Appendix 5

Plume Rise Assessment

Prepared by:

Heggies Pty Ltd

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HEGGIES

7 December 2007

10-5457R2D1.doc

Eastern Star Gas Limited
Suite 1, Level 2, 37 Pitt Street
SYDNEY NSW 2000

Attention: Tim Donnan

Dear Tim

Plume Rise Assessment
Proposed Expansion to Wilga Park Power Station, Narrabri NSW

Please find attached Heggies report detailing the findings of the plume rise assessment carried out for the proposed expansion to the Wilga Park Power Station, Narrabri NSW. Outlined are the inputs, methods and results of the modelling assessment.

If I can provide clarification on any of the information provided within this report or I can assist in any way, please do not hesitate to call.

Yours sincerely,

MARTIN DOYLE

PROJECT CONSULTANT

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1 Introduction

Heggies Pty Ltd (Heggies) has been commissioned by Eastern Star Gas Limited (Eastern Star) to conduct a Plume Rise Assessment (PRA) as part of the Environmental Impact Statement (EIS) for the proposed expansion to the Wilga Park Power Station at Narrabri, NSW.

The Civil Aviation Safety Authority (CASA) require that a full plume rise assessment be undertaken where a proposed facility is located within 15km of an aerodrome and if the facility includes a combustion source which generates an exhaust plume which has a vertical velocity greater than 4.3 m/s at the height of the Obstacle Limitation Surface (OLS). Narrabri Airport is located just over 15 km to the east-north-east of the site of the Wilga Park Power Station and is therefore outside of the OLS for Narrabri Airport; a full plume rise assessment is not required. However, CASA also state that outside of the OLS, if the top of the structure is 110 m or more Above Ground Level (AGL) or if the vertical velocity of the plume at 110 m AGL exceeds 4.3 m/s, CASA may determine that the facility will be a hazard to aircraft operations because of the velocity or location of the efflux. According to CASA's Advisory Circular entitled *Guidelines for Conducting Plume Rise Assessments*, June 2004, exhaust plumes with a vertical velocity in excess of 4.3 m/s may cause damage to an aircraft airframe, or upset an aircraft when flying at low levels.

CASA have requested that the following information be provided;

- The height of the proposed Power Station expansion (AGL); and
- The height where the plume velocity will exceed 4.3 m/s (AGL)

The proposed power station expansion will have 20 exhaust stacks, 10 of which are currently operational, 10 of which are proposed. The 10 current stacks are at a height of 2.5 m Above Ground Level (AGL) with the proposed stacks to have a height of 12.5 m AGL.

2 Assessment Methodology

The Air Pollution Model (TAPM) was used in plume rise mode to analyse plume behaviour from the stacks for meteorological conditions predicted for the site over a modelling period of one year (2006). CASA requirements state that TAPM should be used for a modelling period of five years for a full plume rise assessment. A full plume rise assessment has not been conducted as the Wilga Park Power Station is located greater than 15km from Narrabri Airport and is outside the OLS.

TAPM software, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), is a prognostic model which may be used to predict three-dimensional meteorological data, with no local data inputs required. The model predicts wind speed and direction, temperature, pressure, water vapour, cloud, rain water and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate site-specific hourly meteorological observations.

The TAPM plume rise estimation uses commonly referenced plume rise algorithms for the determination of vertical plume rise velocity. For multiple sources TAPM allows a buoyancy enhancement factor to be input to account for overlapping plumes from multiple stacks. The buoyancy enhancement factor used is based on the Briggs (1984) equations.

The proposed expansion to the Wilga Park facility at Narrabri will have 20 units operating simultaneously with 10 stacks at 2 m AGL and 10 at 12.5 m AGL. The plumes from the stacks may merge for some wind conditions and accordingly the combined plume may rise higher than the plumes would have in isolation.

CASA have determined that TAPM is not suitable for the determination of plume dynamics for plumes that merge significantly.

To conservatively account for the possibility that plume merging may occur between the twenty stacks resulting in enhanced plume rise, a plume rise enhancement factor has been applied to the TAPM exit velocity input. The plume rise enhancement factors have been calculated based on a worst case assumption that all 20 stacks are 12.5 m AGL. The buoyancy enhancement is defined as:

$$E_N = \left[\frac{n+S}{1+S}\right]^{1/3}$$

$$S = 6 \cdot \left[\frac{(n-1)\cdot \Delta s}{n^{1/3}\cdot \Delta z}\right]^{3/2}$$

Where Δs is the stack separation and Δz is the rise of an individual plume (Manins et al, 1992, Briggs, 1975). Inputs used for this assessment are taken from Heggies Air Quality Impact Assessment for the Eastern Star Gas Utilisation Project, report 10-5457R1. As discussed previously, the inputs for the 12.5 m stacks were used for this plume rise assessment in the interests of conservatism. The relevant inputs are given below.

- Stack Height: 12.5 m
- Stack Exit Velocity: 12 m/s
- Stack Diameter: 0.6 m
- Stack Exit Temp: 375°C (648.15K)
- Stack Separation: 10 m
- Rise of Individual Plume: 260 m
- Stack location: Easting 757310, Northing 6638010 AMG co-ordinates

The rise of an individual plume was calculated by running TAPM with one stack with the above stack parameters. The maximum plume rise predicted by the model was used in the subsequent calculation of the plume rise enhancement factor, calculated to be 2.25.

