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**Dual Gas Demonstration Project**

**Statement of Alex Blatchford  
In Response to Expert Evidence from CM Tsesmelis and  
Issue of Updated NOx Plume Dispersion Modelling**

**Prepared with Respect to VCAT Proceedings :  
P1816/2011; P1818/2011; P1820/2011; P1822/2011; P1829/2011; P1846/2011**

**21<sup>st</sup> October 2011**

## Introduction

I have been provided with a copy of Expert Evidence by CM Tsesmelis (signed and dated the 8<sup>th</sup> October 2011). I have reviewed that evidence and I provide this statement in response. I make this statement as a supplement to my earlier evidence, entitled 'Summary Document Describing : IDGCC Process Description, Calculation of Greenhouse Emissions and Best Practice' (dated the 26<sup>th</sup> September 2011).

In addition, this statement outlines the reasons behind a recent request made to URS to conduct an update to NO<sub>x</sub> emission plume dispersion modelling. The URS report summarising this modelling work is attached to this statement.

## Instructions

I have been instructed by Maddocks to answer the following questions with regard to the expert evidence submitted by CM Tsesmelis on available SO<sub>2</sub> Reduction Technology (paragraphs 12 to 14 and 99 to 130) and its applicability to the DGDP :

1. whether the various technologies that Tsesmelis identifies in his report are feasible with Respect to the DGDP;
2. whether the technologies that he identifies – and in particular the technology that he recommends – would satisfy the EPA's condition of 90% reduction;
3. the capacity for the technology that he recommends to be converted at a later date to CO<sub>2</sub> capture;
4. the cost of the technologies that he identifies (and in particular the technology that he recommends).

### 1. Whether the Technologies Identified are Feasible with respect to DGDP

HRL Developments (HRLD) and Tsesemelis appear to be in broad agreement over the applicability (for DGDP) of the range of technologies presented in his report for sulphur absorption and subsequent conversion to elemental sulphur. HRLD's comments on the technologies raised in his report are briefly outlined below in relation to their potential for use by DGDP.

**Rectisol** – Rectisol is a feasible technology for separation of H<sub>2</sub>S and CO<sub>2</sub> at separate streams for DGDP. It is however considered to be one of the most expensive Acid Gas Removal (AGR) processes due to its complexity and refrigeration requirements.

**Selexol** – Selexol is a feasible technology for separation of H<sub>2</sub>S and CO<sub>2</sub> at separate streams for DGDP. If sulphur capture is required with respect to the DGDP, Selexol would be more preferable to Rectisol.

**Sulfinol** – Sulfinol is used at the Buggenham IGCC plant (using a modified solvent know as m-Sulfinol). Sulfinol may not be optimal for the DGDP syngas conditions with a high CO<sub>2</sub> to H<sub>2</sub>S ratio and for providing the required gas quality for a Claus plant (a further enrichment step may be required), although further review would be required.

**Amine (eg MDEA)** – MDEA is used for IGCC syngas treating at several commercial and demonstration sites (including Puertollano) and has a relatively high H<sub>2</sub>S / CO<sub>2</sub> selectivity. Amine plants are generally lower capital cost than physical absorption plants (eg Selexol), however, may

not be able to achieve the required H<sub>2</sub>S concentration required for a straight through Claus plant due to high CO<sub>2</sub> co-absorption (ie further processing may be required).

**Guard Bed Absorbers** – This technology is highly unlikely to be suitable to achieve the required 90% S capture given the quantity of S to be captured, particularly if the sorbent is not able to be regenerated.

**Shell-Paques** – This technology is a possible option, however the use of NaOH scrubbing will require a very high level of washing to prevent carry-over of Na into the gas turbine, which would affect turbine blade life (and which may affect turbine guarantees / warranties). HRLD agrees with Tsesmelis that this equipment would become redundant if CO<sub>2</sub> capture would be required at a later date.

**Catalytic-Redox** – This is a possible technology for conversion of the H<sub>2</sub>S rich stream to elemental S. The operating costs of this plant can be high due to the use of expensive catalysts and the relatively high degradation rate of the catalyst. Operational issues can be a problem with this technology.

**Limestone Addition** - HRLD agrees that this is not a feasible technology for this application.

**Claus Process** – the Claus process for conversion of H<sub>2</sub>S to elemental sulphur is a feasible technology for DGDP, subject to achieving minimum H<sub>2</sub>S concentrations in the acid gas to achieve the required H<sub>2</sub>S to S conversion efficiency.

The sulphur capture technology recommended by Tsesmelis is Selexol (for H<sub>2</sub>S absorption from the syngas), combined with a Claus unit (for conversion of the H<sub>2</sub>S to elemental sulphur). HRLD agrees that the use of Selexol and Claus technologies could be feasible for the DGDP.

## **2. Whether the Recommended Technologies would Satisfy the EPA's Condition of 90% S Reduction**

### ***Discussion on Works Approval Requirement for Achieving 90% S Capture***

The works approval (Section 3.1 (a), Reporting Conditions) states that :

'Before commencing construction, the occupier must submit to the EPA for written approval a report that includes the plans and specification of the works specified in condition 1.2, including details of :

- (a) Sulphur dioxide reduction equipment that will reduce the emissions by at least 90% of uncontrolled emissions (based on the average sulphur level in the coal feedstock).'

This has been interpreted as requiring a 90% reduction in S emissions compared with the design of the plant where there has been no sulphur emission control implemented (based on a coal with an average sulphur level in the resource). Approximately 27% of the S is captured in the ash, hence this interpretation would require a 92.7% overall capture of S in the feed coal. It should be noted that part of the overall S input is emitted from the char burner, which is not proposed to be fitted with S capture (estimated to be 4.5% of the total S emissions). To achieve a 90% overall plant S emission reduction would therefore require 94.3% S capture in the syngas to the CCGT.

An alternative interpretation would be achieving an overall S capture rate of 90% based on the sulphur in the coal (ie a maximum of 10% of the S in the coal is allowed to be emitted to the air).

The EPA Assessment Report (page 26) presents calculations for a 90% reduction in sulphur emissions from the syngas supplied to the gas turbine only (with no S capture required for the char burner), which is a further definition, and which would require the lowest overall S capture (86% of the S in the coal or 14% emission to air).

### ***Selection of Selexol and Claus Technologies for Sulphur Capture***

The sulphur capture technology recommended by Tsesmelis is Selexol (for H<sub>2</sub>S absorption from the syngas), combined with a Claus unit (for conversion of the H<sub>2</sub>S to elemental sulphur). HRLD agrees that the use of Selexol and Claus technologies could be feasible for the DGDP.

