Intended for
Dial a Dump Industries

Document type
Report

Date
September 2015

Project Number
AS13045

PLUME RISE ASSESSMENT
ENERGY FROM WASTE FACILITY

RAMBØLL ENVIRON

ENERGY FROM WASTE FACILITY

Revision	Date	Made by	Checked by	Approved by	Signed
Final	30/09/2015	R.Kellaghan	S. Fishwick	R.Kellaghan	Ronan Kellaghan

Ref AS13045

Ramboll Environ Australia Pty Ltd
Level 3
100 Pacific Highway
PO Box 560
North Sydney
NSW 2060
Australia
T +61 2 9954 8100
F +61 2 9954 8150
www.ramboll-environ.com

CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

APPENDICES

1. INTRODUCTION

The Next Generation (NSW) Pty Ltd lodged an Environmental Impact Statement (EIS) for a proposed Energy from Waste (EfW) facility at Eastern Creek, NSW (Urbis, 2015). During the exhibition period for the EIS, submissions were received from Government Agencies and the public.

The Department of Infrastructure and Regional Development (DIRD) provided a submission as the responsible agency for the Western Sydney Airport, proposed at Badgerys Creek, approximately 14km southwest of the EFW site. The submission raised the issue of aviation safety, both in terms of physical obstacles to aircraft and the potential for plume rise from the exhaust stacks to cause hazards to aircraft operations. Further assessment was recommended to determine if proposed structures might intrude into declared airspace and whether plume rise from the exhaust stacks might pose a hazard to aircraft approaching from the northeast.

To response to this submission, the proponent has commissioned an aviation assessment, which has determined the likely future airspace requirements for the proposed Western Sydney Airport.

Ramboll Environ Australia Pty Ltd (Ramboll Environ) has been commissioned to complete a plume rise assessment, to assess the critical plume height associated with the operation of the EfW facility, in accordance with the Civil Aviation Safety Authority (CASA) requirements.

1.1 Background to assessment requirements

In November 2012, the Civil Aviation Safety Authority (CASA) issued a revised Advisory Circular (AC 139-5(1)) for plume rise assessment. The revised AC updates AC 139-5(0) and introduces a new procedure for plume rise assessment, as follows:

- Completion of Form 1247 by the proponent.
- Assessment of the critical plume velocity (CPV).
- Assessment of the critical plume height (CPH).
- Assessment of the impact of the plume.
- Implementation of mitigation.

Following completion of Form 1247, CASA use a screening tool to determine the critical plume height (CPH) and critical plume velocity (CPV) for a proposed facility. However during consultation completed as part of the EIS, CASA were unable to obtain information from DIRD on the Western Sydney Airport and therefore unable to assess plume rise using their screening tool. A completed Form 1247 is provided in **Appendix 1**, however, a plume rise assessment is also presented in this report, following the requirements outlined in AC 139-5(1) and the accompanying "Plume Rise Assessments - Technical Brief".

The Technical Brief contains less detail on the requirements for plume rise assessment than what was outlined in Attachment A of the previous AC 139-5(0). The requirements in the Technical Brief are summarised below:

- A detailed plume rise assessment should determine the Critical Plume Height (CPH) for a facility.
- The modelling must include meteorological conditions representing every hour of a five year period.
- The frequency of the CPH should be analysed to calculate the 0.1% exceedence level for each year.
- The maximum lateral extent of the plume should also be calculated for each year.
- TAPM (The Air Pollution Model) Version 4 (or later) is a suitable model.
- Buoyancy enhancement due to multiple plumes should be considered using the methodology described by Manins et al (1992)

It is noted that guidance in the previous AC 139-5(0) required that plume analysis should consider average plume velocities. This is important when considering the interpretation of results presented in **Section 4**.

2. OVERVIEW OF ASSESSMENT

2.1 Critical plume velocity

The critical plume velocity (CPV) is the vertical velocity of the plume that may affect the handling characteristics of an aircraft in flight, potentially causing a momentary loss of control.

The CPV is either 4.3 m/s or 10.6 m/s, determined by CASA based on the type of operations at a location and potential risk. For the purposes of this assessment, it is assumed that the CPV would be 4.3 m/s.

2.2 Modelled stack parameters

The proposed facility will have two main stack locations, with each location having two stack ducts. When fully operational, the facility will operate a total of 4 streams, with each stream serviced by one of the four stack ducts. The stack ducts at each location are separated by a few of meters while the two main stack locations are separated by approximately 58m. The location and configuration of the stacks is shown in the Concept Design report submitted as part of the EIS (Fichtner, 2015) and shown in the 3D rendered drawings from the EIS presented in **Figure 1**.

The stack parameters for each of the 4 stack ducts are identical and presented in **Table 2-1**.

Table 2-1: Stack parameters for plume rise modelling

Parameter	Stack Location 1		Stack Location 2	
	Duct 1	Duct 2	Duct 1	Duct 2
Easting, Northing (m MGA)	298633 6257734		298575 6257741	
Latitude, Longitude (decimal degrees)	-33.801426083 150.824722167		-33.801351972 150.824097611	
Height above ground (m)	100	100	100	100
Stack diameter (m)	2.2	2.2	2.2	2.2
Stack exit Velocity	21.7	21.7	21.7	21.7
Stack exit temperature (degC)	120	120	120	120
Ground elevation (m AHD)	~62.5			
Stack heights (m AHD)	~162.5			

Note: Duct 1 and 2 at each location are separated by a few metres

FIGURE 15 – 3D IMAGE OF THE PROPOSED FACILITY FROM THE SOUTH WEST

Figure 1: 3d rendered drawings from the EIS (Urbis, 2015)

2.3 Modelling approach

The Air Pollution Model, or TAPM, is a three-dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. A detailed description of TAPM and its performance can be found in Hurley (2008) and Hurley et al. (2009). TAPM uses fundamental fluid dynamics and scalar transport equations to predict meteorology and pollutant concentrations. It consists of coupled prognostic meteorological and air pollution concentration components. The model predicts airflows that are important to local-scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analyses.

