 0.
                                !
                                units: km

        COARE warm layer computation (IWARM)             ! IWARM =  0
        !
        1: on - 0: off (must be off if SST measured with
        IR radiometer)          Default: 0

        COARE cool skin layer computation (ICOOL)        ! ICOOL =  0
        !
        1: on - 0: off (must be off if SST measured with
        IR radiometer)          Default: 0

   RELATIVE HUMIDITY PARAMETERS

      3D relative humidity from observations or
      from prognostic data? (IRHPROG)       Default:0        ! IRHPROG =
      0   !

         0 = Use RH from SURF.DAT file
             (only if NOOBS = 0,1)
         1 = Use prognostic RH
             (only if NOOBS = 0,1,2)

   TEMPERATURE PARAMETERS

      3D temperature from observations or
      from prognostic data? (ITPROG)        Default:0        ! ITPROG =  0
      !

         0 = Use Surface and upper air stations
             (only if NOOBS = 0)
         1 = Use Surface stations (no upper air observations)
             Use MM5/3D.DAT for upper air data
             (only if NOOBS = 0,1)
         2 = No surface or upper air observations
             Use MM5/3D.DAT for surface and upper air data
             (only if NOOBS = 0,1,2)

      Interpolation type
      (1 = 1/R ; 2 = 1/R**2)                Default:1         ! IRAD =  1
      !

      Radius of influence for temperature
      interpolation (TRADKM)                Default: 500.     ! TRADKM =
      500. !
                                            Units: km

      Maximum Number of stations to include
      in temperature interpolation (NUMTS)  Default: 5        ! NUMTS = 5
```



```
       !

       Conduct spatial averaging of temp-
       eratures (IAVET)  (0=no, 1=yes)      Default: 1        ! IAVET =  1
       !
       (will use mixing ht MNMDAV,HAFANG
        so make sure they are correct)

       Default temperature gradient         Default: -.0098   ! TGDEFB =
       -0.0098 !
       below the mixing height over         Units: K/m
       water (TGDEFB)

       Default temperature gradient         Default: -.0045   ! TGDEFA =
       -0.0045 !
       above the mixing height over         Units: K/m
       water (TGDEFA)

       Beginning (JWAT1) and ending (JWAT2)
       land use categories for temperature                   ! JWAT1 =
       999  !
       interpolation over water -- Make                      ! JWAT2 =
       999  !
       bigger than largest land use to disable

   PRECIP INTERPOLATION PARAMETERS

       Method of interpolation (NFLAGP)     Default: 2       ! NFLAGP =  2
       !
        (1=1/R,2=1/R**2,3=EXP/R**2)
       Radius of Influence  (SIGMAP)        Default: 100.0   ! SIGMAP =
       100. !
        (0.0 => use half dist. btwn         Units: km
         nearest stns w & w/out
         precip when NFLAGP = 3)
       Minimum Precip. Rate Cutoff (CUTP)   Default: 0.01    ! CUTP = 0.01
       !
        (values < CUTP = 0.0 mm/hr)         Units: mm/hr
!END!


---------------------------------------------------------------------------
----

INPUT GROUP: 7 -- Surface meteorological station parameters
--------------

     SURFACE STATION VARIABLES
     (One record per station --  7  records in all)


             1     2
         Name   ID           X coord.   Y coord.   Time   Anem.
                              (km)       (km)      zone   Ht.(m)
       ----------------------------------------------------------
! SS1  ='BER'    10001       374.629    6370.450   -10    10  !
! SS2  ='NEW'    10002       384.034    6355.663   -10    10  !
! SS3  ='NOB'    10003       387.654    6357.119   -10    15  !
! SS4  ='STL'    10004       380.626    6360.969   -10    10  !
! SS5  ='WAL'    10005       375.624    6359.641   -10    10  !
! SS6  ='WIL'    10006       390.999    6371.039   -10    10  !
-------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)

      2
        Six digit integer for station ID

!END!


---------------------------------------------------------------------------
```

```
----

INPUT GROUP: 8 -- Upper air meteorological station parameters
--------------

     UPPER AIR STATION VARIABLES
     (One record per station --  7  records in all)

             1     2
         Name    ID      X coord.   Y coord.  Time zone
                           (km)       (km)
        -----------------------------------------------
! US1  ='BER'   20001    374.629   6370.450   -10  !
! US2  ='NEW'   20002    384.034   6355.663   -10  !
! US3  ='NOB'   20003    387.654   6357.119   -10  !
! US4  ='STL'   20004    380.626   6360.969   -10  !
! US5  ='WAL'   20005    375.624   6359.641   -10  !
! US6  ='WIL'   20006    390.999   6371.039   -10  !
-------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)

      2
        Five digit integer for station ID

!END!


---------------------------------------------------------------------------
----

INPUT GROUP: 9 -- Precipitation station parameters
--------------

     PRECIPITATION STATION VARIABLES
     (One record per station --  0  records in all)
     (NOT INCLUDED IF NPSTA = 0)

            1          2
         Name   Station    X coord.  Y coord.
                  Code       (km)      (km)
         ------------------------------------


-------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)

      2
        Six digit station code composed of state
        code (first 2 digits) and station ID (last
        4 digits)

!END!
```

```
CALPUFF.INP     2.0             File version record

IPL KI Calpuff Base File

---------------- Run title (3 lines) ------------------------------------------

                    CALPUFF MODEL CONTROL FILE
                    --------------------------

---------------------------------------------------------------------------
----

INPUT GROUP: 0 -- Input and Output File Names

--------------
Default Name  Type          File Name
------------  ----          ---------
CALMET.DAT    input    ! METDAT =C:\URS-DATA\NCMETIN\NCMETIN.MET   !
    or
ISCMET.DAT    input    * ISCDAT =             *
    or
PLMMET.DAT    input    * PLMDAT =             *
    or
PROFILE.DAT   input    * PRFDAT =             *
SURFACE.DAT   input    * SFCDAT =             *
RESTARTB.DAT  input    * RSTARTB=             *
---------------------------------------------------------------------------
-----
CALPUFF.LST   output   ! PUFLST =NAPOPB.LST  !
CONC.DAT      output   ! CONDAT =NAPOPB.TRC     !
DFLX.DAT      output   * DFDAT  =             *
WFLX.DAT      output   * WFDAT  =             *

VISB.DAT      output   * VISDAT =             *
TK2D.DAT      output   * T2DDAT =             *
RHO2D.DAT     output   * RHODAT =             *
RESTARTE.DAT  output   * RSTARTE=             *
---------------------------------------------------------------------------
-----
Emission Files
--------------
PTEMARB.DAT   input    * PTDAT  =             *
VOLEMARB.DAT  input    * VOLDAT =             *
BAEMARB.DAT   input    * ARDAT  =             *
LNEMARB.DAT   input    * LNDAT  =             *
---------------------------------------------------------------------------
-----
Other Files
-----------
OZONE.DAT     input    * OZDAT  =             *
VD.DAT        input    * VDDAT  =             *
CHEM.DAT      input    * CHEMDAT=             *
AUX           input    ! AUXEXT =AUX     !
(Extension added to METDAT filename(s) for files
 with auxiliary 2D and 3D data)
H2O2.DAT      input    * H2O2DAT=             *
NH3Z.DAT      input    * NH3ZDAT=             *
HILL.DAT      input    * HILDAT=             *
HILLRCT.DAT   input    * RCTDAT=             *
COASTLN.DAT   input    * CSTDAT=             *
FLUXBDY.DAT   input    * BDYDAT=             *
BCON.DAT      input    * BCNDAT=             *
DEBUG.DAT     output   * DEBUG =             *
MASSFLX.DAT   output   * FLXDAT=             *
MASSBAL.DAT   output   * BALDAT=             *
FOG.DAT       output   * FOGDAT=             *
RISE.DAT      output   * RISDAT=             *
---------------------------------------------------------------------------
-----
All file names will be converted to lower case if LCFILES = T
Otherwise, if LCFILES = F, file names will be converted to UPPER CASE
         T = lower case      ! LCFILES = F !
```



```
         F = UPPER CASE
NOTE: (1) file/path names can be up to 132 characters in length


Provision for multiple input files
----------------------------------

     Number of Modeling Domains (NMETDOM)
                                 Default: 1       ! NMETDOM =   1   !

     Number of CALMET.DAT files for run (NMETDAT)
                                 Default: 1       ! NMETDAT =   1   !

     Number of PTEMARB.DAT files for run (NPTDAT)
                                 Default: 0       ! NPTDAT =   0   !

     Number of BAEMARB.DAT files for run (NARDAT)
                                 Default: 0       ! NARDAT =   0   !

     Number of VOLEMARB.DAT files for run (NVOLDAT)
                                 Default: 0       ! NVOLDAT =   0   !

!END!

-------------
Subgroup (0a)
-------------

  Provide a name for each CALMET domain if NMETDOM > 1
  Enter NMETDOM lines.
                                          a,b
Default Name            Domain Name
------------            ------------
 none                 * DOMAIN1=     *   *END*
 none                 * DOMAIN2=     *   *END*
 none                 * DOMAIN3=     *   *END*


  The following CALMET.DAT filenames are processed in sequence
  if NMETDAT > 1

  Enter NMETDAT lines, 1 line for each file name.