The combination of these technologies can achieve H<sub>2</sub>S to elemental S conversion rates around 95% (or about 97.5% capture of H<sub>2</sub>S in the Selexol and 97.5% conversion of the H<sub>2</sub>S to elemental S in the Claus unit), depending upon a number of factors including the H<sub>2</sub>S content of the acid gas supplied from Selexol to the Claus unit. This is slightly above the 94.3% required S capture efficiency in the syngas (as presented above) to achieve the 90% S emissions reduction. Further processing of the tail gas from the Claus unit can further reduce S emissions if required, but at additional cost.

### **3. The Capacity for the Recommended Technology to be Converted at a Later Date to CO<sub>2</sub> Capture**

The use of Selexol designed for H<sub>2</sub>S absorption would be able to be expanded for CO<sub>2</sub> absorption at a later date by adding a 2<sup>nd</sup> Selexol stage, as suggested by Tsesmelis. However, there may be some design differences in the H<sub>2</sub>S absorption / stripping portion of a Selexol plant with H<sub>2</sub>S absorption (only) and one with both H<sub>2</sub>S and CO<sub>2</sub> absorption. The liquids circulating load would be higher with CO<sub>2</sub> capture, requiring a larger H<sub>2</sub>S stripping column (and associated equipment). The heat duty with CO<sub>2</sub> capture will be higher, requiring additional steam to the H<sub>2</sub>S stripping column reboiler (and hence requiring a larger reboiler). In other words, higher costs would be incurred to install an H<sub>2</sub>S absorber using Selexol to allow it to be subsequently expanded for CO<sub>2</sub> capture. Alternatively, the H<sub>2</sub>S stripping column (and associated equipment) could be replaced if CO<sub>2</sub> capture is subsequently required.

### **4. The Cost of the Recommended Technologies**

Tsesmelis (para 13) claims a single stage Selexol unit (for H<sub>2</sub>S capture) with a Claus unit (for > 5 tons per day of S production required for DGDP) would cost \$ 20 M (+/- 40%). It is not clear whether this is a purchased equipment cost or whether this is the cost of a fully installed plant (there is a very large difference between the two costs). Differences include transport, construction, contractors' fees, engineering and design, civil and structural, craneage, electrical, instrumentation, controls, piping, painting and insulation, owners' costs, legal costs, commissioning, insurance, licensing, cost of initial charge of chemicals / catalyst and spares etc. For the DGDP there will be additional syngas

processing steps and costs (as outlined below) which HRLD believe may not have been included in Tsesmelis's cost estimate.

Additional costs for further syngas processing required for H<sub>2</sub>S capture from an IDGCC plant (given the high gas flow and the high moisture content of the syngas) are as follows :

- The syngas supply to the Selexol needs to be cooled to about 40°C and to condense the majority of the water from the syngas, requiring several large heat exchangers;
- After separation of the H<sub>2</sub>S the syngas needs to be rehumidified (using the separated water from the cooling step) to reduce the impact of cooling the gas and separating the water on the gas turbine output and the overall plant efficiency. This step also requires heating (in a heat exchanger) using medium pressure steam;
- The treated syngas needs to be reheated back to close to the feed temperature (using regenerative heat exchangers);
- To offset the stripping and heating steam required and the reduction in efficiency that occurs from having a sulphur capture plant, an additional HRSG economiser has been added to lower the HRSG outlet temperature (this is feasible given the lower HRSG stack acid dew point following reduction of the H<sub>2</sub>S content in the syngas);
- A COS hydrolyser will also be required to convert the COS to H<sub>2</sub>S (for subsequent capture) to ensure that the required 90% S emissions reduction is achieved.

It should be noted that the Selexol costs for an air blown gasifier (such as DGDP) will also be larger than the equivalent for an oxygen blown plant due to the higher syngas flow.

Initial cost estimates for S capture of \$20 M were provided to the EPA (as presented in the EPA Assessment Report), which was an estimate based on purchased equipment costs and which did not take into account the full costs and complexities required to implement S capture for the DGDP. Further order of magnitude estimates of \$100 M to \$120 M (Further and Better Particulars dated 25<sup>th</sup> August 2011, and Statement by David Walton dated 3<sup>rd</sup> October 2011) considered the complexities and was a total installed cost.

A revised cost estimate of a fully installed Selexol plant with a Claus S recovery system together with the additional equipment items required for the DGDP (as outlined above) is around \$ 90 M for a 300 MW unit. The cost is a factored estimate, based on preliminary process modelling and sized equipment items.

Preliminary modelling has indicated an overall reduction in net output of about 2.8 MW for a 300 MW unit (from increased auxiliary load, lower maximum gross generation and a reduction in generation from the steam demand required for the sulphur capture plant (offset by additional steam generation in the HRSG)), or just under 1%. There is also about a 0.3% reduction in overall plant efficiency.

It should be noted that the original DGDP plant design (as presented in the Works Approval) did not include sulphur capture, and has not been part of discussions with the Engineering Procurement and Construction (EPC) contractor. As such detailed design and process optimisation (including a full assessment of available sulphur capture technologies and engagement with suppliers) has not been conducted that would allow more accurate capital and operating cost and plant performance assessments.

## **Explanation for Updated NO<sub>x</sub> Plume Dispersion Modelling**

David Thornton (formerly of HRL Technology Pty Ltd, now of URS Australia Pty Ltd) has previously conducted plume dispersion modelling of emissions from the proposed DGDP plant.

An error in the application of the calculated NO<sub>x</sub> emission rates (as presented in HRL Technology report HLC/2009/430/R5, dated November 2010) from the plant was recently identified.

NO<sub>x</sub> is predominately emitted from the DGDP stacks in the form of NO (with a small fraction as NO<sub>2</sub>). However, in the plume dispersion modelling NO<sub>x</sub> is modelled as NO<sub>2</sub>, which requires the NO emission rates (in grams / second) from each stack to be converted to NO<sub>2</sub> equivalent. Due to the higher molecular weight of NO<sub>2</sub> compared with NO, the NO<sub>x</sub> emission expressed as NO<sub>2</sub> is higher than when expressed as NO. However this conversion step was not conducted and therefore the NO<sub>x</sub> emission rates (expressed as NO<sub>2</sub>) used in the model was low.

