

## Appendix A

# Tank Design and Emissions Description

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The onsite storage tanks have different designs, with each design affecting the type of emissions from the tanks. The designs have been briefly summarised below, with further detail provided in the Australian Government document *National Pollution Inventory Emissions Estimation Technique Manual for Fuel and Organic Liquid Storage (2012)*. The IDs provided in the Table below are used to identify the tank types throughout this report.

### Brief Description of Tank Designs

Tank Type	ID	Description	Typical Fuel Types
Vertical Fixed Roof	VFR	Fixed roof tanks consist of a cylindrical shell capped with a permanently fixed roof that may be flat, conical or dome-shaped. The tank is generally allowed to vent freely to the atmosphere, or will have pressure/vacuum vents (or a breather valve) installed	Diesel, fuel oil
Horizontal self-bunded tank	HT	A cylindrical tank mounted within a bunded structure to be used to collect product interfaces, drained product from pipework and any product from thermal relief systems. The tank is a free vented tank or may have a pressure vacuum vent subject to Australian Standards requirements.	Minor quantities of mixed product from product interfaces
External Floating Roof	EFR	A typical external floating roof tank consists of an open-topped cylindrical steel shell equipped with a roof that floats on the surface of the stored liquid. The floating roof consists of a deck, fittings and rim seal system. The roof rises and falls with the liquid level in the tank. External floating decks are equipped with a rim seal system attached to the deck perimeter and in contact with the tank wall. The purpose of the floating roof and rim seal system is to reduce evaporative loss of the stored liquid. The external floating roof design is such that evaporative losses from the stored liquid are limited to losses from the rim seal system and deck fittings (standing storage loss) and any exposed liquid on the tank walls (withdrawal loss).	Diesel
External Floating Roof fitted with geodesic dome	DEFR	Domed external floating roof tanks have the heavier type of deck used in external floating roof tanks, as well as a fixed roof at the top of the shell, as for the internal floating roof tank.	Jet fuel
Internal Floating Roof	IFR	An internal floating roof tank has a permanent fixed roof on the tank and a floating roof on top of the stored liquid. The floating roof can either rest directly on the liquid surface (a contact deck) or on pontoons, resting several centimetres above the liquid surface (a non-contact deck). Evaporative losses from floating roofs may come from deck fittings, non-welded deck seams and the annular space between the deck and tank wall. In addition, these tanks are freely vented by circulation vents at the top of the fixed roof.	Jet fuel

As detailed in the Australian Government (2012) document, emissions from storage tanks can be categorised as working and standing losses:

- Working losses are the combined loss from filling and emptying a tank. As the liquid level increases, the pressure inside the tank increases and vapours are expelled from the tank. A loss during emptying occurs when air drawn into the tank becomes saturated with organic vapour and expands, thus exceeding the capacity of the vapour space.
- Standing losses (breathing) occur through the expulsion of vapour from a tank due to the vapour expansion and contraction as a result of changes in temperature and barometric pressure. This loss occurs without any change in the liquid level in the tank. The emissions from breathing are more significant for Vertical Fixed Roof (VFR) tanks that are designed with a headspace above the liquid surface compared to those tanks that have floating roofs that limit the headspace (Doomed External Floating Roof –DEFR- tanks or Internal Floating Roof –IFR- tanks) or do not have roofs to allow vapour build-up (EFR tanks).