                                           a,c,d
Default Name  Type          File Name
------------  ----          ---------
 none         input    * METDAT1=     *   *END*
 none         input    * METDAT2=     *   *END*
 none         input    * METDAT3=     *   *END*

-------------
    a
     The name for each CALMET domain and each CALMET.DAT file is treated
     as a separate input subgroup and therefore must end with an input
     group terminator.
    b
     Use DOMAIN1= to assign the name for the outermost CALMET domain.
     Use DOMAIN2= to assign the name for the next inner CALMET domain.
     Use DOMAIN3= to assign the name for the next inner CALMET domain, etc.
      --------------------------------------------------------------------
      |   When inner domains with equal resolution (grid-cell size)      |
      |   overlap, the data from the FIRST such domain in the list will  |
      |   be used if all other criteria for choosing the controlling     |
      |   grid domain are inconclusive.                                  |
      --------------------------------------------------------------------
    c
     Use METDAT1= to assign the file names for the outermost CALMET domain.
     Use METDAT2= to assign the file names for the next inner CALMET
     domain.
     Use METDAT3= to assign the file names for the next inner CALMET
     domain, etc.
    d
     The filenames for each domain must be provided in sequential order
```

```
-------------
Subgroup (0b)
-------------

  The following PTEMARB.DAT filenames are processed if NPTDAT>0
  (Each file contains a subset of the sources, for the entire simulation)

Default Name  Type          File Name
------------  ----          ---------
 none         input       * PTDAT=     *   *END*


-------------
Subgroup (0c)
-------------

  The following BAEMARB.DAT filenames are processed if NARDAT>0
  (Each file contains a subset of the sources, for the entire simulation)

Default Name  Type          File Name
------------  ----          ---------
 none         input       * ARDAT=     *   *END*


-------------
Subgroup (0d)
-------------

  The following VOLEMARB.DAT filenames are processed if NVOLDAT>0
  (Each file contains a subset of the sources, for the entire simulation)

Default Name  Type          File Name
------------  ----          ---------
 none         input       * VOLDAT=     *   *END*


---------------------------------------------------------------------------
-----

INPUT GROUP: 1 -- General run control parameters
--------------

    Option to run all periods found
    in the met. file     (METRUN)   Default: 0       ! METRUN =   1  !

         METRUN = 0 - Run period explicitly defined below
         METRUN = 1 - Run all periods in met. file

     Starting date:    Year   (IBYR)  --    No default   ! IBYR  =  2005  !
                       Month  (IBMO)  --    No default   ! IBMO  =  0  !
                       Day    (IBDY)  --    No default   ! IBDY  =  0  !
     Starting time:    Hour   (IBHR)  --    No default   ! IBHR  =  0  !
                       Minute (IBMIN) --    No default   ! IBMIN =  0  !
                       Second (IBSEC) --    No default   ! IBSEC =  0  !

     Ending date:      Year   (IEYR)  --    No default   ! IEYR  =  0  !
                       Month  (IEMO)  --    No default   ! IEMO  =  0  !
                       Day    (IEDY)  --    No default   ! IEDY  =  0  !
     Ending time:      Hour   (IEHR)  --    No default   ! IEHR  =  0  !
                       Minute (IEMIN) --    No default   ! IEMIN =  0  !
                       Second (IESEC) --    No default   ! IESEC =  0  !

     (These are only used if METRUN = 0)

     Base time zone:          (ABTZ)  --    No default   ! ABTZ= UTC+1000 !
      (character*8)
     The modeling domain may span multiple time zones.  ABTZ defines the
     base time zone used for the entire simulation.  This must match the
     base time zone of the meteorological data.
     Examples:
         Los Angeles, USA          = UTC-0800
         New York, USA             = UTC-0500
```



```
         Santiago, Chile           = UTC-0400
         Greenwich Mean Time (GMT) = UTC+0000
         Rome, Italy               = UTC+0100
         Cape Town, S.Africa       = UTC+0200
         Sydney, Australia         = UTC+1000

     Length of modeling time-step (seconds)
     Equal to update period in the primary
     meteorological data files, or an
     integer fraction of it (1/2, 1/3 ...)
     Must be no larger than 1 hour
     (NSECDT)                        Default:3600     ! NSECDT =  3600  !
                                     Units: seconds

     Number of chemical species (NSPEC)
                                     Default: 5       ! NSPEC =  1   !

     Number of chemical species
     to be emitted  (NSE)            Default: 3       ! NSE =  1   !

     Flag to stop run after
     SETUP phase (ITEST)             Default: 2       ! ITEST =  2   !
     (Used to allow checking
     of the model inputs, files, etc.)
           ITEST = 1 - STOPS program after SETUP phase
           ITEST = 2 - Continues with execution of program
                       after SETUP

     Restart Configuration:

        Control flag (MRESTART)      Default: 0       ! MRESTART =  0   !

           0 = Do not read or write a restart file
           1 = Read a restart file at the beginning of
               the run
           2 = Write a restart file during run
           3 = Read a restart file at beginning of run
               and write a restart file during run

        Number of periods in Restart
        output cycle (NRESPD)        Default: 0       ! NRESPD =  0   !

           0 = File written only at last period
          >0 = File updated every NRESPD periods

     Meteorological Data Format (METFM)
                                     Default: 1       ! METFM =  1   !

           METFM = 1 - CALMET binary file (CALMET.MET)
           METFM = 2 - ISC ASCII file (ISCMET.MET)
           METFM = 3 - AUSPLUME ASCII file (PLMMET.MET)
           METFM = 4 - CTDM plus tower file (PROFILE.DAT) and
                       surface parameters file (SURFACE.DAT)
           METFM = 5 - AERMET tower file (PROFILE.DAT) and
                       surface parameters file (SURFACE.DAT)

     Meteorological Profile Data Format (MPRFFM)
            (used only for METFM = 1, 2, 3)
                                     Default: 1       ! MPRFFM =  1   !

           MPRFFM = 1 - CTDM plus tower file (PROFILE.DAT)
           MPRFFM = 2 - AERMET tower file (PROFILE.DAT)

     PG sigma-y is adjusted by the factor (AVET/PGTIME)**0.2
     Averaging Time (minutes) (AVET)
                                     Default: 60.0    ! AVET = 60. !
     PG Averaging Time (minutes) (PGTIME)
                                     Default: 60.0    ! PGTIME = 60. !


     Output units for binary concentration and flux files
     written in Dataset v2.2 or later formats
     (IOUTU)                         Default: 1       ! IOUTU =  1   !
```

```
        1 = mass      -  g/m3 (conc) or g/m2/s (dep)
        2 = odour     -  odour_units (conc)
        3 = radiation -  Bq/m3 (conc) or Bq/m2/s (dep)


     Output Dataset format for binary concentration
     and flux files (e.g., CONC.DAT)
     (IOVERS)                   Default: 2       ! IOVERS =  2   !
        1 = Dataset Version 2.1
        2 = Dataset Version 2.2


!END!


---------------------------------------------------------------------------
----

INPUT GROUP: 2 -- Technical options
--------------


     Vertical distribution used in the
     near field (MGAUSS)                   Default: 1     ! MGAUSS =  1   !
        0 = uniform
        1 = Gaussian

     Terrain adjustment method
     (MCTADJ)                              Default: 3     ! MCTADJ =  3   !
        0 = no adjustment
        1 = ISC-type of terrain adjustment
        2 = simple, CALPUFF-type of terrain
            adjustment
        3 = partial plume path adjustment

     Subgrid-scale complex terrain
     flag (MCTSG)                          Default: 0     ! MCTSG =  0   !
        0 = not modeled
        1 = modeled

     Near-field puffs modeled as
     elongated slugs? (MSLUG)              Default: 0     ! MSLUG =  0   !
        0 = no
        1 = yes (slug model used)

     Transitional plume rise modeled?
     (MTRANS)                              Default: 1     ! MTRANS =  1   !
        0 = no  (i.e., final rise only)
        1 = yes (i.e., transitional rise computed)

     Stack tip downwash? (MTIP)            Default: 1     ! MTIP =  1  !
        0 = no  (i.e., no stack tip downwash)
        1 = yes (i.e., use stack tip downwash)

     Method used to compute plume rise for
     point sources not subject to building
     downwash? (MRISE)                     Default: 1     ! MRISE =  1  !
        1 = Briggs plume rise
        2 = Numerical plume rise

     Method used to simulate building
     downwash? (MBDW)                      Default: 1     ! MBDW =   2  !
        1 = ISC method
        2 = PRIME method

     Vertical wind shear modeled above
     stack top (modified Briggs plume rise)?
     (MSHEAR)                              Default: 0     ! MSHEAR =  1  !
        0 = no  (i.e., vertical wind shear not modeled)
        1 = yes (i.e., vertical wind shear modeled)

     Puff splitting allowed? (MSPLIT)      Default: 0     ! MSPLIT =  0  !
        0 = no (i.e., puffs not split)
```



```
        1 = yes (i.e., puffs are split)

     Chemical mechanism flag (MCHEM)       Default: 1     ! MCHEM =  0   !
        0 = chemical transformation not
            modeled
        1 = transformation rates computed
            internally (MESOPUFF II scheme)
        2 = user-specified transformation
            rates used
        3 = transformation rates computed
            internally (RIVAD/ARM3 scheme)
        4 = secondary organic aerosol formation
            computed (MESOPUFF II scheme for OH)
        5 = user-specified half-life with or
            without transfer to child species
        6 = transformation rates computed
            internally (Updated RIVAD scheme with
            ISORROPIA equilibrium)
        7 = transformation rates computed
            internally (Updated RIVAD scheme with
            ISORROPIA equilibrium and CalTech SOA)

     Aqueous phase transformation flag (MAQCHEM)
     (Used only if MCHEM = 6, or 7)        Default: 0     ! MAQCHEM =  0
     !
        0 = aqueous phase transformation
            not modeled
        1 = transformation rates and wet
            scavenging coefficients adjusted
            for in-cloud aqueous phase reactions
            (adapted from RADM cloud model
             implementation in CMAQ/SCICHEM)

     Liquid Water Content flag (MLWC)
     (Used only if MAQCHEM = 1)            Default: 1     ! MLWC =  1   !
        0 = water content estimated from cloud cover
            and presence of precipitation
        1 = gridded cloud water data read from CALMET
            water content output files (filenames are
            the CALMET.DAT names PLUS the extension
            AUXEXT provided in Input Group 0)

     Wet removal modeled ? (MWET)          Default: 1     ! MWET =  0   !
        0 = no
        1 = yes

     Dry deposition modeled ? (MDRY)       Default: 1     ! MDRY =  0   !
        0 = no
        1 = yes
        (dry deposition method specified
         for each species in Input Group 3)


     Gravitational settling (plume tilt)
     modeled ? (MTILT)                     Default: 0     ! MTILT =  0   !
        0 = no
        1 = yes
        (puff center falls at the gravitational
         settling velocity for 1 particle species)

     Restrictions:
         - MDRY  = 1
         - NSPEC = 1  (must be particle species as well)
         - sg    = 0  GEOMETRIC STANDARD DEVIATION in Group 8 is
                      set to zero for a single particle diameter

     Method used to compute dispersion
     coefficients (MDISP)                  Default: 3     ! MDISP =  3   !