A request was made to David Thornton to repeat the modelling with the NO<sub>x</sub> emission rates converted to NO<sub>2</sub> equivalent for modelling purposes. This modelling has been completed, and is outlined in the attached URS report.

It should be noted that the estimated total NO<sub>x</sub> emission rates (ie NO plus NO<sub>2</sub>, without conversion of NO to NO<sub>2</sub>) from each stack have not materially changed between the November 2010 and the October 2011 modelling work, and that they remain within the relevant SEPP (AQM) design criteria.



## Report

### Dual Gas - Air Dispersion Modelling for Nitrogen Dioxide

21 OCTOBER 2011

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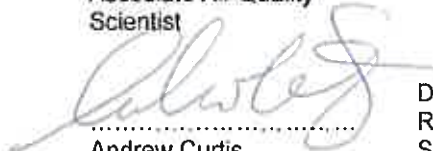
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## Executive Summary

Dual Gas Pty. Ltd. is proposing to build a 600MW power station to demonstrate Integrated Drying Gasification Combined Cycle technology at a commercial scale. This demonstration plant (Dual Gas Demonstration Project-DGDP) will be located within the Energy Brix Australia Corporation site in the Latrobe Valley, Victoria. The Project will comprise two Integrated Drying and Gasification units feeding two Combined Cycle Gas Turbines.

The potential effects of discharges from the Project have been assessed previously, however URS has been asked to re-run the analysis to ensure it accurately models the proposed power station. This assessment has been undertaken to determine cumulative ground level concentrations of nitrogen dioxide (NO<sub>2</sub>) resulting from the proposed power plant in conjunction with other Latrobe Valley (LV) sources, utilising the advanced non-steady state model CALPUFF V 6.42 for comparison with regulatory criteria.

With the DGDP operating on full synthesis gas production with supplementary natural gas duct firing, URS modelled 99.9<sup>th</sup> percentile 1-hour ground level concentrations of NO<sub>2</sub> including other point sources within the Latrobe Valley (background). The results are below State Environment Protection Policy 1-hour Design Ground Level Concentrations (DGLC). The maximum 99.9<sup>th</sup> percentile 1-hour average NO<sub>2</sub> modelled concentration across the modelled grid domain occurs approximately 3-km south-west of Morwell. The maximum 99.9<sup>th</sup> percentile 1-hour average NO<sub>2</sub> modelled concentration at the selected sensitive receptors is at Jeeralang Hill. The predicted concentrations are presented below.

Model Version	Averaging Period	Existing LV sources + DGDP	
		Maximum (99.9%) Modelled (mg/m <sup>3</sup> )	Maximum (99.9%) Receptor (mg/m <sup>3</sup> )
CALPUFF V6.42	1-hour	0.13	0.11
SEPP(AQM) Design criteria (mg/m <sup>3</sup> )		0.19	
SEPP(AQM) Intervention criteria (mg/m <sup>3</sup> )		0.27	
NEPM Criteria (mg/m <sup>3</sup> )		0.23	

## Introduction

Dual Gas Pty. Ltd. (DGPL) is proposing to build, own and operate a Dual Gas Demonstration Project (DGDP) located in the Latrobe Valley, Victoria. The open-ended Latrobe Valley extends approximately 130-km inland from the east coast with the western end located approximately 120-km southeast of Melbourne. The Latrobe Valley is bordered by the Great Dividing Range to the north (peaks approximately 2000 m) and the Strzelecki Range to the south (peaks near 700m). The valley is typically 15-km wide and narrows to approximately 8-km in its western section. DGPL proposes a 600 MW (megawatt) power station consisting of two Combined Cycle Gas Turbine (CCGT) units and two Integrated Drying and Gasification plants.

The proposed Dual Gas Demonstration Project (DGDP) site is located within the existing Energy Brix Australia Corporation (EBAC) complex, south of the township of Morwell (see Appendix A). The primary fuel for the DGDP is synthesis gas, ('syngas'), which will be generated from brown coal in the integrated drying and gasification plants. Natural gas will be used to start-up the plant and as a 'supplementary' fuel.

Expected emissions to atmosphere from the DGDP site during full synthesis gas production with supplementary natural gas combustion will include:

- Oxides of nitrogen (NO<sub>x</sub>);
- Sulphur dioxide (SO<sub>2</sub>);
- Carbon monoxide (CO);
- Particulate matter with an equivalent aerodynamic diameter of 10 micrometres or less (PM<sub>10</sub>); and
- Particulate matter with an equivalent aerodynamic diameter of 2.5 micrometres or less (PM<sub>2.5</sub>).

Previous cumulative air quality dispersion modelling assessments (incorporating emissions from the existing major Latrobe Valley sources plus the proposed DGDP site) have been undertaken by HRL Technology (HRLT).<sup>1</sup> These modelling assessments indicated that predicted ground level concentrations of the emitted species at a modelled spatial resolution of 1-km would be below the relevant State Environment Protection Policy (Air Quality Management) (SEPP (AQM)) Design Criteria.

HRLT dispersion modelling was undertaken using CALPUFF version 6.262. In April 2011, TRC, the model author, released an updated version (6.42). This assessment utilises the current version 6.42.

URS Australia Pty Ltd (URS) were engaged by Maddocks to undertake this assessment to model:

- Dual Gas Demonstration Project together with all other LV sources;
- 1-km grid resolution across the modelling domain;
- Nitrogen dioxide (NO<sub>2</sub>) only; and
- GT operation on syngas only (not Natural Gas) with supplemental gas firing, i.e. worst case scenario.

<sup>1</sup> HLC/2009/430/R5 – November 2010; HLC/2011/046 – February 2011

## Assessment Criteria

The Ambient Air Quality National Environment Protection Measure (NEPM) sets National goals for ambient air quality.

The Victorian State Environment Protection Policy (Ambient Quality Management) sets air quality objectives and goals for the State of Victoria. The State Environment Protection Policy (Ambient Air Quality (SEPP (AAQ))) adopts the requirements of the NEPM (Ambient Air Quality) for six common pollutants. The SEPP (AAQ) standards apply to all of Victoria including regional air quality and sites that are generally representative of general population exposure. The state of ambient concentrations resulting from anthropogenic emissions is determined by EPA Victoria in the Latrobe Valley on an annual basis by comparisons to the SEPP (AAQ) standards and goals with measurements undertaken at Moe and Traralgon, which forms part of the Latrobe Valley Air Monitoring Network (LVAMN).

The intent of the State Environment Protection Policy for Air Quality Management (SEPP (AQM)) is to ensure compliance with the SEPP (AAQ) and consequently the NEPM and therefore protect the beneficial use of the air environment.

