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WAITSIA GAS PROJECT – STAGE 2
AIR DISPERSION MODELLING

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AIR DISPERSION MODELLING

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Prepared by	**Martin Parsons**
Checked by	**Ruth Peiffer**
Approved by	**John Miragliotta**

Ramboll
Suite 3, Level 2
200 Adelaide Terrace
East Perth
WA 6004
Australia

T +61 8 9225 5199
F +61 8 9225 5155
https://ramboll.com

Ramboll Australia Pty Ltd.
ACN 095 437 442
ABN 49 095 437 442

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1. INTRODUCTION

AWE Perth Pty Ltd is a wholly owned subsidiary of AWE Limited. Mitsui E&P Australia Pty Ltd and AWE Ltd are wholly owned subsidiaries of Mitsui & Co. Ltd. Combined they form the unified brand Mitsui E&P Australia Group (MEPAU). MEPAU is an oil and gas exploration and production business with a head office located in Perth, Western Australia.

MEPAU manages the Waitsia Gas Field located on grazing land in the Shire of Irwin, about 16 km south-east of Dongara and 367 km north of Perth (see Figure 1). The field sits within the Geraldton Sandplains bioregion of Western Australia.

The Waitsia Gas Project is the largest conventional onshore Australian discovery in 40 years. It currently consists of five oil and gas wells on petroleum permits L1 and L2. The field was discovered in 2014 and has been developed in stages. The field is currently producing from two wells, Waitsia-01 and Senecio-03 (collectively known as Waitsia Gas Project Stage 1). Wells Waitsia-02, Waitsia-03 and Waitsia-04 wells are currently suspended.

MEPAU is proposing to construct and operate the Waitsia Gas Plant and related infrastructure, collectively known as the Waitsia Gas Project – Stage 2 (WGP2). The Waitsia Gas Project – Stage 2 (WGP2) involves:

- Construction of a gas plant with a maximum capacity of 250 (terajoule) TJ per day (Waitsia Gas Plant).
- The operation of five (5) existing wells.
- The drilling of up to an additional 6 wells.
- A gathering system comprising flowlines and hubs to convey the extracted gas to the plant and the gas distribution network.

Ramboll Australia Pty Ltd (Ramboll) has been engaged by MEPAU to undertake air dispersion modelling to assess the potential air quality impacts of atmospheric emissions from the proposed development of the WGP2, comparing the Ground Level Concentrations (GLCs) predicted at sensitive receptor locations against the relevant ambient air quality criteria. This report presents the approach, methodology and results of air dispersion modelling for the Facility operating under the nominated scenario.

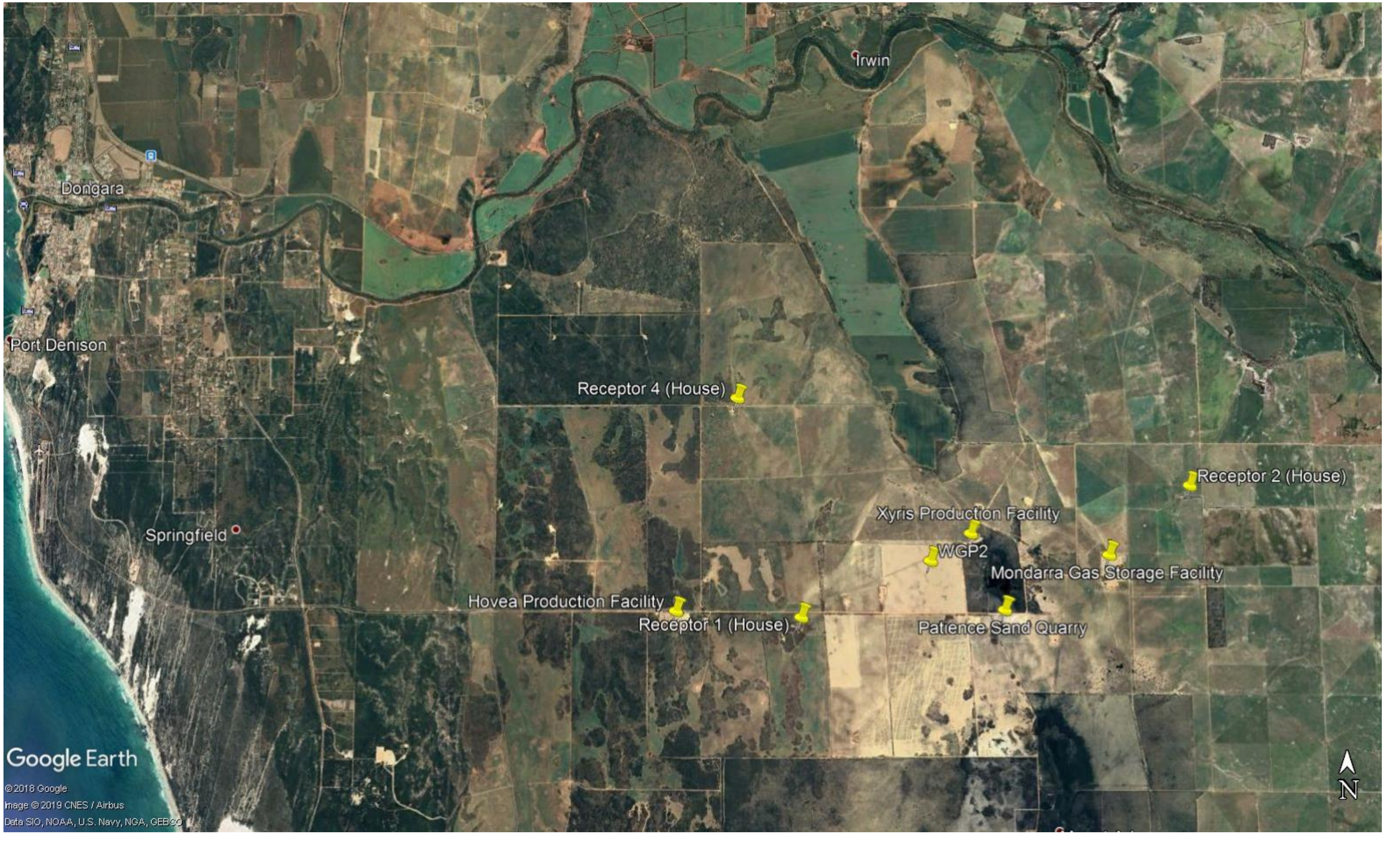

Figure 1. Overview of Project Location

2. ATMOSPHERIC EMISSIONS

2.1 Introduction

This section provides details on the atmospheric emissions of concern from the proposed expansion of the WGP2 and other sources in the region. Emissions of concern from the WGP2 are oxides of nitrogen (NO_X), sulphur dioxide (SO_2), carbon monoxide (CO), particulate matter including $PM_{2.5}$ and PM_{10}, VOCs (including benzene, toluene, ethylbenzene and xylene) (BTEX) and mercury (Hg).

Besides the WGP2 sources, other emission sources that are significant in the region include the Mondarra Gas Storage Facility (MGSF), the Xyris Production Facility (XPF), the Hovea Production Facility and the nearby Patience sand mining operation.

2.2 Waitsia Gas Project – Stage 2 Emissions

Emission sources from the proposed expansion of the WGP2 include the following:

- Compressor gas engines – Compression will be undertaken by two sets of three 2,600kw compressors. Each set of compressors will operate on an n+1 basis and so only 4 compressors will be operating at any one time. Emissions of concern are primarily considered to be NO_X;
- Gas Engine Alternator (GEA) – Power will be supplied by four 2,100kw generators. Then generators will be operating on an n+1 basis and so only three generators will operate at any one time. Emissions of concern are primarily considered to be NO_X;
- Heating Medium Boiler – A 15,000kw Heating Medium Boiler will operate continuously. Emissions of concern are primarily considered to be NO_X;
- Incinerator – An incinerator will be used to incinerate acid gases removed during processing. Emissions of concern are primarily considered to be $NO_{X;}$
- Flare – A flare will operate with a pilot light under normal operations and gas will be rerouted to the flare under an emergency scenario. In the event that the incinerator is not operational, the acid gas emissions will be redirected to the flare.
- Evaporation Pond – A process water pond will be used which can contain some trace amounts of hydrocarbon and so has been included as fugitive emissions sources. Emissions of concern are primarily considered to be BTEX and mercury;
- Vehicular combustion sources – Motor vehicles are considered a negligible source of atmospheric emissions (during both construction and operation), though they can result in relatively high ground level concentrations (GLCs) immediately adjacent to highly trafficked roads under stable, light wind conditions; and
- Fugitive dust from motor vehicle traffic and nearby exposed surfaces. This source is difficult to quantify accurately and therefore model and is considered best addressed through a monitoring and management program.

2.3 Other Regional Emission Sources

Other sources considered as part of this assessment include the proposed XPF, MGSF, the Patience Sand Quarry and the Hovea Production Facility.

2.4 Xyris Production Facility Emissions

The XPF currently processes 10TJ/day however there are plans to increase the production of the facility to ~30TJ/day. Emission sources from the proposed expansion of the XPF have been considered as part of this assessment and include the following:

- Compressor gas engine – Compression will be undertaken by a 750kw CAT G3512 LE Lean burn four stroke. Emissions of concern are primarily considered to be NO_X;
- Gas Engine Alternator (GEA) – Power will be supplied by a 100kw Cummins CG6L-8G1 lean burn four stroke model engine. Emissions of concern are primarily considered to be NO_X;
- Vents – The vents include a gas breakout tank vent, a liquids storage tank vent and a plant vent. The plant vents are only used during plant maintenance when the plant needs to be de-pressured. Emissions of concern include BTEX and Hg.
- Two process water ponds including an evaporation pond and a turkey nest. Both ponds can contain some trace amounts of hydrocarbon and so have been included as fugitive emissions sources.
- Vehicular combustion sources – Motor vehicles are considered a negligible source of atmospheric emissions (during both construction and operation), though they can result in relatively high ground level concentrations (GLCs) immediately adjacent to highly trafficked roads under stable, light wind conditions; and
- Fugitive dust from motor vehicle traffic, construction activities and nearby exposed surfaces. This source is difficult to quantify accurately and therefore model, and is considered best addressed through a monitoring and management program.

2.4.1 Mondarra Gas Storage Facility

The MGSF operates approximately 3 km to the east of the WGP2 as shown in Figure 1. The MGSF is located between two major pipelines that service Perth: the Parmelia Pipeline and the Dampier to Bunbury Natural Gas Pipeline (DBNGP). The MGSF includes the following sources of emissions to air:

- Flare – A small quantity of gas is vented through a permanently lit flare. The gas that reaches the flare is used to maintain a blanket of gas over the liquids, effectively preventing ingress of air into the vessels. The flare can operate under either normal conditions, whereby the facility is in injection mode for 2/3 of the time and in withdrawal mode for 1/3 of the time, or under blow-out conditions, expected to only occur under extreme circumstances on a less that one hour per year basis.
- A vent is maintained at the site for emergency purposes and for purging gas from equipment prior to maintenance.
- Power Generation and Compressors – The MGSF has two natural gas powered 3.2 MW compressor reciprocating engines as well as two 300 kVA natural gas powered GEAs operating.

All emissions information was obtained from a previous modelling assessment as supplied by the APA Group (Synergetics, 2011).

2.4.2 Patience Sand Quarry

A sand quarry excavating and transporting 3000 tonnes per year of sand operates approximately 1 km to the south of the WGP2 as shown in Figure 1. The main sources of emissions associated with the quarry include the excavation and loading of the product, wind erosion of the quarry and the transport of the product.

2.4.3 Hovea Production Facility

The Hovea Production Facility is located approximately 5 km to the west of the WGP2 as shown in Figure 1. It is currently under care and maintenance with no known plans to operate into the future. The Hovea Production Facility does have an evaporation pond and a sump where stored water can contain some trace amounts of hydrocarbon. The evaporation ponds have been included in this assessment as fugitive sources.

2.5 Emissions Scenarios

For the operation of the WGP2, there are some variations in the emissions that can occur. For this modelling assessment, these are simplified into normal operations and emergency operations.

Normal operations at the WGP2 includes emissions from the generators, the compressors, the flare with a pilot flame, the heating medium boilers and the incinerator. The normal operations case that has been considered is the upper limit of such operations.

Emergency operations at the WGP2 includes emissions from the plant when the flare is operating at peak flow conditions. It has conservatively assumed that all other sources would remain operational. It is expected that emergency operations would only occur for a small number of hours, and as such this assessment has focussed on short term impacts (i.e. less than 24 hours) for this scenario.

2.6 Emissions Rates

Emission rates for the WGP2 and XPF sources were derived from a number of sources including manufacturer provided fuel consumption rates and emission factors, the National Pollutant Inventory (NPI) Combustion Sources Emissions Estimations Manual (NPI, 2008) and the NPI Oil and Gas Emissions Estimations Manual (NPI, 1999).

Emissions estimates for the sand quarry were derived from handling, wind erosion and haulage emissions factors outlined in the NPI Mining Emissions Estimations Manual (NPI, 2012).

Emission rates from the ponds were determined using the US EPA's WATER9 program which consists of analytical expressions for estimating air emissions of individual waste constituents in wastewater collection, storage, treatment, and disposal facilities.

2.7 Summary

A summary of the source parameters and emissions rates for the proposed expansion of the WGP2, as well as the XPF, MGSF, Hovea Production Facility and sand mining operations utilised in this assessment are presented in Table 1 to Table 5.