        1 = dispersion coefficients computed from measured values
            of turbulence, sigma v, sigma w
        2 = dispersion coefficients from internally calculated
            sigma v, sigma w using micrometeorological variables
```

```
        (u*, w*, L, etc.)
    3 = PG dispersion coefficients for RURAL areas (computed using
        the ISCST multi-segment approximation) and MP coefficients in
        urban areas
    4 = same as 3 except PG coefficients computed using
        the MESOPUFF II eqns.
    5 = CTDM sigmas used for stable and neutral conditions.
        For unstable conditions, sigmas are computed as in
        MDISP = 3, described above.  MDISP = 5 assumes that
        measured values are read

 Sigma-v/sigma-theta, sigma-w measurements used? (MTURBVW)
 (Used only if MDISP = 1 or 5)         Default: 3     ! MTURBVW =  3  !
    1 = use sigma-v or sigma-theta measurements
        from PROFILE.DAT to compute sigma-y
        (valid for METFM = 1, 2, 3, 4, 5)
    2 = use sigma-w measurements
        from PROFILE.DAT to compute sigma-z
        (valid for METFM = 1, 2, 3, 4, 5)
    3 = use both sigma-(v/theta) and sigma-w
        from PROFILE.DAT to compute sigma-y and sigma-z
        (valid for METFM = 1, 2, 3, 4, 5)
    4 = use sigma-theta measurements
        from PLMMET.DAT to compute sigma-y
        (valid only if METFM = 3)

 Back-up method used to compute dispersion
 when measured turbulence data are
 missing (MDISP2)                      Default: 3     ! MDISP2 =  3  !
 (used only if MDISP = 1 or 5)
    2 = dispersion coefficients from internally calculated
        sigma v, sigma w using micrometeorological variables
        (u*, w*, L, etc.)
    3 = PG dispersion coefficients for RURAL areas (computed using
        the ISCST multi-segment approximation) and MP coefficients in
        urban areas
    4 = same as 3 except PG coefficients computed using
        the MESOPUFF II eqns.

 [DIAGNOSTIC FEATURE]
 Method used for Lagrangian timescale for Sigma-y
 (used only if MDISP=1,2 or MDISP2=1,2)
 (MTAULY)                              Default: 0     ! MTAULY =  0  !
    0 = Draxler default 617.284 (s)
    1 = Computed as Lag. Length / (.75 q) -- after SCIPUFF
   10 < Direct user input (s)             -- e.g., 306.9


 [DIAGNOSTIC FEATURE]
 Method used for Advective-Decay timescale for Turbulence
 (used only if MDISP=2 or MDISP2=2)
 (MTAUADV)                             Default: 0     ! MTAUADV =  0  !
    0 = No turbulence advection
    1 = Computed (OPTION NOT IMPLEMENTED)
   10 < Direct user input (s)   -- e.g., 800


 Method used to compute turbulence sigma-v &
 sigma-w using micrometeorological variables
 (Used only if MDISP = 2 or MDISP2 = 2)
 (MCTURB)                              Default: 1     ! MCTURB =  1  !
    1 = Standard CALPUFF subroutines
    2 = AERMOD subroutines

 PG sigma-y,z adj. for roughness?      Default: 0     ! MROUGH =  0  !
 (MROUGH)
    0 = no
    1 = yes

 Partial plume penetration of          Default: 1     ! MPARTL =  1  !
 elevated inversion modeled for
 point sources?
 (MPARTL)
```



```
    0 = no
    1 = yes

 Partial plume penetration of          Default: 1     ! MPARTLBA =  0
 !
 elevated inversion modeled for
 buoyant area sources?
 (MPARTLBA)
    0 = no
    1 = yes

 Strength of temperature inversion     Default: 0     ! MTINV =  0  !
 provided in PROFILE.DAT extended records?
 (MTINV)
    0 = no (computed from measured/default gradients)
    1 = yes

 PDF used for dispersion under convective conditions?
                                       Default: 0     ! MPDF =  0  !
 (MPDF)
    0 = no
    1 = yes

 Sub-Grid TIBL module used for shore line?
                                       Default: 0     ! MSGTIBL = 0  !
 (MSGTIBL)
    0 = no
    1 = yes

 Boundary conditions (concentration) modeled?
                                       Default: 0     ! MBCON = 0  !
 (MBCON)
    0 = no
    1 = yes, using formatted BCON.DAT file
    2 = yes, using unformatted CONC.DAT file

 Note:  MBCON > 0 requires that the last species modeled
        be 'BCON'.  Mass is placed in species BCON when
        generating boundary condition puffs so that clean
        air entering the modeling domain can be simulated
        in the same way as polluted air.  Specify zero
        emission of species BCON for all regular sources.

 Individual source contributions saved?
                                       Default: 0     ! MSOURCE = 0  !
 (MSOURCE)
    0 = no
    1 = yes


 Analyses of fogging and icing impacts due to emissions from
 arrays of mechanically-forced cooling towers can be performed
 using CALPUFF in conjunction with a cooling tower emissions
 processor (CTEMISS) and its associated postprocessors.  Hourly
 emissions of water vapor and temperature from each cooling tower
 cell are computed for the current cell configuration and ambient
 conditions by CTEMISS. CALPUFF models the dispersion of these
 emissions and provides cloud information in a specialized format
 for further analysis. Output to FOG.DAT is provided in either
 'plume mode' or 'receptor mode' format.

 Configure for FOG Model output?
                                       Default: 0     ! MFOG =  0   !
 (MFOG)
    0 = no
    1 = yes  - report results in PLUME Mode format
    2 = yes  - report results in RECEPTOR Mode format


 Test options specified to see if
 they conform to regulatory
 values? (MREG)                        Default: 1     ! MREG =  0   !
```

```
        0 = NO checks are made
        1 = Technical options must conform to USEPA
            Long Range Transport (LRT) guidance
                       METFM    1 or 2
                       AVET     60. (min)
                       PGTIME   60. (min)
                       MGAUSS   1
                       MCTADJ   3
                       MTRANS   1
                       MTIP     1
                       MRISE    1
                       MCHEM    1 or 3 (if modeling SOx, NOx)
                       MWET     1
                       MDRY     1
                       MDISP    2 or 3
                       MPDF     0 if MDISP=3
                                1 if MDISP=2
                       MROUGH   0
                       MPARTL   1
                       MPARTLBA 0
                       SYTDEP   550. (m)
                       MHFTSZ   0
                       SVMIN    0.5 (m/s)


!END!


---------------------------------------------------------------------------
----

INPUT GROUP: 3a, 3b -- Species list
-------------------

------------
Subgroup (3a)
------------

  The following species are modeled:

! CSPEC =       TRACER !         !END!

                                                                   Dry
                                                                   OUTPUT GROUP
    SPECIES          MODELED          EMITTED       DEPOSITED
    NUMBER
     NAME         (0=NO, 1=YES)    (0=NO, 1=YES)    (0=NO,
     (0=NONE,
   (Limit: 12                                        1=COMPUTED-GAS
   1=1st CGRUP,
    Characters                                       2=COMPUTED-PARTICLE
    2=2nd CGRUP,
    in length)                                       3=USER-SPECIFIED)
    3= etc.)

!       TRACER  =         1,               1,           0,
0   !

!END!

  Note:  The last species in (3a) must be 'BCON' when using the
         boundary condition option (MBCON > 0).  Species BCON should
         typically be modeled as inert (no chem transformation or
         removal).


-------------
Subgroup (3b)
-------------
  The following names are used for Species-Groups in which results
  for certain species are combined (added) prior to output.  The
  CGRUP name will be used as the species name in output files.
  Use this feature to model specific particle-size distributions
```



```
  by treating each size-range as a separate species.
  Order must be consistent with 3(a) above.


---------------------------------------------------------------------------
----


INPUT GROUP: 4 -- Map Projection and Grid control parameters
--------------

     Projection for all (X,Y):
     -------------------------

     Map projection
     (PMAP)                     Default: UTM    ! PMAP = UTM  !

         UTM :  Universal Transverse Mercator
         TTM :  Tangential Transverse Mercator
         LCC :  Lambert Conformal Conic
          PS :  Polar Stereographic
          EM :  Equatorial Mercator
        LAZA :  Lambert Azimuthal Equal Area

     False Easting and Northing (km) at the projection origin
     (Used only if PMAP= TTM, LCC, or LAZA)
     (FEAST)                    Default=0.0     ! FEAST  = 0.000  !
     (FNORTH)                   Default=0.0     ! FNORTH = 0.000  !

     UTM zone (1 to 60)
     (Used only if PMAP=UTM)
     (IUTMZN)                   No Default      ! IUTMZN =  56   !

     Hemisphere for UTM projection?
     (Used only if PMAP=UTM)
     (UTMHEM)                   Default: N      ! UTMHEM = S  !
         N   :  Northern hemisphere projection
         S   :  Southern hemisphere projection

     Latitude and Longitude (decimal degrees) of projection origin
     (Used only if PMAP= TTM, LCC, PS, EM, or LAZA)
     (RLAT0)                    No Default      ! RLAT0 = 0N  !
     (RLON0)                    No Default      ! RLON0 = 0E  !

         TTM :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         LCC :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         PS  :  RLON0 identifies central (grid N/S) meridian of projection
                RLAT0 selected for convenience
         EM  :  RLON0 identifies central meridian of projection
                RLAT0 is REPLACED by 0.0N (Equator)
         LAZA:  RLON0 identifies longitude of tangent-point of mapping
         plane
                RLAT0 identifies latitude of tangent-point of mapping plane

     Matching parallel(s) of latitude (decimal degrees) for projection
     (Used only if PMAP= LCC or PS)
     (XLAT1)                    No Default      ! XLAT1 = 0N  !
     (XLAT2)                    No Default      ! XLAT2 = 0N  !