## Appendix B

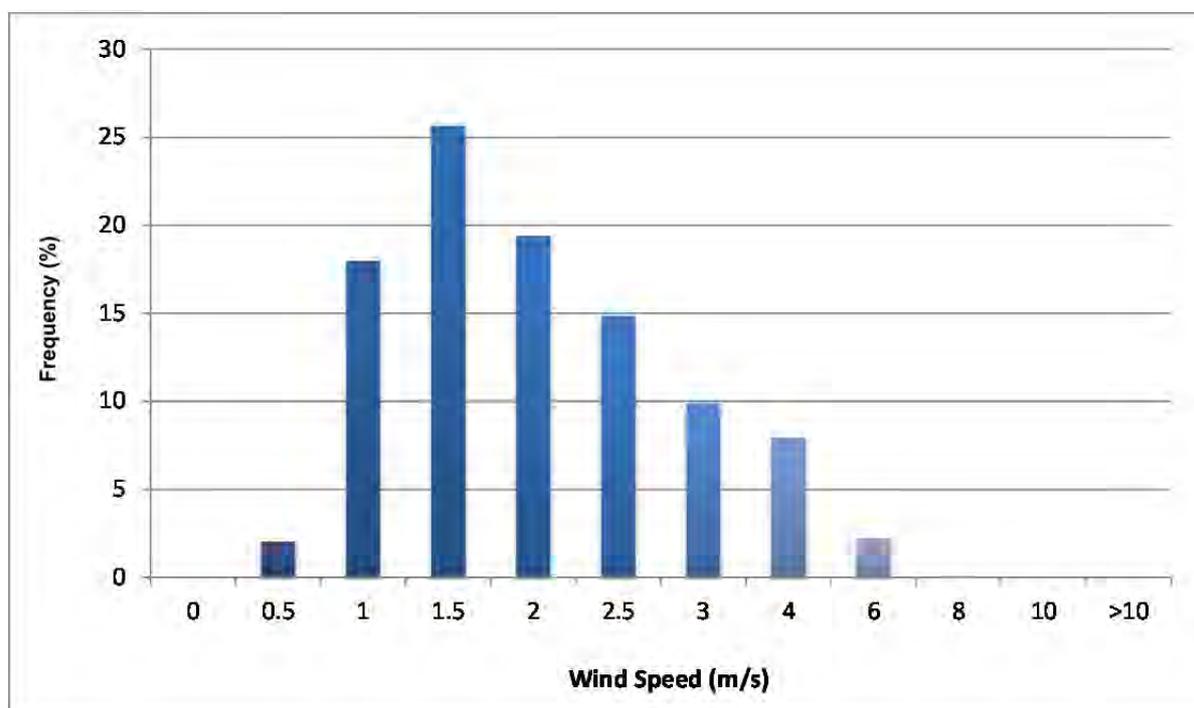
# Meteorological Review

## Appendix B Meteorological Review

This **Appendix B** discusses the meteorological data used for the Clyde dispersion modelling, in terms of wind speed, stability class and mixing height. The data was developed using the TAPM and CALMET programs as previously discussed.

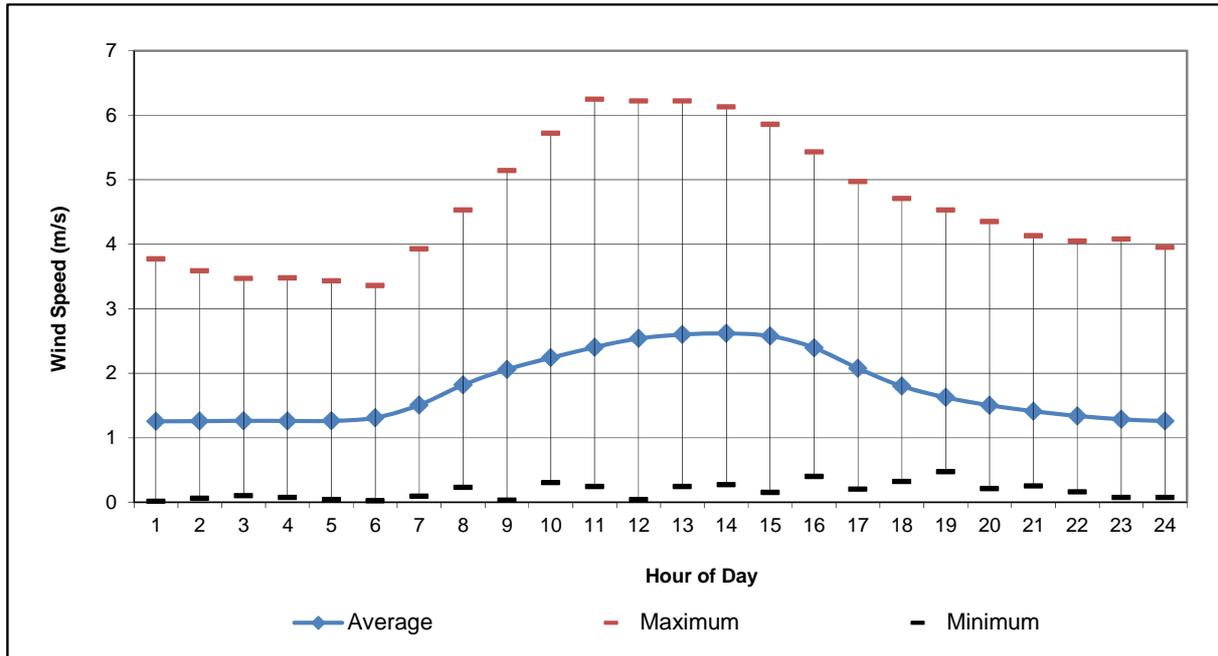
### Wind Speed

The frequency distribution of hourly averaged wind speed values from the CALMET data generated for the assessment is shown below in the following Figure. As shown, wind speeds in the area are relatively low, with speeds less than 2 m/s occurring for nearly 65% of the time. Medium to strong winds (> 4 m/s) occurring approximately 10% of the time.



