APPENDIX 3

Air Quality and Greenhouse Gas Impact Assessment

Wells Environmental Services

REPORT

ASHTON COAL GAS DRAINAGE PROJECT: STAGE 2- AIR QUALITY ASSESSMENT AND MANAGEMENT

ASHTON COAL OPERATIONS LTD C/O WELLS ENVIRONMENTAL SERVICES

Job No: 5527 C

17 May 2012

A PEL Company

PROJECT TITLE:	**ASHTON COAL GAS DRAINAGE PROJECT: STAGE 2 – AIR QUALITY ASSESSMENT & MANAGEMENT**
JOB NUMBER:	**5527 C**
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ES1 EXECUTIVE SUMMARY

The proposed Ashton Gas Drainage Project involves the construction and operation of a series of gas drainage boreholes, a central gas drainage plant (including ventilation stack and flare(s)) and potential additional mobile gas drainage plant. The Ashton Gas Drainage Project will ensure the safe and controlled drainage of goaf gas in a cost effective manner allowing continued and efficient underground mining.

The project will result in emissions to air from the gas drainage system, the ventilation stack and the flare(s). Dispersion modelling has been used to predict the air quality impacts from the operation of the proposed central and mobile gas drainage plant. Modelling results indicate that the operation of Ashton Gas Drainage Project would not compromise air quality goals.

Air quality impacts during the construction phase will be short lived and are expected to be easily controlled through commonly applied dust management measures.

The installation of a flare at the central gas drainage plant has the potential to result in greenhouse gas savings greater than 271 kt CO_2-e / annum. If 100% flaring occurred, GHG savings could reach 438 kt CO_2-e / annum.

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1 INTRODUCTION

Ashton Coal Operations Limited (ACOL) seek approval for the construction and operation of gas drainage and flaring infrastructure to assist in the drainage and treatment of goaf gas from their underground operations. The drainage system would ensure the safe and controlled drainage of goaf gas in a cost effective manner allowing continued and efficient underground mining.

The works include the construction and operation of a series of gas drainage boreholes, a central gas drainage plant (including ventilation stack and flare) and potential mobile gas drainage plant for use prior to commissioning of the central gas drainage plant and for emergency use. Further details on the project are provided in the main body of the Environmental Assessment (EA).

1.1 Scope and Objectives

PAEHolmes have been commissioned by ACOL, to assess the potential for air quality impacts associated with the proposed development.

The primary objective of the study is to identify all potential air quality and greenhouse gas emissions from the construction and operation of the project and provide a qualitative assessment of impact.

1.2 Methodology

The objectives of the study will be addressed by the following scope of work:

- Provide a description of the ambient receiving environment, including background pollution concentrations, prevailing meteorological conditions, terrain, topography and closest sensitive receptors;
- Quantify emissions to air from the operation of the project and assess the potential impacts against appropriate impact assessment criteria;
- Consider potential impacts during construction and outline management measures;
- Provide a cumulative impact assessment based on estimated concentrations and representative background pollution concentrations.
- Prepare an Air Quality Impact Assessment in accordance with the NSW Office of Environment and Heritage (OEH)[a] "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*" (**NSW DEC, 2005**);

[a] The NSW EPA exists as a legal entity operated within the Office of Environment and Heritage (OEH) which came into existence in April 2011. OEH was previously part of the Department of Environment, Climate Change and Water (DECCW). The DECCW was also recently known as the Department of Environment and Climate Change (DECC), and prior to that the Department of Environment and Conservation (DEC). The terms NSW EPA, OEH, DECCW, DECC and DEC are interchangeable in this report.

2 STATUTORY REQUIREMENTS

Construction and operation of the goaf gas drainage project will result in emissions to air from the central and mobile gas drainage system, the ventilation stack and the flare. Emissions to air are summarised as follows:

- Fugitive dust emissions can be expected during construction. These emissions are expected to be limited in scale and duration and easily controllable by conventional means. In addition, emissions from diesel-powered construction equipment are also typically too small and too widely dispersed to give rise to significant off-site concentrations.
- The flaring of coal seam methane will result in emissions of oxides of nitrogen (NO_x), carbon monoxide (CO) and small amounts of volatile organic compounds (VOCs).
- Emissions from the free venting stack will be mostly methane (~90%) with smaller amounts of nitrogen, carbon dioxide (CO_2) and potentially other hydrocarbons, which may be odorous. Methane is less dense than air and will continue to rise and disperse from the release point at the vent stack. Ground level concentrations would therefore not be expected to reach levels that would result in an explosive risk or health risk to persons working in the vicinity of the site.
- Combustion of diesel at the mobile gas drainage unit will include emission of coarse and fine fractions of particulate matter (PM_{10} and $PM_{2.5}$), oxides of nitrogen (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2) and organic compounds.

The emission rates for CO and SO_2 from diesel exhausts are lower than emissions for NO_x, however, the 1-hour air quality goals are higher. Therefore, compliance with the NO_x criteria will demonstrate compliance with the 1-hour CO and SO_2 criteria. Diesel exhaust emissions can contain organic hydrocarbons, however, the emissions of these pollutants produced from the mobile diesel generator are too low to cause air quality impacts at sensitive receptors. It is also unlikely that any significant impacts would arise due to VOCs from the flaring, given the destruction efficiency of flaring (>99% for well operated flare) and buffer distances to residences.

Therefore, the key pollutants considered in this report, from flaring of goaf gas and combustion of diesel fuel are oxides of nitrogen (NOx) and particulate matter.

2.1 Particulate Matter

Emissions of particulate matter are generally considered in three separate size fractions. These are described as total suspended particulate matter (TSP), particulate matter with equivalent aerodynamic diameters 10 μm or less (PM_{10}) and particles with equivalent aerodynamic diameters of 2.5 μm and less ($PM_{2.5}$). Particulate matter has the capacity to affect health and to cause nuisance effects. The extent to which health or nuisance effects occur, relates to the size and/or by chemical composition of the particulate matter. The human respiratory system has in-built defensive systems that prevent particles larger than approximately 10 μm from reaching the more sensitive parts of the respiratory system. Particles with aerodynamic diameters less than 10 μm are referred to as PM_{10}.

Larger particulate matter, while not able to affect health, can soil materials and generally degrade aesthetic elements of the environment. For this reason air quality goals make reference to measures of the total mass of all particles suspended in the air. This is referred to as Total Suspended Particulate matter (TSP). In practice, particles larger than 30 to 50 μm settle out of the atmosphere too quickly to be regarded as air pollutants. The upper size range for TSP is usually taken to be 30 μm. TSP includes PM_{10}.

2.2 Oxides of Nitrogen

The key pollutant released from combustion and flaring of goaf gas and combustion of diesel fuel, will be oxides of nitrogen (NO_x). NO_x is comprised of nitric oxide (NO) and nitrogen dioxide (NO_2), however NO is not generally considered harmful to human health and not considered an air pollutant at the concentrations that are typically found in ambient environments. Effects of NO_2 include respiratory infections, asthma and chronic lung disease.

2.3 Summary of Air Quality Goals

The NSW Office of Environment and Heritage (OEH) prescribe ambient impact assessment criteria which are outlined in their "Approved Methods for Modelling and Assessment of Air Pollutants in NSW (**NSW DEC, 2005**). The impact assessment criteria refer to the total pollutant load in the environment and impacts from new sources of these pollutants must be added to existing background levels for compliance assessment.

In June 1998, the National Environment Protection Council of Environment Ministers agreed to set uniform standards for ambient air quality to apply to all States and Territories. These standards are contained in the National Environment Protection Measure (NEPM) for ambient air quality. These NEPM set standards for ambient levels of "criteria pollutants" to be achieved within 10 years of commencement and aim to protect the community against the detrimental health impacts of air pollution. In July 2003 a variation to the Ambient Air Quality NEPM was made to extend its coverage to $PM_{2.5}$ and set "Advisory Reporting Standards" for averaging periods of 1-day and 1-year. It is important to note that the advisory reporting standards were established to assess monitoring data representative of average population and are not used for compliance or impact assessment for specific projects.

Table 2.1 summarises the air quality goals that are relevant to this study.