Table 1: Source Parameters and Emission Rates for WGP2

Emission Source	Gas Engine Generator	Export Gas Compressor Gas Turbine	Inlet Gas Compressor Gas Turbine	Heating Medium	Acid Gas Incinerator	Flare (Normal)	Flare (Peak Flow Rate)	Evap Pond
Stack Height (m)	3.5	9.8	9.8	8	18.5	18	18	-
Stack Internal Diameter (m)	0.35	1.27	1.27	0.9	1.4	0.5	0.5	-
Exit Velocity (m/s) [per unit]	63.8	31.4	31.4	30	16.3	20	20	-
Temperature (ºC)	400	450	450	400	815	-	-	-
Package Length (m)	12	6	6	3		-	-	-
Package Width (m)	4	2.5	2.5	3	2.1	-	-	-
Package Height (m)	3.5	2.7	2.7	4	17	18	18	-
Area (m^2)	-	-	-	-	-	-	-	21,576
NOx	6.57E-01	7.93E+00	7.93E+00	2.04E+00	1.66E+00	9.04E-04	4.46E+01	Nil
CO	1.48E+00	6.53E-01	6.53E-01	8.12E-01	3.14E-01	4.96E-03	2.44E+02	Nil
$PM_{2.5}$	2.05E-04	1.49E-02	1.49E-02	7.37E-02	2.85E-02	Negl	Negl	Nil
PM_{10}	2.05E-04	1.49E-02	1.49E-02	7.37E-02	2.85E-02	Negl	Negl	Nil
SO_2	2.06E-03	4.04E-03	4.04E-03	2.42E-03	9.36E-04	3.77E-06	1.88E-01	Nil
Benzene	1.17E-03	9.32E-05	9.32E-05	2.05E-03	1.49E-01	Negl	Negl	9.21E-03
Toluene	1.08E-03	1.03E-03	1.03E-03	3.26E-03	1.26E-01	Negl	Negl	4.48E-03
Ethylbenzene	1.05E-04	2.52E-04	2.52E-04	Negl	1.10E-01	Negl	Negl	1.61E-04
Xylene	4.89E-04	4.97E-04	4.97E-04	Negl	1.10E-01	Negl	Negl	3.34E-03
Hg	Negl	Negl	Negl	Negl	Negl	Negl	Negl	6.56E-06

Table 2: Source Parameters and Emission Rates for XPF

Emission Source	Gas Engine Generator	Export Gas Compressor Engine	Gas Breakout Tank	Liquids Storage Tank	Plant Vent	Sump	Turkeys Nest
Capacity (kw)	100	750	N/A	N/A	N/A	N/A	N/A
Stack Height (m)	2	5	8	8	5	N/A	N/A
Stack Internal Diameter (m)	0.114	0.179	0.29	0.146	0.1	N/A	N/A
Exit Velocity (m/s)	9.6	24.5	0.09	0.01	245	N/A	N/A
Temperature (°C)	300-400	300-400	23	20-30	0 to -5	25	25
Dimensions	N/A	N/A	N/A	N/A	N/A	33mx33mx2.5m	35mx25mx2.5m
Emission Rates							
NOx	1.30E-01	8.28E-01	N/A	N/A	N/A	N/A	N/A
CO	8.54E-02	5.44E-01	N/A	N/A	N/A	N/A	N/A
$PM_{2.5}$	1.18E-05	7.53E-05	N/A	N/A	N/A	N/A	N/A
PM_{10}	1.18E-05	7.53E-05	N/A	N/A	N/A	N/A	N/A
SO_2	1.19E-04	7.58E-04	N/A	N/A	N/A	N/A	N/A
Benzene	2.75E-03	1.73E-02	1.67E-04	4.70E-06	5.40E-02	2.37E-04	3.46E-04
Toluene	2.16E-03	1.36E-02	1.31E-04	3.69E-06	4.24E-02	1.08E-04	1.61E-04
Ethylbenzene	1.83E-04	1.15E-03	1.11E-05	3.12E-07	3.58E-03	3.88E-06	5.76E-06
Xylenes	8.46E-04	5.32E-03	5.13E-05	1.44E-06	1.66E-02	8.31E-05	1.25E-04
Hg	4.67E-08	2.94E-07	2.83E-09	7.98E-11	9.17E-07	4.14E-07	4.39E-07

Table 3: Source Parameters and Emission Rates for Mondarra Gas Storage Facility

Emission Source	Export Gas Compressor Engine	Gas Engine Generator	Flare
Total Quantity	2	2	1
Quantity Operating	2	2	1
Stack Height (m)	9	9	12.6
Stack Internal Diameter (m)	0.3	0.2	4.5
Exit Velocity (m/s)	15	21	0.14
Temperature (°C)	460	450	1000
Emission Rates			
NOx	3.31E+00	4.14E-01	2.03E-02
CO	2.17E+00	2.72E-01	1.17E-01
$PM_{2.5}$	2.78E-04	2.78E-05	1.67E-03
PM_{10}	2.78E-04	2.78E-05	1.67E-03
SO_2	3.06E-03	2.78E-04	0.00E+00
Benzene	1.67E-03	2.78E-04	5.56E-07
Toluene	1.67E-03	2.78E-04	8.33E-07
Ethylbenzene	2.78E-04	2.78E-05	0.00E+00
Xylenes	8.33E-04	8.33E-05	0.00E+00
Hg	0.00E+00	0.00E+00	0.00E+00
Locations			
Zone	50 J	50 J	50 J
Easting - Unit 1 (mE)	317215	317115	317332
Northing - Unit 1 (mN)	6756189	6756164	6756254
Easting - Unit 2 (mE)	317214	317116	
Northing - Unit 2 (mN)	6756211	6756150	

.

Table 4: Sand Mining Emissions Rates

Source	Unit	PM_{10}	$PM_{2.5}$
Excavation and Loading (8.0 t/day)	g/s	0.027	0.0136
Wind Erosion (6.54 Ha)	g/s	0.36	0.18
Haulage 300 m x 2 X Trucks/Day[1]	g/s	0.011	0.0055

Notes:

1. Assumed 82 t total load from 50 t haul truck https://www.cat.com/en_AU/products/new/equipment/off-highway-trucks/off-highway-trucks/18256246.html

Table 5: Source Parameters and Emission Rates for Hovea Facility

Emission Source	Evaporation Pond	Turkeys Nest
Zone	50 J	50 J
Easting (mE)	309752	309735
Northing (mN)	6755033	6755144
Temperature (°C)	25	25
Dimensions	45mx35mx1m	29mx24mx1.5m
Emissions Rates		
Benzene	5.47E-04	2.08E-04
Toluene	2.85E-04	1.00E-04
Ethylbenzene	1.03E-05	3.59E-06
Xylenes	2.11E-04	7.66E-05
Hg	2.40E-07	1.59E-07

3. IMPACT ASSESSMENT CRITERIA

3.1 Ambient Air Quality

In February 2017, the DWER published the Guidance Statement for Risk Assessments (DER, 2017) which lists Specific Consequence Criteria to be considered in determining public health and environment impacts. The publications containing air quality criteria relevant to this assessment include:

- National Environment Protection (Ambient Air Quality) Measure (NEPC, 2016);
- National Environment Protection (Air Toxics) Measure (NEPC, 2011); and
- Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW EPA, 2016).

The National Environment Protection (Ambient Air Quality) Measure specifies standards and goals for a range of pollutants relevant to this assessment, including CO, NO_2, SO_2, PM_{10} and $PM_{2.5}$ (Table 6).

Table 6: National Environment Protection (Ambient Air Quality) Measure Ambient Air Quality Standards and Goals

Pollutant	Averaging period	Maximum concentration standard[1]	Maximum allowable exceedances
Carbon monoxide	8 hours	10,000 µg/m^3	1 day a year
Nitrogen dioxide	1 hour 1 year	246 µg/m^3 62 µg/m^3	1 day a year None
Sulphur dioxide	1 hour 1 day 1 year	570 µg/m^3 228 µg/m^3 60 µg/m^3	1 day a year 1 day a year None
Particles as PM_{10}	1 day 1 year	50 µg/m^3 25 µg/m^3	None None
Particles as $PM_{2.5}$	1 day 1 year	25 µg/m^3 8 µg/m^3	None None

Notes:

1. Referenced to 0ºC, and 101.3 kPa

The National Environment Protection (Air Toxics) Measure specifies monitoring investigation levels for several key pollutants relevant to this assessment, including BTEX, established for use in assessing the significance of monitored levels of air toxics with respect to protection of human health as outlined in Table 7.

Table 7: National Environment Protection (Air Toxics) Measure Ambient Air Quality Monitoring Investigation Levels

Pollutant	Averaging period	Monitoring investigation level[1]	Goal
Benzene	Annual average	9.6 µg/m^3	8-year goal is to gather sufficient data nationally to facilitate development of a standard.
Toluene	24 hours Annual average	3769 µg/m^3 377 µg/m^3	8-year goal is to gather sufficient data nationally to facilitate development of a standard.
Xylenes (as total of ortho, meta and para isomers)	24 hours Annual average	1085 µg/m^3 868 µg/m^3	8-year goal is to gather sufficient data nationally to facilitate development of a standard.

Notes:

1. Referenced to 0ºC, and 101.3 kPa

The NSW EPA (2016) specifies statutory impact assessment criteria for modelling and assessing emissions of air pollutants from stationary sources. Impact assessment criteria have been established for various individual toxic air pollutants and for individual odorous air pollutants, including (but not limited to) mercury and BTEX. The NSW EPA (2016) impact assessment criteria for inorganic mercury, benzene and ethylbenzene are based on toxicity to humans.

For the purposes of assessing potential impacts upon human health, additional ambient air quality criteria are often adopted from the World Health Organisation (WHO) for mercury. The WHO has published a Concise International Chemical Assessment Document (CICAD) for Elemental Mercury and Inorganic Mercury Compounds: Human Health Aspects (WHO, 2003), which determines a tolerable concentration of 0.2 µg/m^3 for long-term inhalation exposure to elemental mercury vapour.

DWER recommends that for each pollutant modelled, the assessment must account for existing concentrations caused by other sources plus (if significant) the background concentration (whether natural or man-made) to estimate the cumulative concentration.

For the contribution to be properly assessed, DWER requires modelling results (as described in the foregoing point) to be presented for:

- The existing emissions plus background concentration (pre-proposal);
- The proposed development in isolation (excluding existing emissions); and
- The combined (existing plus proposed plus background) emissions.

A summary of the standards applicable for this assessment are summarised in Table 8 below.

Table 8: Ambient Air Quality Standards Applicable to WGP2

Pollutant	Averaging Period	Ambient Air Concentration ($\mu g/m^3$)[1]	Type	Reference
Carbon monoxide	8 hours	10,000	human health	NEPC (2016)
Nitrogen dioxide	1-hour	246	human health	NEPC (2016)
	Annual	62	human health	NEPC (2016)
Sulphur dioxide	1-Hour	570	human health	NEPC (2016)
	24-Hour	228	human health	NEPC (2016)
	Annual	60	human health	NEPC (2016)
Particles as PM_{10}	24-Hour	50	human health	NEPC (2016)
	Annual	25	human health	NEPC (2016)
Particles as $PM_{2.5}$	24-Hour	20[2]	human health	NEPC (2016)
	Annual	7[2]	human health	NEPC (2016)
Mercury inorganic	1-hour	1.8	human health	NSW EPA (2016)
	Annual	0.2	human health	WHO (2003)
Benzene	1-hour	29	human health	NSW EPA (2016)
	Annual	9.6	human health	NEPC (2011)
Ethylbenzene	1-Hour	7,344	human health	NSW EPA (2016)
Toluene	1-Hour	330	human health	NSW EPA (2016)
	24-hour	3,769	human health	NEPC (2011)
	Annual	377	human health	NEPC (2011)
Xylene	1-hour	174	human health	NSW EPA (2016)
	24-hour	1,085	human health	NEPC (2011)
	Annual	868	human health	NEPC (2011)

Notes:

1. Referenced to 0ºC, and 101.3 kPa
2. $PM_{2.5}$ concentrations presented are from proposed 2025 changes to National Environment Protection (Ambient Air Quality) Measure.

3.2 Workplace Exposure Standards

Workplace exposure standards for approximately 700 substances and mixtures have been established in Australia by Safe Work Australia, an Australian government statutory body. These are legal concentration limits that must not be exceeded. Workplace exposure standards are generally less conservative than ambient air quality standards to account for the general health of the workforce and shorter exposure times. Relevant workplace exposure standards are presented in Table 9.

Table 9: Workplace Exposure Standards

Pollutant	Averaging Period	Criteria ($\mu g/m^3$)[1]	Criteria Reference
NO_2	15-Minute	9400	Safe Work Australia (2013)
	8-Hour	5,600	Safe Work Australia (2013)
SO_2	15-Minute	13,000	Safe Work Australia (2013)
	8-Hour	5,200	Safe Work Australia (2013)
CO	8-hour	34,000	Safe Work Australia (2013)
Mercury	8-hour	25	Safe Work Australia (2013)
Benzene	8-hour	3,200	Safe Work Australia (2013)
Toluene	15-Minute	574,000	Safe Work Australia (2013)
	8-Hour	191,000	Safe Work Australia (2013)
	24-hour	3,769	NEPC (2011)
Ethylbenzene	15-Minute	543,000	Safe Work Australia (2013)
	8-Hour	434,000	Safe Work Australia (2013)
Xylene	15-Minute	655,000	Safe Work Australia (2013)
	8-Hour	350,000	Safe Work Australia (2013)
	24-hour	1,085	NEPC (2011)

Notes:

1. Referenced to 0ºC, and 101.3 kPa

4. ATMOSPHERIC DISPERSION MODELLING

4.1 Important Dispersion Processes to be Modelled

The relevant dispersion processes are dependent on the type of source, the topography, land use variations and general wind patterns. For the sources considered, the following meteorology and dispersion processes are important:

4.1.1 Plume Rise above the Stable Boundary Layer

Generally the buoyant plumes such as from the generators and compressors will penetrate any low inversion and remain above the inversion.

4.1.2 Morning Fumigation

This occurs in the morning when the morning mixed layer grows to the plume height and the plumes can be mixed rapidly to the ground. This phenomenon is generally considered to lead to the highest concentrations for distances greater than 5 to 10 km from the sources.

4.1.3 Plume Downwash due to Nearby Structures

Downwash of the plume by the turbulent eddies that develop when air flows over and around buildings. If the plume is emitted into or is caught in such an eddy, it can be brought to ground much sooner than would otherwise occur, resulting in higher GLCs.

4.1.4 Convective Dispersion

During the day time, the heated earth's surface will generate convective cells of rising and descending air which can bring any plume to the ground within several hundred metres of the source.

4.1.5 Terrain Effects on Airflow

Topography can impact significantly on air flow and therefore the dispersion of pollutants. The site however is generally flat and undulating and as such is considered to have only a minimal impact on dispersion.

4.1.6 Inclusion of Other Regional Sources – Cumulative Assessment

For pollutants where there is a significant cumulative impact (i.e. background levels are significant), the impact assessment needs to include existing regional sources and/or background concentrations.

4.2 Model Selection

Due to the number of sources in the region located some distance from each other, the air dispersion modelling has been using the CALPUFF air dispersion model with a meteorological dataset from 2018.

4.3 Meteorological Processing

The closest meteorological monitoring stations with the applicable data available for this study were Geraldton (~50km away) and Mullewa (~90km away). Due to the distances and the fact that Geraldton is located on the coast and Mullewa is located in a semi-arid environment, neither dataset was considered suitable for use in this assessment.