### 2.1 National Environment Protection Measure

In June 1998, the National Environment Protection Council (NEPC) made Australia's first national ambient air quality standards as part of the National Environment Protection Measure for Ambient Air Quality (the 'Air NEPM'). The Air NEPM sets national standards for six key air pollutants to which most Australians are exposed. The national standard for nitrogen dioxide (Table 2-1) is set higher than that of the SEPP (AQM) Design Criteria (see section 2.2.1) which has been used in this assessment. It should also be noted that the Air NEPM criteria are standards applicable to air sheds (representing a population of 25,000 people), whilst the SEPP (AQM) Design Criteria are for the assessment of the impacts from industrial emissions.

Table 2-1 NEPM NO<sub>2</sub> criteria

Species	Averaging Period	NEPM Criteria (mg/m <sup>3</sup> )
Nitrogen dioxide	1-hour	0.23

### 2.2 Victorian Ambient Air Quality Assessment Criteria

With respect to NO<sub>2</sub>, the SEPP (AQM) provides two standards which may be considered indicative of an impact:

- The Design Criteria (Schedule A); and
- The Intervention Criteria (Schedule C).

#### 2.2.1 Design criteria

In Victoria, the SEPP (AQM) provides Design Criteria for Ground Level Concentrations (GLCs) (Design Criteria) for emissions from stacks and other industrial sources. Design Criteria are indicators for assessing the potential impact of new or modified sources of emissions to air in Victoria and are formulated to protect the beneficial uses of the ambient air environment which includes the health and well-being of human life.

## 2 Assessment Criteria

The SEPP (AQM) defines air quality indicators as Class 1, 2, 3 or unclassified indicators depending on their likely distribution, toxicity, odour characteristic or hazard rating. This reflects the current understanding of the health effects compounds, thereby ensuring that beneficial uses of the environment are protected, including life, health and well-being of humans, local amenity and aesthetic enjoyment and visibility.

Schedule A of the SEPP (AQM) provides Design Criteria for the purpose of assessment of proposals for new emission sources or modifications to existing emission sources. The Design Criteria relevant to the dispersion modelling assessment of air quality effects from the DGDP for NO<sub>2</sub> is set out in Table 2-2.

Table 2-2 SEPP (AQM) Schedule A - Design Criteria: NO<sub>2</sub>

Species	Averaging Period	Design Criteria (mg/m <sup>3</sup> )
Nitrogen dioxide	1-hour	0.19

### 2.2.2 Intervention criteria

The intervention criteria are concentrations used for assessing measurement data. The intervention criteria provide a trigger for further investigation by EPA where measured concentrations exceed the standard. By definition, concentrations below the intervention criteria are considered not to be harmful to the beneficial use of the atmosphere as they do not warrant investigation by EPA.

The intervention criteria relevant to the dispersion modelling assessment of air quality effects from the DGDP for NO<sub>2</sub> is set out in Table 2-3.

Table 2-3 SEPP (AQM) Intervention Criteria for NO<sub>2</sub>

Species	Averaging Period	Intervention criteria (ppm)	Intervention criteria (mg/m <sup>3</sup> )
Nitrogen dioxide	1-hour	0.14	0.27 <sup>2</sup>

<sup>2</sup> Converted from ppm at 25 degrees

## Air Quality Modelling

As with previous assessments undertaken by HRLT, dispersion modelling was undertaken using the CALPUFF dispersion model. CALPUFF is a multi-layer, multispecies non-steady-state Gaussian puff dispersion model which is able to simulate the effects of time and space varying meteorological conditions. This enables the model to account for a variety of effects including terrain, plume fumigation and low wind speed dispersion.

### 3.1 Modelled scenarios

Since the last assessment by HRLT that included nitrogen dioxide (HLC/2009/430/R5 – November 2010), the distributors of the CALPUFF modelling system have released an updated version of the model (version 6.42). Version 6.262 has been used in all previous assessments. URS would normally run both models in a situation like this to determine whether any changes in predicted concentrations are as a result of the changes in predicted emissions or as a result of technical 'tweaks' to the model. However, in the time available, URS has been instructed to undertake this current assessment with the latest version 6.42 only. Therefore URS is unable to assess the causes for any changes in predicted concentrations in this report compared to earlier studies.

Modelling of the following scenario with CALPUFF version 6.42 has been undertaken:

- All background Latrobe Valley sources (as in previous HRLT assessments - Energy Brix, Hazelwood, Yallourn, Loy Yang A & B, Jeeralang A & B power stations, and Australian Paper) in conjunction with the proposed DGDP, in order to provide ground-level concentrations of NO<sub>2</sub> across the model domain at a spatial resolution of 1-km.

### 3.2 Dispersion modelling methodology

Dispersion modelling follows the following general steps:

- Emissions estimation;
- Meteorological modelling;
- Dispersion modelling; and
- Post processing.

#### 3.2.1 Emissions estimation

##### *Dual Gas Demonstration Project*

As per previous HRLT assessments, NO<sub>x</sub> emissions (Appendix B) for the proposed 600MW DGDP reflect the operation of two gasifiers providing full capacity for two gas turbines with maximum supplementary duct firing on natural gas. All inputs to the model from the DGDP are as per previous assessments with the exception of new NO<sub>x</sub> emission rates.

Emission estimates have been supplied by Dual Gas to URS and have been calculated for each stack from tender specifications, supplier guarantees, State Environment Protection Policy (SEPP) Schedule E limits and predicted emission levels from process modelling. In this report, all references to NO and NO<sub>x</sub> values are expressed as NO<sub>2</sub>.

## 3 Air Quality Modelling

### *Existing Latrobe Valley sources (background levels)*

NO<sub>x</sub> (total oxides of nitrogen) emissions information from additional sources in the Latrobe Valley has been derived from EPA Victoria site license information and is as per previous HRLT assessments. These sources, mainly comprising electricity generation facilities, are the major contributors to NO<sub>2</sub> background levels in the Latrobe Valley. In addition, 70<sup>th</sup> percentile hourly background values for NO<sub>2</sub> of 0.017 mg/m<sup>3</sup> have been included for the Latrobe Valley and are derived from EPA Victoria's ambient air monitoring network. This background value incorporates all sources of NO<sub>2</sub>, including motor vehicles and the paper manufacturing industry. However, the majority of NO<sub>x</sub> emissions in the Latrobe Valley are contributed by the electricity generation sector. As all electricity generators and Australian Paper are already included as point sources in the model, the additional incorporation of the EPA Victoria supplied background value is in effect double counting and hence conservative.