Table 2.1: Air quality standards / goals for particulate matter concentrations

Pollutant	Standard	Averaging Period	Source
PM_{10}	50 $\mu g/m^3$	24-Hour	NSW DEC (2005) (assessment criteria)
	30 $\mu g/m^3$	Annual	NSW DEC (2005) (assessment criteria)
	50 $\mu g/m^3$	24-Hour	NEPM (allows five exceedances per year)
$PM_{2.5}$	25 $\mu g/m^3$	24-Hour	NEPM Advisory Reporting Standard
	8 $\mu g/m^3$	Annual	NEPM Advisory Reporting Standard
Nitrogen Dioxide	246 $\mu g/m^3$ (0.12 ppm)	1-Hour	NSW DEC (2005) (assessment criteria)
	62 $\mu g/m^3$ (0.03 ppm)	Annual	NSW DEC (2005) (assessment criteria)

The Approved Methods include impact assessment criteria for complex mixtures of odorous air pollutants. They have been refined to take account of population density in the area. **Table 2.2** lists the odour impact assessment criterion to be exceeded not more than 1% of the time, for different population densities.

Table 2.2: Impact Assessment Criteria for the Assessment of Odorous air pollutants

Population of affected community	Impact Assessment Criteria for Complex Mixtures of Odorous Air Pollutants (OU, nose-response-time average, 99th percentile)
≤ ~2	7
~10	6
~30	5
~125	4
~500	3
Urban (2000) and/or schools and hospitals	2

The difference between odour goals is based on considerations of risk of odour impact rather than differences in odour acceptability between urban and rural areas. For a given odour level there will be a wide range of responses in the population exposed to the odour. In a densely populated area there will therefore be a greater risk that some individuals within the community will find the odour unacceptable than in a sparsely populated area. Dispersion models are generally only able to directly predict concentrations over an averaging period of 3-minutes or greater. The human nose, however, responds to odours over periods of the order of a second or so. During a 3-minute period, odour levels can fluctuate significantly above and below the mean depending on the nature of the source. To determine more rigorously the ratio between the one-second peak concentrations and 1-hour average concentrations (referred to as peak-to-mean ratio), OEH commissioned a study by Katestone Scientific Pty Ltd (1995, 1998). This study recommended peak-to-mean ratio for a range of circumstances. The ratio is also dependent on atmospheric stability and the distance from the source.

3 EXISTING ENVIRONMENT

3.1 Location of Privately-owned Residences

Privately-owned residences in the vicinity of the proposed drainage site are located to the east in Camberwell village and to the south / southeast on agricultural land holdings, as shown in **Figure 3.1**. The closest private residence is approximately 1km from the central gas drainage plant and flare site and 400m from the nearest planned gas well.

Residence locations are shown in **Figure 3.1**, along with the approximate location of the proposed central gas drainage plant and flare site and an indicative location for the mobile gas drainage plant. This indicative location is chosen for modelling to assess worst case potential impacts at residence locations to the south / southeast.

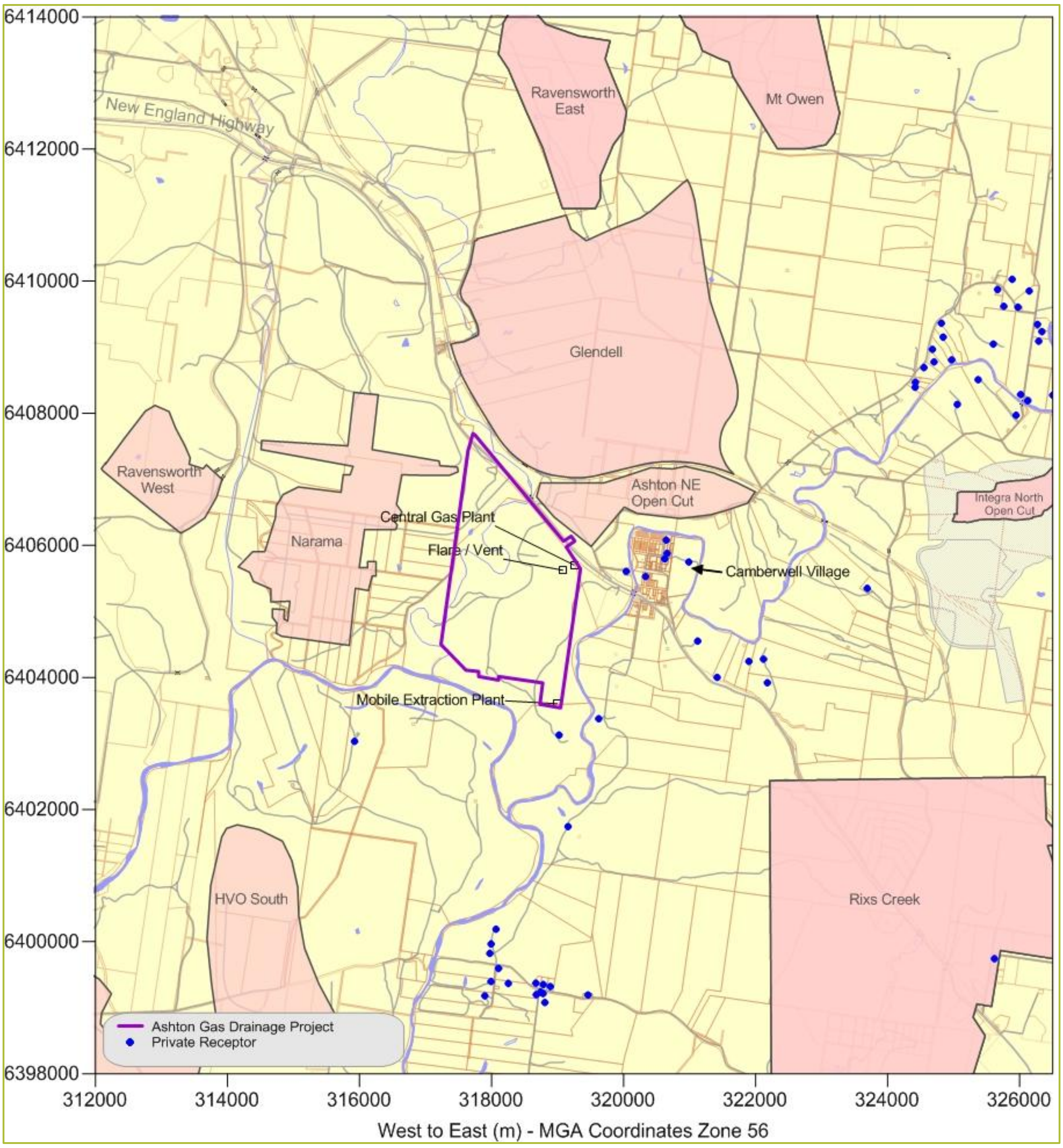


Figure 3.1: Locations of Closest Residences

3.2 Dispersion Meteorology

Annual and seasonal windroses for the Ashton repeater site from July 2007 to June 2008 were analysed and are shown in **Figure 3.2**. The dominant winds are from the west-northwest and the east-southeast for all seasons, with less wind from the west-northwest during summer and from the east-southeast during winter.