Frequency Distribution of Wind Speed; Clyde CALMET Data, 2011

The following Figure shows the distribution of wind speeds by hour of day. As shown, there is little variation in the average wind speeds throughout the day. Peak wind speeds, however, tend to occur between 10 am and 3 pm.



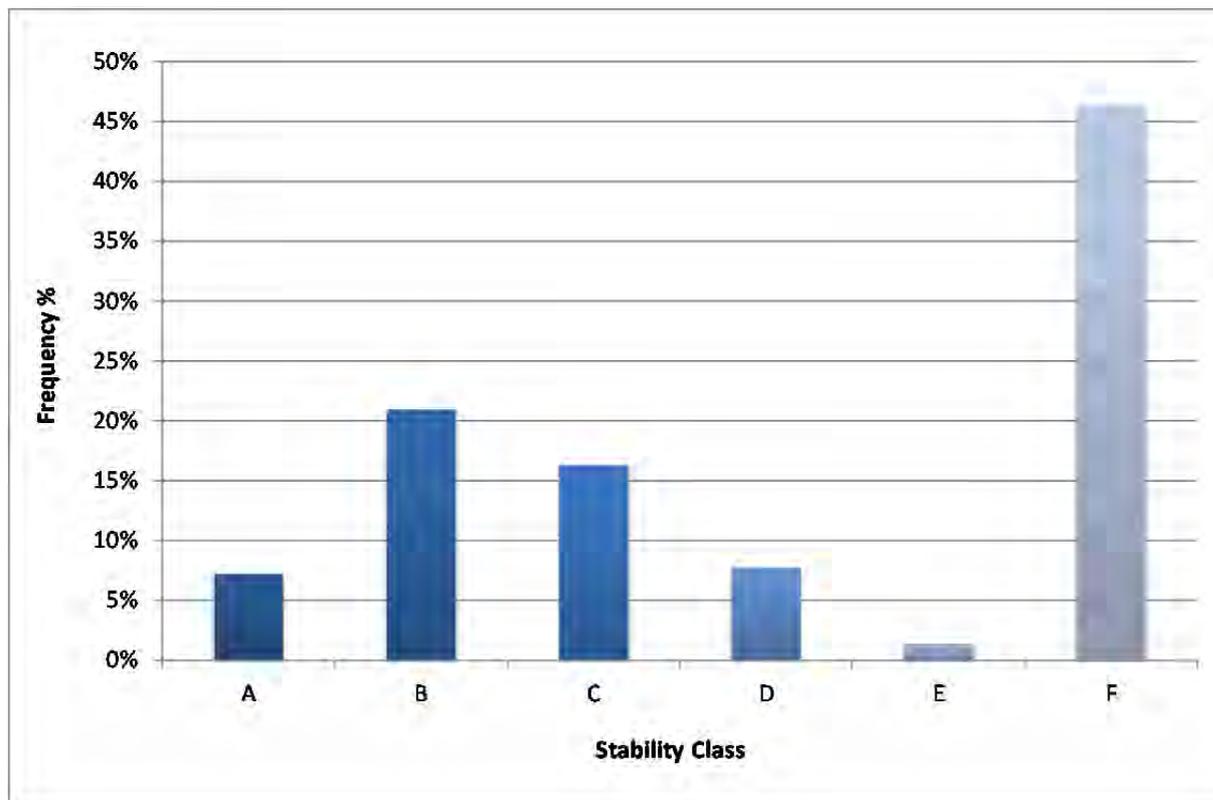
Wind Speed by Hour of Day; Clyde CALMET Data, 2011

### Stability Class

An important aspect of plume dispersion is the atmospheric turbulence level in the region of the plume, near the ground in this case. Turbulence acts to increase the cross-sectional area of the plume due to random motions, thus diluting or diffusing a plume. For traditional dispersion modelling using Gaussian plume models, categories of atmospheric stability are used in conjunction with other meteorological data to describe atmospheric conditions and thus dispersion.