         LCC :  Projection cone slices through Earth's surface at XLAT1 and
         XLAT2
         PS  :  Projection plane slices through Earth at XLAT1
                (XLAT2 is not used)

     ----------
     Note:  Latitudes and longitudes should be positive, and include a
            letter N,S,E, or W indicating north or south latitude, and
            east or west longitude.  For example,
            35.9  N Latitude  =  35.9N
            118.7 E Longitude = 118.7E
```

```
     Datum-region
     ------------

     The Datum-Region for the coordinates is identified by a character
     string.  Many mapping products currently available use the model of
     the
     Earth known as the World Geodetic System 1984 (WGS-84).  Other local
     models may be in use, and their selection in CALMET will make its
     output
     consistent with local mapping products.  The list of Datum-Regions
     with
     official transformation parameters is provided by the National Imagery
     and
     Mapping Agency (NIMA).

     NIMA Datum - Regions(Examples)
     ----------------------------------------------------------------------
     --------
     WGS-84    WGS-84 Reference Ellipsoid and Geoid, Global coverage
     (WGS84)
     NAS-C     NORTH AMERICAN 1927 Clarke 1866 Spheroid, MEAN FOR CONUS
     (NAD27)
     NAR-C     NORTH AMERICAN 1983 GRS 80 Spheroid, MEAN FOR CONUS (NAD83)
     NWS-84    NWS 6370KM Radius, Sphere
     ESR-S     ESRI REFERENCE 6371KM Radius, Sphere

     Datum-region for output coordinates
     (DATUM)                   Default: WGS-84    ! DATUM = WGS-84  !


METEOROLOGICAL Grid:

     Rectangular grid defined for projection PMAP,
     with X the Easting and Y the Northing coordinate

            No. X grid cells (NX)      No default     ! NX =  101   !
            No. Y grid cells (NY)      No default     ! NY =  101   !
        No. vertical layers (NZ)       No default     ! NZ =  12   !

           Grid spacing (DGRIDKM)      No default     ! DGRIDKM = .1 !
                                       Units: km

                Cell face heights
                    (ZFACE(nz+1))      No defaults
                                       Units: m
   ! ZFACE = .0, 20.0, 30.0, 50.0, 100.0, 150.0, 250.0, 300.0, 400.0,
   600.0,
              1000.0, 1500.0, 2500.0 !

            Reference Coordinates
           of SOUTHWEST corner of
                 grid cell(1, 1):

            X coordinate (XORIGKM)     No default     ! XORIGKM = 379.95 !
            Y coordinate (YORIGKM)     No default     ! YORIGKM = 6354.95 !
                                      Units: km


COMPUTATIONAL Grid:

     The computational grid is identical to or a subset of the MET. grid.
     The lower left (LL) corner of the computational grid is at grid point
     (IBCOMP, JBCOMP) of the MET. grid.  The upper right (UR) corner of the
     computational grid is at grid point (IECOMP, JECOMP) of the MET. grid.
     The grid spacing of the computational grid is the same as the MET.
     grid.

        X index of LL corner (IBCOMP)      No default     ! IBCOMP =  1   !
                  (1 <= IBCOMP <= NX)
```



```
        Y index of LL corner (JBCOMP)      No default     ! JBCOMP =  1   !
                  (1 <= JBCOMP <= NY)


        X index of UR corner (IECOMP)      No default     ! IECOMP =  101
        !
                  (1 <= IECOMP <= NX)

        Y index of UR corner (JECOMP)      No default     ! JECOMP =  101
        !
                  (1 <= JECOMP <= NY)



SAMPLING Grid (GRIDDED RECEPTORS):

     The lower left (LL) corner of the sampling grid is at grid point
     (IBSAMP, JBSAMP) of the MET. grid.  The upper right (UR) corner of the
     sampling grid is at grid point (IESAMP, JESAMP) of the MET. grid.
     The sampling grid must be identical to or a subset of the
     computational
     grid.  It may be a nested grid inside the computational grid.
     The grid spacing of the sampling grid is DGRIDKM/MESHDN.

        Logical flag indicating if gridded
        receptors are used (LSAMP)         Default: T     ! LSAMP = T !
        (T=yes, F=no)

        X index of LL corner (IBSAMP)      No default     ! IBSAMP =  1   !
         (IBCOMP <= IBSAMP <= IECOMP)

        Y index of LL corner (JBSAMP)      No default     ! JBSAMP =  1   !
         (JBCOMP <= JBSAMP <= JECOMP)


        X index of UR corner (IESAMP)      No default     ! IESAMP =  101
        !
         (IBCOMP <= IESAMP <= IECOMP)

        Y index of UR corner (JESAMP)      No default     ! JESAMP =  101
        !
         (JBCOMP <= JESAMP <= JECOMP)


       Nesting factor of the sampling
        grid (MESHDN)                      Default: 1     ! MESHDN =  1  !
        (MESHDN is an integer >= 1)

!END!


---------------------------------------------------------------------------
----


INPUT GROUP: 5 -- Output Options
--------------
                                                *                        *
     FILE                          DEFAULT VALUE            VALUE THIS RUN
     ----                          -------------            --------------

   Concentrations (ICON)                 1                  !  ICON =  1   !
   Dry Fluxes (IDRY)                     1                  !  IDRY =  0   !
   Wet Fluxes (IWET)                     1                  !  IWET =  0   !
   2D Temperature (IT2D)                 0                  !  IT2D =  0   !
   2D Density (IRHO)                     0                  !  IRHO =  0   !
   Relative Humidity (IVIS)              1                  !  IVIS =  0   !
    (relative humidity file is
     required for visibility
     analysis)
   Use data compression option in output file?
   (LCOMPRS)                           Default: T         ! LCOMPRS = F !
```

```
   *
    0 = Do not create file, 1 = create file


    QA PLOT FILE OUTPUT OPTION:

       Create a standard series of output files (e.g.
       locations of sources, receptors, grids ...)
       suitable for plotting?
       (IQAPLOT)                       Default: 1         !  IQAPLOT =  1
       !
         0 = no
         1 = yes

    DIAGNOSTIC PUFF-TRACKING OUTPUT OPTION:

       Puff locations and properties reported to
       PFTRAK.DAT file for postprocessing?
       (IPFTRAK)                       Default: 0         ! IPFTRAK =  0
       !
         0 = no
         1 = yes, update puff output at end of each timestep
         2 = yes, update puff output at end of each sampling step

    DIAGNOSTIC MASS FLUX OUTPUT OPTIONS:

       Mass flux across specified boundaries
       for selected species reported?
       (IMFLX)                         Default: 0         ! IMFLX =  0  !
         0 = no
         1 = yes (FLUXBDY.DAT and MASSFLX.DAT filenames
                  are specified in Input Group 0)

       Mass balance for each species
       reported?
       (IMBAL)                         Default: 0         ! IMBAL =  0  !
         0 = no
         1 = yes (MASSBAL.DAT filename is
              specified in Input Group 0)


    NUMERICAL RISE OUTPUT OPTION:

       Create a file with plume properties for each rise
       increment, for each model timestep?
       This applies to sources modeled with numerical rise
       and is limited to ONE source in the run.
       (INRISE)                        Default: 0         ! INRISE =  0  !
         0 = no
         1 = yes (RISE.DAT filename is
                  specified in Input Group 0)


    LINE PRINTER OUTPUT OPTIONS:

       Print concentrations (ICPRT)    Default: 0         ! ICPRT =  0   !
       Print dry fluxes (IDPRT)        Default: 0         ! IDPRT =  0   !
       Print wet fluxes (IWPRT)        Default: 0         ! IWPRT =  0   !
       (0 = Do not print, 1 = Print)

       Concentration print interval
       (ICFRQ) in timesteps            Default: 1         ! ICFRQ =  1   !
       Dry flux print interval
       (IDFRQ) in timesteps            Default: 1         ! IDFRQ =  1   !
       Wet flux print interval
       (IWFRQ) in timesteps            Default: 1         ! IWFRQ =  1   !

       Units for Line Printer Output
       (IPRTU)                         Default: 1         ! IPRTU =  3   !
                        for              for
                  Concentration    Deposition
           1 =       g/m**3         g/m**2/s
           2 =      mg/m**3        mg/m**2/s
```



```
           3 =      ug/m**3        ug/m**2/s
           4 =      ng/m**3        ng/m**2/s
           5 =     Odour Units

       Messages tracking progress of run
       written to the screen ?
       (IMESG)                         Default: 2         ! IMESG =  2   !
         0 = no
         1 = yes (advection step, puff ID)
         2 = yes (YYYYJJJHH, # old puffs, # emitted puffs)


     SPECIES (or GROUP for combined species) LIST FOR OUTPUT OPTIONS

                 ---- CONCENTRATIONS ----   ------ DRY FLUXES ------
                 ------ WET FLUXES ------   -- MASS FLUX --
   SPECIES
   /GROUP        PRINTED?  SAVED ON DISK?   PRINTED?  SAVED ON DISK?
   PRINTED?  SAVED ON DISK?   SAVED ON DISK?
   -------       ------------------------   ------------------------
   ------------------------   ---------------
!       TRACER =     0,           1,           0,           0,           0,
0,           0   !

  Note:  Species BCON (for MBCON > 0) does not need to be saved on disk.


     OPTIONS FOR PRINTING "DEBUG" QUANTITIES (much output)

       Logical for debug output
       (LDEBUG)                                    Default: F     ! LDEBUG = F
       !

       First puff to track
       (IPFDEB)                                    Default: 1     ! IPFDEB =
       1  !

       Number of puffs to track
       (NPFDEB)                                    Default: 1     ! NPFDEB =
       1  !

       Met. period to start output
       (NN1)                                       Default: 1     ! NN1 =  1
       !

       Met. period to end output
       (NN2)                                       Default: 10    ! NN2 =  10
       !

!END!


---------------------------------------------------------------------------
----


INPUT GROUP: 6a, 6b, & 6c -- Subgrid scale complex terrain inputs
-------------------------

---------------
Subgroup (6a)
---------------
       Number of terrain features (NHILL)      Default: 0     ! NHILL =  0
       !

       Number of special complex terrain
       receptors  (NCTREC)                     Default: 0     ! NCTREC =
       0   !