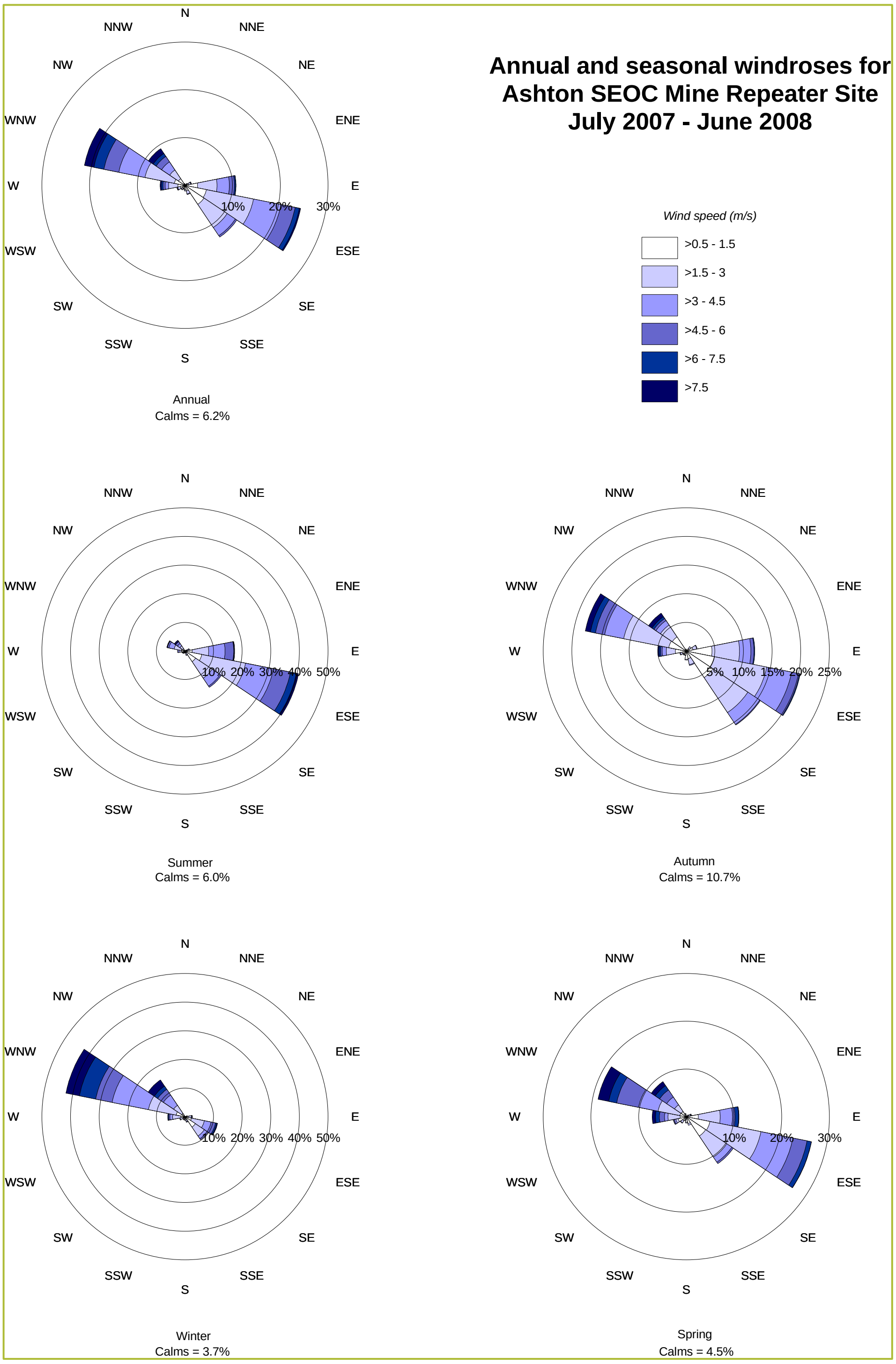


Figure 3.2: Wind Roses for ACOL repeater site– July 2007 to June 2008

3.3 Ambient Air Quality

Air quality standards and goals refer to pollutant levels that include the contribution from specific projects as well as existing sources. Therefore, to assess impacts against all the relevant air quality standards and goals (see **Section 2.3**) it is necessary to have information or estimates on existing background pollutant levels in the area.

Existing sources of particulate matter in the regional airshed include extensive open cut mining operations. PM_{10} concentration is monitored at 8 locations in the vicinity of ACOL. **Table 3.1** presents the annual average PM_{10} concentrations measured at the Ashton TEOM's between 2008 and 2011. All sites from 2008 show annual averages below the OEH criterion of 30 µg/m^3.

Table 3.1: Annual average PM_{10} concentrations at each Ashton TEOM monitoring site (µg/m^3)

TEOM Site	2008	2009	2010	2011
1	25.9	29.5	22.1	22.0
2	18.2	19.8	14.8	14.4
3	22.5	27.3	20.0	20.4
4	23.1	28.7	22.4	23.3
7	21.5	24.3	19.5	19.7
8	25.1	28.0	22.2	22.4

Existing sources of other pollutants in the local or regional airshed include fossil fuel electricity generation (Bayswater and Liddell coal fired power stations), mining sources (mining fleets, explosives) and transport related emissions. Limited data are available for other pollutants, however monitoring data collected as part of MacGen's monitoring campaign indicates that 1-hour NO_2 levels are generally less than 25% of the air quality goals (based on the 95th percentiles) with maximum 1-hour NO_2 concentrations typically less than 50% of the air quality goal (**Katestone, 2009**).

4 IMPACTS

The impact assessment follows a conventional approach commonly used for air quality assessment in Australia and outlined in the NSW OEH "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*".

4.1 Construction Phase Impacts

The primary emissions during construction will be dust and particulate matter. The majority of the particulate matter (PM) emissions generated from construction will be in the coarse size fractions, generally referred to as PM_{10}. Particulate matter (PM) emissions in the fine size fractions, generally referred to <$PM_{2.5}$ are typically associated with combustion sources.

Construction dust will be generated from:

- Trucks and light vehicles travelling on existing unpaved access roads.
- Clearing and earthworks for bore holes, central gas drainage plant and flares.
- Drilling of the gas drainage bore holes.
- Stockpiling of excavated material.
- Wind erosion from exposed ground.

For the construction of the central gas drainage plant, an area of approximately 25 m by 75 m is proposed to be used. The bore holes are anticipated to be surrounded by a perimeter fence of an area of 25 m^2. The soil and vegetation will be fully rehabilitated upon completion of construction phase. The rehabilitation works expected on the site include hydro seeding for stabilizing exposed soils and re-vegetation.

Dispersion modeling predictions of air quality impacts during the construction were not considered necessary, given that construction will be short lived and impacts are expected to be minor and easily controlled through commonly applied dust management measures. Procedures for controlling dust impacts during construction are outlined in **Section 5**. There would be some minor emissions as a result of construction vehicles (exhaust emissions) which would include oxides of nitrogen (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2) and organic compounds. However these emissions are typically minor for projects of this scale and would not give rise to significant off-site concentrations.

4.2 Operational Phase Impacts

4.2.1 Modelling Approach

Dispersion modelling has been used to predict the air quality impacts from the operation of the proposed central gas drainage plant and flares. Modelling results are presented for worst case short term impacts from the operation of the following sources:

- Flare stack at the central gas drainage plant.
- Free ventilation stack at the central gas drainage plant and simultaneous use of a mobile gas drainage plant (where required).
- Diesel generator at the mobile gas drainage plant.

The CALMET/CALPUFF modelling system was chosen for this study. CALMET is a meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects.

The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the three-dimensional meteorological fields that are utilised in the CALPUFF dispersion model. CALMET uses the meteorological inputs in combination with land use and geophysical information for the modelling domain to predict gridded meteorological fields for the region.

CALPUFF is a multi-layer, multi-species non-steady state puff dispersion model that can simulate the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal (**Scire *et al*., 2000**).

Table 4.1 provides a summary of the modelling set up for this project. CALMET was run using observed hourly data from the Ashton Repeater site for 2008 /2009. Upper air data were extracted from TAPM[b] to provide the necessary upper air files. Cloud amount and cloud heights were sourced from the nearest available dataset (Bureau of Meteorology (BoM) automatic weather station at Williamtown).

The performance of the CALMET model is compared with observations made at Ashton based on the annual and seasonal wind roses extracted for a point within the CALMET domain (**Figure 4.1**). The CALMET annual wind rose displays similar characteristics to the measured wind speeds at the Ashton site.

Table 4.1: Model Set Up

TAPM (v 4.0.4)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grid points	25 x 25 x 25
Year of analysis	2008/2009
Centre of analysis (local coordinates)	Ashton Site (319985, 6406252)
Input data	Ashton Repeater Site - hourly observed data
CALMET (v. 6)	
Meteorological grid domain	20 km x 20 km
Meteorological grid resolution	0.2 km
Reference Grid Coordinate (SW corner)	310000, 6396000
Input data	Ashton Repeater Site - hourly observed data TAPM upper air data Cloud data from Williamtown BoM

[b] The Air Pollution Model, or TAPM, is a three dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. Detailed description of the TAPM model and its performance can be found in Hurley (2008) and Hurley, Edwards et al. (2009). TAPM was set up with 4 domains, with a resolution of 30 km, 10 km, 3 km and 1 km respectively.