TAPM was used to predict plume rise from the proposed facility. In accordance with the technical brief, five years of hourly meteorology were modelled and results are presented for each year. The most recent five years (2010 – 2014) were modelled. TAPM allows for surface level observation data from nearby meteorological stations to be included in the modelling, referred to as data assimilation. In generating observation files for data assimilation, TAPM requires the used to indicate the number of vertical model levels to assimilate each side of the nearest model level to the observation. It would be unusual to 'nudge' the model with observations beyond the first few vertical model levels, say beyond 50m Surface measurements of wind speed at 10m would not influence wind speeds at stack height (100m) and therefore were not included for this assessment. There is no requirement from CASA to include data assimilation for plume rise modelling. The TAPM model settings are listed in **Table 2**.

Table 2: TAPM settings

Parameter	Setting
Model Version	TAPM v.4.0.4
Number of grids (spacing)	4 (30km, 10km, 3km, 1km)
Number of grid points (nx,ny)	25 x 25
Vertical grids / vertical extent	25 / 8000m (~400mb)
Centre of analysis (local coordinates)	298633, 6257734
Year of analysis	2010 - 2014
Terrain and landuse	Default TAPM values based on land-use and soils data sets from Geoscience Australia and the US Geological Survey, Earth Resources Observation Systems (EROS) Data Center Distributed Active Archive Center (EDC DAAC).

2.4 Buoyancy enhancement

The assessment of plume rise from multiple stacks is assessed by applying a buoyancy enhancement factor to account for the merging of the plumes. The procedure for deriving a buoyancy enhancement factor is described in Manins et al (1992) and has been adopted for this assessment, described as follows.

A single stack duct was modelled using TAPM without buoyancy enhancement. The final plume rise heights were analysed for each of the five years to obtain the highest average final plume rise height for a single plume. The average final plume rise was applied to the procedure described in Manins et al (1992) to obtain a buoyancy enhancement factor, which is then used in a second model run to simulate the enhanced plume rise. The procedure is outlined in equations 1 – 3 below.

Step 1 – derive a dimensionless separation factor (S) where:	$S = 6 \times \left[\frac{(N-1)\Delta s}{N^{1/3} \times \Delta z}\right]^{3/2}$ $N = number\ of\ stacks$ $\Delta s = spacing\ between\ stacks$ $\Delta z = rise\ of\ an\ individual\ plume$	Eq.1
Step 2 – derive the effective number of stacks (N_E)	$N_E = \left[\frac{N+S}{1+S}\right]$	Eq.2
Step 3 - derive the rise enhancement factor (E_N)	$E_N = {N_E}^{1/3} < N^{1/3}$	Eq.3

The buoyancy enhancement procedure described in Manins et al (1992) is valid for identical and evenly spaced stacks. Although the stacks proposed for the EfW are identical, they are not evenly spaced. As described previously, there the two sets of adjacent stack ducts separated by a few meters and located approximately 58m apart.

A buoyancy enhancement factor was therefore derived for the two adjacent stack ducts and separately for the two separate stack locations (on the basis that the plume from the adjacent ducts is merged instantaneously and treated as one combined plume). The derived buoyancy enhancement factor for the adjacent stack ducts (1.3) was combined with the buoyancy enhancement factor for the separate stack locations (1.2) for a combined buoyancy enhancement of 1.5.

3. OVERVIEW OF PRESCRIBED AIRSPACE

The prescribed airspace for the Western Sydney Airport has yet to be prescribed, therefore Airspace Design Solutions has been commissioned to determine the likely future airspace requirements for the proposed Western Sydney Airport (ADC, 2015). Prescribed airspace is defined by the Obstacle Limitation Surface (OLS) and PAN-OPS protection surfaces. For the purpose of this assessment, plume rise is assessed against the OLS.

The aviation assessment indicates that due to the positioning of the proposed EfW facility on the proposed runways extended centreline, penetrations of the OLS would generally not be tolerated, and plume rise is generally considered in the same manner as physical obstacles for aviation safety (ADC, 2015).

Based on a desktop review of the information available for the Western Sydney Airport, the aviation assessment has determined the most critical surface in relation to the OLS would be the Outer Horizontal Surface, estimated to be approximately 223 m AHD. This OLS of 223 m AHD is used for the assessment of plume rise.

4. PLUME RISE RESULTS

4.1 Analysis of all critical plume heights

The gradual plume rise output file from TAPM has been analysed to obtain the critical plume heights (CPH) for the proposed facility. The CPH are defined as the heights where the plume vertical velocity is greater than 4.3 m/s and therefore may impact handling characteristics of aircraft in flight.

For each year of modelling, all heights where the vertical velocity is ≥ 4.3 m/s were extracted and the minimum, maximum and average CPH are presented in **Table 4-1**. TAPM outputs are given in height above ground level (AGL), therefore the heights in AGL are converted to AHD by adding a ground elevation of 62.5 m. For all years, the average CPH is below the OLS, however the maximum is above the OLS for each year.

The CASA technical brief requires "the frequency of the CPH should be analysed to calculate the 0.1% exceedence level for each year". Therefore, the 99.9th percentile of all CPH model results is presented in **Table 4-1**, representing in 2010, for example, the 14th highest critical plume height. Also presented is the 99th and 95th percentiles of all CPH. A frequency distribution of the critical plume heights is presented in **Figure 2**. The plot shows that less than 5% of all critical plume heights are greater than the OLS.

Table 4-1: Critical plume heights where plume vertical velocity is greater than 4.3 m/s

Statistic	CPH (m AHD)					OLS (m AHD)
	2010	2011	2012	2013	2014	
Minimum	171	171	171	171	171	223
Maximum	365	311	311	330	324	
Average	181	180	181	181	180	
Median	174	174	174	174	174	
99.9th%ile	326	285	291	308	302	
99th%ile	271	246	253	257	255	
95th%ile	215	210	215	217	213	