Emission rates and modelled stack parameters for the background sources are presented in Appendix B.

### 3.2.2 Nitrogen dioxide

Nitrogen oxides are emitted mainly in the form of nitric oxide (NO), but once released into the atmosphere are oxidised to nitrogen dioxide (NO<sub>2</sub>). Depending on the source, the amount of NO<sub>2</sub> in the exhaust stream as it is released is approximately 5 to 10% of total NO<sub>x</sub>. The predominant short-term transformation process is the reaction of nitric oxide with ambient ozone to form nitrogen dioxide:  $\text{NO} + \text{O}_3 \rightarrow \text{NO}_2 + \text{O}_2$ . Since the reaction is a 1 to 1 transformation that does not affect total NO<sub>x</sub> concentrations, the maximum extent of conversion of NO to NO<sub>2</sub> that can be expected in the emission plume is directly related to the maximum ambient concentration of ozone. One of the most common atmospheric chemistry issues a modelling assessment is required to address is estimating NO<sub>2</sub> from modelled NO<sub>x</sub> concentrations.

In this assessment, it has been assumed that 30% (as per previous HRLT assessments, based on historical LVAMN measurements (Delaney, 2007) and (Janssen et al., 1988)), of NO transforms to NO<sub>2</sub> after the exhaust gases are discharged from the stack. The NO<sub>2</sub>/NO<sub>x</sub> ratio can be higher in townships where vehicles and domestic heating contribute to elevated levels of NO<sub>x</sub> and lower close to the emission sources. Where measured oxidation rate information exists for individual air quality stations, this has been used to predict ground level concentrations of NO<sub>2</sub> at the relevant site (as per previous HRLT assessments). Available oxidation ratios relevant to these stations are presented in Appendix B.

### 3.2.3 Meteorological modelling

To provide consistency with previous HRLT modelling assessments, URS has utilised the 3-D meteorological dataset for the year 1991. During this year, surface observation stations extended to the extremities of the valley.

The annual meteorological data used with CALPUFF was generated in two stages:

- Stage 1 - The Air Pollution Model (TAPM), a self-contained PC-based model developed by the Commonwealth Scientific and Industrial Organisation (CSIRO) Australia, was used with synoptic data and meteorological measurements in the Latrobe Valley to generate a 3-D meteorological dataset which included winds, temperature profiles and mixing layer heights. The following settings were used:

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### 3 Air Quality Modelling

- GEODATA 9-second (~250m) terrain height database;
  - Default databases for land use, synoptic analyses and sea surface temperatures;
  - Surface meteorological measurements from 6 stations in the Latrobe Valley;
  - Grid of 51 by 31 grid points;
  - 25 vertical levels (10m, 25m, 50m, 100m, 150m, 200m, 250m, 300m, 400m, 500m, 600m, 750m, 1000m, 1250m, 1500m, 1750m, 2000m, 2500m, 3000m, 3500m, 4000m, 5000m, 6000m, 7000m and 8000m)
  - An outer grid of 15km horizontal resolution; and
  - Two nested grids with horizontal resolutions of 4km and 1km.
- Stage 2 - Output from TAPM (extracted for 6 upper air stations and 2 surface stations) together with observed surface measurements (6 stations) were configured for use with diagnostic model CALMET V6.212. CALMET is able to use meteorological data, either observed or synthetically derived, together with surface land use and terrain information to generate the 3-D meteorological dataset for use with CALPUFF.

Previous HRLT reports have undertaken extensive verification of the 1991 meteorological data set as being representative of present-day meteorological conditions in the Latrobe Valley.

#### 3.2.4 Dispersion Modelling

##### *CALPUFF setup*

To maintain consistency with previous HRLT NO<sub>2</sub> assessments, the following model options have been selected:

- Irwin rural wind profile coefficients;
- Stack-tip downwash selected;
- Partial plume penetration mode;
- Partial plume terrain adjustment; and
- Turbulence characteristics determined from internally calculated micrometeorological variables.

##### *Dispersion modelling resolution*

As the meteorological modelling was undertaken at a resolution of 1-km, the model includes terrain heights and land use at 1-km resolution only. It should be noted that the use of low resolution meteorology, terrain and land use information has the potential to result in both over and under prediction of ground level concentration as the low resolution has the potential to 'miss' terrain and land use features that are less than 1-km in spatial dimension.

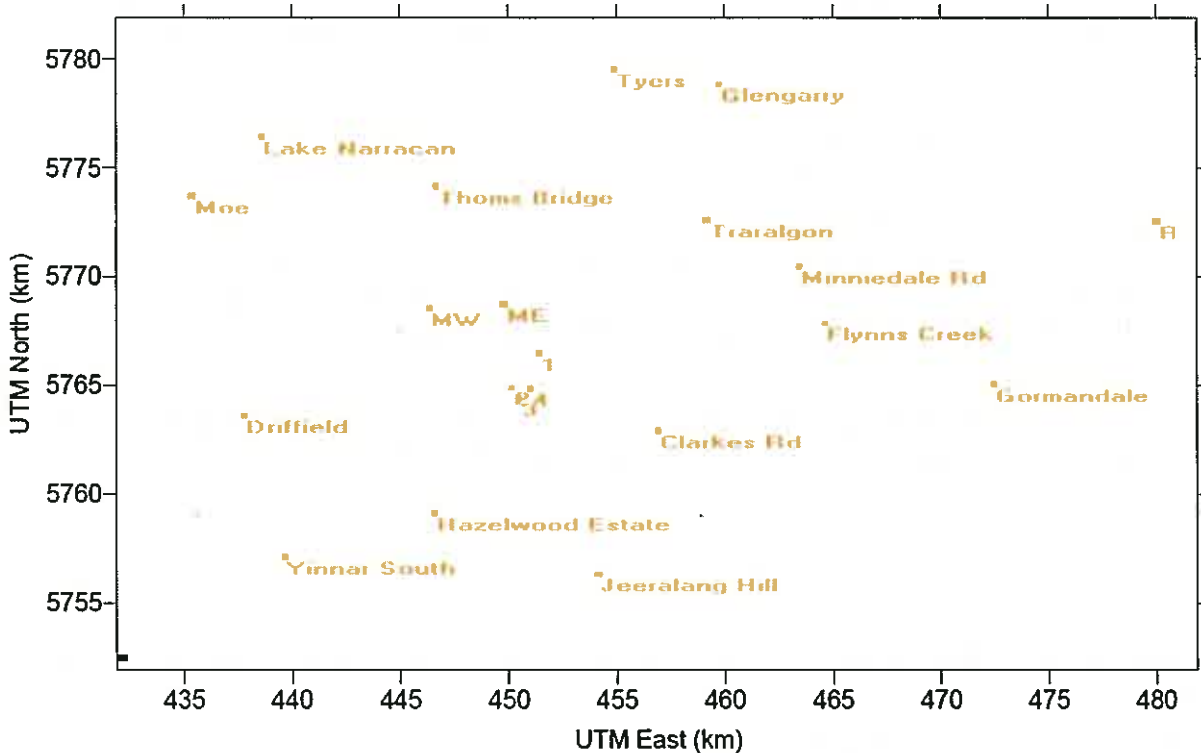
The south-west corner of both the meteorological and dispersion modelling grids is located at 431.4kmE and 5751.4kmN.