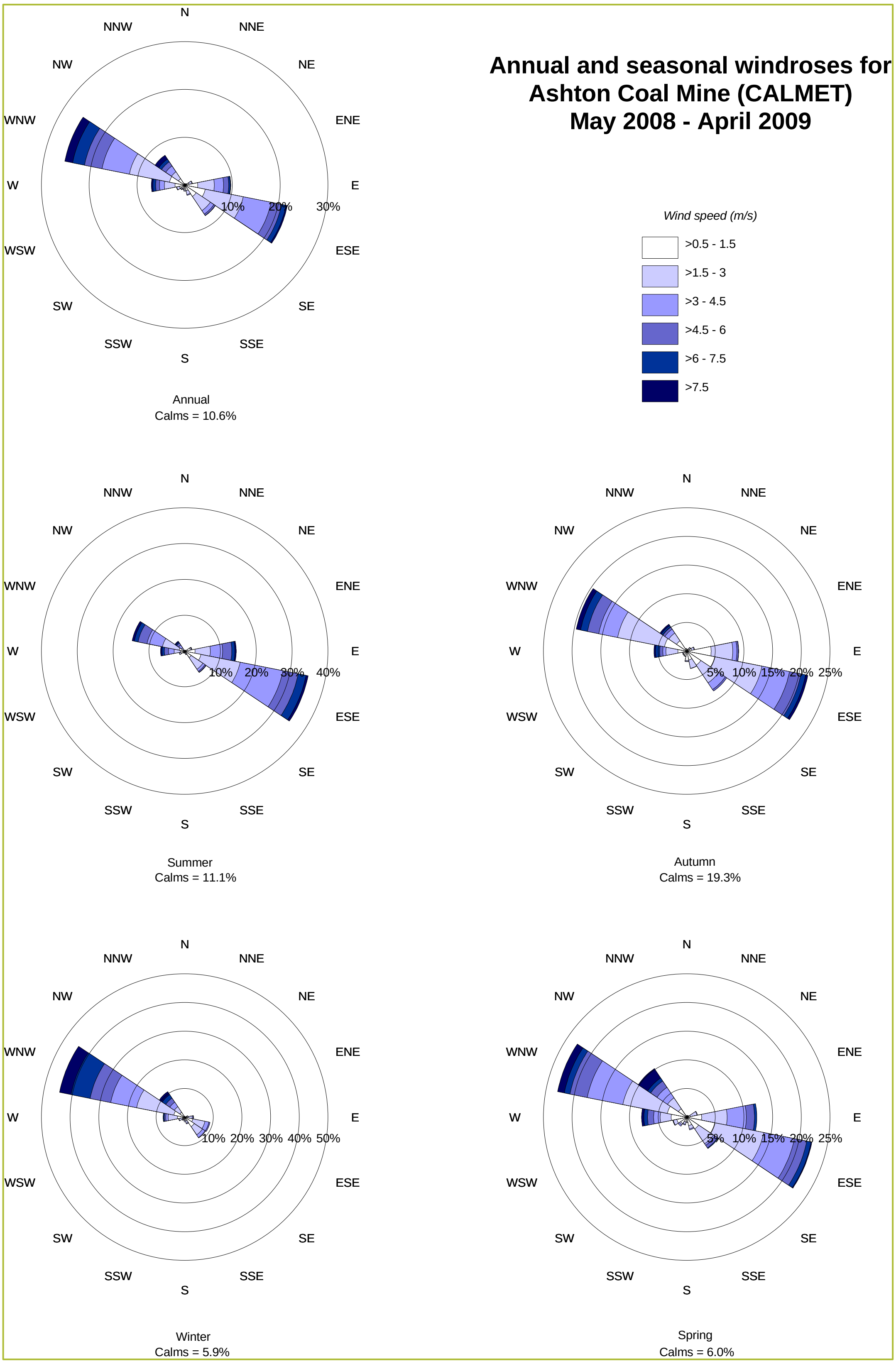


Figure 4.1: Wind Roses for CALMET

4.2.2 Emissions to Air

The following emission sources have been considered for the central and mobile gas drainage plant and flares:

- An enclosed flare for combustion of goaf gas and destruction of methane.
- A remote ventilation stack for the venting of excess goaf gas.
- Short term temporary use of a mobile gas drainage plant including diesel powered compressor.

The pollutants considered for the modelling assessment are:

- NO_x from flaring at the central gas drainage plant. Flaring is a high-temperature oxidation process used to burn waste gases containing methane. In combustion, gaseous hydrocarbons react with atmospheric oxygen to form carbon dioxide (CO_2) and water. Emissions from flaring include oxides of nitrogen (NO_x) and small amounts of unburned hydrocarbons and carbon monoxide (CO). The quantities of hydrocarbon emissions generated relate to the degree of combustion. Properly operated flares achieve at least 98% combustion efficiency in the flare plume, meaning that hydrocarbon and CO emissions amount to less than 2% of hydrocarbons in the gas stream. The creation of smoke or particles from a correctly operated flare would be minor (**US EPA, 1995**).
- NO_x and PM_{10} from the combustion of diesel at the mobile gas drainage plant. NO_x emissions from diesel combustion are higher than emission rates for CO and Sulphur Dioxide (SO_2); however, the air quality goals for CO and SO_2 are higher than NO_2. Therefore, compliance with the NO_2 criteria will demonstrate compliance with the other criteria.
- Odour from the venting of excess goaf gas. Emissions from the free vent stack will be primarily methane and CO_2, which are odourless, however small quantities of odorous hydrocarbons may be present. Methane is non-toxic and therefore not considered as an air pollutant. Fugitive methane emissions typically only present as an explosive risk in confined spaces, and control measures to prevent explosive risk are to provide adequate ventilation. Methane is less dense than air and will continue to rise and disperse from the release point at the vent stack. Ground level concentrations would therefore not be expected to reach levels that could result in an explosive risk or health risk to persons working in the vicinity of the site. Monitoring for methane in the vicinity of the central gas extraction plant will be conducted.

4.2.3 Emissions from Flaring

The emission parameters adopted for the assessment are given in **Table 4.2**. The flares are enclosed within a flare stack, and the actual stack height and diameter have therefore been modelled. The stack height and diameter have assumed based on similar flare stack designs. The exit velocity is conservatively set to 10 m/s (may be higher) and the effective exit temperature is set to 1273 K in accordance with typical approaches for modelling flare emissions (**Robe, 2009**).

Emission estimates have been derived from emission factors presented in the US EPA AP42 for Industrial Flares. Emissions rate calculations have assumed a total potential maximum gas flow to flare of 4,500 L/s. Initially there is estimated to be 2 flares operational, for a gas flow rate of 1,200 l/s, however when mining in the lower barrett seam, the maximum flow rate may be reached.

Table 4.2: Emissions and Stack Parameters – Flares

Parameter	Value
Stack Height	10 m
Stack Diameter	1 m
Exit Velocity	10 m/s
Temperature	1000 °C
Mass Emission Rates	
NO_x	4.9 g/s

4.2.4 Ventilation Stack

Odour concentrations (OU) were not available for the goaf gas ventilation stack. An equivalent odour concentration (OU) has been determined based on measurements of gas from an underground mine in the southern highlands of NSW (**PAEHolmes, 2011**). The gas analysis for this mine indicated the presence of odorous hydrocarbons at low concentrations and the equivalent odour concentration (OU) was determined based on the measured concentration (% v/s) for each compound and the equivalent odour detection threshold.

A conservatively high estimated odour concentration of 1000 OU is adopted for this assessment, based on this gas composition. Modelling assumes excess goaf gas venting at potential maximum gas flow 4,500 L/s at the central gas plant. The derived ventilation stack parameters and emissions estimates are listed in **Table 4.3**.