       Terrain and CTSG Receptor data for
       CTSG hills input in CTDM format ?
       (MHILL)                                 No Default     ! MHILL =  2
       !
```

```
       1 = Hill and Receptor data created
           by CTDM processors & read from
           HILL.DAT and HILLRCT.DAT files
       2 = Hill data created by OPTHILL &
           input below in Subgroup (6b);
           Receptor data in Subgroup (6c)

       Factor to convert horizontal dimensions  Default: 1.0   ! XHILL2M =
       1.0 !
       to meters (MHILL=1)

       Factor to convert vertical dimensions    Default: 1.0   ! ZHILL2M =
       1.0 !
       to meters (MHILL=1)

       X-origin of CTDM system relative to      No Default     ! XCTDMKM =
       0 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

       Y-origin of CTDM system relative to      No Default     ! YCTDMKM =
       0 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

! END !

---------------
Subgroup (6b)
---------------

                      1 **
     HILL information


HILL           XC        YC       THETAH  ZGRID  RELIEF    EXPO 1    EXPO 2
SCALE 1    SCALE 2    AMAX1     AMAX2
 NO.          (km)      (km)      (deg.)   (m)     (m)       (m)       (m)
 (m)         (m)       (m)       (m)
----          ----      ----      ------  -----  ------    ------    ------
-------    -------    -----     -----

---------------
Subgroup (6c)
---------------

    COMPLEX TERRAIN RECEPTOR INFORMATION

                      XRCT         YRCT        ZRCT          XHH
                      (km)         (km)         (m)
                     ------        -----      ------         ----


-------------------
1
     Description of Complex Terrain Variables:
          XC, YC  = Coordinates of center of hill
          THETAH  = Orientation of major axis of hill (clockwise from
                    North)
          ZGRID   = Height of the  0  of the grid above mean sea
                    level
          RELIEF  = Height of the crest of the hill above the grid
          elevation
          EXPO 1  = Hill-shape exponent for the major axis
          EXPO 2  = Hill-shape exponent for the major axis
          SCALE 1 = Horizontal length scale along the major axis
          SCALE 2 = Horizontal length scale along the minor axis
          AMAX    = Maximum allowed axis length for the major axis
          BMAX    = Maximum allowed axis length for the major axis

          XRCT, YRCT = Coordinates of the complex terrain receptors
          ZRCT    = Height of the ground (MSL) at the complex terrain
                    Receptor
          XHH     = Hill number associated with each complex terrain
          receptor
```



```
                    (NOTE: MUST BE ENTERED AS A REAL NUMBER)

   **
     NOTE: DATA for each hill and CTSG receptor are treated as a separate
           input subgroup and therefore must end with an input group
           terminator.

--------------------------------------------------------------------------
----


INPUT GROUP: 7 -- Chemical parameters for dry deposition of gases
--------------

      SPECIES     DIFFUSIVITY      ALPHA STAR      REACTIVITY    MESOPHYLL
      RESISTANCE     HENRY'S LAW COEFFICIENT
       NAME        (cm**2/s)
       (s/cm)                (dimensionless)
      -------     -----------      ----------      ----------
      --------------------     -----------------------


!END!

--------------------------------------------------------------------------
----


INPUT GROUP: 8 -- Size parameters for dry deposition of particles
-------------

     For SINGLE SPECIES, the mean and standard deviation are used to
     compute a deposition velocity for NINT (see group 9) size-ranges,
     and these are then averaged to obtain a mean deposition velocity.

     For GROUPED SPECIES, the size distribution should be explicitly
     specified (by the 'species' in the group), and the standard deviation
     for each should be entered as 0.  The model will then use the
     deposition velocity for the stated mean diameter.

      SPECIES      GEOMETRIC MASS MEAN        GEOMETRIC STANDARD
       NAME             DIAMETER                   DEVIATION
                        (microns)                  (microns)
      -------      -------------------        ------------------

!END!

--------------------------------------------------------------------------
----


INPUT GROUP: 9 -- Miscellaneous dry deposition parameters
-------------

     Reference cuticle resistance (s/cm)
     (RCUTR)                            Default: 30    !  RCUTR = 30.0 !
     Reference ground resistance  (s/cm)
     (RGR)                              Default: 10    !    RGR = 10.0 !
     Reference pollutant reactivity
     (REACTR)                           Default: 8     ! REACTR = 8.0 !

     Number of particle-size intervals used to
     evaluate effective particle deposition velocity
     (NINT)                             Default: 9     !   NINT =  9  !

     Vegetation state in unirrigated areas
     (IVEG)                             Default: 1     !   IVEG =  1   !
        IVEG=1 for active and unstressed vegetation
        IVEG=2 for active and stressed vegetation
        IVEG=3 for inactive vegetation
```

!END!

```
-------------------------------------------------------------------------------
----
```

INPUT GROUP: 10 -- Wet Deposition Parameters

```
                    Scavenging Coefficient -- Units: (sec)**(-1)

      Pollutant      Liquid Precip.       Frozen Precip.
      ---------      --------------       --------------
```

!END!

```
-------------------------------------------------------------------------------
----
```

INPUT GROUP: 11a, 11b -- Chemistry Parameters

Subgroup (11a)

Several parameters are needed for one or more of the chemical transformation mechanisms. Those used for each mechanism are:

Mechanism (MCHEM)	MOZ	BCKO3	MNH3	MAVGNH3	BCKNH3	RNITE1	RNITE2	RNITE3	MH2O2	BCKH2O2	BCKPMF	OFRAC	VCNX	NDECAY
0 None	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1 MESOPUFF II	X	X	.	.	X	X	X	X	.	.	.	.	.	.
2 User Rates	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3 RIVAD	X	X	.	.	X	.	.	.	.	.	.	.	.	.
4 SOA	X	X	.	.	.	.	.	.	.	.	X	X	X	.
5 Radioactive Decay	.	.	.	.	.	.	.	.	.	.	.	.	.	X
6 RIVAD/ISORRPIA	X	X	X	X	X	X	.	.	X	X	.	.	.	.
7 RIVAD/ISORRPIA/SOA	X	X	X	X	X	X	.	.	X	X	X	X	.	.

```
     Ozone data input option (MOZ)     Default: 1            ! MOZ =  0   !
     (Used only if MCHEM = 1, 3, 4, 6, or 7)
        0 = use a monthly background ozone value
        1 = read hourly ozone concentrations from
            the OZONE.DAT data file

     Monthly ozone concentrations in ppb (BCKO3)
     (Used only if MCHEM = 1,3,4,6, or 7 and either
        MOZ = 0, or
        MOZ = 1 and all hourly O3 data missing)
                                       Default: 12*80.
     !  BCKO3 = 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00,
     80.00, 80.00, 80.00, 80.00 !

     Ammonia data option (MNH3)        Default: 0            ! MNH3 =  0
     !
     (Used only if MCHEM = 6 or 7)
        0 = use monthly background ammonia values (BCKNH3) - no vertical
        variation
        1 = read monthly background ammonia values for each layer from
            the NH3Z.DAT data file
```



```
     Ammonia vertical averaging option (MAVGNH3)
     (Used only if MCHEM = 6 or 7, and MNH3 = 1)
        0 = use NH3 at puff center height (no averaging is done)
        1 = average NH3 values over vertical extent of puff
                                  Default: 1            ! MAVGNH3 =  1
                                  !

     Monthly ammonia concentrations in ppb (BCKNH3)
     (Used only if MCHEM = 1 or 3, or
               if MCHEM = 6 or 7, and MNH3 = 0)
                                  Default: 12*10.
     !  BCKNH3 = 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00,
     10.00, 10.00, 10.00, 10.00 !

     Nighttime SO2 loss rate in %/hour (RNITE1)
     (Used only if MCHEM = 1, 6 or 7)
     This rate is used only at night for MCHEM=1
     and is added to the computed rate both day
     and night for MCHEM=6,7 (heterogeneous reactions)
                                  Default: 0.2          ! RNITE1 = .2
                                  !

     Nighttime NOx loss rate in %/hour (RNITE2)
     (Used only if MCHEM = 1)
                                  Default: 2.0          ! RNITE2 = 2.0
                                  !

     Nighttime HNO3 formation rate in %/hour (RNITE3)
     (Used only if MCHEM = 1)
                                  Default: 2.0          ! RNITE3 = 2.0
                                  !

     H2O2 data input option (MH2O2)    Default: 1            ! MH2O2 =  1
     !
     (Used only if MCHEM = 6 or 7, and MAQCHEM = 1)
        0 = use a monthly background H2O2 value
        1 = read hourly H2O2 concentrations from
            the H2O2.DAT data file

     Monthly H2O2 concentrations in ppb (BCKH2O2)
     (Used only if MQACHEM = 1 and either
        MH2O2 = 0 or
        MH2O2 = 1 and all hourly H2O2 data missing)
                                  Default: 12*1.
     !  BCKH2O2 = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00,
     1.00, 1.00, 1.00 !


 --- Data for SECONDARY ORGANIC AEROSOL (SOA) Options
     (used only if MCHEM = 4 or 7)

     The MCHEM = 4 SOA module uses monthly values of:
          Fine particulate concentration in ug/m^3 (BCKPMF)
          Organic fraction of fine particulate     (OFRAC)
          VOC / NOX ratio (after reaction)         (VCNX)

     The MCHEM = 7 SOA module uses monthly values of:
          Fine particulate concentration in ug/m^3 (BCKPMF)
          Organic fraction of fine particulate     (OFRAC)

     These characterize the air mass when computing
     the formation of SOA from VOC emissions.
     Typical values for several distinct air mass types are:
```

Month	1 Jan	2 Feb	3 Mar	4 Apr	5 May	6 Jun	7 Jul	8 Aug	9 Sep	10 Oct	11 Nov	12 Dec
Clean Continental												
BCKPMF	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
OFRAC	.15	.15	.20	.20	.20	.20	.20	.20	.20	.20	.20	.15
VCNX	50.	50.	50.	50.	50.	50.	50.	50.	50.	50.	50.	50.

Clean Marine (surface)

```
        BCKPMF  .5   .5   .5   .5   .5   .5   .5   .5   .5   .5   .5   .5
        OFRAC  .25  .25  .30  .30  .30  .30  .30  .30  .30  .30  .30  .25
        VCNX    50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.