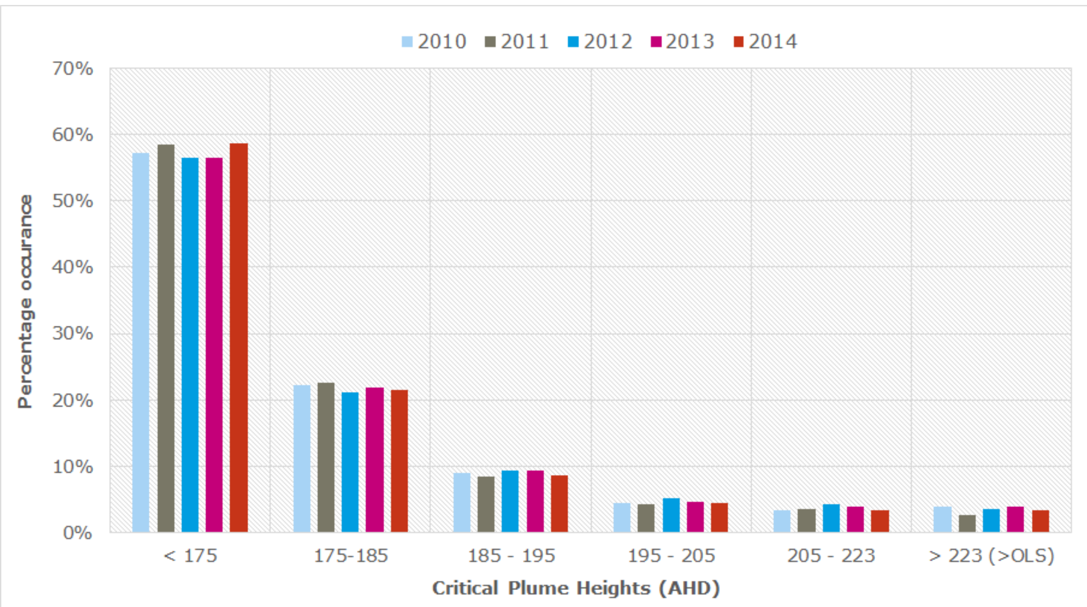


Figure 2: Frequency distribution of all CPH model results

4.2 Analysis of average plume velocity and frequency of occurrence of CPV

It is noted that previous CASA guidance used different wording for plume analysis, requiring heights above the ground where the average vertical velocity exceeds 4.3 m/s for various percentages of the time (i.e. 100%, 50%, 0.1%). The analysis in **Section 4.1** is presented for all critical plume heights and vertical velocities ≥ 4.3 m/s, i.e. plume velocity is not averaged by height or presented as a frequency of occurrence by height.

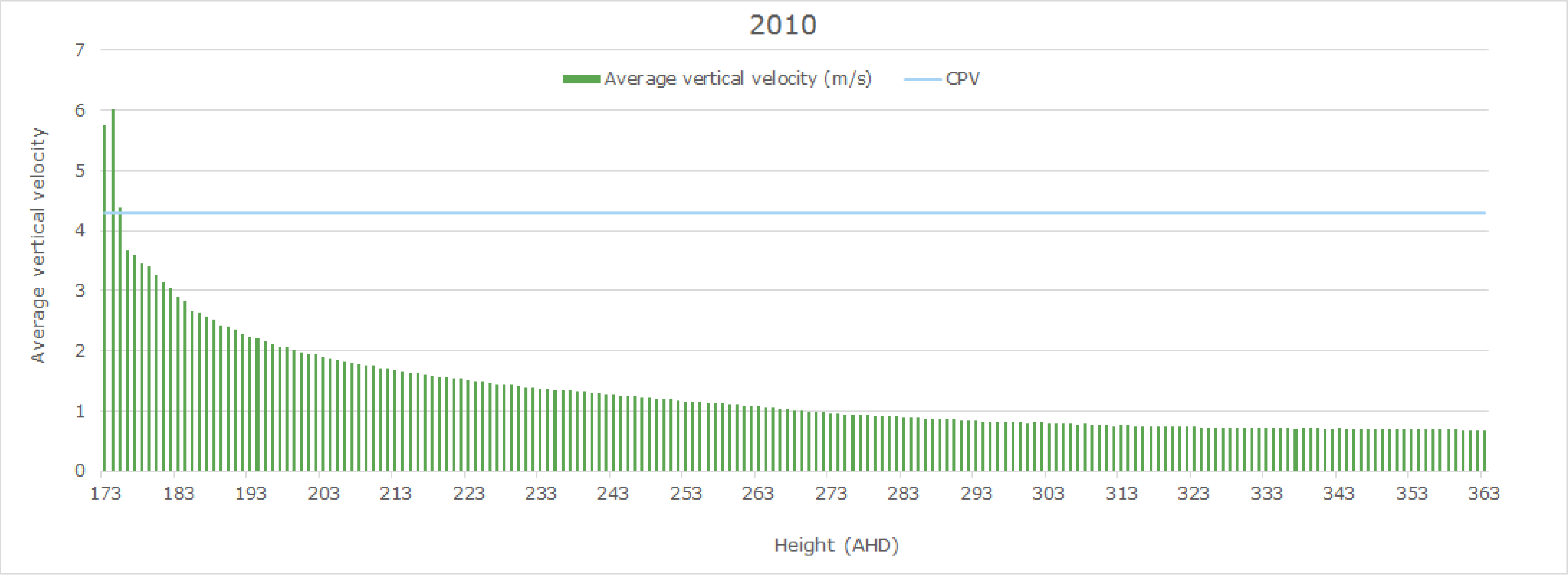
Additional analysis is presented in **Figure 3**, showing the plume velocity averaged by height. The plots clearly show that average plume velocity is well below the OLS of 223 m AHD for all years of analysis.