##### *Sensitive receptors*

Sensitive receptor locations are as per previously completed assessments by HRLT. These locations include the present-day Latrobe Valley Air Monitoring Network (LVAMN) stations located at Moe and Traralgon (Figure 3-1).

### 3 Air Quality Modelling

Figure 3-1 Sensitive receptor locations. MW = Morwell West; ME = Morwell East; R = Rosedale South; 1,2,3,4 = Homesteads.



#### Post processing

Following dispersion modelling, the results have been processed to select the ninth highest modelled value for each modelled grid point and receptor, as required by Schedule C of the SEPP (AQM). The ninth highest value is equivalent to the 99.9<sup>th</sup> percentile of modelled values for one year.

For comparison with the SEPP (AQM) design criteria, predicted concentrations are required to be reported as the 99.9<sup>th</sup> percentile values for one-hour concentrations. This is due to maximum model predictions at small averaging periods tending to over predict typically observed values. This is the highest ground-level concentration at each receptor after the highest 0.1% (top nine hours) of predictions has been discarded.

## Results

As discussed earlier, previous HRLT dispersion modelling assessments for NO<sub>2</sub> were undertaken using CALPUFF version 6.262. This assessment utilises the most recent updated version (6.42) only. Dispersion modelling was undertaken for the following scenario:

- All background Latrobe Valley sources (Energy Brix, Hazelwood, Yallourn, Loy Yang A & B, Jeeralang A & B power stations, and Australian Paper) in conjunction with the proposed DGDP.

### 4.1 Dispersion modelling

#### 4.1.1 Maximum (99.9%) predictions

Table 4-1 provides a comparison of the predicted NO<sub>2</sub> concentrations at the maximum (99.9%) modelled location and the maximum modelled receptor.

Table 4-1 Predicted NO<sub>2</sub> concentrations (mg/m<sup>3</sup>) expressed as the 99.9<sup>th</sup> percentile 1-hour average at the most exposed modelled location and sensitive receptor. 30% conversion of NO<sub>x</sub> to NO<sub>2</sub>.

Model Version	Averaging Period	Scenario - Existing LV sources + DGDP	
		Maximum (99.9%) Modelled	Maximum (99.9%) Receptor
CALPUFF V6.42	1-hour	0.13	0.11
SEPP(AQM) Design criteria		0.19	
SEPP(AQM) Intervention criteria		0.27	
NEPM Criteria, SEPP(AAQ) Air Quality Objective		0.23	

Ground-level concentration contour plots of NO<sub>x</sub> for the 99.9<sup>th</sup> percentile derived from the dispersion model results are presented in Appendix C.

The maximum 99.9<sup>th</sup> percentile 1-hour average NO<sub>2</sub> modelled concentration across the grid domain occurs at grid coordinates 445.900, 5765.900. This location is approximately 3-km south-west of Morwell. The maximum 99.9<sup>th</sup> percentile 1-hour average NO<sub>2</sub> modelled concentration at sensitive receptors was at receptor 17 - Jeeralang Hill.

#### 4.1.2 Sensitive receptors

As per previous HRLT assessments, a total of 21 sensitive receptors were included in this modelling assessment. Modelled 1-hour 99.9<sup>th</sup> percentile concentration values at all sites and including present-day Latrobe Valley Air Monitoring Network (LVAMN) stations located at Moe and Traralgon are listed below in Table 4-2. All modelled sensitive receptor values are below the assessment criteria.

Where measured oxidation rates information exists for individual air quality stations, this has been used to predict ground level concentrations of NO<sub>2</sub> at the relevant site. These sites are Moe, Traralgon, Rosedale South and Jeeralang Hill (see Appendix C). All other sites have been estimated to have a NO<sub>2</sub>/NO<sub>x</sub> ratio of 30%, based on historical LVAMN measurements (see Section 3.2.2).

## 4 Results

Table 4-2 99.9<sup>th</sup> percentile modelled values for NO<sub>2</sub> (mg/m<sup>3</sup>) at sensitive receptors

Receptor	UTM coordinates (km)		Scenario - Existing LV sources + DGDP CALPUFF V6.42
1 - Driffield	437.3	5763.0	0.06
2 - Hazelwood Est.	446.3	5758.4	0.08
3 - Clarkes Road	456.9	5762.3	0.07
4 - Glengarry	459.8	5778.7	0.04
5 - Morwell West	446.1	5768.1	0.10
6 - Thoms Bridge	446.4	5773.9	0.07
7 - Minniedale Rd	463.6	5770.1	0.07
8 - Moe	434.9	5773.4	0.06
9 - Traralgon	459.2	5772.3	0.09
10 - Morwell East	449.6	5768.3	0.10
11 - Rosedale Sth	480.5	5772.2	0.05
12 - Yinnar Sth	439.3	5756.3	0.09
13 - Tyers	454.8	5779.4	0.05
14 - Lake Narracan	438.2	5776.2	0.05
15 - Gormandale	472.8	5764.5	0.06
16 - Flynns Creek	464.8	5767.4	0.08
17 - Jeeralang Hill	454.0	5755.5	0.11
18 - Homestead 1	451.3	5765.9	0.09
19 - Homestead 2	449.9	5764.3	0.09
20 - Homestead 3	450.3	5763.8	0.08
21 - Homestead 4	450.8	5764.3	0.09
SEPP(AQM) Design criteria			0.19
SEPP(AQM) Intervention criteria			0.27
NEPM Criteria			0.23

Although the maximum 99.9<sup>th</sup> percentile 1-hour average NO<sub>2</sub> modelled concentration at sensitive receptors occurs at Jeeralang Hill, the highest value at a location where a population is present is Morwell West.