     Urban - low biogenic (controls present)
        BCKPMF  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.
        OFRAC  .20  .20  .25  .25  .25  .25  .25  .25  .20  .20  .20  .20
        VCNX     4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.

     Urban - high biogenic (controls present)
        BCKPMF  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.
        OFRAC  .25  .25  .30  .30  .30  .55  .55  .55  .35  .35  .35  .25
        VCNX    15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.

     Regional Plume
        BCKPMF  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.
        OFRAC  .20  .20  .25  .35  .25  .40  .40  .40  .30  .30  .30  .20
        VCNX    15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.

     Urban - no controls present
        BCKPMF 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100.
        OFRAC  .30  .30  .35  .35  .35  .55  .55  .55  .35  .35  .35  .30
        VCNX     2.   2.   2.   2.   2.   2.   2.   2.   2.   2.   2.   2.

     Default: Clean Continental
     !  BCKPMF = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00,
     1.00, 1.00, 1.00 !
     !  OFRAC  = 0.15, 0.15, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20,
     0.20, 0.20, 0.15 !
     !  VCNX   = 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00,
     50.00, 50.00, 50.00, 50.00 !

 --- End Data for SECONDARY ORGANIC AEROSOL (SOA) Option


     Number of half-life decay specification blocks provided in Subgroup
     11b
     (Used only if MCHEM = 5)
     (NDECAY)                                   Default: 0      ! NDECAY =
     0   !

!END!


--------------
Subgroup (11b)
--------------

     Each species modeled may be assigned a decay half-life (sec), and the
     associated
     mass lost may be assigned to one or more other modeled species using a
     mass yield
     factor. This information is used only for MCHEM=5.

     Provide NDECAY blocks assigning the half-life for a parent species and
     mass yield
     factors for each child species (if any) produced by the decay.
     Set HALF_LIFE=0.0 for NO decay (infinite half-life).


                               a            b
        SPECIES      Half-Life   Mass Yield
         NAME          (sec)       Factor
        -------      ---------   ----------

     *   SPEC1   =    3600.,        -1.0   *    (Parent)
     *   SPEC2   =     -1.0,         0.0   *    (Child)
   *END*

--------
    a
     Specify a half life that is greater than or equal to zero for 1 parent
     species
```



```
     in each block, and set the yield factor for this species to -1
    b
     Specify a yield factor that is greater than or equal to zero for 1 or
     more child
     species in each block, and set the half-life for each of these species
     to -1

     NOTE: Assignments in each block are treated as a separate input
           subgroup and therefore must end with an input group terminator.
           If NDECAY=0, no assignments and input group terminators should
           appear.

---------------------------------------------------------------------------
----


INPUT GROUP: 12 -- Misc. Dispersion and Computational Parameters
---------------

     Horizontal size of puff (m) beyond which
     time-dependent dispersion equations (Heffter)
     are used to determine sigma-y and
     sigma-z (SYTDEP)                           Default: 550.   ! SYTDEP =
     5.5E02 !

     Switch for using Heffter equation for sigma z
     as above (0 = Not use Heffter; 1 = use Heffter
     (MHFTSZ)                                   Default: 0      ! MHFTSZ =
     0   !

     Stability class used to determine plume
     growth rates for puffs above the boundary
     layer (JSUP)                               Default: 5      ! JSUP =  5
     !

     Vertical dispersion constant for stable
     conditions (k1 in Eqn. 2.7-3)  (CONK1)     Default: 0.01   ! CONK1 =
     .01 !

     Vertical dispersion constant for neutral/
     unstable conditions (k2 in Eqn. 2.7-4)
     (CONK2)                                    Default: 0.1    ! CONK2 =
     .1 !

     Factor for determining Transition-point from
     Schulman-Scire to Huber-Snyder Building Downwash
     scheme (SS used for Hs < Hb + TBD * HL)
     (TBD)                                      Default: 0.5    ! TBD = .5
     !
        TBD < 0   ==> always use Huber-Snyder
        TBD = 1.5 ==> always use Schulman-Scire
        TBD = 0.5 ==> ISC Transition-point

     Range of land use categories for which
     urban dispersion is assumed
     (IURB1, IURB2)                             Default: 10     ! IURB1 =
     10  !
                                                         19     ! IURB2 =
                                                         19  !

     Site characterization parameters for single-point Met data files
     ---------
     (needed for METFM = 2,3,4,5)

        Land use category for modeling domain
        (ILANDUIN)                              Default: 20     ! ILANDUIN
        =  20  !

        Roughness length (m) for modeling domain
        (Z0IN)                                  Default: 0.25   ! Z0IN =
        .25 !

        Leaf area index for modeling domain
```

```
   (XLAIIN)                               Default: 3.0    ! XLAIIN =
   3.0 !

   Elevation above sea level (m)
   (ELEVIN)                               Default: 0.0    ! ELEVIN =
   .0 !

   Latitude (degrees) for met location
   (XLATIN)                               Default: -999.  ! XLATIN =
   -999.0 !

   Longitude (degrees) for met location
   (XLONIN)                               Default: -999.  ! XLONIN =
   -999.0 !

Specialized information for interpreting single-point Met data files
-----

   Anemometer height (m) (Used only if METFM = 2,3)
   (ANEMHT)                               Default: 10.    ! ANEMHT =
   10.0 !

   Form of lateral turbulance data in PROFILE.DAT file
   (Used only if METFM = 4,5 or MTURBVW = 1 or 3)
   (ISIGMAV)                              Default: 1      ! ISIGMAV =
   1  !
       0 = read sigma-theta
       1 = read sigma-v

   Choice of mixing heights (Used only if METFM = 4)
   (IMIXCTDM)                             Default: 0      ! IMIXCTDM
   =  0  !
       0 = read PREDICTED mixing heights
       1 = read OBSERVED mixing heights

Maximum length of a slug (met. grid units)
(XMXLEN)                                  Default: 1.0    ! XMXLEN =
1.0 !

Maximum travel distance of a puff/slug (in
grid units) during one sampling step
(XSAMLEN)                                 Default: 1.0    ! XSAMLEN =
1.0 !

Maximum Number of slugs/puffs release from
one source during one time step
(MXNEW)                                   Default: 99     ! MXNEW =
99   !

Maximum Number of sampling steps for
one puff/slug during one time step
(MXSAM)                                   Default: 99     ! MXSAM =
99   !

Number of iterations used when computing
the transport wind for a sampling step
that includes gradual rise (for CALMET
and PROFILE winds)
(NCOUNT)                                  Default: 2      ! NCOUNT =
2   !

Minimum sigma y for a new puff/slug (m)
(SYMIN)                                   Default: 1.0    ! SYMIN =
1.0  !

Minimum sigma z for a new puff/slug (m)
(SZMIN)                                   Default: 1.0    ! SZMIN =
1.0  !

Maximum sigma z (m) allowed to avoid
numerical problem in calculating virtual
time or distance.  Cap should be large
enough to have no influence on normal events.
```



```
Enter a negative cap to disable.
(SZCAP_M)                                 Default: 5.0e06 ! SZCAP_M =
5.0E06 !

Default minimum turbulence velocities sigma-v and sigma-w
for each stability class over land and over water (m/s)
(SVMIN(12) and SWMIN(12))

                ----------  LAND  ----------       ---------  WATER
                ----------
   Stab Class :  A    B    C    D    E    F         A    B    C    D
   E    F
                ---  ---  ---  ---  ---  ---       ---  ---  ---  ---
                ---  ---
Default SVMIN : .50, .50, .50, .50, .50, .50,      .37, .37, .37, .37,
.37, .37
Default SWMIN : .20, .12, .08, .06, .03, .016,     .20, .12, .08, .06,
.03, .016

      ! SVMIN = 0.500, 0.500, 0.500, 0.500, 0.500, 0.500, 0.370,
      0.370, 0.370, 0.370, 0.370, 0.370!
      ! SWMIN = 0.200, 0.120, 0.080, 0.060, 0.030, 0.016, 0.200,
      0.120, 0.080, 0.060, 0.030, 0.016!

Divergence criterion for dw/dz across puff
used to initiate adjustment for horizontal
convergence (1/s)
Partial adjustment starts at CDIV(1), and
full adjustment is reached at CDIV(2)
(CDIV(2))                                 Default: 0.0,0.0  ! CDIV =
.0, .0 !

Search radius (number of cells) for nearest
land and water cells used in the subgrid
TIBL module
(NLUTIBL)                                 Default: 4      ! NLUTIBL =
4  !

Minimum wind speed (m/s) allowed for
non-calm conditions. Also used as minimum
speed returned when using power-law
extrapolation toward surface
(WSCALM)                                  Default: 0.5    ! WSCALM =
.5 !

Maximum mixing height (m)
(XMAXZI)                                  Default: 3000.  ! XMAXZI =
3000.0 !

Minimum mixing height (m)
(XMINZI)                                  Default: 50.    ! XMINZI =
50.0 !

Default wind speed classes --
5 upper bounds (m/s) are entered;
the 6th class has no upper limit
(WSCAT(5))                       Default   :
                                 ISC RURAL : 1.54, 3.09, 5.14, 8.23,
                                 10.8 (10.8+)

                          Wind Speed Class :  1     2     3     4     5
                                             ---   ---   ---   ---
                                             ---
                                   ! WSCAT = 1.54, 3.09, 5.14, 8.23,
                                   10.80 !

Default wind speed profile power-law
exponents for stabilities 1-6
(PLX0(6))                        Default   : ISC RURAL values
                                 ISC RURAL : .07, .07, .10, .15, .35,
                                 .55
                                 ISC URBAN : .15, .15, .20, .25, .30,
                                 .30
```

```
                          Stability Class :  A     B     C     D     E
                          F
                                             ---   ---   ---   ---
                                             ---   ---
                                  ! PLX0 = 0.15, 0.15, 0.20, 0.25,
                                  0.30, 0.30 !

     Default potential temperature gradient
     for stable classes E, F (degK/m)
     (PTG0(2))                 Default: 0.020, 0.035
                                  ! PTG0 = 0.020,   0.035 !