Heggies conservative approach is to assume that the plume rise enhancement factor is applied to the exit velocity of the stack. As the stack efflux velocity adopted for the air quality impact assessment was 12 m/s, the application of the buoyancy enhancement factors to the original exit velocity result in a revised exit velocity of 27 m/s. This is deemed to be a highly conservative estimation of the influence of the merged stacks on vertical velocity.

The modelling period was 1 January 2006 to 31 December 2006. TAPM was used in a nested mode, consisting of 25 × 25 × 25 grid points, and 30-km, 10-km, 3-km spaced horizontal grids for meteorology. The number of vertical levels was set to 25 and the grid centre coordinates were extracted over the plume source. No observational meteorology data was assimilated into the model.

3 Results and Discussion

3.1 Frequency of Exceedance of Critical Vertical Velocity

As per CASA requirements, the frequency with which the average vertical plume velocity exceeds the critical vertical velocity has been calculated. Analysis of the plume rise data indicates that the critical vertical velocity of 4.3 m/s is not exceeded at any height. The lowest height of the plume output from the model is 20m.

Table 1 shows the maximum, minimum and average vertical velocity and the average height at which these velocities are predicted. **Table 2** shows the maximum, minimum and average plume heights and the average vertical velocity of the plume predicted at these heights.

Table 1 Minimum, Average and Maximum Plume Vertical Velocity and Associated Average Heights

	Vertical Velocity (m/s)	Average Height AGL (m)
Minimum	0.03	57.2
Average	0.89	61.8
Maximum	4.2	24

Table 2 Minimum, Average and Maximum Heights AGL of Plume and Associated Average Plume Vertical Velocity

	Height AGL (m)	Average Vertical Velocity (m/s)
Minimum	20	2.1
Average	71	0.5
Maximum	531	0.99

Table 1 indicates that the maximum vertical velocity predicted is 4.2 m/s at an average height of 24m AGL. This is well below the CASA criterion of 4.3 m/s at 110m AGL. **Table 2** shows that the maximum height of the plume is 531m AGL and the average vertical velocity at this height is 0.99 m/s.

Further analysis of the data provides information on the vertical velocity of the plume at 110m AGL, as requested by CASA. This information is presented in **Table 3** below.

Table 3 Minimum, Average and Maximum Plume Vertical Velocity at 110m AGL

	Vertical Velocity (m/s)
Minimum	0.04
Average	0.5
Maximum	1.67

The maximum vertical velocity of the plume at 110m AGL is predicted to be 1.67 m/s, well below the CASA criterion of 4.3 m/s.

4 CONCLUSIONS

An assessment has been conducted of the potential hazard that exhaust plumes from the proposed expansion to the Wilga Park Power Station, Narrabri, NSW present to aviation activities in the surrounding region.

The Air Pollution Model (TAPM) was used in plume rise mode to analyse plume behaviour from the stacks for meteorological conditions predicted for the site over a modelling period of one year (2006).

The plume rise from a single stack was modelled, and a plume rise enhancement factor was applied to the vertical velocity inputs to conservatively account for the impact of enhanced buoyancy as a result of the twenty plumes merging.

The maximum vertical velocity of the plume is predicted to be 4.2 m/s at 24m AGL. The maximum plume height is predicted to be 531m AGL. The associated plume vertical velocity at 531m AGL is predicted to be 0.99 m/s.

An assessment of the plume vertical velocity at 110m AGL, as requested by CASA, indicates that the maximum velocity is predicted to be1.67 m/s. This is significantly below the CASA criterion of 4.3 m/s.

5 REFERENCES

Briggs, G.A., 1975. *"Plume Rise from Multiple Sources"*, Cooling Tower Environment – 1974. Conference Proceedings. CONF-740302 pp 161-179

CASA, 2004. AC 139-05 (0) Guidelines for Conducting Plume Rise Assessment, June 2004.

Manins, P.C., Carras, J.N., Williams, D.L., 1992. *"Plume Rise from Multiple Stacks"*. Clean Air Australia Vol 26 Part 2, May 1992.

Australian Government
Civil Aviation Safety Authority

File: 04/3465

28 November 2007

Tim Donnan
Environmental Officer
Eastern Star Gas Limited
GPO Box 4526
Sydney NSW 2001

Dear Mr Donnan

RE: Proposed PowerStation Expansion, Narrabri NSW

I refer to your letter to Mr Kim Jones of 22 October 2007 in which you sought an opinion from the Civil Aviation Safety Authority (CASA) whether a plume impact assessment was required for the proposed PowerStation expansion at Narrabri NSW.

You have rightly pointed out that within 15km of the aerodrome if a structure, or in this case, a plume having a vertical velocity greater than 4.3m/s infringes the obstacle limitation surface (OLS) of the of the aerodrome CASA will be advised of the infringement by the aerodrome operator and will be required to assess its impact on air navigation at the aerodrome.

Outside the OLS of the aerodrome if the top of the structure is 110m or more above ground level, or, if the velocity of the plume at 110m above ground level exceeds 4.3m/s, CASA may determine in writing that it is, or will be, a hazard to aircraft operations because of the velocity or location of the efflux.

Please advise the height above ground of the proposed PowerStation expansion and also the height above ground where the plume velocity will exceed 4.3m/s.

Yours Sincerely

Frank Leonardi
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Airways and Aerodromes Branch

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