### 4.1.3 Source apportionment

Relative contributions of total NO<sub>x</sub> to the predicted 99.9<sup>th</sup> percentile concentration at the most exposed sensitive receptor where a human population is present (receptor 5 - Morwell West) were extracted from CALPUFF and are shown in Table 4-3.

## 4 Results

**Table 4-3** Predicted concentrations (mg/m<sup>3</sup>) of total NO<sub>x</sub> apportioned to each source within the dispersion modelling for the 99.9<sup>th</sup> percentile 1-hour average at receptor 5 – Morwell West.

Source	Scenario - Existing LV sources + DGDP CALPUFF V6.42
Loy Yang A1	0.000
Loy Yang A2	0.000
Loy Yang B	0.000
Hazelwood 1	0.036
Hazelwood 2	0.037
Hazelwood 3	0.038
Hazelwood 4	0.036
Hazelwood 5	0.034
Hazelwood 6	0.034
Hazelwood 7	0.032
Hazelwood 8	0.031
Energy Brix 1	0.000
Energy Brix 2	0.000
Energy Brix 3	0.000
Energy Brix 4	0.000
Yallourn Stage 1	0.000
Yallourn Stage 2	0.000
Australian Paper DP35	0.000
Australian Paper DP36	0.000
Australian Paper DP44	0.000
Australian Paper DP45	0.000
Australian Paper DP51	0.000
Australian Paper DP54	0.000
Australian Paper DP55	0.000
Jeeralang A1	0.000
Jeeralang A2	0.000
Jeeralang A3	0.000
Jeeralang A4	0.000
Jeeralang B1	0.000
Jeeralang B2	0.000
Jeeralang B3	0.000
Dual Gas - Combined Cycle Gas Turbine 1	0.000
Dual Gas - Combined Cycle Gas Turbine 2	0.000
Dual Gas - Char Burner 1	0.000
Dual Gas - Char Burner 2	0.000
Dual Gas - Air Pre Heater 1	0.000
Dual Gas - Air Pre Heater 2	0.000
Dual Gas - Pre Dryer 1	0.000
Dual Gas - Pre Dryer 2	0.000
<b>Total</b>	<b>0.278</b>

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## 4 Results

The total value listed in Table 4-3 is the modelled value of total NO<sub>x</sub> at this receptor prior to conversion to NO<sub>2</sub>. However, the purpose of Table 4-3 is to show that emissions from the Hazelwood power station are the highest contributors to the 99.9<sup>th</sup> percentile 1-hour modelled concentration at Morwell West, and that the contribution from all other sources is effectively zero.

## Conclusion

URS has been engaged by Maddocks to undertake a dispersion modelling assessment using CALPUFF version 6.42 to:

- Provide ambient predictions of NO<sub>2</sub> which incorporate background Latrobe Valley sources (Energy Brix, Hazelwood, Yallourn, Loy Yang A & B, Jeeralang A & B power stations, and Australian Paper) in conjunction with the proposed DGDP across the model domain at a spatial resolution of 1-km.

Utilising the current CALPUFF version (6.42) has resulted in a slightly higher result (0.13 mg/m<sup>3</sup>) for NO<sub>2</sub> across the modelling domain at a spatial resolution of 1-km compared with the most recent HRLT assessment in November 2010 (0.12 mg/m<sup>3</sup>). Because the results have been predicted using a different version of the CALPUFF dispersion model to that used previously, URS is unable to determine whether the difference is due to the modelled NO<sub>x</sub> emission rates or technical changes in the model. However, predicted results continue to comply with the relevant Design Criteria, NEPM and other SEPP Criteria across the modelling domain and also at the selected sensitive receptors.

In keeping with previous HRLT assessments, 70<sup>th</sup> percentile hourly background values for NO<sub>2</sub> have been incorporated into the presented results. This background value incorporates all sources of NO<sub>2</sub>, including motor vehicles and the paper manufacturing industry. However, the majority of NO<sub>x</sub> emissions in the Latrobe Valley are contributed by the electricity generation sector. As all electricity generators and Australian Paper are already included as point sources in the model, the additional incorporation of the EPA Victoria supplied background value is in effect double counting and hence conservative. Modelled results for NO<sub>2</sub> however still comply with the relevant Design Criteria.

The source apportionment exercise traces back the contribution of each modelled source for a particular receptor. This exercise has demonstrated that for the assessed hour of the modelled year where the 99.9<sup>th</sup> percentile value is highest at the sensitive receptor located at Morwell West, the contribution to this value from the proposed Dual Gas site is zero. All of the predicted concentrations at this receptor for this hour are contributed by the Hazelwood power station.

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## References

Delaney, W. (2007). Assessment of Latrobe Valley Air Quality with the inclusion of a 400MW IDGCC Power Plant using CALPUFF. HRL Technology Pty Ltd, Report No: HLC/2006/081.

Janssen, L. H. J. M., Van Wakeren, J. H. A., Van Duuren, H., & Elshout, A. J. (1988). 'A Classification of NO Oxidation Rates in Power Plant Plumes Based on Atmospheric Conditions.' *Atmospheric Environment*, vol. 22, pp. 43 - 53.

SKM (2009). *Dual Gas Demonstration Project: Desktop Air Quality Assessment - Final*. Sinclair Knight Merz, Malvern VIC 3144 Australia.

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## Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Maddocks and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 14 October 2011.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between 17 and 21 October 2011 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