     Default plume path coefficients for
     each stability class (used when option
     for partial plume height terrain adjustment
     is selected -- MCTADJ=3)
     (PPC(6))             Stability Class :  A     B     C     D     E
     F
                             Default  PPC : .50,  .50,  .50,  .50,
                             .35,  .35
                                             ---   ---   ---   ---
                                             ---   ---
                                  !  PPC = 0.50, 0.50, 0.50, 0.50,
                                  0.35, 0.35 !

     Slug-to-puff transition criterion factor
     equal to sigma-y/length of slug
     (SL2PF)                            Default: 10.       ! SL2PF =
     10.0 !

     Puff-splitting control variables ------------------------

       VERTICAL SPLIT
       --------------

       Number of puffs that result every time a puff
       is split - nsplit=2 means that 1 puff splits
       into 2
       (NSPLIT)                         Default:   3       ! NSPLIT =
       3  !

       Time(s) of a day when split puffs are eligible to
       be split once again; this is typically set once
       per day, around sunset before nocturnal shear develops.
       24 values: 0 is midnight (00:00) and 23 is 11 PM (23:00)
       0=do not re-split    1=eligible for re-split
       (IRESPLIT(24))                   Default:  Hour 17 = 1
       !  IRESPLIT = 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0 !

       Split is allowed only if last hour's mixing
       height (m) exceeds a minimum value
       (ZISPLIT)                        Default: 100.      ! ZISPLIT =
       100.0 !

       Split is allowed only if ratio of last hour's
       mixing ht to the maximum mixing ht experienced
       by the puff is less than a maximum value (this
       postpones a split until a nocturnal layer develops)
       (ROLDMAX)                        Default: 0.25      ! ROLDMAX =
       0.25 !


       HORIZONTAL SPLIT
       ----------------

       Number of puffs that result every time a puff
       is split - nsplith=5 means that 1 puff splits
       into 5
       (NSPLITH)                        Default:   5       ! NSPLITH =
       5  !

       Minimum sigma-y (Grid Cells Units) of puff
```



```
       before it may be split
       (SYSPLITH)                       Default:  1.0       ! SYSPLITH =
       1.0 !

       Minimum puff elongation rate (SYSPLITH/hr) due to
       wind shear, before it may be split
       (SHSPLITH)                       Default:  2.        ! SHSPLITH =
       2.0 !

       Minimum concentration (g/m^3) of each
       species in puff before it may be split
       Enter array of NSPEC values; if a single value is
       entered, it will be used for ALL species
       (CNSPLITH)                       Default:  1.0E-07   ! CNSPLITH =
       1.0E-07 !

     Integration control variables ------------------------

       Fractional convergence criterion for numerical SLUG
       sampling integration
       (EPSSLUG)                        Default:   1.0e-04  ! EPSSLUG =
       1.0E-04 !

       Fractional convergence criterion for numerical AREA
       source integration
       (EPSAREA)                        Default:   1.0e-06  ! EPSAREA =
       1.0E-06 !

       Trajectory step-length (m) used for numerical rise
       integration
       (DSRISE)                         Default:   1.0      ! DSRISE =
       1.0 !

       Boundary Condition (BC) Puff control variables
       ------------------------

       Minimum height (m) to which BC puffs are mixed as they are emitted
       (MBCON=2 ONLY).  Actual height is reset to the current mixing height
       at the release point if greater than this minimum.
       (HTMINBC)                        Default:   500.     ! HTMINBC =
       500.0 !

       Search radius (km) about a receptor for sampling nearest BC puff.
       BC puffs are typically emitted with a spacing of one grid cell
       length, so the search radius should be greater than DGRIDKM.
       (RSAMPBC)                        Default:   10.      ! RSAMPBC =
       10.0 !

       Near-Surface depletion adjustment to concentration profile used when
       sampling BC puffs?
       (MDEPBC)                         Default:   1        ! MDEPBC =
       1  !
          0 = Concentration is NOT adjusted for depletion
          1 = Adjust Concentration for depletion

!END!


---------------------------------------------------------------------------
----


INPUT GROUPS: 13a, 13b, 13c, 13d -- Point source parameters
--------------------------------

---------------
Subgroup (13a)
---------------

     Number of point sources with
     parameters provided below      (NPT1)  No default  !  NPT1 =  1  !

     Units used for point source
```

```
     emissions below                (IPTU)  Default: 1  !  IPTU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr
           8 =     Bq/s  (Bq = becquerel = disintegrations/s)
           9 =     GBq/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (13d)        (NSPT1) Default: 0  !  NSPT1 =  0  !

     Number of point sources with
     variable emission parameters
     provided in external file      (NPT2)  No default  !  NPT2 =  0  !

     (If NPT2 > 0, these point
     source emissions are read from
     the file: PTEMARB.DAT)

!END!

---------------
Subgroup (13b)
---------------
                                      a
          POINT SOURCE: CONSTANT DATA
          -----------------------------

b          c
  Source       X         Y       Stack    Base     Stack    Exit  Exit
  Bldg.  Emission
   No.     Coordinate Coordinate Height Elevation Diameter  Vel.  Temp.
   Dwash   Rates
              (km)      (km)       (m)      (m)       (m)  (m/s) (deg. K)
  ------   ---------- ---------- ------  ------   -------- ----- --------
  ----- --------
   1 ! SRCNAM = NAPOP !
   1 ! X =  385.796, 6360.071,    68.0,   9.0,       1.5,  26.5,  418.0,
   1.0, 1.0E00 !
   1 ! ZPLTFM  =       .0 !
   1 ! FMFAC  =      1.0 !   !END!

--------

    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

     SRCNAM  is a 12-character name for a source
             (No default)
     X       is an array holding the source data listed by the column
     headings
             (No default)
     SIGYZI  is an array holding the initial sigma-y and sigma-z (m)
             (Default: 0.,0.)
     FMFAC   is a vertical momentum flux factor (0. or 1.0) used to
     represent
             the effect of rain-caps or other physical configurations that
             reduce momentum rise associated with the actual exit velocity.
             (Default: 1.0  -- full momentum used)
     ZPLTFM  is the platform height (m) for sources influenced by an
     isolated
             structure that has a significant open area between the surface
             and the bulk of the structure, such as an offshore oil
             platform.
             The Base Elevation is that of the surface (ground or ocean),
             and the Stack Height is the release height above the Base (not
             above the platform).  Building heights entered in Subgroup 13c
```



```
             must be those of the buildings on the platform, measured from
             the platform deck.  ZPLTFM is used only with MBDW=1 (ISC
             downwash method) for sources with building downwash.
             (Default: 0.0)

    b
     0. = No building downwash modeled
     1. = Downwash modeled for buildings resting on the surface
     2. = Downwash modeled for buildings raised above the surface (ZPLTFM >
     0.)
     NOTE: must be entered as a REAL number (i.e., with decimal point)

    c
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IPTU
     (e.g. 1 for g/s).

---------------
Subgroup (13c)
---------------

           BUILDING DIMENSION DATA FOR SOURCES SUBJECT TO DOWNWASH
           -------------------------------------------------------
Source
a
 No.       Effective building height, width, length and X/Y offset (in
 meters)
           every 10 degrees.  LENGTH, XBADJ, and YBADJ are only needed for
           MBDW=2 (PRIME downwash option)
------
--------------------------------------------------------------------

 1    ! SRCNAM  =   NAPOP !
 1    ! HEIGHT  =  63.0,   42.0,   42.0,   42.0,   63.0,   63.0,
                   63.0,   63.0,   63.0,   63.0,   63.0,   63.0,
                   63.0,   63.0,   63.0,   63.0,   63.0,   63.0,
                   63.0,   63.0,   63.0,   63.0,   63.0,   63.0,
                   63.0,   63.0,   63.0,   63.0,   63.0,   63.0,
                   63.0,   63.0,   63.0,   63.0,   63.0,   63.0!
 1    ! WIDTH  =   13.19,   41.0,   43.75,   45.0,   17.0,   17.0,
                   16.5,   15.5,   14.0,   12.0,   14.5,   16.0,
                   17.5,   18.0,   18.0,   17.5,   16.5,   15.0,
                   13.19,   14.25,   15.75,   16.5,   17.0,   17.0,
                   16.5,   15.5,   14.0,   12.5,   14.5,   16.5,
                   17.5,   18.0,   18.0,   17.75,   16.5,   15.0!
 1    ! LENGTH =   12.5,   41.0,   44.0,   45.0,   17.5,   18.0,
                   17.5,   16.5,   15.0,   13.12,   14.25,   15.75,
                   16.5,   17.5,   17.5,   16.5,   15.5,   14.0,
                   12.5,   14.5,   16.0,   17.0,   18.0,   18.0,
                   17.5,   16.63,   15.0,   13.12,   14.25,   15.75,
                   16.75,   17.5,   17.0,   16.5,   15.5,   14.0!
 1    ! XBADJ  =   -.5,   -199.5,   -202.5,   -198.5,   1.0,   1.25,
                   1.5,   1.87,   2.0,   2.19,   .88,   -1.25,
                   -3.25,   -5.5,   -7.5,   -8.5,   -10.0,   -11.0,
                   -11.5,   -14.0,   -16.5,   -17.5,   -18.5,   -19.25,
                   -19.0,   -18.38,   -17.0,   -15.31,   -15.13,   -14.5,
                   -13.5,   -12.0,   -10.0,   -8.0,   -5.5,   -3.0!
 1    ! YBADJ  =   -8.72,   22.0,   -9.37,   -40.75,   -3.5,   -1.5,
                   .25,   1.75,   4.0,   5.5,   6.75,   8.5,
                   9.25,   10.0,   10.25,   10.25,   10.12,   9.5,
                   8.72,   8.0,   6.63,   5.25,   3.5,   1.5,
                   -.75,   -2.25,   -4.0,   -5.75,   -7.25,   -8.25,
                   -9.25,   -10.0,   -10.25,   -10.38,   -10.0,   -9.5!
!END!