Table 4.3: Emissions and Stack Parameters – Ventilation Stack

Parameter	Value
Stack Height	12 m
Stack Diameter	0.5 m
Gas Flow (m^3/s) – Central Plant	4.5 m^3/s
Exit Velocity – Central Plant	6 m/s
Assumed Temperature	20 °C
Emission Rates	
Odour Concentration from Ventilation Stack	1000 OU
Derived Odour Emission Rate – Central Plant	4,500 OU.m^3/s

4.2.5 Power Generation Units

The estimated emissions to air from the operation of the diesel compressor have been calculated based on fuel consumption and emission factors for stationary small (less than 450 kW) diesel engines (**DEWHA, 2008**). The estimated emissions are shown in **Table 4.4**.

Table 4.4: Estimated emissions to air from diesel compressor

Pollutant	Fuel Consumption l/hr	Emission Factor kg/m^3	Emission Rate (kg/hr)
CO	48	16	0.768
NOx	48	72	3.456
PM10	48	5.1	0.245
PM2.5	48	5.1	0.245
SO2	48	0.017	0.001
VOCs	48	5.3	0.254

The assumed stack parameters for a typical diesel compressor exhaust are shown in **Table 4.5**.

Table 4.5: Emissions and Stack Parameters – Diesel Compressor

Parameter	Value
Stack Height	3.3 m
Stack Diameter	0.12 m
Exit Velocity	28 m/s
Temperature	300 °C

4.2.6 Modelling results

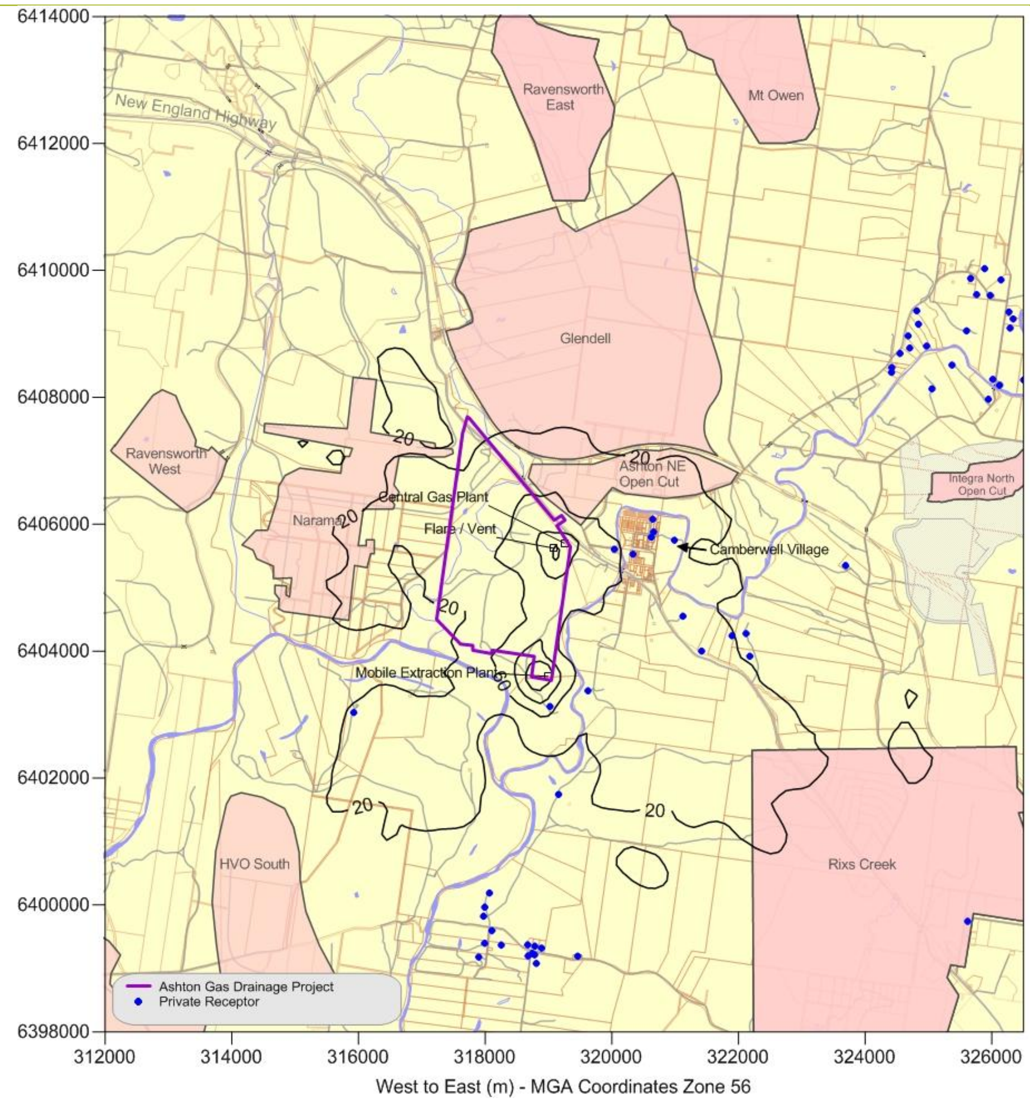
Modelling results are presented for predicted pollutant concentrations for the worst case operation of the central gas drainage plant and simultaneous operation of the mobile gas drainage plant.

4.2.6.1 Nitrogen Dioxide (NO_2)

Maximum 1-hour average NO_x ground level concentrations (glcs) have been predicted due to emissions from the diesel-powered generator and flaring and are shown in **Figure 4.2**.

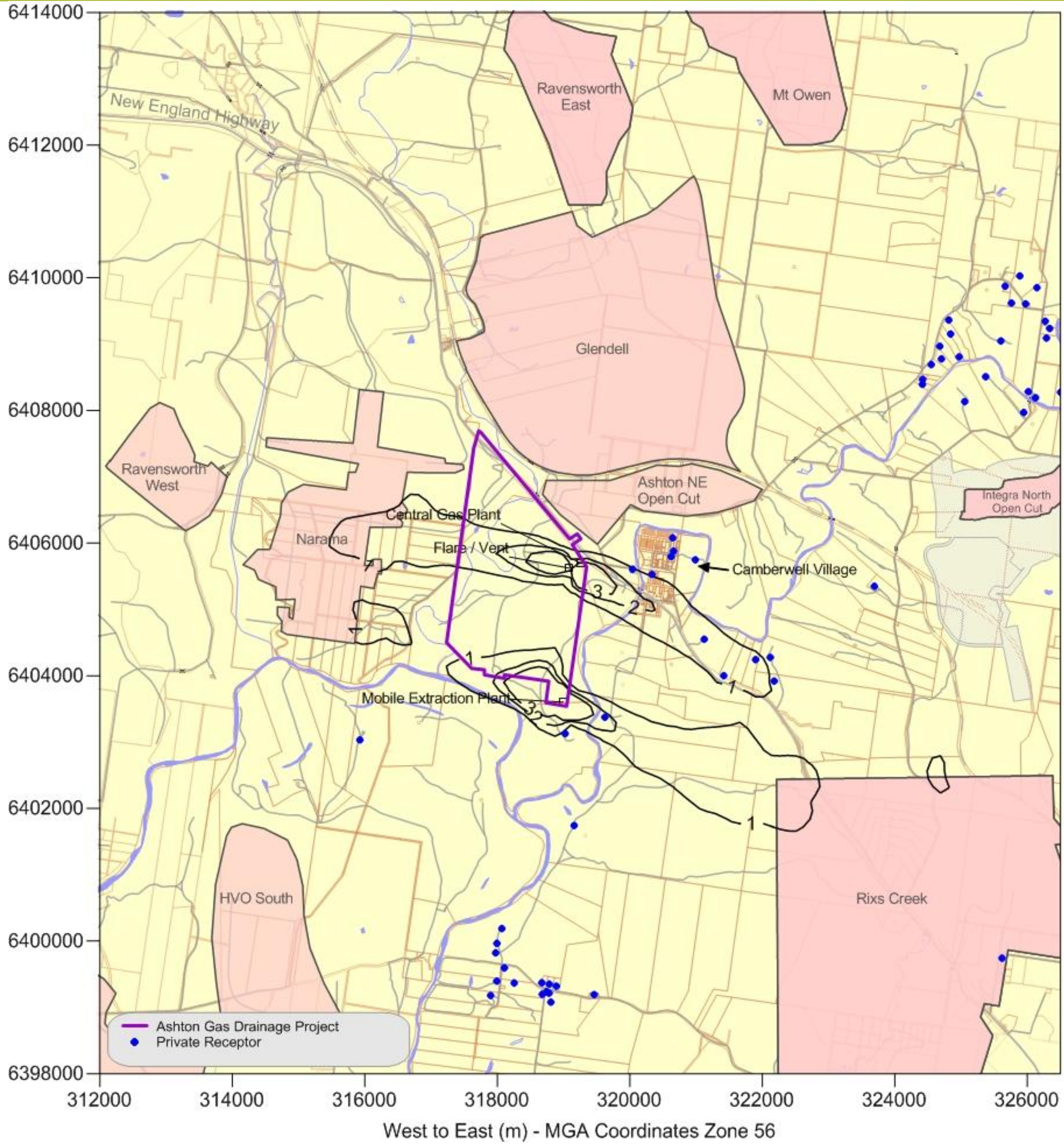
Generally, at the point of emission, NO will comprise the greatest proportion of the emission with 95% by volume of the NO_x. The remaining 5% will be mostly NO_2. Ultimately, however, all nitric oxides emitted into the atmosphere are oxidised to NO_2 and then further to other higher oxides of nitrogen. Generally, for plumes impacting close to the source, the time interval for oxidation is not sufficient to have converted a large proportion of the plume to the more harmful NO_2. However, in order to be conservative, we have assumed 100% conversion of NO_x to NO_2. In reality, the short term conversion of NO_x to NO_2 is probably less than 20% at the distances where highest glcs are predicted.