In the absence of suitable monitored data, the TAPM (The Air Pollution Model) prognostic meteorological model developed by CSIRO was used to generate a gridded meteorological dataset for the modelling domain for 2018. The TAPM output was used as inputs into the CALMET meteorological processor to develop a meteorological data file suitable for use in CALPUFF.

An annual wind rose generated by the CALMET meteorological processor using TAPM generated data for the WGP2 site is presented in Figure 2, with the annual frequency of wind speeds presented in Table 10.

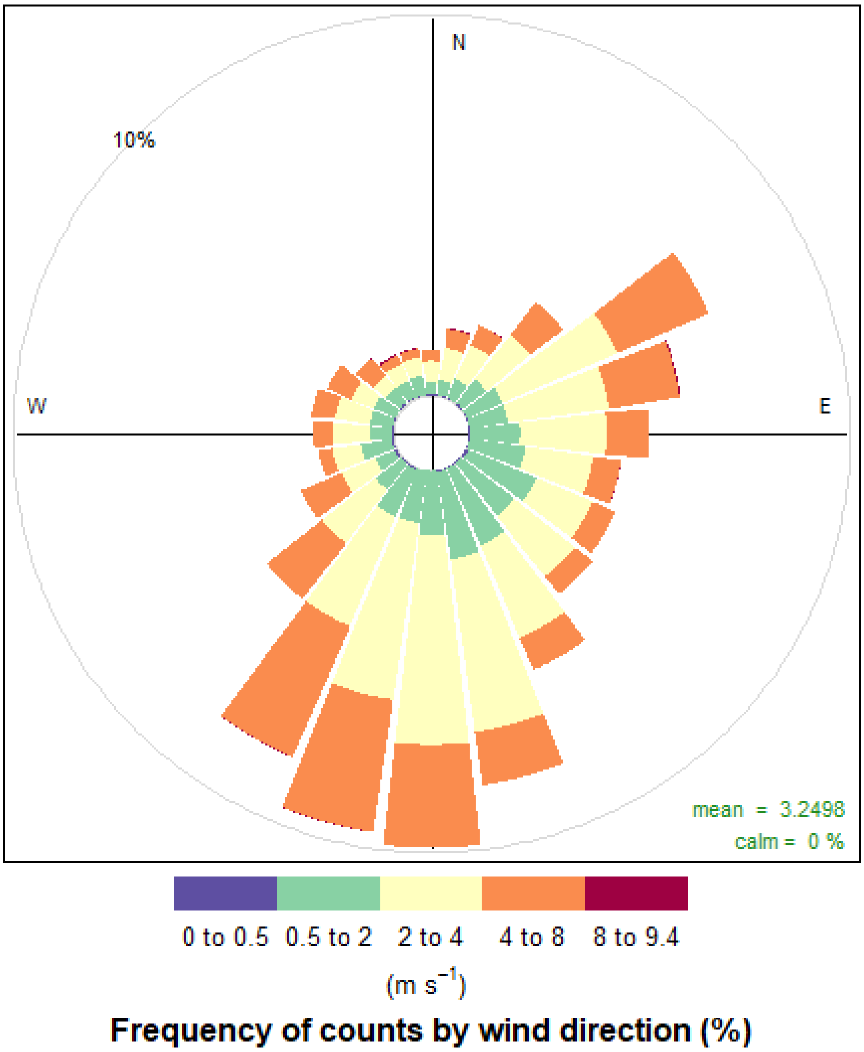

Figure 2. CALMET Generated Wind Rose

Table 10: Distribution of Wind Speeds for 2018 (CALMET-Generated Data)

Wind Speed	Calms	0.5–1.5 m/s	1.5-3.0 m/s	3.0-4.5 m/s	4.5-6.0 m/s	6.0-7.5 m/s	>7.5m/s
(%)	0.7	11.4	37.1	29.0	16.1	5.1	0.6

4.3.1 Model Validation against Meteorology

TAPM was used to generate the prognostic data for input into CALMET and then CALPUFF. The ability of TAPM to predict meteorological variables has been verified at numerous sites around the world (Hurley et al, 2004; Hurley, 2008). To verify the ability of the model to accurately predict wind direction and speed for this study, the TAPM predictions have been compared against the data from 3-hourly averaged data from the Bureau of Meteorology (BOM) meteorological monitoring station in Geraldton [Site name: Geraldton Airport, Site number: 008315, Latitude: 28.80° S, Longitude: 114.70° E, Elevation: 30 m (BOM 2019)].

Figure 3 presents the BOM meteorological station in Geraldton Airport. Some differences are expected when compared against the prognostic data as outline in Figure 2 due to the distance between the two locations and their distances from the coast: ~9 km and ~16 km, respectively. The main differences observed are:

- BOM dataset from Geraldton Airport shows an overall higher proportion of stronger winds (>8 m/s) blowing mostly from the south, which is likely related to its greater proximity to the coast;
- The prognostic-generated dataset for WGP2 presents a higher proportion of winds blowing from the east and northeast.

For the purposes of this assessment, the TAPM-generated dataset is considered representative of the region and is deemed appropriate for use in this assessment.

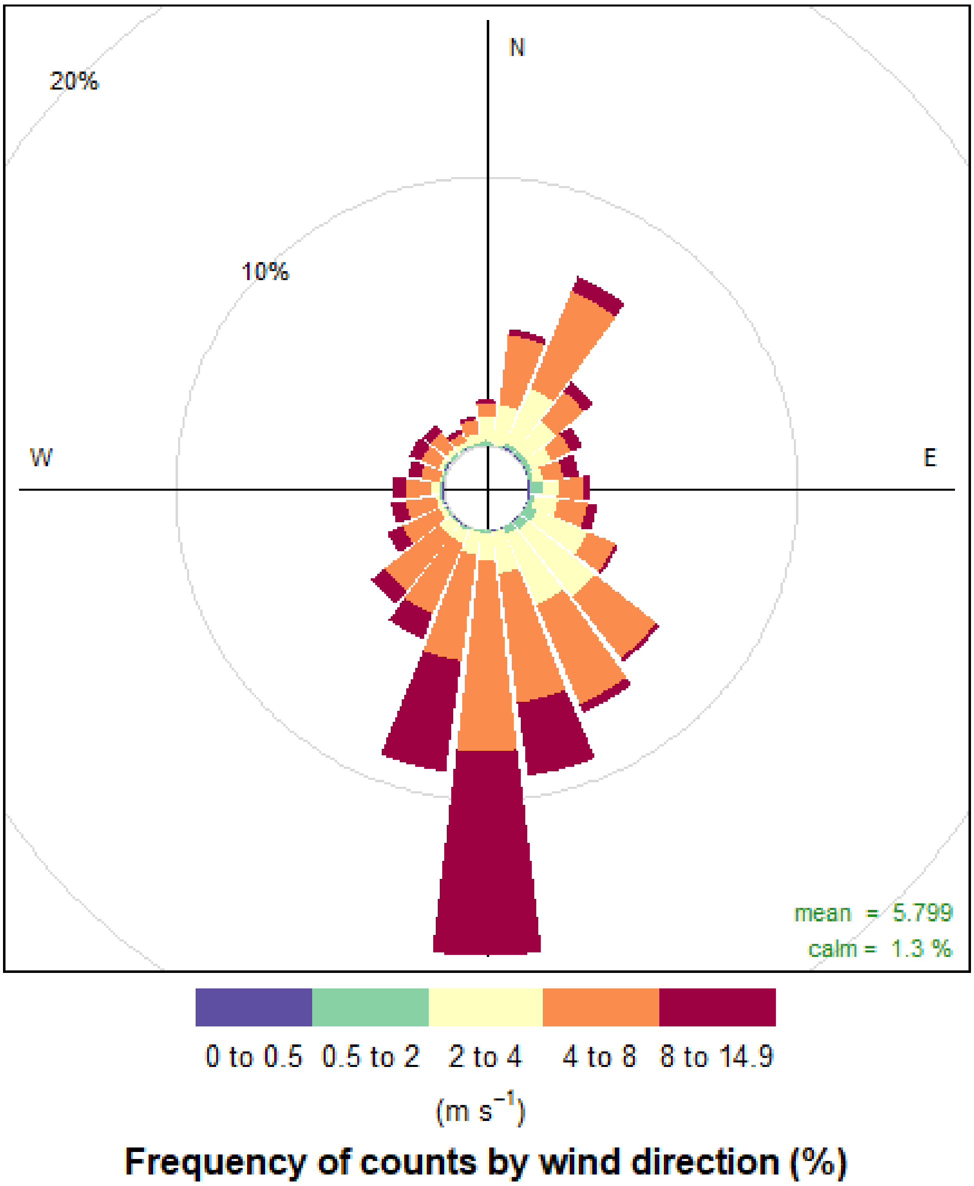

Figure 3. Annual (2018) Wind Rose from BOM measured dataset from Geraldton Airport

4.4 CALPUFF Model Set Up

The following model set up options within CALPUFF were used:

- Building downwash was included using the BPIP-Prime algorithms with site layout and elevation. All buildings assessed to potentially influence sources were included in the modelling;
- Grid spacings of 250 m over a 19 km x 19 km model domain were applied, centred approximately on the site;
- No chemical transformation or deposition, except for the prediction of NO_2 (as discussed in Section 4.6);

A summary of the CALPUFF inputs applied in this assessment is provided in Appendix 1.

4.5 Short Term Averaging Periods

Some workplace exposure standards are based on short term (15-minute) averages. However, air dispersion modelling is generally undertaken in 1 hour time steps and in order to compare the predicted concentrations against the nominated standards, a simple averaging-time scaling factor was used to estimate short-term peak concentrations. This adjustment primarily addresses the effect of meandering (fluctuations in the wind about the mean flow for the hour) on the average lateral distribution of material. The scaling factor used to adjust the lateral dispersion coefficient[1] for averaging time is the 1/5th power law:

$$Cl = Cs\ (60 / tl)^{0.2}$$

where
Cl = Concentration for new averaging period;
Cs = Concentration for the 1 hour average period;
tl = the averaging time (min.) of interest

4.6 Treatment of Oxides of Nitrogen

A key element in assessing the potential environmental impacts from ground level NO_2 concentrations is estimating NO_2 concentrations from modelled NO_x emissions. The final NO_2 concentration is a combination of the NO emitted as NO_2 from the source stacks and the amount of NO that is converted to NO_2 by oxidation in the plume after release.

Generally, after the NO_x is emitted from the stack, additional NO_2 is formed as the plume mixes and reacts with the surrounding air. There are several reactions that both form and destroy NO_2, but the primary reaction is oxidation with ozone according to the following reaction:

$$NO + O_3 \rightarrow NO_2 + O_2$$

This reaction is essentially instantaneous as the plume entrains the surrounding air. It is limited by the amount of ozone available and by how quickly the plume mixes with the surrounding air. Thus the ratio of NO_2 to NO_x increases as the plume disperses downwind. After release, the NO is converted to NO_2 by chemical reactions, primarily involving ozone in the presence of sunlight and to a lesser extent due to other reactive gases.

In order to predict NO_2 concentrations, Ramboll has applied the US Environmental Protection Agency (USEPA) Ozone Limiting Method (OLM). This method assumes that ozone is the limiting reagent (i.e. the ozone concentration is less than the remaining NOx concentration) and requires an NO_2 to NO_x in-stack ratio. In the absence of a site-specific in-stack ratio, it has been assumed that 10% of NO_x emissions are NO_2 (a common assumption for gas combustion sources). Hourly average ozone concentrations for application in the OLM were obtained from the Caversham ambient air quality monitoring station as discussed in Section 4.10.

The OLM approach is considered conservative over short-term averaging periods as it assumes the reaction between NO_x and ozone occurs instantaneously, when in reality this is likely to take place over a number of hours, during which time the plume is subject to dispersion.

4.7 Ozone

Photochemical smog is an air pollution problem commonly found in large cities. It is characterised by high ozone concentrations at ground level, and can be generated through the interaction of NO_x and reactive organic compounds (ROC) which includes BTEX in the environment.

The proposed WGP2 expansion is expected to be a relatively small emitter of NOx. Based on the emission rates provided in Table 1 and assuming continuous release throughout the year, it is estimated that the proposed WGP2 will emit approximately 1,300 tonnes of NO_x and 30 tonnes of VOCs annually.

By comparison, data from the NPI indicates a total of 760,000 tonnes of NO_x were emitted to the Kalgoorlie airshed for the 2018/2019 reporting year, where ozone is not considered a contaminant of concern.

In considering these figures, and the likelihood that the surrounding region is unlikely to have elevated concentrations of ozone given its rural and remote settings, photochemical modelling of NO_x and VOC emissions from the WGP2 has not been undertaken as part of this assessment.

4.8 Receptors

Concentrations for all relevant compounds and averaging periods were predicted at three farmhouses surrounding the facility as show in Figure 1 and at an onsite receptor to assess occupational exposure impacts at site. Table 11 presents the locations of the dwelling and onsite locations.

Table 11: Receptor Locations (UTM coordinates)

Receptor	mE	mN	Type
Rec_001	311822	6755012	Dwelling
Rec_002	318515	6757359	Dwelling
Rec_003	314800	6756400	Onsite
Rec_004	310650	6758684	Dwelling

4.9 Building Downwash

According to modelling guidance "rules of thumb", downwash should be considered when nearby structures are more than 40% of the stack height. For the WGP2 sources, dimensions for relevant structures were provided by MEPAU and included as buildings. For the MGSF, building information was obtained from the previous modelling assessment as supplied by the APA Group (Synergetics, 2011).

4.10 Background Concentrations Used in the Modelling

The WGP2 is located in a remote location with no significant local sources of CO, SO_2, NO_2 or air toxics (other than those included as sources in this assessment). Particulate matter could arise from wind-blown dust but is still likely to be significantly lower than in a suburban environment affected by road transport and other combustion sources. No background monitoring data was identified in this assessment that was either in the immediate proximity of the study site or deemed to be representative of this location. Rather, most ambient air quality monitoring sites are located either in densely populated areas or near large known polluters in industrial zones.

The Western Australian Department of Water and Environment Regulation (DWER) collects air quality data from a number of monitoring stations throughout the Perth, Kwinana, Southwest, Kalgoorlie and Midwest regions of the state. Only two sites monitoring the pollutants of interest were identified that were not in a densely populated area and were not under the strong direct influence of a large polluting source: Caversham (NE suburbs of Perth) and Rolling Green (outer east rural site). Data from Caversham (DWER, 2018) was used as the more conservative estimate (a semi-rural, outer suburban setting being more likely to have higher concentrations of most pollutants compared with a rural one).