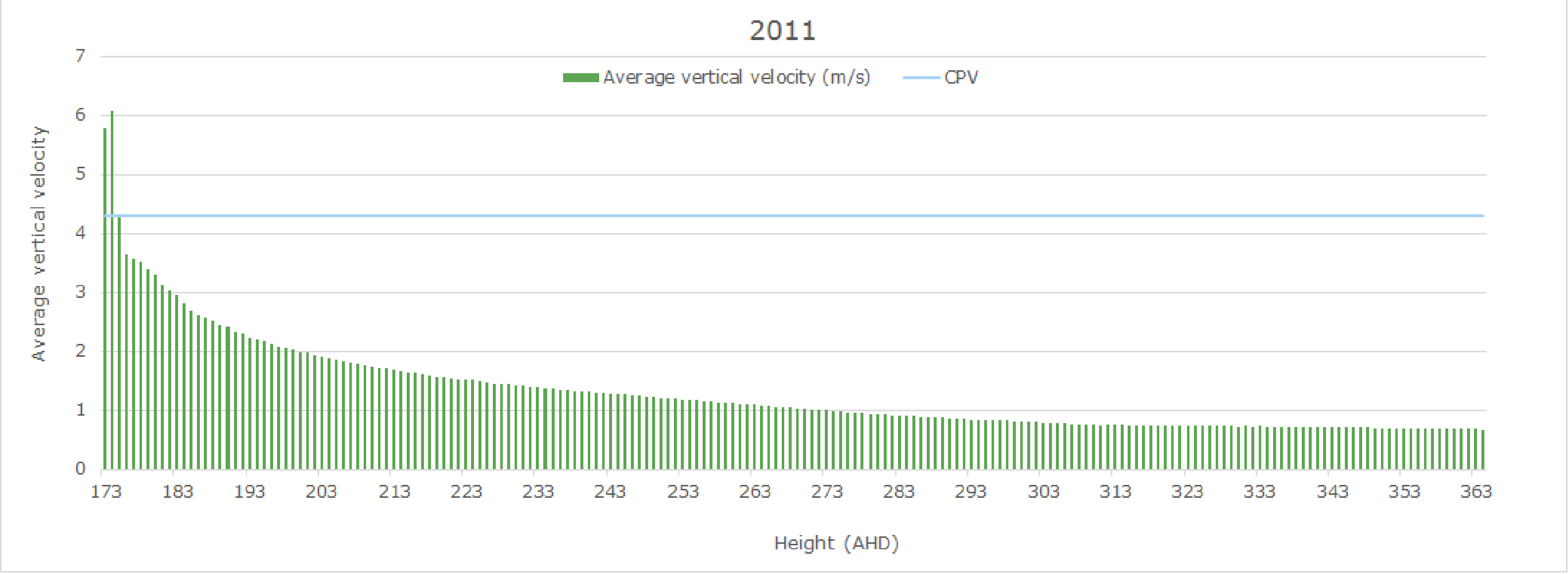
The frequency of occurrence of the critical plume velocity is presented in **Figure 4** for various selected heights. The plots show that the percentage occurrence of critical plume velocities above 4.3 m/s at the OLS of 223 m AHD is very small and difficult to see in the plots. Therefore the percentage occurrence of critical plume velocities above 4.3 m/s at the OLS also presented in **Table 4-2**.

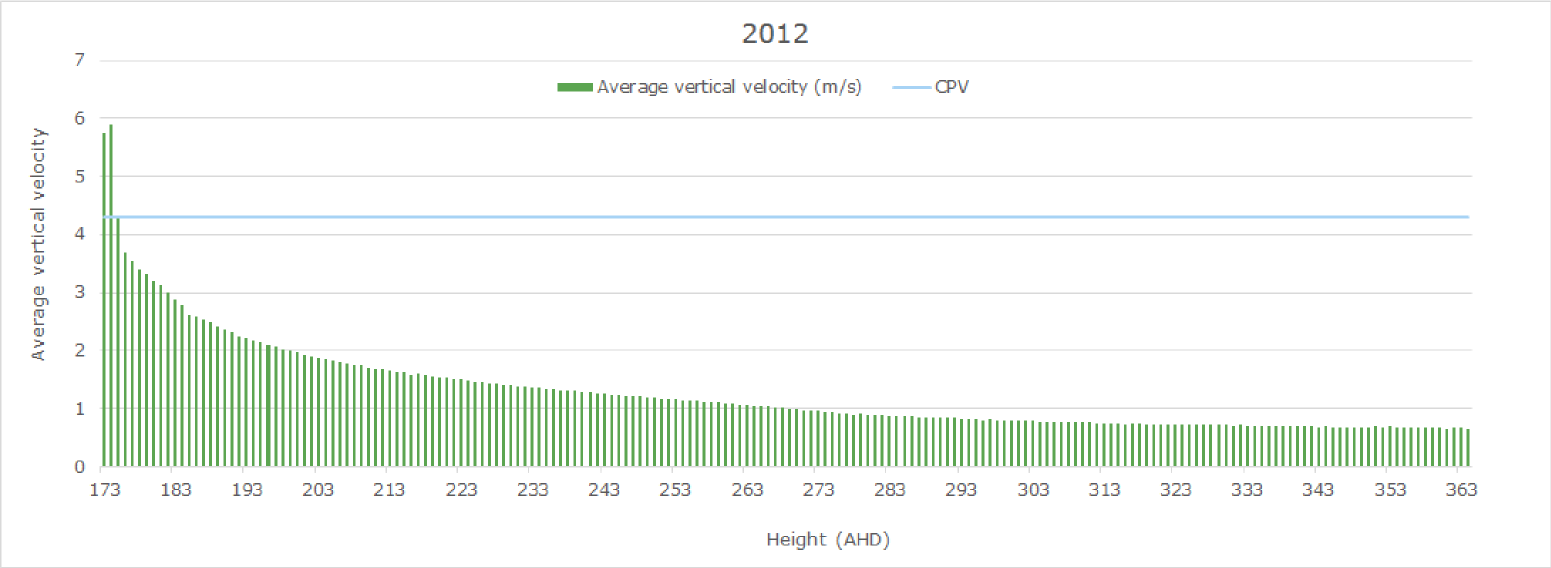
Table 4-2: Percentage occurrence of plume vertical velocity greater than 4.3 m/s at OLS (223m AHD)