The results indicate that at the closest residential receivers, the maximum predicted 1-hour NO_2 (assuming 100% conversion of NO_x) is approximately 60 µg/m^3 which is below the impact assessment criteria of 246 µg/m^3. Annual average NO_x concentrations have also been predicted and are shown in **Figure 4.3** The results indicate that at the closest residential receivers, the predicted annual NO_2 is less than 3.0 µg/m^3, compared to impact assessment criteria of 62 µg/m^3.



Species: NO$_X$	Location: Ashton Coal	Scenario: Maximum	Percentile: Maximum	Averaging Time: 1-Hour
Model Used: CALPUFF v6.42	**Units:** µg/m^3	**Guideline:** OEH =246 µg /m^3	**Met Data:** CALMET	**Plot:** K Dissanayake

Figure 4.2: Maximum Predicted 1-Hr Ground-Level Nitrogen Dioxide Concentrations



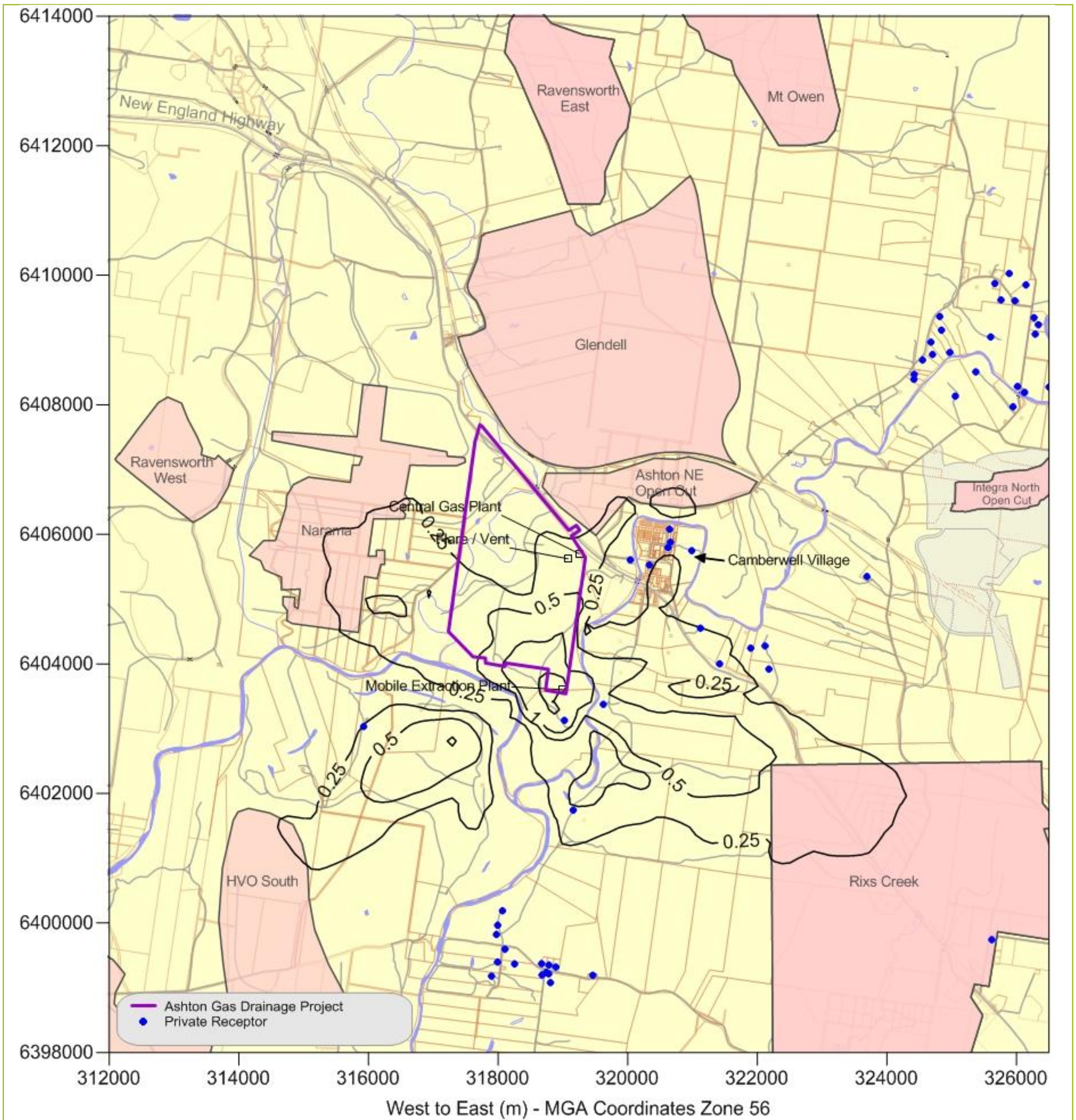
Species:	Location:	Scenario:	Percentile:	Averaging Time:
NOx	Ashton Coal	Maximum	N/A	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	µg/m^3	OEH =62 µg /m^3	CALMET-Generated	K Dissanayake