The Environment Protection Authority Victoria (Vic EPA) State Environment Protection Policy (Ambient Air Quality) (SEPP (AQM)) (Gov. of Vic., 2001) recommends the 75th percentile concentration (concentration which is exceeded by 25% of concentrations for that averaging period) should be adopted as a background level for short term averages. For comparison against the short term workplace exposure standards, the 1 hour average was utilised. Annual averages were used for long term averages.

Table 12 presents a summary of the background concentrations obtained from the Caversham monitoring station (2017) and utilised as part of this assessment. No representative background data was available for Hg and BTEX, however it is unlikely that there are any significant sources of these compounds, other than those modelled.

Table 12: Nominated Background Concentrations for Pollutants

Pollutant	Averaging Period	Representative Background ($\mu g/m^3$)
NO_2	15-Minute 1-hour, 8-hour	39
	Annual	10
SO_2	15-Minute 1-hour, 8-hour	31
	1-day	9
	Annual	9
CO	8-hour	250
PM_{10}	24-hour	20
	Annual	16
$PM_{2.5}$	24-hour	9
	Annual	9

It should be noted that the annual average for $PM_{2.5}$ is already in exceedance of the guideline. It is unlikely that this is representative of conditions in the region, however in the absence of site-specific data, it has been utilised. Additionally, MEPAU has commissioned an air quality monitoring program which will provide accurate site-specific baseline data.

5. PREDICTED CONCENTRATIONS

The following sections present the predicted concentrations of NO_2, CO, SO_2, PM_{10}, $PM_{2.5}$, Hg and BTEX using the model CALPUFF. GLCs of the modelled compounds have been predicted within the modelling domain. The predicted GLCs for the proposed expansion of the WGP2 operating both in isolation and cumulatively with existing sources and background concentrations at the nominated receptor locations, are summarised in Table 13 to Table 20.

Tables 13 to 18 present the predicted concentrations and the percentage of the ambient air quality guideline values, both with and without background concentrations, at the nominated sensitive receptor locations. Tables 19 to 20 present the predicted concentrations and the percentage of the workplace exposure standards, both with and without background concentrations, at the nominated onsite receptor location.

The results of the air dispersion modelling assessment show that predicted GLCs for most compounds in isolation and cumulatively are well below the corresponding ambient air quality and workplace exposure standard criteria at the nominated receptor locations, with the exception of the scenarios that consider annual average background concentrations of $PM_{2.5}$. The annual average background concentrations of $PM_{2.5}$ were obtained from the Caversham monitoring station and were already in exceedance of the guideline before consideration of emissions from other sources. Given the rural nature and lack of industry in the region around the proposed facility it is highly likely that the actual background concentrations of $PM_{2.5}$ in the region are significantly below the monitored concentrations at Caversham. The annual average concentrations of $PM_{2.5}$ predicted for the proposed expansion of the WGP2 and other existing sources, without consideration of background concentrations, are equal to 4% of the annual average $PM_{2.5}$ guideline.

When considered without measured background concentrations, short term impacts from NO_2 were predicted to be the main pollutant of concern from the WGP2 and MGSF, although predicted concentrations remain well below the nominated guideline. Figure 3 presents a contour plot of predicted cumulative concentrations of NO_2 (under normal operations) in the region excluding background.

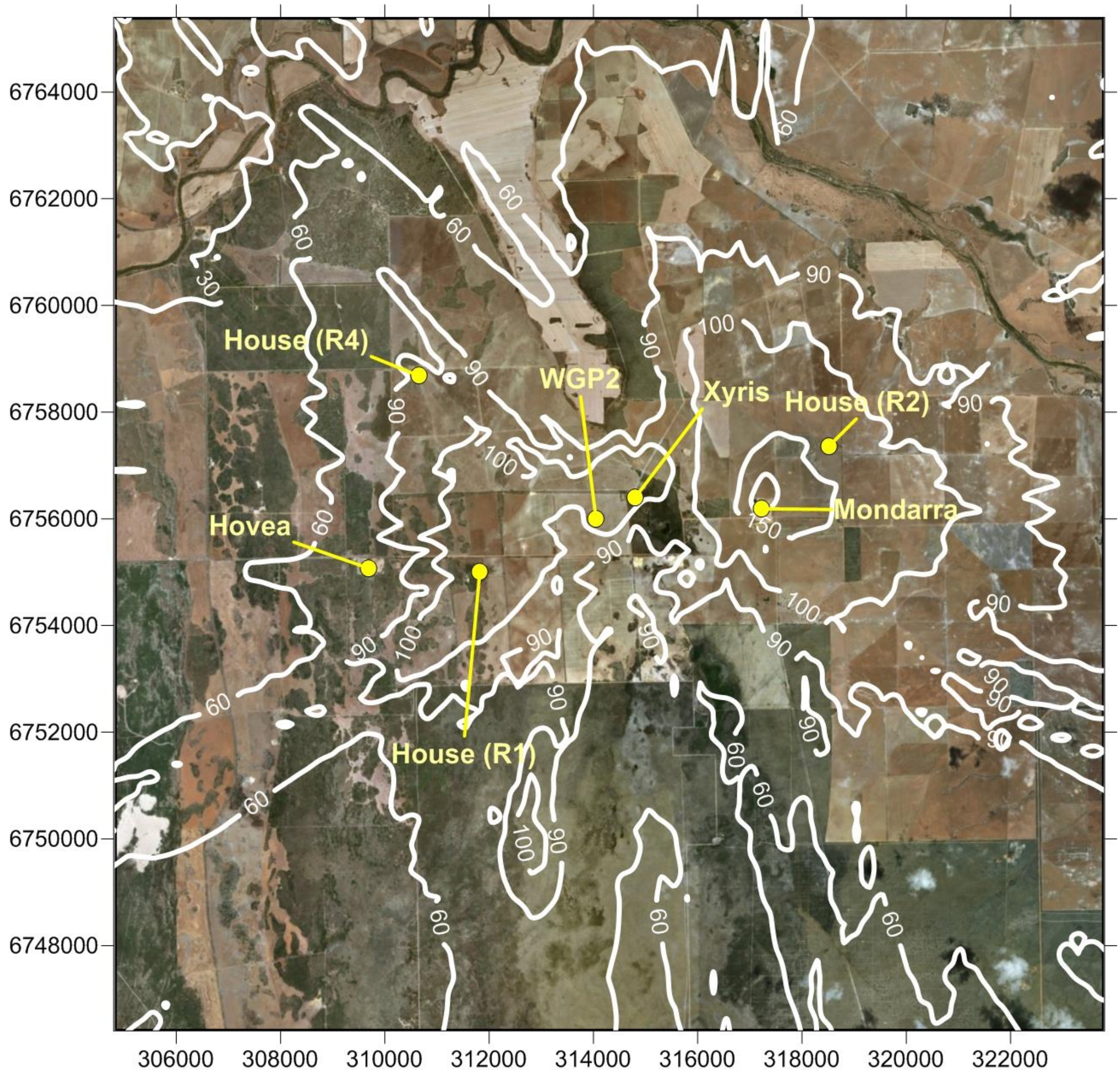

Figure 4. Maximum Predicted 1-hour Average GLCs of NO_2 for Cumulative Operations Without Nominated Background Concentrations

Table 13: Predicted Concentrations and Percentage of Guideline without Background at Sensitive Receptor 1

Pollutant	Averaging Period	Criteria (µg/m³)	Existing		WGP2 in Isolation		Cumulative - Normal Operations		Cumulative - Emergency Operations	
			Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.
NO_2	1-hour Max	246	86	35%	127	52%	130	53%	130	53%
	Annual Av	62	1.1	2%	2.8	4.5%	3.8	6%	3.8	6%
SO_2	1-hour Max	570	0.09	0.02%	0.43	0.07%	0.45	0.08%	0.45	0.08%
	24-hour Max	228	0.012	0.005%	0.06	0.027%	0.07	0.032%	0.07	0.032%
	Annual Av	60	0.0010	0.002%	0.0036	0.0060%	0.005	0.008%	0.005	0.008%
CO	8-hour Max	10,000	44	0.4%	130	1.3%	139	1.4%	139	1.4%
PM_{10}	24-hour Max	50	1.1	2%	0.485	0.970%	1.3	3%	1.3	3%
	Annual Av	25	0.1	0.4%	0.03066	0.1226%	0.1	0.5%	0.1	0.5%
$PM_{2.5}$	24-hour Max	25	1.1	4%	0.485	1.941%	1.3	5%	1.3	5%
	Annual Av	8	0.1	1%	0.03066	0.3832%	0.1	2%	0.1	2%
Mercury	1-hour Max	2	0.00005	0.003%	0.00083	0.046%	0.00083	0.046%	0.0008	0.05%
	Annual Av	0.2	0.0000004	0.0002%	0.0000045	0.0023%	0.0000050	0.0025%	0.000005	0.0025%
Benzene	1-hour Max	29	1.07	3.7%	2.8	10%	3	12%	3	12%
	Annual Av	9.6	0.0071	0.074%	0.027	0.28%	0.034	0.36%	0.03	0.36%
Toluene	1-hour Max	330	0.84	0.25%	2.2	0.7%	2.7	0.8%	3	0.8%
	Annual Av	377	0.0056	0.0015%	0.021	0.006%	0.027	0.007%	0.03	0.007%
Ethylbenzene	1-hour Max	7,344	0.07	0.0010%	1.75	0.024%	1.76	0.024%	1.8	0.024%
Xylene	1-hour Max	330	0.33	0.10%	1.9	0.57%	2.1	0.6%	2.1	0.6%
	Annual Av	868	0.0023	0.00026%	0.018	0.0020%	0.020	0.0023%	0.02	0.002%

Table 14: Predicted Concentrations and Percentage of Guideline with Background at Sensitive Receptor 1

Pollutant	Averaging Period	Criteria (µg/m³)	Background		Existing		WGP2 in Isolation		Cumulative - Normal Operations		Cumulative - Emergency Operations	
			Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.
NO_2	1-hour Max	246	39	16%	125	51%	166	67%	169	69%	169	69%
	Annual Av	62	10	16%	11	18%	13	21%	14	22%	14	22%
SO_2	1-hour Max	570	31	5%	31	5%	31	6%	31	6%	31	6%
	24-hour Max	228	9	4%	9	4%	9	4%	9	4%	9	4%
	Annual Av	60	9	15%	9	15%	9	15%	9	15%	9	15%
CO	8-hour Max	10,000	250	3%	294	3%	380	4%	389	4%	389	4%
PM_{10}	24-hour Max	50	20	40%	21	42%	20	41%	21	43%	21	43%
	Annual Av	25	16	64%	16	65%	16	65%	16	65%	16	65%
$PM_{2.5}$	24-hour Max	25	9	37%	10	41%	10	39%	11	43%	11	43%
	Annual Av	8	9	113%	9	114%	9	113%	9	114%	9	114%

Notes:

Annual average background concentrations of $PM_{2.5}$ are above the guideline before the addition of other regional and WGP2 sources. This data was obtained from the Caversham monitoring station located in the Perth Metropolitan Area. Given its rural nature, it is likely that background $PM_{2.5}$ concentrations will be significantly below the concentrations presented as background in this table, however they have been included in this assessment for completeness.

Table 15: Predicted Concentrations and Percentage of Guideline without Background at Sensitive Receptor 2

Pollutant	Averaging Period	Criteria (µg/m³)	Existing		WGP2 in Isolation		Cumulative - Normal Operations		Cumulative - Emergency Operations	
			Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.
NO_2	1-hour Max	246	117	48%	86	35%	117	48%	117	48%
	Annual Av	62	1.9	3%	0.5	0.8%	2.4	4%	2.4	4%
SO_2	1-hour Max	570	0.38	0.07%	0.11	0.02%	0.38	0.07%	0.38	0.07%
	24-hour Max	228	0.059	0.026%	0.01	0.005%	0.06	0.026%	0.06	0.026%
	Annual Av	60	0.0022	0.004%	0.0005	0.0008%	0.003	0.005%	0.003	0.005%
CO	8-hour Max	10,000	180	1.8%	45	0.4%	180	1.8%	180	1.8%
PM_{10}	24-hour Max	50	2.1	4%	0.094	0.188%	2.1	4%	2.1	4%
	Annual Av	25	0.05	0.2%	0.00361	0.0144%	0.1	0.2%	0.05	0.2%
$PM_{2.5}$	24-hour Max	25	2.1	9%	0.094	0.377%	2.1	9%	2.1	9%
	Annual Av	8	0.0	1%	0.00361	0.0451%	0.05	1%	0.05	1%
Mercury	1-hour Max	2	0.000036	0.0020%	0.00021	0.012%	0.00022	0.012%	0.0002	0.01%
	Annual Av	0.2	0.00000014	0.000069%	0.0000006	0.0003%	0.0000007	0.0004%	0.0000007	0.0004%
Benzene	1-hour Max	29	0.50	1.7%	0.7	2%	1.0	3%	1	3%
	Annual Av	9.6	0.0029	0.030%	0.004	0.04%	0.007	0.07%	0.01	0.1%
Toluene	1-hour Max	330	0.39	0.12%	0.6	0.2%	0.8	0.2%	1	0.2%
	Annual Av	377	0.0025	0.0007%	0.003	0.001%	0.006	0.001%	0.01	0.001%
Ethylbenzene	1-hour Max	7,344	0.03	0.0005%	0.50	0.007%	0.50	0.0068%	0.5	0.007%
Xylene	1-hour Max	330	0.15	0.05%	0.5	0.15%	0.5	0.15%	0.5	0.2%
	Annual Av	868	0.0011	0.00013%	0.003	0.0003%	0.004	0.0004%	0.00	0.0004%

Table 16: Predicted Concentrations and Percentage of Guideline with Background at Sensitive Receptor 2

Pollutant	Averaging Period	Criteria (µg/m³)	Background		Existing		WGP2 in Isolation		Cumulative - Normal Operations		Cumulative - Emergency Operations	
			Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.
NO_2	1-hour Max	246	39	16%	156	64%	125	51%	156	64%	156	64%
	Annual Av	62	10	16%	12	19%	10	17%	12	20%	12	20%
SO_2	1-hour Max	570	31	5%	31	6%	31	5%	31	6%	31	6%
	24-hour Max	228	9	4%	9	4%	9	4%	9	4%	9	4%
	Annual Av	60	9	15%	9	15%	9	15%	9	15%	9	15%
CO	8-hour Max	10,000	250	3%	430	4%	295	3%	430	4%	430	4%
PM_{10}	24-hour Max	50	20	40%	22	44%	20	40%	22	44%	22	44%
	Annual Av	25	16	64%	16	65%	16	64%	16	65%	16	65%
$PM_{2.5}$	24-hour Max	25	9	37%	11	46%	9	38%	11	46%	11	46%
	Annual Av	8	9	113%	9	113%	9	113%	9	113%	9	113%

Notes:

Annual average background concentrations of $PM_{2.5}$ are above the guideline before the addition of other regional and WGP2 sources. This data was obtained from the Caversham monitoring station located in the Perth Metropolitan Area. Given its rural nature, it is likely that background $PM_{2.5}$ concentrations will be significantly below the concentrations presented as background in this table, however they have been included in this assessment for completeness.