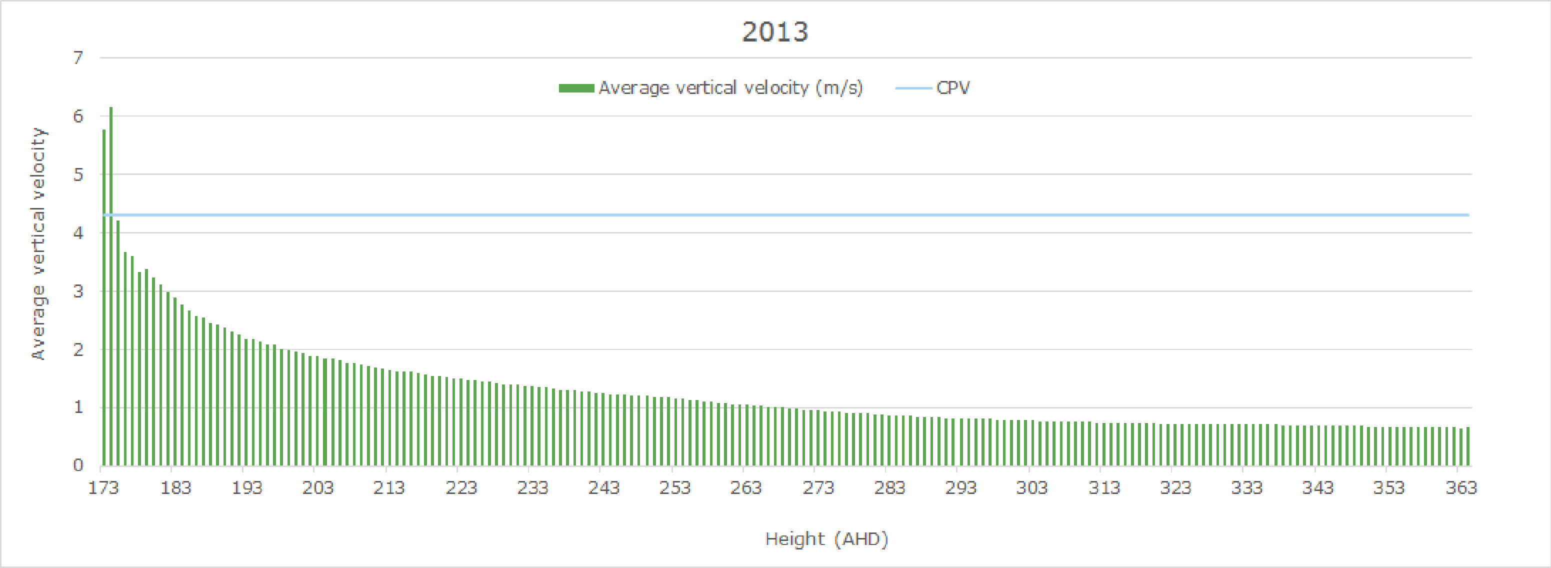
2010	2011	2012	2013	2014
0.23%	0.22%	0.43%	0.39%	0.15%

Percentage value represents the critical plume velocities as the proportion of all plume velocities at each height


2010
Average vertical velocity (m/s)
CPV
Average vertical velocity
Height (AHD)


2011
Average vertical velocity (m/s)
CPV
Average vertical velocity
Height (AHD)


2012
Average vertical velocity (m/s)
CPV
Average vertical velocity
0
1
2
3
4
5
6
7
173
183
193
203
213
223
233
243
253
263
273
283
293
303
313
323
333
343
353
363
Height (AHD)


2013
Average vertical velocity (m/s)
CPV
Average vertical velocity
0
1
2
3
4
5
6
7
173
183
193
203
213
223
233
243
253
263
273
283
293
303
313
323
333
343
353
363
Height (AHD)