Figure 4.3: Annual Average Predicted Ground-Level NO_2 Concentrations

4.2.6.2 Particulate Matter

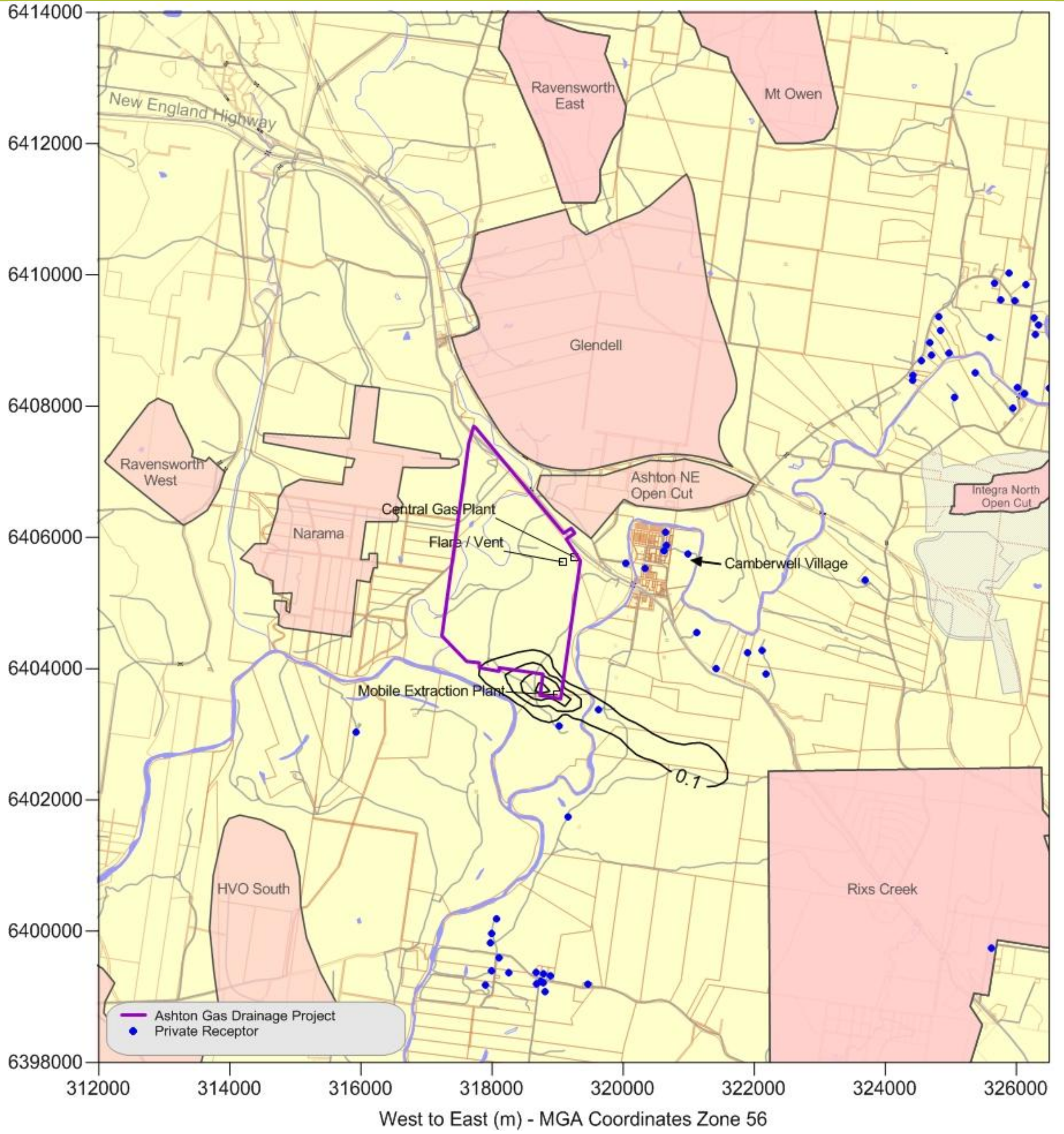
Maximum 24-hour and annual average PM_{10} concentrations have been predicted due to emissions from the diesel-powered generator and are shown in **Figure 4.4** and **Figure 4.5**.

The incremental increase in ambient concentrations of PM_{10} is less than 2 µg /m^3 at the closest residential receiver for 24-hour averages and less than 0.2 µg /m^3 on an annual basis.



Species:	Location:	Scenario:	Percentile:	Averaging Time:
PM_{10}	Ashton Coal	Maximum	Maximum	24-Hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	$\mu g/m^3$	OEH =50 μg /m^3	CALMET-Generated	K Dissanayake

Figure 4.4: Maximum Predicted 24-Hour Ground-Level PM_{10} Concentrations



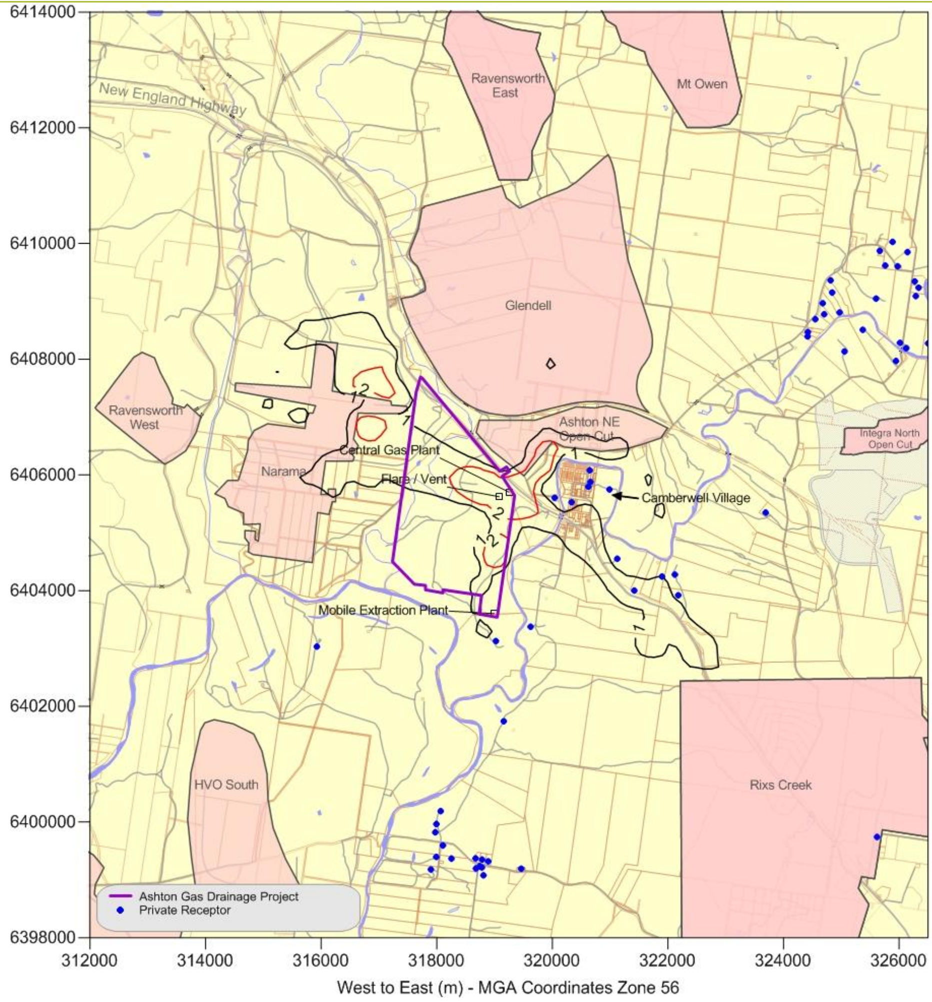
Species:	**Location:**	**Scenario:**	**Percentile:**	**Averaging Time:**
PM_{10}	Ashton Coal	Maximum	Maximum	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	µg/m^3	OEH =30 µg /m^3	CALMET-Generated	K Dissanayake

Figure 4.5: Annual Average Predicted Ground-Level PM_{10} Concentrations

4.2.6.3 Odour

Contour plots of the predicted odour concentration, at the 99th percentile level and expressed as a nose response average (1-second) value, are presented in **Figure 4.6**. A peak-to-mean ratio of 25 has been applied to the 1-hour model predictions to adjust to a nose response average (1-second). This peak-to-mean ratio is for surface wake free point sources and is valid for stability class D,E and F in the near field. It has been conservatively applied to all stability classes for near and far field.

The results indicate that the odour concentration at all residences is predicted to be less than the most stringent odour goal of 2 OU.



Species:	Location:	Scenario:	Percentile:	Averaging Time:
Odour	Ashton Coal	Maximum	99th	Nose Response
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	OU	2 OU	CALMET-Generated	K Dissanayake

Figure 4.6: Predicted Ground-Level Odour Concentrations

4.3 Cumulative Impacts

To assess impacts against the relevant air quality standards and goals, it is necessary to have information on the background concentrations to which the Project is likely to contribute.

The addition of an incremental increase in 24-hour PM_{10} of less than 2 µg /m^3 at the closest residential receiver for 24-hour averages and less than 0.2 µg /m^3 on an annual basis is considered sufficiently low to not result in any additional cumulative impacts.