Table 17: Predicted Concentrations and Percentage of Guideline without Background at Sensitive Receptor 4

Pollutant	Averaging Period	Criteria (µg/m³)	Existing		WGP2 in Isolation		Cumulative - Normal Operations		Cumulative - Emergency Operations	
			Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.
NO_2	1-hour Max	246	86	35%	91	37%	91	37%	91	37%
	Annual Av	62	0.7	1%	1.3	2.1%	2.0	3%	2.0	3%
SO_2	1-hour Max	570	0.09	0.02%	0.15	0.027%	0.15	0.03%	0.15	0.03%
	24-hour Max	228	0.007	0.003%	0.01	0.007%	0.02	0.008%	0.02	0.008%
	Annual Av	60	0.0006	0.001%	0.0013	0.0021%	0.002	0.003%	0.002	0.003%
CO	8-hour Max	10,000	44	0.4%	44	0.4%	44	0.4%	44	0.4%
PM_{10}	24-hour Max	50	0.5	1%	0.107	0.214%	0.6	1%	0.6	1%
	Annual Av	25	0.05	0.2%	0.01039	0.0416%	0.06	0.2%	0.06	0.2%
$PM_{2.5}$	24-hour Max	25	0.5	2%	0.107	0.429%	0.6	2%	0.6	2%
	Annual Av	8	0.05	1%	0.01039	0.1299%	0.06	1%	0.06	1%
Mercury	1-hour Max	2	0.000020	0.0011%	0.00022	0.012%	0.00022	0.012%	0.00022	0.012%
	Annual Av	0.2	0.00000033	0.000167%	0.0000015	0.0007%	0.0000018	0.0009%	0.0000018	0.0009%
Benzene	1-hour Max	29	0.37	1.3%	1.0	4%	1.0	4%	1	4%
	Annual Av	9.6	0.0036	0.037%	0.010	0.11%	0.014	0.14%	0.01	0.1%
Toluene	1-hour Max	330	0.30	0.09%	0.8	0.2%	0.8	0.2%	1	0.2%
	Annual Av	377	0.0028	0.0007%	0.008	0.002%	0.011	0.003%	0.01	0.003%
Ethylbenzene	1-hour Max	7,344	0.03	0.0004%	0.63	0.0086%	0.63	0.0086%	0.6	0.009%
Xylene	1-hour Max	330	0.12	0.04%	0.6	0.20%	0.6	0.20%	0.6	0.2%
	Annual Av	868	0.0012	0.00013%	0.007	0.0008%	0.008	0.0009%	0.01	0.0009%

Table 18: Predicted Concentrations and Percentage of Guideline with Background at Sensitive Receptor 4

Pollutant	Averaging Period	Criteria (µg/m³)	Background		Existing		WGP2 in Isolation		Cumulative - Normal Operations		Cumulative - Emergency Operations	
			Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.
NO_2	1-hour Max	246	39	16%	125	51%	130	53%	130	53%	130	53%
	Annual Av	62	10	16%	11	17%	11	18%	12	19%	12	19%
SO_2	1-hour Max	570	31	5%	31	5%	31	5%	31	5%	31	5%
	24-hour Max	228	9	4%	9	4%	9	4%	9	4%	9	4%
	Annual Av	60	9	15%	9	15%	9	15%	9	15%	9	15%
CO	8-hour Max	10,000	250	3%	294	3%	294	3%	294	3%	294	3%
PM_{10}	24-hour Max	50	20	40%	21	41%	20	40%	21	41%	21	41%
	Annual Av	25	16	64%	16	65%	16	64%	16	65%	16	65%
$PM_{2.5}$	24-hour Max	25	9	37%	10	39%	9	38%	10	40%	10	40%
	Annual Av	8	9	113%	9	113%	9	113%	9	113%	9	113%

Notes:

Annual average background concentrations of $PM_{2.5}$ are above the guideline before the addition of other regional and WGP2 sources. This data was obtained from the Caversham monitoring station located in the Perth Metropolitan Area. Given its rural nature, it is likely that background $PM_{2.5}$ concentrations will be significantly below the concentrations presented as background in this table, however they have been included in this assessment for completeness.

Table 19: Predicted Concentrations and Percentage of Guideline without Background at Onsite Receptor

Pollutant	Averaging Period	Criteria (µg/m³)	Existing		WGP2 in Isolation		Cumulative - Normal Operations		Cumulative - Emergency Operations	
			Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.
NO_2	15-Minute Max	9400	138	1%	109	1%	138	1%	138	1%
	8-Hour Max	5,600	69	1%	55	1%	69	1%	69	1%
SO_2	15-Minute Max	13,000	0.3	0.003%	0.3	0.003%	0.3	0.003%	0.3	0.003%
	8-Hour Max	5,200	0.2	0.003%	0.2	0.003%	0.2	0.003%	0.2	0.003%
CO	8-Hour Max	34,000	124	0.4%	123	0.4%	124	0.4%	124	0.4%
Mercury	8-Hour Max	25	0.00013	0.00053%	0.0015	0.006%	0.0015	0.006%	0.0015	0.006%
Benzene	8-Hour Max	3,200	4.07	0.127%	2	0.1%	4	0.1%	4	0.1%
Toluene	15-Minute Max	574,000	6.4	0.00111%	2	0.000%	6	0.001%	6	0.001%
	8-Hour Max	191,000	3.20	0.00167%	1	0.001%	3	0.002%	3	0.002%
	24-Hour Max	3,769	0.56	0.0148%	0	0.01%	1	0.02%	1	0.02%
Ethylbenzene	15-Minute Max	543,000	0.54	0.000099%	0.8	0.0001%	0.8	0.0001%	0.8	0.0001%
	8-Hour Max	434,000	0.27	0.000062%	0.4	0.00009%	0.4	0.00009%	0.4	0.00009%
Xylene	15-Minute Max	655,000	2.50	0.00038%	2	0.0002%	3	0.0004%	3	0.0004%
	8-Hour Max	350,000	1.25	0.00036%	1	0.0002%	1	0.0004%	1	0.0004%
	24-Hour Max	1,085	0.219	0.0202%	0.3	0.02%	0.3	0.03%	0.3	0.03%

Table 20: Predicted Concentrations and Percentage of Guideline with Background at Onsite Receptor

Pollutant	Averaging Period	Criteria (µg/m³)	Background		Existing		WGP2 in Isolation		Cumulative - Normal Operations		Cumulative - Emergency Operations	
			Conc. (µg/m³)	Conc. (µg/m³)	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.	Conc. (µg/m³)	% of Guide.
NO_2	15-Minute Max	9400	39	0.4%	177	2%	148	2%	177	2%	177	2%
	8-Hour Max	5,600	39	0.7%	108	2%	94	2%	108	2%	108	2%
SO_2	15-Minute Max	13,000	31	0.2%	31	0.2%	31	0.2%	31	0.2%	31	0.2%
	8-Hour Max	5,200	31	0.6%	31	0.6%	31	0.6%	31	0.6%	31	0.6%
CO	8-Hour Max	34,000	250	0.7%	374	1%	373	1%	374	1%	374	1%

6. CONCLUSIONS

MEPAU manages the Waitsia Gas Field located on grazing land in the Shire of Irwin, about 16 km south-east of Dongara and 367 km north of Perth. The field sits within the Geraldton Sandplains bioregion of Western Australia.

The Waitsia Gas Project is the largest conventional onshore Australian discovery in 40 years. It currently consists of five oil and gas wells on petroleum permits L1 and L2. The field was discovered in 2014 and has been developed in stages. The field is currently producing from two wells, Waitsia-01 and Senecio-03 (collectively known as Waitsia Gas Project Stage 1). Wells Waitsia-02, Waitsia-03 and Waitsia-04 wells are currently suspended.

MEPAU is proposing to construct and operate the Waitsia Gas Plant and related infrastructure, collectively known as the Waitsia Gas Project – Stage 2 (WGP2).

Air dispersion modelling was undertaken to assess the potential air quality impacts of atmospheric emissions from the proposed WGP2, comparing the GLCs predicted at sensitive receptor locations against the relevant ambient air quality criteria.

The modelling indicated that predicted GLCs for most compounds in isolation and cumulatively are well below the corresponding ambient air quality and workplace exposure standard criteria at the nominated receptor locations, with the exception of the scenarios that consider annual average background concentrations of $PM_{2.5}$.

The annual average background concentrations of $PM_{2.5}$ were obtained from the Caversham monitoring station and were already in exceedance of the guideline before consideration of emissions from other sources. Given the rural nature and lack of industry in the region around the proposed facility it is highly likely that the actual background concentrations of $PM_{2.5}$ in the region are significantly below the monitored concentrations at Caversham. The annual average concentrations of $PM_{2.5}$ from WGP2 and other existing sources predicted without consideration of background concentrations are only 1% of the guideline.

When considered without potential background concentrations of pollutants, short term impacts from NO_2 were predicted to be the main pollutant of concern from the WGP2 and MGSF, although predicted concentrations were still well below the nominated guideline.

The assessment incorporated a number of conservative assumptions, in the absence of more accurate or representative input data. This means that any uncertainties associated with the modelling are balanced by the conservativeness of the assessment, and that the outcomes reported are likely to be over-estimates of the pollutant concentrations that will actually be experienced at the receptors.

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APPENDIX 1
CALPUFF INPUT FILE

```
CALPUFF.INP     7.0             Generated by CALPUFF View 8.5.0 - 12/06/2019


---------------- 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 = ..\..\Waitsia\CALPUFF_Mitsui\CALMET.DAT !
   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 = CALPUFF.LST !
CONC.DAT      output   ! CONDAT = CONC.DAT !
DFLX.DAT      output   ! DFDAT = DFLX.DAT !
WFLX.DAT      output   ! WFDAT = WFLX.DAT !

VISB.DAT      output   * VISDAT = *
TK2D.DAT      output   * T2DDAT = *
RHO2D.DAT     output   * RHODAT = *
RESTARTE.DAT  output   * RSTARTE = *
-------------------------------------------------------------------------------
Other Files
-----------
OZONE.DAT     input    * OZDAT = *
VD.DAT        input    * VDDAT = *
CHEM.DAT      input    * CHEMDAT = *
AUX           input    * AUXEXT = *
(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 = *
PFTRAK.DAT    output   * TRKDAT = *
-------------------------------------------------------------------------------
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 CALMET.DAT Domains (NMETDOM)
                             Default: 1      ! NMETDOM = 1 !

    Number of CALMET.DAT files (NMETDAT)
    (Total for ALL Domains)
                             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 !

    Number of FLARE source files (FLEMARB.DAT)
    with time-varying data (NFLDAT)
                             Default: 0      ! NFLDAT = 0 !

    Number of ROAD source files (RDEMARB.DAT)
    with time-varying data (NRDDAT)
                             Default: 0      ! NRDDAT = 0 !

    Number of BUOYANT LINE source files (LNEMARB.DAT)
    with time-varying data (NLNDAT)
                             Default: 0      ! NLNDAT = 0 !
    Note:  Only 1 BUOYANT LINE source file is allowed
    -----


!END!

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

```
Subgroup (0a)
-------------
  Provide a name for each CALMET domain if NMETDOM > 1
  Enter NMETDOM lines.
                                    a,b
Default Name             Domain Name
------------             ------------
* DOMAINLIST = *


  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    * METDAT=      *    *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) – PTEMARB.DAT files
-------------

  POINT Source File Names
  The following PTEMARB.DAT filenames are processed if NPTDAT>0
  A total of NPTDAT lines is expected with one file name assigned per line
  Each line is treated as an input group and must terminate with END
```

```
  (surrounded by delimiters)
  (Each file contains emissions parameters for the entire period modeled
   for 1 or more sources)

Default Name  Type          File Name
------------  ----          ---------
* PTDATLIST = *


-------------
Subgroup (0c) – BAEMARB.DAT files
-------------

  BUOYANT AREA Source File Names
  The following BAEMARB.DAT filenames are processed if NARDAT>0
  A total of NARDAT lines is expected with one file name assigned per line
  Each line is treated as an input group and must terminate with END
  (surrounded by delimiters)
  (Each file contains emissions parameters for the entire period modeled
   for 1 or more sources)

Default Name  Type          File Name
------------  ----          ---------
* ARDATLIST = *


-------------
Subgroup (0d) – VOLEMARB.DAT files
-------------

  VOLUME Source File Names
  The following VOLEMARB.DAT filenames are processed if NVOLDAT>0
  A total of NVOLDAT lines is expected with one file name assigned per line
  Each line is treated as an input group and must terminate with END
  (surrounded by delimiters)
  (Each file contains emissions parameters for the entire period modeled
   for 1 or more sources)

Default Name  Type          File Name
------------  ----          ---------
* VOLDATLIST = *

-------------
Subgroup (0e) – FLEMARB.DAT files
-------------

  FLARE Source File Names
  The following FLEMARB.DAT filenames are processed if NFLDAT>0
  A total of NFLDAT lines is expected with one file name assigned per line
  Each line is treated as an input group and must terminate with END
  (surrounded by delimiters)
```

```
  (Each file contains emissions parameters for the entire period modeled
   for 1 or more sources)

Default Name  Type          File Name
------------  ----          ---------
* FLEMARBLIST = *


-------------
Subgroup (0f) – RDEMARB.DAT files
-------------

  ROAD Source File Names
  The following RDEMARB.DAT filenames are processed if NRDDAT>0
  A total of NRDDAT lines is expected with one file name assigned per line
  Each line is treated as an input group and must terminate with END
  (surrounded by delimiters)
  (Each file contains emissions parameters for the entire period modeled
   for 1 or more sources)

Default Name  Type          File Name
------------  ----          ---------
* RDEMARBLIST = *


-------------
Subgroup (0g) – LNEMARB.DAT file
-------------

  BUOYANT LINE Source File Name  (not more than 1)
  The following LNEMARB.DAT filename is processed if NLNDAT>0
  The assignment is treated as an input group and must terminate with END
  (surrounded by delimiters)

Default Name  Type          File Name
------------  ----          ---------
* LNEMARBLIST = *

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

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

    Option to run all periods found
    in the met. file     (METRUN)   Default: 0       ! METRUN = 0 !