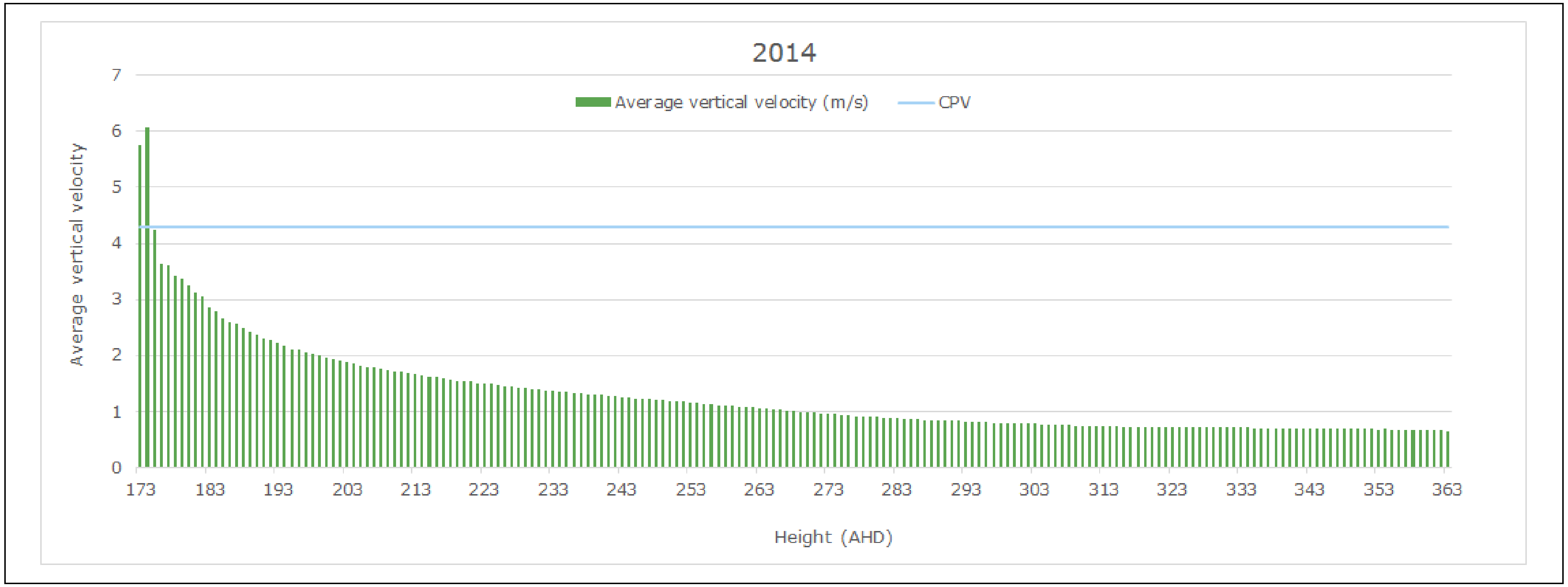
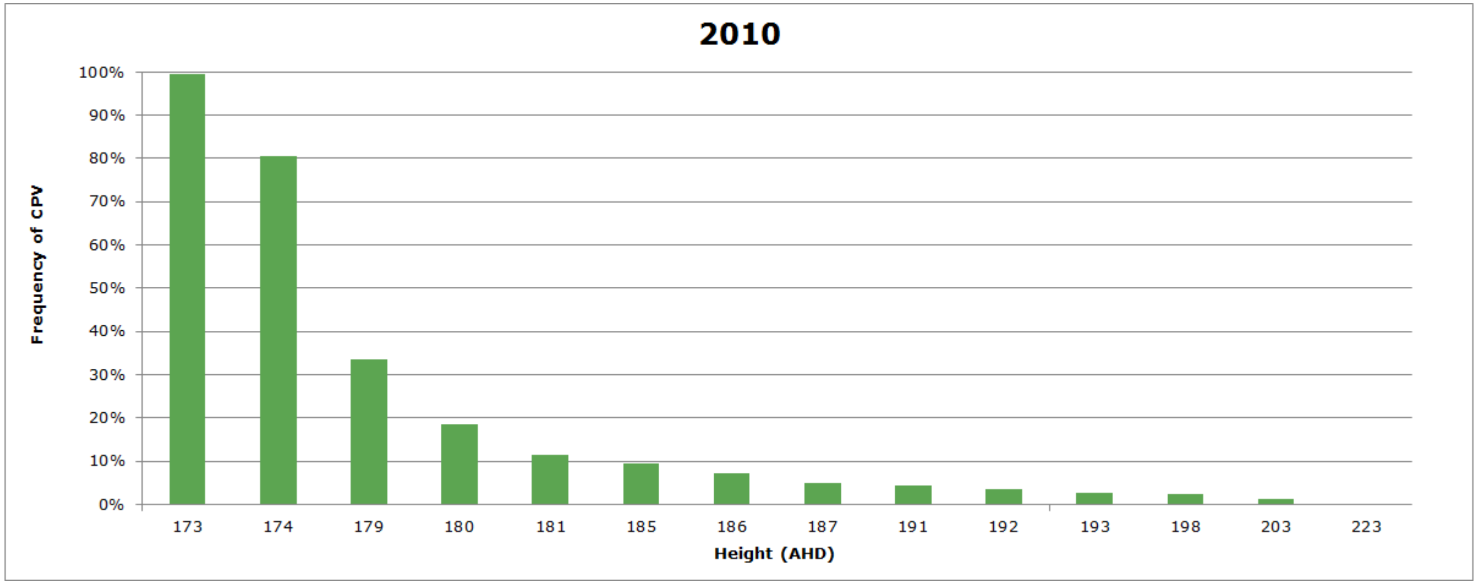
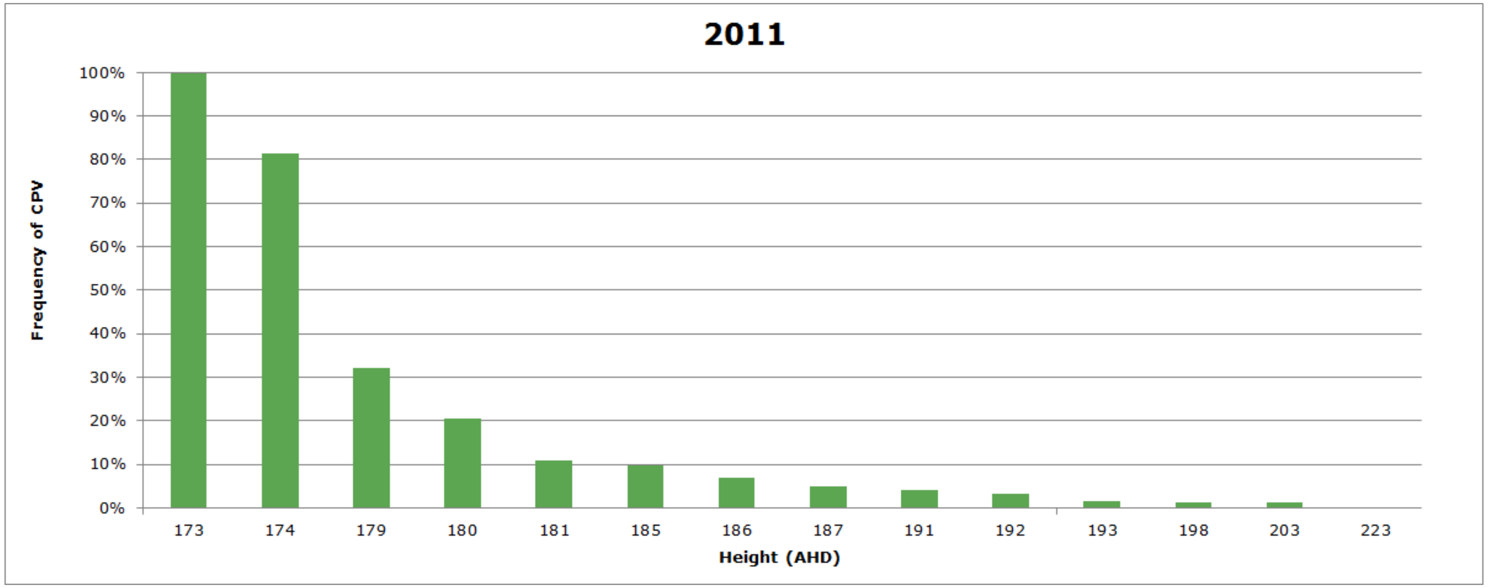