The predicted incremental increase in 1-hour NO_x is approximately 25% of the air quality goal at the closest receptor location. The actual NO_2 concentrations at these locations are expected to be significantly less than what was modelled, based on the conservative assumption that 100% of NO_x is NO_2. On this basis, the cumulative impact of emissions from this project, combined with existing background levels (generally less than 25% of the goal), would not be expected to approach air quality goals.

The predicted incremental concentrations for other pollutants are expected to be minor and would not result in any potential cumulative impacts. A relatively small and short term increase in construction dust emissions are expected however separation distances to nearest residences (400m from the nearest planned gas well from and 1km from central gas drainage plant) will mean that the cumulative impacts to existing air pollution levels are expected to be negligible.

4.4 Greenhouse Gas Emissions

Carbon Dioxide (CO_2) and methane (CH_4) are the most significant greenhouse gas (GHG) emissions from gas drainage. The pre-drainage of goaf gas reduces the amount of dilute methane released via mine ventilation shafts.

An estimate has been made of the GHG emissions associated with the operation of the goaf gas drainage system. Comparisons are presented for GHG emissions associated with goaf gas venting and flaring. The following assumptions have been made in the analysis:

- The goaf gas flow rate will vary up to a maximum of 4,500 L/s. To estimate typical GHG emissions for the site on an annual basis, the maximum flow rate (4,500 L/s) is assumed to occur for 20% of the time, an average flow rate (1,200 L/s) is assumed to occur for 60% of the time and the low flow rate (600 L/s) is assumed to occur for 20% of the time;
- The goaf gas comprises approximately 90% methane and 10% CO_2;
- The capacity of each flare is 600 L/s with flares added as gas flow is increased, up to a maximum of 4,500 L/s. For the purposes of estimating GHG emissions, flaring is assumed to occur for the average flow rate (1,200 l/s) with excess venting assumed to be required for 20% of the time (at maximum flow rates of 4,500 L/s);

Inventories of GHG emissions can be calculated using published emission factors. Different gases have different greenhouse warming effects (referred to as global warming potentials) and emission factors take into account the global warming potentials of the gases created during combustion. The estimated GHG emissions are referred to in terms of CO_2-equivalent (CO_2-e) emission by applying the relevant global warming potential. Three 'scopes' of emissions (scope 1, scope 2 and scope 3) are defined for GHG accounting and reporting purposes.

GHG emissions were estimated using the methodologies detailed in the National Greenhouse and Energy Reporting System Measurement Technical Guidelines (NGER guidelines) June 2009 (**DCC, 2009**). The NGER guidelines were established as part of the National Greenhouse and Energy Reporting (NGER) Determination 2008 commenced on 1 July 2008 and made under subsection 10 (3) of the *National Greenhouse and Energy Reporting (NGER) Act 2007*.

The estimated GHG emissions (tonnes (t) CO_2-e / annum) are presented in **Table 4.6**. Under the flaring scenario considered, it is estimated that more than 271 kt CO_2-e / annum could potentially be saved. If 100% flaring occurred, GHG savings would reach 438 kt CO_2-e / annum.

Table 4.6: Estimated GHG emissions from Goaf Gas Drainage

Scenario	Emissions (t co2-e / annum)			
	Venting	Flaring	Total	GHG Savings
All Gas Vented - 600 L/s for 20% of year - 1,200 L/s for 60% of year - 4,500 L/s for 20% of year	708,259	-	708,259	N/A
Venting @ 4,500 L/s for 20% of year Flaring @ 1,200 L/s for 100% of year	365,321	72,128	437,449	**270,810**
Flaring @ 4,500 L/s for 100% of year	-	270,480	270,480	**437,779**

It is noted that much of the annual GHG emissions reported in **Table 4.6** would currently occur from the operating mine, released through other pathways such as ventilation shafts and existing wells. The annual GHG emissions from ACOL operations would be reduced as a result of the project proceeding with flaring. The use of electricity to power the central gas drainage plant would contribute to GHG emissions as would the combustion of diesel in the compressor used at the mobile gas drainage plant. However these emissions are minor compared to goaf gas emissions. There would be a small increase in diesel consumption during construction however this will constitute only a minor contribution of the total GHG emissions from the site.

5 MANAGEMENT AND MONITORING

Mitigation measures employed to control dust generation during construction would include, but not necessarily limited to the following:

- Emissions from vegetation stripping and topsoil clearing, particularly during dry and windy conditions, can be effectively controlled by increasing the moisture content of the soil / surface with a water truck;
- When conditions are excessively dusty and windy, the use of a water truck (for water spraying of travel routes) can be used;
- Limiting the extent of clearing of vegetation and topsoil to the designated footprint required for pads and central gas drainage plant;
- Minimising the number of stockpiles on-site and minimising the number of work faces on stockpiles;
- All vehicles should be confined to a designated route with speed limits enforced; and
- Trips and trip distances should be controlled and reduced where possible, for example by coordinating delivery and removal of materials to avoid unnecessary trips;

Due to the small scale and temporary nature of construction phase, monitoring (in addition to that already conducted by ACOL) is not required for construction.

ACOL is continuing to investigate other options for gas management in additional to flaring, such as connection with existing gas networks or onsite power generation. The assessment of these options would be subject to future development consent modifications. Under all of these options, significant reductions in GHG emissions will be achieved.

6 CONCLUSIONS

Emissions from the operation of the central gas drainage system, including flaring and ventilation and the mobile gas drainage plant are minor and significantly less than air quality goals.

Air quality impacts during the construction phase will be short lived and are expected to be easily controlled through commonly applied dust management measures.

The installation of flares at the central gas drainage plant will reduce greenhouse gas emissions by 145 kt CO_2-e / annum and up to 438 kt CO_2-e / annum if 100% flaring occurred.

7 REFERENCES

DCC (2009) National Greenhouse and Energy Reporting Measurement Technical Guidelines for the estimation of greenhouse gas emissions by facilities in Australia, Commonwealth of Australia, June 2009.

DEWHA (2008) National Pollutant Inventory Emission Estimation Technique Manual for Combustion Engines 3.0, Department of the Environment, Water, Heritage and the Arts, Canberra, Australia. http://www.npi.gov.au/handbooks/approved_handbooks/eng.html

Hurley, P. (2008). TAPM V4. Part 1: Technical Description, CSIRO Marine and Atmospheric Research Paper.

Hurley, P., M. Edwards, et al. (2009). "Evaluation of TAPM V4 for Several Meteorological and Air Pollution Datasets." Air Quality and Climate Change 43(3): 19.

NEPC (1998). National Environmental Protection (Ambient Air Quality) Measure Environment Protection and Heritage Council, as amended 7 July 2003.

Katestone Scientific Pty Ltd (1995) "The evaluation of peak-to-mean ratios for odour assessments" Volume 1 - Main Report, May 1995.

Katestone Scientific (1998) "Report from Katestone Scientific to Environment Protection Authority of NSW, Peak to Mean Ratios for Odour Assessments".

Katestone Environmental Pty Ltd (2009) "Air Quality Impact Assessment for the Proposed Bayswater B Power Station Project" September 2009.

NSW DEC (2005) "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW", August 2005.

PAEHolmes (2011) "Air Quality Impact Assessment: BHP Billiton Illawarra Coal – Appin Gas Drainage", 14 November 2011.

POEO (2010) "Protection of the Environment Operations (Clean Air) Regulations", 2010.

Robe, F (2009). Flare Modelling CASANZ 2009 Conference Joint Odour and Modelling Workshop – Perth September 6, 2009. TRC Atmospheric Study Group.

Scire, J.S., D.G. Strimaitis and R.J. Yamartino (2000). A User's Guide for the CALPUFF Dispersion Model (Version 5), Earth Tech, Inc., Concord, MA

TRC (2010) "Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the "Approved Methods for Modelling and Assessment of Air Pollutants in NSW, Australia", prepared for NSW DECCW, Sydney Australia.

US EPA (1995) Compilation of Air Pollutant Emission Factors – Volume 1: Stationary Point and Area Sources, AP-42 Fifth Edition, Office of Air Quality Planning and Standards, Office of Air and Radiation, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711, January 1995.