         METRUN = 0 - Run period explicitly defined below
         METRUN = 1 - Run all periods in met. file

     Starting date:    Year   (IBYR)  --    No default   ! IBYR = 2018 !
                       Month  (IBMO)  --    No default   ! IBMO = 1 !
```

```
              Day    (IBDY)  --    No default   ! IBDY = 1 !
Starting time:    Hour   (IBHR)  --    No default   ! IBHR = 1 !
              Minute (IBMIN) --    No default   ! IBMIN = 0 !
              Second (IBSEC) --    No default   ! IBSEC = 0 !

Ending date:      Year   (IEYR)  --    No default   ! IEYR = 2018 !
              Month  (IEMO)  --    No default   ! IEMO = 12 !
              Day    (IEDY)  --    No default   ! IEDY = 31 !
Ending time:      Hour   (IEHR)  --    No default   ! IEHR = 23 !
              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+0800 !
 (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:
   Greenwich Mean Time (GMT) = UTC+0000
   EST                     = UTC-0500
   CST                     = UTC-0600
   MST                     = UTC-0700
   PST                     = UTC-0800
   Los Angeles, USA          = UTC-0800
   New York, USA             = UTC-0500
   Santiago, Chile           = UTC-0400
   UK                      = UTC+0000
   Western Europe            = UTC+0100
   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 = 20 !

Number of chemical species
to be emitted  (NSE)            Default: 3       ! NSE = 20 !

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)

Sigma-y is adjusted by the factor (AVET/PGTIME)**0.2 to either decrease it if the averaging time selected is less than the base averaging time, or increase it if the averaging time is greater. The base averaging time is denoted as PGTIME due to historical reasons as this adjustment was originally applied to the PG sigma option. It is now applied to all dispersion options.
The factor is applied to the ambient turbulence sigma-v (m/s) and does not alter buoyancy enhancement or far-field Heffter growth.

Averaging Time (minutes) (AVET)
                Default: 60.0   ! AVET = 60 !

```
     Base 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)

!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

Apply stack-tip downwash to FLARE sources?
(MTIP_FL) Default: 0 ! MTIP_FL = 0 !
0 = no (no stack-tip downwash)
1 = yes (apply stack-tip downwash)

Plume rise module for FLARE sources
(MRISE_FL) Default: 2 ! MRISE_FL = 2 !
1 = Briggs module
2 = Numerical rise module

Method used to simulate building
downwash? (MBDW) Default: 1 ! MBDW = 2 !
1 = ISC method
2 = PRIME method

Vertical wind shear modeled above
stack top? (MSHEAR) Default: 0 ! MSHEAR = 0 !
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 = 1 ! !END!
! CSPEC = 2 ! !END!
! CSPEC = 3 ! !END!
! CSPEC = 4 ! !END!
! CSPEC = 5 ! !END!
! CSPEC = 6 ! !END!
! CSPEC = 7 ! !END!
! CSPEC = 8 ! !END!
! CSPEC = 9 ! !END!
! CSPEC = 10 ! !END!
! CSPEC = 11 ! !END!
! CSPEC = 12 ! !END!
! CSPEC = 13 ! !END!
! CSPEC = 14 ! !END!
! CSPEC = 15 ! !END!
! CSPEC = 16 ! !END!
! CSPEC = 17 ! !END!
! CSPEC = 18 ! !END!
! CSPEC = 19 ! !END!
! CSPEC = 20 ! !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.)

!            1  =          1,              1,          0,               0   !
!            2  =          1,              1,          0,               0   !
!            3  =          1,              1,          0,               0   !
!            4  =          1,              1,          0,               0   !
!            5  =          1,              1,          0,               0   !
!            6  =          1,              1,          0,               0   !
!            7  =          1,              1,          0,               0   !
!            8  =          1,              1,          0,               0   !
!            9  =          1,              1,          0,               0   !
!           10  =          1,              1,          0,               0   !
!           11  =          1,              1,          0,               0   !
!           12  =          1,              1,          0,               0   !
!           13  =          1,              1,          0,               0   !
!           14  =          1,              1,          0,               0   !
!           15  =          1,              1,          0,               0   !
!           16  =          1,              1,          0,               0   !
!           17  =          1,              1,          0,               0   !
!           18  =          1,              1,          0,               0   !
!           19  =          1,              1,          0,               0   !
!           20  =          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 = 0.0 !
     (FNORTH)               Default=0.0     ! FNORTH = 0.0 !

     UTM zone (1 to 60)
     (Used only if PMAP=UTM)
     (IUTMZN)               No Default      ! IUTMZN = 50 !

     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 = 0.00N !
     (RLON0)                No Default      ! RLON0 = 0.00E !

         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 = 30S !
```

```
(XLAT2)                 No Default      ! XLAT2 = 60S !

   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 (outermost if nested CALMET grids are used):

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

     No. X grid cells (NX)      No default     ! NX = 20 !
     No. Y grid cells (NY)      No default     ! NY = 20 !
   No. vertical layers (NZ)      No default     ! NZ = 10 !

    Grid spacing (DGRIDKM)      No default     ! DGRIDKM = 1 !
                                Units: km

        Cell face heights
           (ZFACE(nz+1))      No defaults
```

```
                         Units: m
! ZFACE =  0.0, 20.0, 40.0, 80.0, 160.0, 320.0, 640.0, 1200.0, 2000.0, 3000.0, 4000.0 !

          Reference Coordinates
         of SOUTHWEST corner of
              grid cell(1, 1):

          X coordinate (XORIGKM)     No default     ! XORIGKM = 304.3000 !
          Y coordinate (YORIGKM)     No default     ! YORIGKM = 6745.9000 !
                         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 = 20 !
                 (1 <= IECOMP <= NX)

        Y index of UR corner (JECOMP)      No default     ! JECOMP = 20 !
                 (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 = 20 !
         (IBCOMP <= IESAMP <= IECOMP)

        Y index of UR corner (JESAMP)      No default     ! JESAMP = 20 !
         (JBCOMP <= JESAMP <= JECOMP)


       Nesting factor of the sampling
        grid (MESHDN)                     Default: 1     ! MESHDN = 4 !
        (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 = T !

   *
    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
          6 =      TBq/m**3       TBq/m**2/s    TBq=terabecquerel
          7 =      GBq/m**3       GBq/m**2/s    GBq=gigabecquerel
          8 =       Bq/m**3        Bq/m**2/s    Bq=becquerel (disintegrations/s)

       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?
   -------      ------------------------   ------------------------   ------------------------   ---------------
!           1 =     1,          1,          1,          0,          1,          0,          0   !
!           2 =     1,          1,          1,          0,          1,          0,          0   !
!           3 =     1,          1,          1,          0,          1,          0,          0   !
!           4 =     1,          1,          1,          0,          1,          0,          0   !
!           5 =     1,          1,          1,          0,          1,          0,          0   !
!           6 =     1,          1,          1,          0,          1,          0,          0   !
!           7 =     1,          1,          1,          0,          1,          0,          0   !
!           8 =     1,          1,          1,          0,          1,          0,          0   !
!           9 =     1,          1,          1,          0,          1,          0,          0   !
!          10 =     1,          1,          1,          0,          1,          0,          0   !
!          11 =     1,          1,          1,          0,          1,          0,          0   !
!          12 =     1,          1,          1,          0,          1,          0,          0   !
!          13 =     1,          1,          1,          0,          1,          0,          0   !
!          14 =     1,          1,          1,          0,          1,          0,          0   !
!          15 =     1,          1,          1,          0,          1,          0,          0   !
!          16 =     1,          1,          1,          0,          1,          0,          0   !
!          17 =     1,          1,          1,          0,          1,          0,          0   !
!          18 =     1,          1,          1,          0,          1,          0,          0   !
!          19 =     1,          1,          1,          0,          1,          0,          0   !
!          20 =     1,          1,          1,          0,          1,          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 = 1000 !

       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 = 0.0 !
     CALPUFF coordinate system, in Kilometers (MHILL=1)

     Y-origin of CTDM system relative to      No Default     ! YCTDMKM = 0.0 !
     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)
     -------     -----------      ----------      ----------    --------------------     ----------------------
* DRYGAS = *

!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)
     -------      -------------------       ------------------
* DRYPART = *
!END!
```

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

INPUT GROUP: 9 -- Miscellaneous dry deposition parameters
--------------

     Reference cuticle resistance (s/cm)
     (RCUTR)                           Default: 30    ! RCUTR = 30 !
     Reference ground resistance  (s/cm)
     (RGR)                             Default: 10    ! RGR = 10 !
     Reference pollutant reactivity
     (REACTR)                          Default: 8     ! REACTR = 8 !

     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.
       ---------      --------------       --------------
* WETDEPOS = *
!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:

```
                                           S
                         M           B  R  O
                         A  B  R  R  R    C  H  4  B      N
                     B    V  C  N  N  N  M  K  -  -  C  O    D
                     C  M  G  K  I  I  I  H  H  I  I  K  F  V  E
                   M  K  N  N  N  T  T  T  2  2  S  S  P  R  C  C
                   O  O  H  H  H  E  E  E  O  O  R  R  M  A  N  A
Mechanism (MCHEM)    Z  3  3  3  3  1  2  3  2  2  P  P  F  C  X  Y
-----------------    -----------------------------------------------
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  X  X  .  .  .  .
7 RIVAD/ISORRPIA/SOA X  X  X  X  X  X  .  .  X  X  X  X  X  X  .  .
```

Ozone data input option (MOZ)   Default: 1   ! MOZ = 1 !
(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 = 0.2 !

    Nighttime NOx loss rate in %/hour (RNITE2)
    (Used only if MCHEM = 1)
                              Default: 2.0        ! RNITE2 = 2 !

    Nighttime HNO3 formation rate in %/hour (RNITE3)
    (Used only if MCHEM = 1)
                              Default: 2.0        ! RNITE3 = 2 !

    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 ISORROPIA Option
    (used only if MCHEM = 6 or 7)

    Minimum relative humidity used in ISORROPIA computations (RH_ISRP)
                              Default: 50.        ! RH_ISRP = 50.0 !
                              Units: %

    Minimum SO4 used in ISORROPIA computations (SO4_ISRP)
                              Default: 0.4        ! SO4_ISRP = 0.4 !
                              Units: ug/m3

  --- 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 2 3 4 5 6 7 8 9 10 11 12
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov 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) Options

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
       -------      ---------   ----------
* SPECHLLIST = *

--------
    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 = 550 !

     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 = 0.01 !

Vertical dispersion constant for neutral/
unstable conditions (k2 in Eqn. 2.7-4)
(CONK2) Default: 0.1 ! CONK2 = 0.1 !

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 = 0.5 !
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 !

Maximum travel distance of a puff/slug (in
grid units) during one sampling step
(XSAMLEN) Default: 1.0 ! XSAMLEN = 1 !

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 !

Minimum sigma z for a new puff/slug (m)
(SZMIN) Default: 1.0 ! SZMIN = 1 !

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 = 5000000 !

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 = 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.37, 0.37, 0.37, 0.37, 0.37, 0.37 !
! SWMIN = 0.2, 0.12, 0.08, 0.06, 0.03, 0.016, 0.2, 0.12, 0.08, 0.06, 0.03, 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 = 0.5 !

Maximum mixing height (m)
(XMAXZI)   Default: 3000. ! XMAXZI = 3000 !

Minimum mixing height (m)
(XMINZI)   Default: 50.   ! XMINZI = 50 !

Temperatures (K) used for defining upper bound of
categories for emissions scale-factors
11 upper bounds (K) are entered; the 12th class has no upper limit
(TKCAT(11))
Default   : 265., 270., 275., 280., 285., 290., 295., 300., 305., 310., 315. (315.+)
<<   <<   <<   <<   <<   <Temperature Class : 1   2   3   4   5
6   7   8   9   10   11   (12)
---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ----
! TKCAT = 265., 270., 275., 280., 285., 290., 295., 300., 305., 310., 315. !

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 = 0.07, 0.07, 0.1, 0.15, 0.35, 0.55 !

Default potential temperature gradient

```
for stable classes E, F (degK/m)
(PTG0(2))                 Default: 0.020, 0.035
                        ! PTG0 = 0.02, 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 = 0.5, 0.5, 0.5, 0.5, 0.35, 0.35 !

Slug-to-puff transition criterion factor
equal to sigma-y/length of slug
(SL2PF)                     Default: 10.       ! SL2PF = 10 !

Receptor-specific puff/slug properties (e.g., sigmas and height above
ground at the time when the trajectory is nearest the receptor) may be
extrapolated forward or backward in time along the current step using
the current dispersion, for receptors that lie upwind of the puff/slug
position at the start of a step, or downwind at the end of a step.
Specify the upwind/downwind extrapolation zone in sigma-y units.
Using FCLIP=1.0 clips the the upwind zone at one sigma-y at the start
of the step and the downwind zone at one sigma-y at the end of the step.
This is consistent with the sampling done in CALPUFF versions through
v6.42 prior to the introduction of the FCLIP option.
The default is No Extrapolation, FCLIP=0.0.
(FCLIP)                     Default: 0.0       ! FCLIP = 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 !
```

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 !

Minimum puff elongation rate (SYSPLITH/hr) due to
wind shear, before it may be split
(SHSPLITH) Default: 2. ! SHSPLITH = 2 !

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 = 0 !

Integration control variables ------------------------

Fractional convergence criterion for numerical SLUG
sampling integration
(EPSSLUG) Default: 1.0e-04 ! EPSSLUG = 0.0001 !

Fractional convergence criterion for numerical AREA
source integration
(EPSAREA) Default: 1.0e-06 ! EPSAREA = 1E-006 !