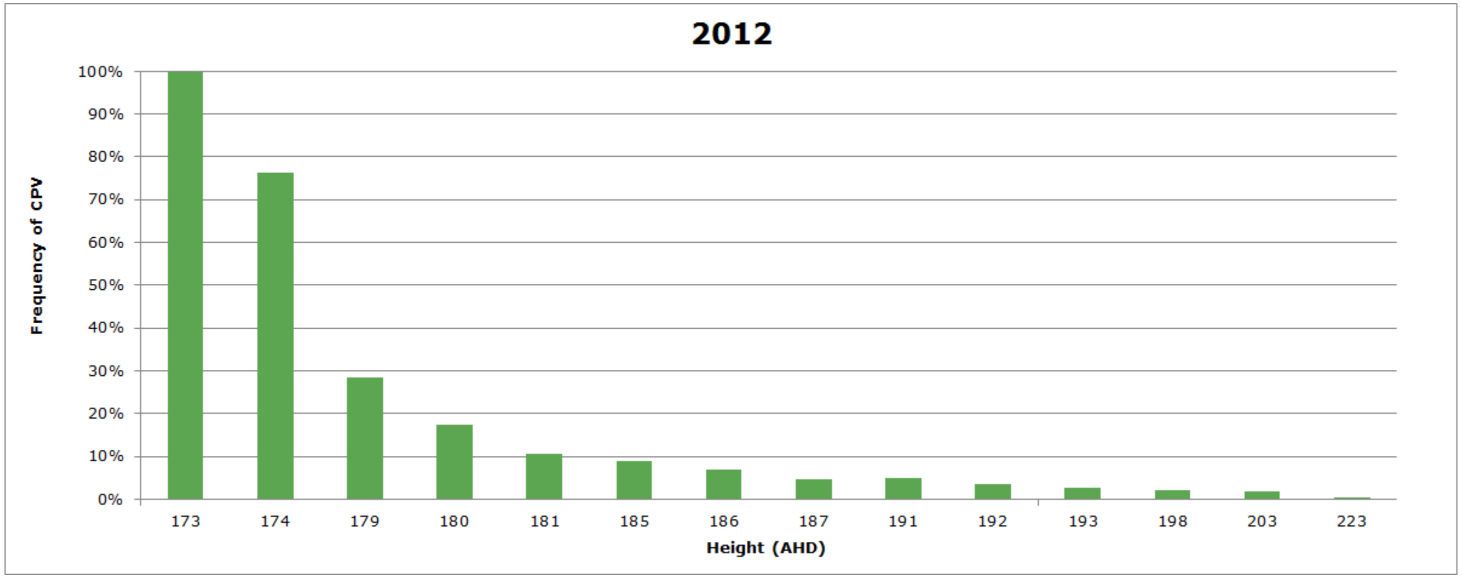
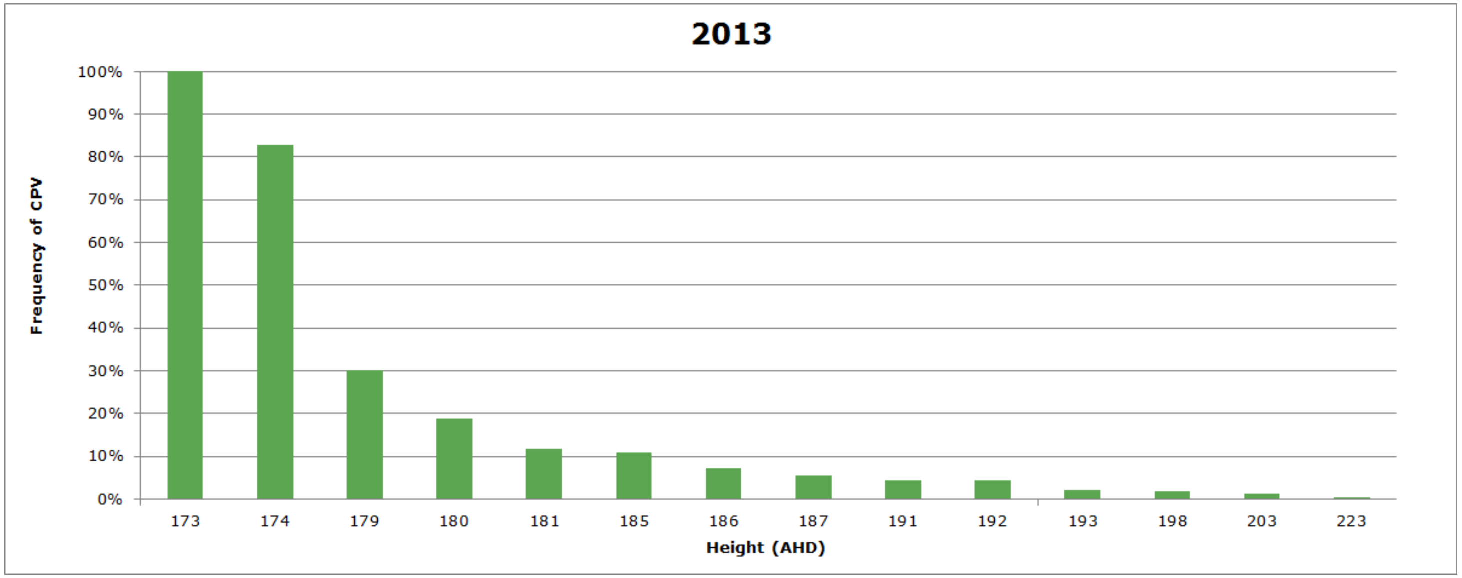