--------

    a
     Building height, width, length, and X/Y offset from the source are
     treated
     as a separate input subgroup for each source and therefore must end
     with
```

```
     an input group terminator.  The X/Y offset is the position, relative
     to the
     stack, of the center of the upwind face of the projected building,
     with the
     x-axis pointing along the flow direction.

---------------
Subgroup (13d)
---------------
                                                a
          POINT SOURCE: VARIABLE EMISSIONS DATA
          ---------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 13b.  Factors entered multiply the rates in 13b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use PTEMARB.DAT and NPT2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)


--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


---------------------------------------------------------------------------
----


INPUT GROUPS: 14a, 14b, 14c, 14d -- Area source parameters
--------------------------------

---------------
Subgroup (14a)
---------------

     Number of polygon area sources with
     parameters specified below (NAR1)       No default  !  NAR1 =  0   !

     Units used for area source
     emissions below          (IARU)       Default: 1  !  IARU =   1  !
           1 =        g/m**2/s
           2 =       kg/m**2/hr
           3 =       lb/m**2/hr
           4 =     tons/m**2/yr
           5 =     Odour Unit * m/s  (vol. flux/m**2 of odour compound)
           6 =     Odour Unit * m/min
           7 =     metric tons/m**2/yr
           8 =     Bq/m**2/s  (Bq = becquerel = disintegrations/s)
           9 =     GBq/m**2/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (14d)        (NSAR1) Default: 0  !  NSAR1 =  0  !
```



```
     Number of buoyant polygon area sources
     with variable location and emission
     parameters (NAR2)                       No default  !  NAR2 =  0   !
     (If NAR2 > 0, ALL parameter data for
     these sources are read from the file: BAEMARB.DAT)

!END!

---------------
Subgroup (14b)
---------------
                                       a
          AREA SOURCE: CONSTANT DATA
          ----------------------------
                                                              b
Source           Effect.    Base      Initial    Emission
 No.             Height   Elevation   Sigma z     Rates
                   (m)       (m)        (m)
-------          ------    ------     --------   ---------


--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.
    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IARU
     (e.g. 1 for g/m**2/s).

---------------
Subgroup (14c)
---------------

           COORDINATES (km) FOR EACH VERTEX(4) OF EACH POLYGON
           --------------------------------------------------------
Source                                                             a
 No.       Ordered list of X followed by list of Y, grouped by source
------     ------------------------------------------------------------


--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.


---------------
Subgroup (14d)
---------------
                                                a
          AREA SOURCE: VARIABLE EMISSIONS DATA
          --------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 14b.  Factors entered multiply the rates in 14b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use BAEMARB.DAT and NAR2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
```

```
                                 0, 5, 10, 15, 20, 25, 30, 35, 40,
                                 45, 50, 50+)


--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


---------------------------------------------------------------------------
----

INPUT GROUPS: 15a, 15b, 15c -- Line source parameters
---------------------------

---------------
Subgroup (15a)
---------------

     Number of buoyant line sources
     with variable location and emission
     parameters (NLN2)                              No default  !  NLN2 =
     0   !

     (If NLN2 > 0, ALL parameter data for
      these sources are read from the file: LNEMARB.DAT)

     Number of buoyant line sources (NLINES)        No default   ! NLINES =
     0  !

     Units used for line source
     emissions below               (ILNU)           Default: 1  !  ILNU =
     1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr
           8 =     Bq/s  (Bq = becquerel = disintegrations/s)
           9 =     GBq/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (15c)        (NSLN1) Default: 0  !  NSLN1 =  0  !

     Maximum number of segments used to model
     each line (MXNSEG)                             Default: 7   ! MXNSEG =
     7  !

     The following variables are required only if NLINES > 0.  They are
     used in the buoyant line source plume rise calculations.

        Number of distances at which                Default: 6   ! NLRISE =
        6  !
        transitional rise is computed

        Average building length (XL)                No default   ! XL = .0
        !
                                                    (in meters)

        Average building height (HBL)               No default   ! HBL = .0
        !
                                                    (in meters)

        Average building width (WBL)                No default   ! WBL = .0
        !
                                                    (in meters)
```



```
        Average line source width (WML)             No default   ! WML = .0
        !
                                                    (in meters)

        Average separation between buildings (DXL)  No default   ! DXL = .0
        !
                                                    (in meters)

        Average buoyancy parameter (FPRIMEL)        No default   ! FPRIMEL
        = .0 !
                                                    (in m**4/s**3)

!END!

---------------
Subgroup (15b)
---------------

          BUOYANT LINE SOURCE: CONSTANT DATA
          ----------------------------------

a
Source     Beg. X      Beg. Y      End. X    End. Y     Release    Base
Emission
 No.     Coordinate  Coordinate  Coordinate Coordinate  Height    Elevation
 Rates
            (km)        (km)        (km)       (km)       (m)       (m)
------   ----------  ----------  ---------  ----------  -------   ---------
---------

--------

    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by ILNTU
     (e.g. 1 for g/s).

---------------
Subgroup (15c)
---------------
                                                      a
          BUOYANT LINE SOURCE: VARIABLE EMISSIONS DATA
          ----------------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 15b.  Factors entered multiply the rates in 15b.
     Skip sources here that have constant emissions.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
```

```
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


---------------------------------------------------------------------------
----


INPUT GROUPS: 16a, 16b, 16c -- Volume source parameters
---------------------------

---------------
Subgroup (16a)
---------------

     Number of volume sources with
     parameters provided in 16b,c (NVL1)     No default  !  NVL1 =  0   !

     Units used for volume source
     emissions below in 16b       (IVLU)     Default: 1  !  IVLU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr
           8 =     Bq/s  (Bq = becquerel = disintegrations/s)
           9 =     GBq/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (16c)      (NSVL1)    Default: 0  !  NSVL1 =  0  !

     Number of volume sources with
     variable location and emission
     parameters                   (NVL2)     No default  !  NVL2 =   0   !

     (If NVL2 > 0, ALL parameter data for
      these sources are read from the VOLEMARB.DAT file(s) )

!END!

---------------
Subgroup (16b)
---------------
                                                a
           VOLUME SOURCE: CONSTANT DATA
           ------------------------------

b
         X           Y        Effect.    Base     Initial    Initial
         Emission
     Coordinate  Coordinate   Height   Elevation  Sigma y    Sigma z
     Rates
        (km)       (km)         (m)       (m)        (m)        (m)
     ----------  ----------   ------    ------    --------   --------
     --------


--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IVLU
     (e.g. 1 for g/s).

---------------
```



```
Subgroup (16c)
---------------
                                                 a
          VOLUME SOURCE: VARIABLE EMISSIONS DATA
          ----------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 16b.  Factors entered multiply the rates in 16b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use VOLEMARB.DAT and NVL2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


---------------------------------------------------------------------------
----

INPUT GROUPS: 17a & 17b -- Non-gridded (discrete) receptor information
-----------------------

---------------
Subgroup (17a)
---------------

     Number of non-gridded receptors (NREC)  No default  !  NREC =  34   !

!END!

---------------
Subgroup (17b)
---------------
                                                 a
           NON-GRIDDED (DISCRETE) RECEPTOR DATA
           ------------------------------------

                     X            Y          Ground        Height   b
Receptor        Coordinate    Coordinate    Elevation    Above Ground
  No.              (km)          (km)          (m)           (m)
--------        ----------    ----------    ---------    ------------
     1 ! X =      386.998,      6362.55,       2.449,         0.000!   !END!
     2 ! X =      387.134,     6362.274,       1.871,         0.000!   !END!
     3 ! X =      387.207,     6361.994,       7.028,         0.000!   !END!
     4 ! X =       387.24,     6361.688,       4.165,         0.000!   !END!
     5 ! X =       387.27,     6361.393,       6.189,         0.000!   !END!
     6 ! X =      387.265,     6361.094,       9.474,         0.000!   !END!
     7 ! X =      387.216,     6360.799,       6.777,         0.000!   !END!
     8 ! X =      387.098,     6360.513,       2.991,         0.000!   !END!
     9 ! X =      386.975,     6360.246,       4.213,         0.000!   !END!
    10 ! X =      386.826,     6359.996,       1.372,         0.000!   !END!
    11 ! X =      386.714,     6359.711,       2.213,         0.000!   !END!
    12 ! X =      386.598,     6359.464,       2.313,         0.000!   !END!
    13 ! X =      386.499,     6359.186,       4.234,         0.000!   !END!
```

```
    14 ! X =     386.305,   6358.943,       2.976,       0.000!   !END!
    15 ! X =     386.159,   6358.706,       2.761,       0.000!   !END!
    16 ! X =      385.98,   6358.454,       5.529,       0.000!   !END!
    17 ! X =     385.848,   6358.178,       4.697,       0.000!   !END!
    18 ! X =     385.717,   6357.885,       0.584,       0.000!   !END!
    19 ! X =      381.75,   6360.433,      21.204,       0.000!   !END!
    20 ! X =      382.03,   6360.237,      21.102,       0.000!   !END!
    21 ! X =     382.291,    6360.08,       9.612,       0.000!   !END!
    22 ! X =     382.595,    6360.03,       8.022,       0.000!   !END!
    23 ! X =     382.786,     6359.8,       5.027,       0.000!   !END!
    24 ! X =     383.051,   6359.679,      17.439,       0.000!   !END!
    25 ! X =     383.256,   6359.451,      11.780,       0.000!   !END!
    26 ! X =     383.337,   6359.154,       9.699,       0.000!   !END!
    27 ! X =     383.331,   6358.859,       9.041,       0.000!   !END!
    28 ! X =     383.549,   6358.648,       6.775,       0.000!   !END!
    29 ! X =     383.828,   6358.516,       5.499,       0.000!   !END!
    30 ! X =     384.059,   6358.335,       4.236,       0.000!   !END!
    31 ! X =     384.399,    6358.26,       3.181,       0.000!   !END!
    32 ! X =     384.643,   6358.299,       3.443,       0.000!   !END!
    33 ! X =     384.884,   6358.322,       3.751,       0.000!   !END!
    34 ! X =     384.922,   6358.116,       3.361,       0.000!   !END!


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    a
     Data for each receptor are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     Receptor height above ground is optional.  If no value is entered,
     the receptor is placed on the ground.
```

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