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 !

```
     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 !

     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 = 19 !

     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 = SRC_1 !
  1 ! X =  314.118, 6756.082,    3.6, 52.67,     0.35,  63.8, 673.15,  1.0,      1,      0,      0,
     0,      0,      0,      0,      0,      0,      0,      0,      0,      0,      0,      0,
     0,      0,      0,      0,      0 !
  1 ! ZPLTFM =      0.0 !
  1 ! FMFAC =      1.0 !   !END!

  2 ! SRCNAM = SRC_2 !
  2 ! X =  314.130, 6756.082,    3.6, 52.47,     0.35,  63.8, 673.15,  1.0,      0,      1,      0,
     0,      0,      0,      0,      0,      0,      0,      0,      0,      0,      0,      0,
     0,      0,      0,      0,      0 !
  2 ! ZPLTFM =      0.0 !
  2 ! FMFAC =      1.0 !   !END!

  3 ! SRCNAM = SRC_3 !
  3 ! X =  314.171, 6756.082,    3.6, 51.78,     0.35,  63.8, 673.15,  1.0,      0,      0,      1,
     0,      0,      0,      0,      0,      0,      0,      0,      0,      0,      0,      0,
     0,      0,      0,      0,      0 !
  3 ! ZPLTFM =      0.0 !
  3 ! FMFAC =      1.0 !   !END!

  4 ! SRCNAM = SRC_4 !
  4 ! X =  314.183, 6756.082,    3.6, 51.58,     0.35,  63.8, 673.15,  1.0,      0,      0,      0,
     1,      0,      0,      0,      0,      0,      0,      0,      0,      0,      0,      0,
     0,      0,      0,      0,      0 !
  4 ! ZPLTFM =      0.0 !
  4 ! FMFAC =      1.0 !   !END!

  5 ! SRCNAM = SRC_5 !
  5 ! X =  314.036, 6755.822,    9.8, 54.23,     1.27,  31.4, 723.15,  0.0,      0,      0,      0,
     0,      1,      0,      0,      0,      0,      0,      0,      0,      0,      0,      0,
     0,      0,      0,      0,      0 !
  5 ! ZPLTFM =      0.0 !
  5 ! FMFAC =      1.0 !   !END!

  6 ! SRCNAM = SRC_6 !
  6 ! X =  314.056, 6755.822,    9.8,  54.0,     1.27,  31.4, 723.15,  0.0,      0,      0,      0,
```

```
   0,    0,    1,    0,    0,    0,    0,    0,    0,    0,    0,    0,
   0,    0,    0,    0,    0 !
6 ! ZPLTFM =    0.0 !
6 ! FMFAC =    1.0 !   !END!

7 ! SRCNAM = SRC_7 !
7 ! X =  314.076, 6755.822,    9.8, 53.76,    1.27,  31.4, 723.15,  0.0,    0,    0,    0,
   0,    0,    0,    1,    0,    0,    0,    0,    0,    0,    0,    0,
   0,    0,    0,    0,    0 !
7 ! ZPLTFM =    0.0 !
7 ! FMFAC =    1.0 !   !END!

8 ! SRCNAM = SRC_8 !
8 ! X =  314.135, 6755.822,    9.8, 52.99,    1.27,  31.4, 723.15,  0.0,    0,    0,    0,
   0,    0,    0,    0,    1,    0,    0,    0,    0,    0,    0,    0,
   0,    0,    0,    0,    0 !
8 ! ZPLTFM =    0.0 !
8 ! FMFAC =    1.0 !   !END!

9 ! SRCNAM = SRC_9 !
9 ! X =  314.155, 6755.822,    9.8,  52.7,    1.27,  31.4, 723.15,  0.0,    0,    0,    0,
   0,    0,    0,    0,    0,    1,    0,    0,    0,    0,    0,    0,
   0,    0,    0,    0,    0 !
9 ! ZPLTFM =    0.0 !
9 ! FMFAC =    1.0 !   !END!

10 ! SRCNAM = SRC_10 !
10 ! X =  314.175, 6755.822,    9.8, 52.39,    1.27,  31.4, 723.15,  0.0,    0,    0,    0,
   0,    0,    0,    0,    0,    0,    1,    0,    0,    0,    0,    0,
   0,    0,    0,    0,    0 !
10 ! ZPLTFM =    0.0 !
10 ! FMFAC =    1.0 !   !END!

11 ! SRCNAM = SRC_11 !
11 ! X =  314.050, 6755.912,   25.0, 54.71,    0.25,  60.0, 328.15,  0.0,    0,    0,    0,
   0,    0,    0,    0,    0,    0,    0,    1,    0,    0,    0,    0,
   0,    0,    0,    0,    0 !
11 ! ZPLTFM =    0.0 !
11 ! FMFAC =    1.0 !   !END!

12 ! SRCNAM = SRC_12 !
12 ! X =  314.147, 6755.912,   25.0, 53.38,    0.25,  60.0, 328.15,  0.0,    0,    0,    0,
   0,    0,    0,    0,    0,    0,    0,    0,    1,    0,    0,    0,
   0,    0,    0,    0,    0 !
12 ! ZPLTFM =    0.0 !
12 ! FMFAC =    1.0 !   !END!

13 ! SRCNAM = SRC_13 !
13 ! X =  314.188, 6755.735,   18.5, 49.64,    1.4,  16.3, 1123.15,  0.0,    0,    0,    0,
   0,    0,    0,    0,    0,    0,    0,    0,    0,    1,    0,    0,
   0,    0,    0,    0,    0 !
```

```
13 ! ZPLTFM =     0.0 !
13 ! FMFAC =     1.0 !   !END!

14 ! SRCNAM = SRC_14 !
14 ! X =  314.188, 6755.715,    18.5,  49.6,       1.4,  16.3, 1123.15,  0.0,       0,       0,       0,
   0,       0,       0,       0,       0,       0,       0,       0,       0,       0,       1,       0,
   0,       0,       0,       0,       0 !
14 ! ZPLTFM =     0.0 !
14 ! FMFAC =     1.0 !   !END!

15 ! SRCNAM = SRC_15 !
15 ! X =  314.176, 6755.911,     8.0, 52.92,       0.9,  30.0, 673.15,  0.0,       0,       0,       0,
   0,       0,       0,       0,       0,       0,       0,       0,       0,       0,       0,       1,
   0,       0,       0,       0,       0 !
15 ! ZPLTFM =     0.0 !
15 ! FMFAC =     1.0 !   !END!

16 ! SRCNAM = SRC_16 !
16 ! X =  314.128, 6755.911,     8.0, 53.65,       0.9,  30.0, 673.15,  0.0,       0,       0,       0,
   0,       0,       0,       0,       0,       0,       0,       0,       0,       0,       0,       0,
   1,       0,       0,       0,       0 !
16 ! ZPLTFM =     0.0 !
16 ! FMFAC =     1.0 !   !END!

17 ! SRCNAM = SRC_17 !
17 ! X =  314.145, 6755.674,   18.33,  50.2,     0.058,  20.0, 1273.0,  0.0,       0,       0,       0,
   0,       0,       0,       0,       0,       0,       0,       0,       0,       0,       0,       0,
   0,       1,       0,       0,       0 !
17 ! ZPLTFM =     0.0 !
17 ! FMFAC =     1.0 !   !END!

18 ! SRCNAM = SRC_18 !
18 ! X =  314.145, 6755.674,   63.27,  50.2,    10.051,  20.0, 1273.0,  0.0,       0,       0,       0,
   0,       0,       0,       0,       0,       0,       0,       0,       0,       0,       0,       0,
   0,       0,       1,       0,       0 !
18 ! ZPLTFM =     0.0 !
18 ! FMFAC =     1.0 !   !END!

19 ! SRCNAM = SRC_19 !
19 ! X =  314.145, 6755.674,   76.09,  50.2,    13.045,  20.0, 1273.0,  0.0,       0,       0,       0,
   0,       0,       0,       0,       0,       0,       0,       0,       0,       0,       0,       0,
   0,       0,       0,       1,       0 !
19 ! ZPLTFM =     0.0 !
19 ! 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 = SRC_1 !
   1 ! HEIGHT =    3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
                3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
                3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
                3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
```

```
               3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
               3.50,    3.50,    3.50,    3.50,    3.50,    3.50 !
   1 ! WIDTH  =   6.02,    7.86,    9.46,   10.78,   11.76,   12.39,
              12.64,   12.51,   12.00,   12.51,   12.64,   12.39,
              11.76,   10.78,    9.46,    7.86,    6.02,    4.00,
               6.02,    7.86,    9.46,   10.78,   11.76,   12.39,
              12.64,   12.51,   12.00,   12.51,   12.64,   12.39,
              11.76,   10.78,    9.46,    7.86,    6.02,    4.00 !
   1 ! LENGTH =  12.51,   12.64,   12.39,   11.76,   10.78,    9.46,
               7.86,    6.02,    4.00,    6.02,    7.86,    9.46,
              10.78,   11.76,   12.39,   12.64,   12.51,   12.00,
              12.51,   12.64,   12.39,   11.76,   10.78,    9.46,
               7.86,    6.02,    4.00,    6.02,    7.86,    9.46,
              10.78,   11.76,   12.39,   12.64,   12.51,   12.00 !
   1 ! XBADJ  = -11.00,  -10.84,  -10.36,   -9.55,   -8.46,   -7.12,
              -5.55,   -3.82,   -1.97,   -2.14,   -2.25,   -2.30,
              -2.27,   -2.17,   -2.01,   -1.78,   -1.50,   -1.18,
              -1.51,   -1.80,   -2.04,   -2.21,   -2.31,   -2.35,
              -2.31,   -2.20,   -2.03,   -3.88,   -5.61,   -7.17,
              -8.51,   -9.59,  -10.39,  -10.86,  -11.01,  -10.82 !
   1 ! YBADJ  =  -0.87,   -1.68,   -2.44,   -3.12,   -3.71,   -4.19,
              -4.54,   -4.75,   -4.82,   -4.74,   -4.52,   -4.16,
              -3.67,   -3.08,   -2.38,   -1.62,   -0.81,    0.03,
               0.87,    1.68,    2.44,    3.12,    3.71,    4.19,
               4.54,    4.75,    4.82,    4.74,    4.52,    4.16,
               3.67,    3.08,    2.38,    1.62,    0.81,   -0.03 !
!END!
   2 ! SRCNAM = SRC_2 !
   2 ! HEIGHT =   3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
               3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
               3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
               3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
               3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
               3.50,    3.50,    3.50,    3.50,    3.50,    3.50 !
   2 ! WIDTH  =   6.02,    7.86,    9.46,   10.78,   11.76,   12.39,
              12.64,   12.51,   12.00,   12.51,   12.64,   12.39,
              11.76,   10.78,    9.46,    7.86,    6.02,    4.00,
               6.02,    7.86,    9.46,   10.78,   11.76,   12.39,
              12.64,   12.51,   12.00,   12.51,   12.64,   12.39,
              11.76,   10.78,    9.46,    7.86,    6.02,    4.00 !
   2 ! LENGTH =  12.51,   12.64,   12.39,   11.76,   10.78,    9.46,
               7.86,    6.02,    4.00,    6.02,    7.86,    9.46,
              10.78,   11.76,   12.39,   12.64,   12.51,   12.00,
              12.51,   12.64,   12.39,   11.76,   10.78,    9.46,
               7.86,    6.02,    4.00,    6.02,    7.86,    9.46,
              10.78,   11.76,   12.39,   12.64,   12.51,   12.00 !
   2 ! XBADJ  = -10.96,  -10.84,  -10.38,  -17.27,  -17.66,  -17.51,
             -16.83,  -15.64,  -13.97,  -13.96,   -2.45,   -2.49,
              -2.45,   -2.34,   -2.16,   -1.91,   -1.60,   -1.25,
              -1.55,   -1.81,   -2.01,    5.50,    6.88,   -2.23,
              -2.17,   -2.04,   -1.85,   -3.69,   -5.42,   -6.98,
```

```
             -8.33,   -9.42,  -10.23,  -10.73,  -10.91,  -10.75 !
   2 ! YBADJ   =   -0.68,   -1.48,   -2.25,    6.07,    4.00,    1.81,
             -0.44,   -2.67,   -4.82,   -6.83,   -4.51,   -4.19,
             -3.74,   -3.17,   -2.50,   -1.77,   -0.97,   -0.15,
              0.68,    1.48,    2.25,   -6.07,   -4.00,    4.04,
              4.41,    4.65,    4.75,    4.70,    4.51,    4.19,
              3.74,    3.17,    2.50,    1.77,    0.97,    0.15 !
!END!
   3 ! SRCNAM = SRC_3 !
   3 ! HEIGHT  =    3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
              3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
              3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
              3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
              3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
              3.50,    3.50,    3.50,    3.50,    3.50,    3.50 !
   3 ! WIDTH   =    6.02,    7.86,    9.46,   10.78,   11.76,   12.39,
             12.64,   12.51,   12.00,   12.51,   12.64,   12.39,
             11.76,   10.78,    9.46,    7.86,    6.02,    4.00,
              6.02,    7.86,    9.46,   10.78,   11.76,   12.39,
             12.64,   12.51,   12.00,   12.51,   12.64,   12.39,
             11.76,   10.78,    9.46,    7.86,    6.02,    4.00 !
   3 ! LENGTH  =   12.51,   12.64,   12.39,   11.76,   10.78,    9.46,
              7.86,    6.02,    4.00,    6.02,    7.86,    9.46,
             10.78,   11.76,   12.39,   12.64,   12.51,   12.00,
             12.51,   12.64,   12.39,   11.76,   10.78,    9.46,
              7.86,    6.02,    4.00,    6.02,    7.86,    9.46,
             10.78,   11.76,   12.39,   12.64,   12.51,   12.00 !
   3 ! XBADJ   =  -10.68,  -10.59,  -10.16,   -9.43,   -8.42,   -7.14,
             -5.65,   -3.99,   -2.21,   -2.44,   -2.60,   -2.68,
             -2.68,   -2.60,   -2.44,   -2.20,   -1.90,   -1.54,
             -1.83,   -2.06,   -2.23,   -2.33,   -2.36,   -2.32,
             -2.21,   -2.03,   -1.79,   -3.58,   -5.26,   -6.78,
             -8.09,   -9.16,   -9.95,  -10.44,  -10.61,  -10.46 !
   3 ! YBADJ   =   -0.57,   -1.33,   -2.05,   -2.71,   -3.28,   -3.76,
             -4.12,   -4.36,   -4.46,   -4.43,   -4.26,   -3.97,
             -3.55,   -3.03,   -2.41,   -1.72,   -0.98,   -0.21,
              0.57,    1.33,    2.05,    2.71,    3.28,    3.76,
              4.12,    4.36,    4.46,    4.43,    4.26,    3.97,
              3.55,    3.03,    2.41,    1.72,    0.98,    0.21 !
!END!
   4 ! SRCNAM = SRC_4 !
   4 ! HEIGHT  =    3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
              3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
              3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
              3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
              3.50,    3.50,    3.50,    3.50,    3.50,    3.50,
              3.50,    3.50,    3.50,    3.50,    3.50,    3.50 !
   4 ! WIDTH   =    6.02,    7.86,    9.46,   10.78,   11.76,   12.39,
             12.64,   12.51,   12.00,   12.51,   12.64,   12.39,
             11.76,   10.78,    9.46,    7.86,    6.02,    4.00,
              6.02,    7.86,    9.46,   10.78,   11.76,   12.39,
```

```
               12.64,   12.51,   12.00,   12.51,   12.64,   12.39,
               11.76,   10.78,    9.46,    7.86,    6.02,    4.00 !
   4 ! LENGTH  =   12.51,   12.64,   12.39,   11.76,   10.78,    9.46,
                7.86,    6.02,    4.00,    6.02,    7.86,    9.46,
               10.78,   11.76,   12.39,   12.64,   12.51,   12.00,
               12.51,   12.64,   12.39,   11.76,   10.78,    9.46,
                7.86,    6.02,    4.00,    6.02,    7.86,    9.46,
               10.78,   11.76,   12.39,   12.64,   12.51,   12.00 !
   4 ! XBADJ   =  -10.68,  -10.57,  -10.14,  -17.15,  -17.61,  -17.54,
              -16.93,  -15.81,  -14.21,  -14.26,   -2.57,   -2.65,
               -2.65,   -2.57,   -2.42,   -2.19,   -1.89,   -1.54,
               -1.83,   -2.07,   -2.25,    5.38,    6.83,   -2.35,
               -2.25,   -2.07,   -1.83,   -3.62,   -5.30,   -6.81,
               -8.13,   -9.19,   -9.97,  -10.46,  -10.62,  -10.46 !
   4 ! YBADJ   =   -0.61,   -1.37,   -2.08,    6.49,    4.43,    2.24,
               -0.01,   -2.27,   -4.46,   -6.51,   -4.25,   -3.95,
               -3.53,   -3.00,   -2.38,   -1.69,   -0.94,   -0.17,
                0.61,    1.37,    2.08,   -6.49,   -4.43,    3.78,
                4.13,    4.36,    4.46,    4.42,    4.25,    3.95,
                3.53,    3.00,    2.38,    1.69,    0.94,    0.17 !
!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: EMISSION-RATE SCALING FACTORS
           -------------------------------------------

      Use this subgroup to identify temporal variations in the emission
      rates given in 13b.  Factors assigned 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.

      Sets of emission-rate scale factors are defined in Input Group 19, and
      are referenced by the FACTORNAME.  Provide NSPT1 lines that identify the
      emission-rate scale factor table for each source-species combination that
      uses the scaling option.  Note that a scale-factor table can be used with
      more than one source-species combination so a FACTORNAME can be repeated.
```

```
  Source-             Source      Species      Scale-factor table
  Species              Name   b    Name   c     Name        d
   No.               (SRCNAM)     (CSPEC)      (FACTORNAME)
  ------             ------------ ------------ --------------------


--------
    a
     Assignment for each source-specie is treated as a separate input subgroup
     and therefore must end with an input group terminator.
    b
     Source name must match one of the SRCNAM names defined in Input Group 13b
    c
     Species name must match one of the CSPEC names of emitted species defined in Input Group
3
    d
     Scale-factor name must match one of the FACTORNAME names defined in Input Group 19


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


INPUT GROUPS: 14a, 14b, 14c, 14d -- Area source parameters
--------------------------------

---------------
Subgroup (14a)
---------------

     Number of polygon area sources with
     parameters specified below (NAR1)       No default  ! NAR1 = 1 !

     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)
-------         ------    ------     --------   ---------

   1 ! SRCNAM = SRC_20 !
   1 ! X =        0.0,    63.61,        0.0,       0,       0,       0,       0,       0,       0,
      0,       0,       0,       0,       0,       0,       0,       0,       0,       0,       0,       0,
      0,       1 !
!END!

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

   1 ! SRCNAM = SRC_20 !
   1 ! XVERT =  313.67383, 313.67383, 313.90583, 313.90583 !
   1 ! YVERT =  6756.0607, 6756.1537, 6756.1537, 6756.0607 !
!END!

--------
    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: EMISSION-RATE SCALING FACTORS

Use this subgroup to identify temporal variations in the emission
rates given in 14b. Factors assigned 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.

Sets of emission-rate scale factors are defined in Input Group 19, and
are referenced by the FACTORNAME. Provide NSAR1 lines that identify the
emission-rate scale factor table for each source-species combination that
uses the scaling option. Note that a scale-factor table can be used with
more than one source-species combination so a FACTORNAME can be repeated.

Source-Species No.	Source Name b (SRCNAM)	Species Name c (CSPEC)	Scale-factor table Name d (FACTORNAME)

----
a
Data for each species are treated as a separate input subgroup
and therefore must end with an input group terminator.
b
Source name must match one of the SRCNAM names defined in Input Group 14b
c
Species name must match one of the CSPEC names of emitted species defined in Input Group
3
d
Scale-factor name must match one of the FACTORNAME names defined in Input Group 19

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 = *
(in meters)

Average building height (HBL) No default * HBL = *
(in meters)

Average building width (WBL) No default * WBL = *
(in meters)

Average line source width (WML) No default * WML = *
(in meters)

Average separation between buildings (DXL) No default * DXL = *
(in meters)

Average buoyancy parameter (FPRIMEL) No default * FPRIMEL = *