Figure 3: Plume velocity averaged by height


2010
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Frequency of CPV
173
174
179
180
181
185
186
187
191
192
193
198
203
223
Height (AHD)


2011
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Frequency of CPV
173
174
179
180
181
185
186
187
191
192
193
198
203
223
Height (AHD)


2012
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Frequency of CPV
173
174
179
180
181
185
186
187
191
192
193
198
203
223
Height (AHD)


2013
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Frequency of CPV
173
174
179
180
181
185
186
187
191
192
193
198
203
223
Height (AHD)

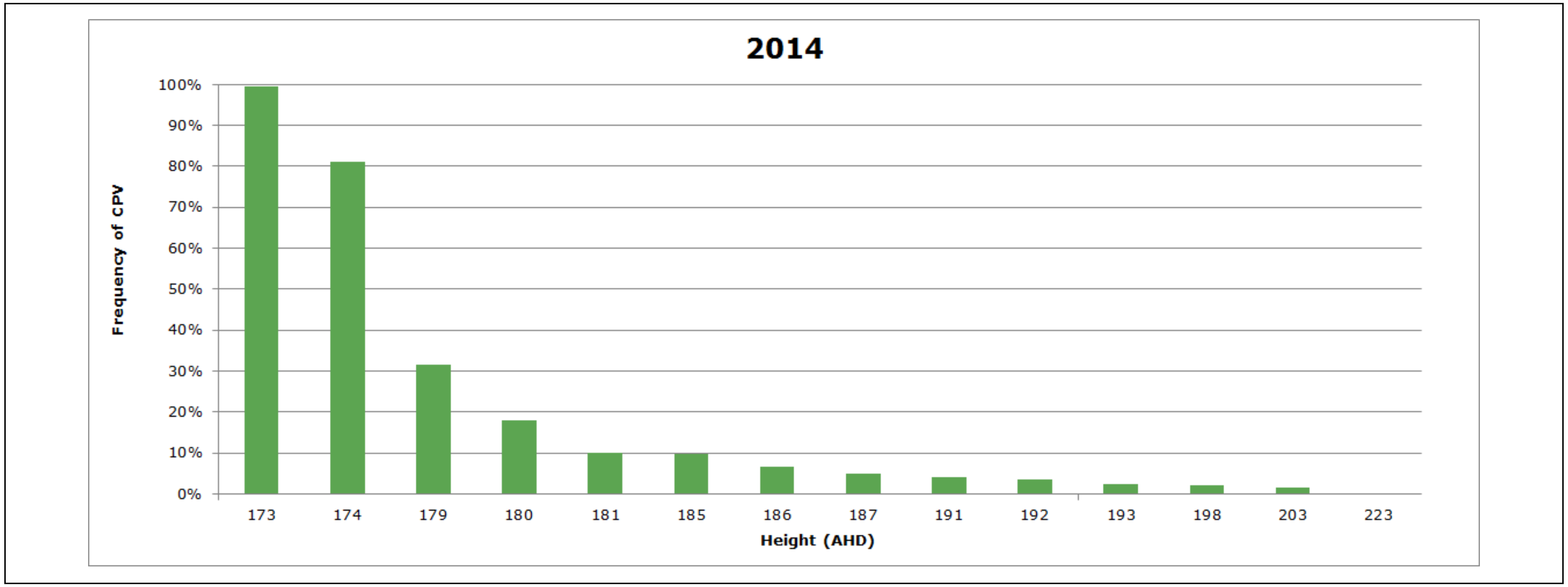


Figure 4: Frequency of CPV at various heights

4.3 Plume displacement

The gradual plume rise output file provides information on the lateral plume radius (Ry) and the west-east and south-north plume distance from source (Dx and Dy). These data can be interpreted to derive the maximum plume displacement for all CPH (the maximum plume displacement for heights where the vertical velocities are greater than 4.3 m/s). Dx and Dy are combined to derive the distance that the plume travels and added to the plume radius to get the maximum plume displacement.

The results are presented in **Table 4-3**. The penetration of the OLS by a vertical velocity in excess of 4.3 m/s occurs for only a very small area in the immediate vicinity of the stacks. The maximum plume displacement of 30m in any direction, from both stack locations, is presented visually in **Figure 5**.

Table 4-3: Maximum plume displacement where plume vertical velocity is greater than 4.3 m/s

Statistic	Plume displacement (m)				
	2010	2011	2012	2013	2014
Maximum	31	29	30	30	30

Figure 5: Maximum plume displacement for CPH

5. CONCLUSION

In the absence of prescribed airspace for the proposed Western Sydney Airport, an aviation assessment was commissioned to determine the likely future airspace requirements. Based on a desktop review an obstacle limitation surface (OLS) of approximately 223 m AHD has been derived. The OLS is compared against the critical plume heights, defined as the heights where the plume vertical velocity is greater than 4.3 m/s (the critical plume velocity).

Plume rise modelling indicates that the average critical plume height is below the OLS for each year modelled. The maximum critical plume height is above the OLS, however less than 5% of all critical plume heights are greater than the OLS.

Plots of the plume velocity averaged by height clearly show that average plume velocity is well below the OLS for all years of analysis. Also, the percentage occurrence of critical plume velocities above 4.3 m/s, at the OLS is very small (less than 0.4% for all years). Finally, the penetration of the OLS by critical plume heights occurs for only a very small area in the immediate vicinity of the stacks.

Where plume rise from a new facility has the potential to exceed the critical plume velocity, the CASA Advisory Circular lists mitigation measures that might include inserting a symbol of aviation charts to enhance awareness of plume rise or designation of a danger area or restricted area.

6. REFERENCES

ADS (2015). Aviation Assessment of Proposed Energy from Waste Facility, Eastern Creek. 11 September 2015.

Fichtner (2015). The Next Generation (TNG EFW) Energy from Waste Facility, Eastern Creek. Concept Design Report. 11/03/2015.

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

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

Urbis (2015). Environmental Impact Statement. The Next Generation NSW Energy From Waste Facility, Eastern Creek. April 2015.

APPENDIX 1
COMPLETED FORM 1247

Australian Government
Civil Aviation Safety Authority

Application for Operational Assessment of a Proposed Plume Rise

Proponent Details

Contact Name	**Mr Ian Malouf**
Company Name	**Dial a Dump Industries**
Address	**32 Burrows Road Alexandria NSW 2015**
Phone (BH)	**(02) 9519-9999**
Email Address	**ianmalouf@dadi.com.au**
Date Submitted	
File Reference: (CASA use only)	

Details of the Proposed Facility and Prior Consultation

Type of facility	**Energy from Waste Facility**
Location of the nearest town (direction and distance)	Minchinbury, 1.2 km north
Location of the facility in latitude and longitude (degrees, minutes, seconds)	Lat: 33 48 05.1339 Long: 150 49 28.9998
Proximity to any other existing or planned facility that generates a plume rise (if known)	N/A
Distance to the nearest aerodrome or landing area including helicopter landing sites	Sydney Airport - > 15km Bankstown Airport- > 15km Proposed Western Sydney Airport - ~14km
Height of the stack or tallest structure at the site above ground level (AGL)	100 m
Elevation of the location of the facility above mean sea level (AMSL)	64m
Date the facility will commence operation	
For single stacks: Stack exit velocity (metres per second) Stack exit temperature (degrees celsius) Stack radius (metres) Stack height (metres above ground level)	

For multiple stacks please give median, mean and range for each parameter: Stack separation distance (metres) Stack exit velocity (metres per second) Stack exit temperature (degrees celsius) Stack radius (metres) Stack height (metres above ground level)	2 stack locations each having 2 adjacent stack ducts. All 4 stack ducts have same parameters. Stack location separation distance = 58 m. At each location stack ducts separated by a few meters. Exit velocity = 21.7 m/s Temperature = 120 degC Stack radius = 2.2 m Stack Height = 100m
For facilities with multiple configurations please give the parameters for the worst case scenario: Stack separation distance (metres) Stack exit velocity (metres per second) Stack exit temperature (degrees celsius) Stack radius (metres) Stack height (metres above ground level)	N/A
For facilities with multiple configurations please give the parameters for the normal operating scenario: Stack separation distance (metres) Stack exit velocity (metres per second) Stack exit temperature (degrees celsius) Stack radius (metres) Stack height (metres above ground level)	N/A
Details of any prior consultation with: a. CASA b. Dept of Defence c. Aerodrome Operator d. Other relevant party	Consultation with CASA and Department of Infrastructure and Development during EIS submission regarding potential impacts on Western Sydney Airport. Consultant with Sydney Airport who indicated that they are not concerned with the development

Submitted By:

Name:	Signature: .... …….
Contact Phone:	
Email Address:	
Date:	