**Appendix A Site location**

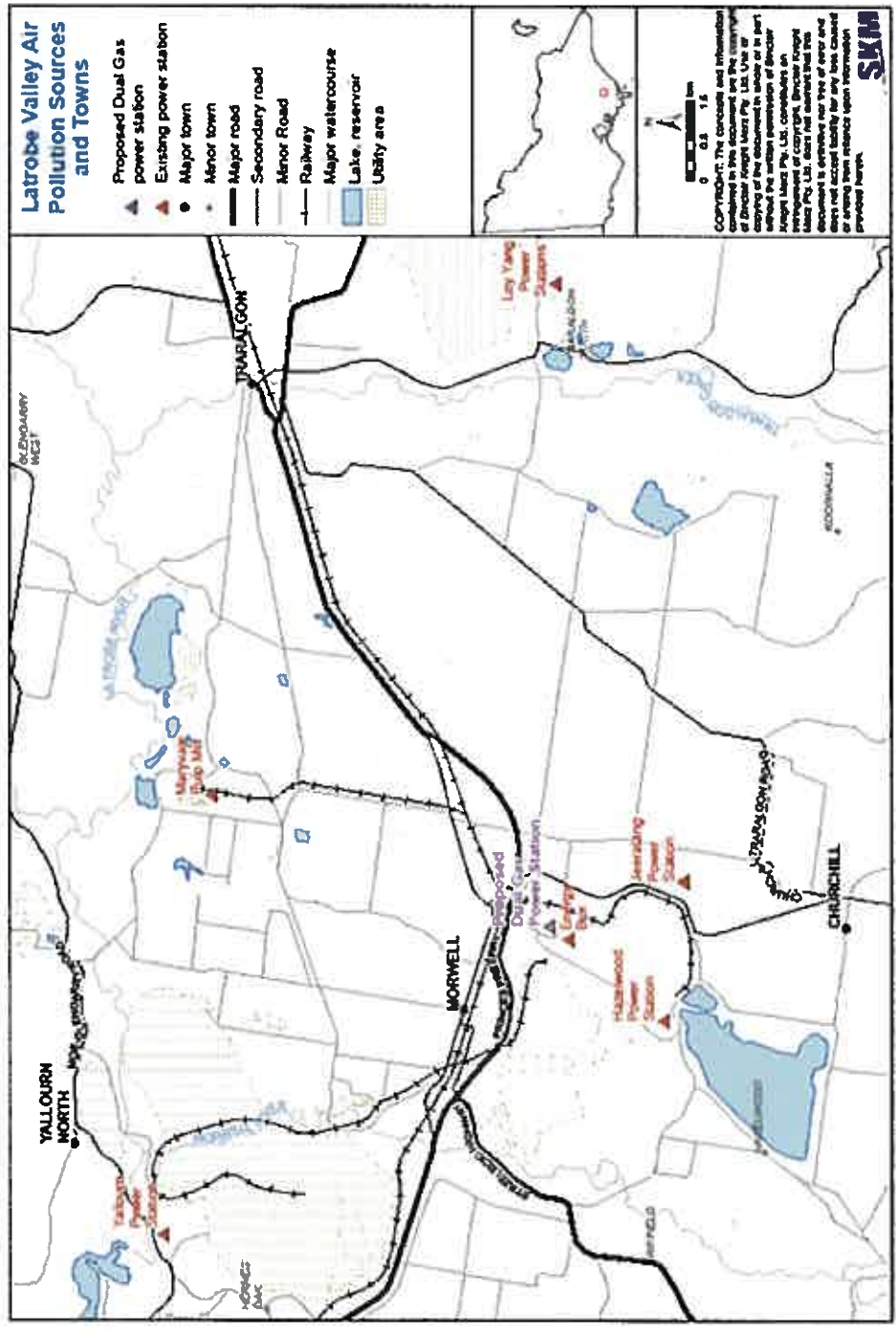


Figure A1. Proposed Dual Gas Demonstration Project Power Station site location. Source: SKM (2009)

**Appendix B Modelled emission rates; Stack parameters; NO<sub>2</sub>/NO<sub>x</sub> ratios.**

Appendix B

Table B-1 Modelled emission rates – proposed Dual Gas Demonstration Project Power Station (provided by Dual Gas).

	CCGT 1	CCGT 2	Char Burner 1	Char Burner 2	Air Pre Heater 1	Air Pre Heater 2	Pre Dryer 1	Pre Dryer 2
<b>NO<sub>x</sub> (g/s)</b> - syngas with supplementary natural gas firing	49.02	49.02	19.30	19.30	0.28	0.28	1.83	1.83

CCGT = Combined Cycle Gas Turbine.

Table B-2 Modelled emission rates – other Latrobe Valley sources

	Loy Yang A (x2) / Loy Yang B (x1)	Yallourn Units 1 and 2 (Stage 1)	Yallourn Units 3 and 4 (Stage 2)	Hazel -wood (x 8)	Energy Brix (x4)	AP Source 35	AP Source 36	AP Source 44	AP Source 45	AP Source 51	AP Source 54	AP Source 55	Jeera -lang A (x4) & B (x3)
<b>NO<sub>x</sub> (g/s)</b>	475 / 420	215	215	167	36	8.5	8.3	12.5	4.7	8.3	4	8.3	32

## Appendix B

Table B-3 Modelled stack parameters – proposed Dual Gas Demonstration Project Power Station (provided by Dual Gas).

	Eastings (m)	Northing (m)	Stack elevation (m asl)	Stack height (m)	Stack diameter (m)	Stack temp (K)	Stack exit velocity (m/s)
CCGT 1	448,605	5,766,045	87	80	5.05	417	33
CCGT 2	448,643	5,766,029	88	80	5.05	417	33
Char Burner 1	448,603	5,766,002	88	80	1.37	423	32.8
Char Burner 2	448,590	5,765,973	88	80	1.37	423	32.8
Air Pre Heater 1	448,559	5,766,088	88	80	0.43	623	33.1
Air Pre Heater 2	448,572	5,766,080	88	80	0.43	623	33.1
Pre Dryer 1	448,547	5,766,040	88	80	1.31	416	33.2
Pre Dryer 2	448,522	5,765,982	88	80	1.31	416	33.2

Table B-4 Modelled stack parameters – other Latrobe Valley sources.

	Number of point sources	Stack elevation (m asl)	Stack height (m)	Stack diameter (m)	Stack temp (K)	Stack exit velocity (m/s)
Loy Yang A	2	110	260	11	448	28.4
Loy Yang B	1	115	255	11	448	28.4
Yallourn Stage 1	1	61	168	10.7	468	23.9
Yallourn Stage 2	1	61	168	10.7	470	26.2
Hazelwood	8	85	137	6.4	488	22.8
Energy Brix	4	73	92	5.5	573	13.0
Australian Paper	7	39 - 51	50 - 75	0.6 - 2.6	381 - 463	10 - 29
Jeeralang A and B	7	89	32	4.7 - 5.2	706 - 789	35 - 39

Appendix B

Table B-5 NO<sub>2</sub>/NO<sub>x</sub> ratios based on historical Latrobe Valley Air Monitoring Network (LVAMN) measurements.

LVAMN Air Quality Station	NO <sub>2</sub> /NO <sub>x</sub>
Moe	0.50
Traralgon	0.56
Rosedale South	0.30
Jeeralang Hill	0.45

## Appendix C Contour Plot





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