```
                              (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: EMISSION-RATE SCALING FACTORS
     --------------------------------------------------

    Use this subgroup to identify temporal variations in the emission
    rates given in 15b.  Factors assigned multiply the rates in 15b.
    Skip sources here that have constant emissions.  For more elaborate
    variation in source parameters, use LNEMARB.DAT and NLN2 > 0.

    Sets of emission-rate scale factors are defined in Input Group 19, and
    are referenced by the FACTORNAME.  Provide NSLN1 lines that identify the
    emission-rate scale factor table for each source-species combination that
    uses the scaling option.  Note that a scale-factor table can be used with
    more than one source-species combination so a FACTORNAME can be repeated.


 Source-           Source     Species     Scale-factor table
 Species            Name  b    Name  c     Name        d
  No.             (SRCNAM)    (CSPEC)     (FACTORNAME)
 ------           ------------ ------------ ---------------------
```

----
a
Data for each species are treated as a separate input subgroup
and therefore must end with an input group terminator.
b
Source name must match one of the SRCNAM names defined in Input Group 15b
c
Species name must match one of the CSPEC names of emitted species defined in Input Group
3
d
Scale-factor name must match one of the FACTORNAME names defined in Input Group 19

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
Source       X          Y        Effect.    Base     Initial    Initial    Emission
 No.      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: EMISSION-RATE SCALING FACTORS
        -------------------------------------------

     Use this subgroup to identify temporal variations in the emission
     rates given in 16b.  Factors assigned 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.

     Sets of emission-rate scale factors are defined in Input Group 19, and
     are referenced by the FACTORNAME.  Provide NSVL1 lines that identify the
     emission-rate scale factor table for each source-species combination that
     uses the scaling option.  Note that a scale-factor table can be used with
     more than one source-species combination so a FACTORNAME can be repeated.


  Source-              Source      Species      Scale-factor table
  Species               Name   b    Name   c     Name        d
   No.                (SRCNAM)     (CSPEC)      (FACTORNAME)
  ------              ------------ ------------ ---------------------
```

```
--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.
    b
     Source name must match one of the SRCNAM names defined in Input Group 16b
    c
     Species name must match one of the CSPEC names of emitted species defined in Input Group
3
    d
     Scale-factor name must match one of the FACTORNAME names defined in Input Group 19


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

INPUT GROUP: 17  -- FLARE source control parameters (variable emissions file)
---------------

     Number of flare sources defined in FLEMARB.DAT file(s)
     (NFL2)                         Default: 0     ! NFL2 = 0 !

     (At least 1 FLEMARB.DAT file is needed if NFL2 > 0)

!END!


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


INPUT GROUPS: 18a, 18b, 18c -- Road Emissions parameters
--------------------------

---------------
Subgroup (18a)
---------------

     Emissions from roads are generated from individual line segments defined
     by a sequence of coordinates provided for each road-link.  Each link
     is entered as a discrete source and is defined as a section of the road
     for which emissions are uniform.

     A long, winding isolated road might be characterized by a single link made
     up of many coordinate triples (x,y,z) that describe its pathway.  These
     points should be sufficient to resolve curves, but need not have uniform
     spacing.  For example, a straight flat segment can be defined by 2 points,
     regardless of the distance covered.  Long line segments are automatically
     divided further within the model into segments that are limited by the
     grid-cell boundaries (no segment may extend across multiple cells).
     One emission rate (g/m/s) for each species is used for the entire road.
```

Near a congested intersection, many short links may be required to resolve
the spatial and temporal distribution of emissions. Each is entered and
modeled as a discrete source.

Number of road-links with emission parameters
provided in Subgroup 18b (NRD1)   No default   ! NRD1 = 0 !

Number of road-links with arbitrarily time-varying
emission parameters (NRD2)   No default   ! NRD2 = 0 !
(If NRD2 > 0, ALL variable road data
are read from the file: RDEMARB.DAT)

Emissions from one or more of the roads presented in Subgroup 18b
may vary over time-based cycles or by meteorology. This variability
is modeled by applying an emission-rate scale factor specified for
particular road links and species in Subgroup 18c.

Number of road links and species combinations
with variable emission-rate scale-factors
(NSFRDS)   Default: 0   ! NSFRDS = 0 !

!END!

Subgroup (18b)

DATA FOR ROADS WITH CONSTANT OR SCALED EMISSION PARAMETERS[a]

Road No.	Effect. Height (mAGL)	Initial Sigma z (m)	Initial Sigma y (m)	Emission Rates[b] (g/s/m)
-------	------	------	--------	---------
c				

----

a
Data for each of the NRD1 roads are treated as a separate input subgroup
and therefore must end with an input group terminator.

b
NSPEC Emission rates must be entered (one for every pollutant modeled).
Enter emission rate of zero for secondary pollutants.

c
Road-source names are entered without spaces, and may be 16 characters long.

```
Subgroup (18c)
---------------
                         a
    EMISSION-RATE SCALING FACTORS
    -----------------------------

    Use this subgroup to identify temporal variations in the emission
    rates given in 18b.  Factors assigned multiply the rates in 18b.
    Skip sources here that have constant emissions.  For more elaborate
    variation in source parameters, use RDEMARB.DAT and NRD2 > 0.

    Sets of emission-rate scale factors are defined in Input Group 19, and
    are referenced by the FACTORNAME.  Provide NSFRDS lines that identify the
    emission-rate scale factor table for each source-species combination that
    uses the scaling option.  Note that a scale-factor table can be used with
    more than one source-species combination so a FACTORNAME can be repeated.


 Source-          Source      Species      Scale-factor table
 Species           Name   b    Name   c     Name        d
  No.            (SRCNAM)     (CSPEC)      (FACTORNAME)
 ------          ------------ ------------ --------------------



--------
   a
    Assignment for each source-specie is treated as a separate input subgroup
    and therefore must end with an input group terminator.
   b
    Source name must match one of the SRCNAM names defined in Input Group 18b
   c
    Species name must match one of the CSPEC names of emitted species defined in Input Group
3
   d
    Scale-factor name must match one of the FACTORNAME names defined in Input Group 19

---------------
Subgroup (18d)
---------------
                              a
       COORDINATES FOR EACH NAMED ROAD
       ------------------------------

               X          Y         Ground
Coordinate      Coordinate  Coordinate   Elevation
 No.              (km)        (km)         (m)
----------      ----------  ----------   ---------

--------
   a
```

```
     Each line of coordinates is treated as a separate input subgroup
     and therefore must end with an input group terminator.


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


INPUT GROUPS: 19a, 19b -- Emission rate scale-factor tables
----------------------

     Use this group to enter variation factors applied to emission rates for any
     source-specie combinations that use this feature.  The tables of emission-rate
     scale factors are referenced by the name assigned to FACTORNAME.  These names
     do not need to include specific source or species names used in the simulation,
     particularly if one factor table is used for many types of sources and species,
     but should be descriptive.  But if a factor table applies to just one source,
     the reference name for it should generally contain that source-name.
     FACTORNAME must NOT include spaces.

     The FACTORTYPE for each table must be one of the following:

        CONSTANT1          1   scaling factor
        MONTH12           12  scaling factors: months 1-12
        DAY7               7   scaling factors: days 1-7
                        [SUNDAY,MONDAY, ... FRIDAY,SATURDAY]
        HOUR24            24  scaling factors: hours 1-24
        HOUR24_DAY7      168 scaling factors: hours 1-24,
                         repeated  7 times: SUNDAY, MONDAY, ... SATURDAY
        HOUR24_MONTH12   288 scaling factors: hours 1-24,
                         repeated 12 times: months 1-12
        WSP6               6   scaling factors: wind speed classes 1-6
                        [speed classes (WSCAT) defined in Group 12]
        WSP6_PGCLASS6     36  scaling factors: wind speed classes 1-6
                         repeated  6 times: PG classes A,B,C,D,E,F
                        [speed classes (WSCAT) defined in Group 12]
        TEMPERATURE12     12  scaling factors: temperature classes 1-12
                        [temperature classes (TKCAT) defined in Group 12]

     The number of tables defined may exceed the number of tables referenced in the
     input groups for each source type above (for convenience), but tables for all
     FACTORNAME names referenced must be present here.

---------------
Subgroup (19a)
---------------

     Number of Emission Scale-Factor
     tables                       (NSFTAB) Default: 0  ! NSFTAB = 0 !

     !END!
```

Subgroup (19b)
----

a,b,c
Enter factors for NSFTAB Emission Scale-Factor tables

----
a
Assignments for each table are treated as a separate input subgroup and therefore must end with an input group terminator.
b
FACTORNAME must be no longer than 40 characters
c
Spaces are NOT allowed in any FACTORNAME or FACTORTYPE assignment, and the names are NOT case-sensitive

----

INPUT GROUPS: 20a, 20b, 20c -- Non-gridded (discrete) receptor information
----

Subgroup (20a)

Number of non-gridded receptors (NREC) No default ! NREC = 0 !

Group names can be used to assign receptor locations in
Subgroup 17c and thereby provide an identification that
can be referenced when postprocessing receptors. The
default assignment name X is used when NRGRP = 0.

Number of receptor group names (NRGRP) Default: 0 ! NRGRP = 0 !

!END!

Subgroup (20b)

Provide a name for each receptor group if NRGRP>0.
Enter NRGRP lines.
a,b
Group Name

----
* RGRPNAMLIST = *

----
a
Each group name provided is treated as a separate input subgroup
and therefore must end with an input group terminator.
b
Receptor group names must not include blanks.

Subgroup (20c)
----

a
NON-GRIDDED (DISCRETE) RECEPTOR DATA

Receptor No.	Group Name c	X Coordinate (km)	Y Coordinate (km)	Ground Elevation (m)	Height b Above Ground (m)

----
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.
c
Receptors can be assigned using group names provided in 17b. If no
group names are used (NRGRP=0) then the default assignment name X
must be used.