The most well-known stability classification is the Pasquill-Gifford scheme, which denotes stability classes from A to F. Class A is described as highly unstable and occurs in association with strong surface heating and light winds, leading to intense convective turbulence and much enhanced plume dilution. At the other extreme, class F denotes very stable conditions associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions plumes can remain relatively undiluted for considerable distances downwind. Intermediate stability classes grade from moderately unstable (B), through neutral (D) to slightly stable (E). Whilst classes A and F are strongly associated with clear skies, class D is linked to windy and/or cloudy weather, and short periods around sunset and sunrise when surface heating or cooling is small.

As a general rule, unstable (or convective) conditions dominate during the daytime and stable flows are dominant at night. This diurnal pattern is most pronounced when there is relatively little cloud cover and light to moderate winds. The frequency distribution of estimated stability classes in the meteorological file is shown in the following Figure. The data show a total of 47% of hours with either E or F class. This is consistent with the expected occurrence of stable conditions at inland locations that experience a high proportion of calm wind conditions. Stable and calm conditions decrease the dispersion of pollutants in the atmosphere and can lead to increased ground level concentrations close to an emission source.

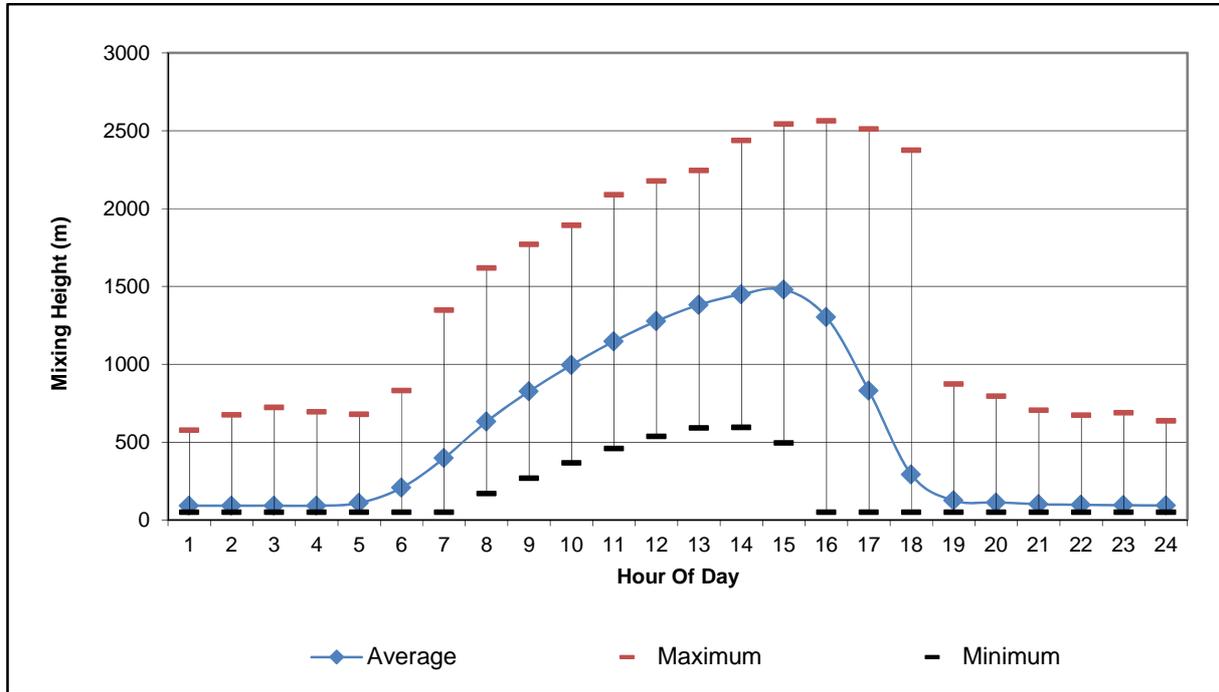


Frequency Distribution of Stability Class; Clyde CALMET Data; 2011

### ***Mixing Height***

Mixing height is the depth of the atmospheric surface layer beneath an elevated temperature inversion. It is an important parameter within air pollution meteorology. Vertical diffusion or mixing of a plume is generally considered to be limited by the mixing height, as the air above this layer tends to be stable, with restricted vertical motions.

CALMET was used to calculate mixing heights in the assessment. The diurnal variation of mixing height is summarised in the following Figure. Mixing heights are lower during the night and early morning hours (< 1000 m), increasing after sunrise to a maximum of 2600 metres by mid-afternoon. This pattern of a marked diurnal cycle is consistent with the Project's inland location.



Hourly Mixing Height; Clyde CALMET Data; 2011

## Appendix C

# Assessment Criterion Derivation – Naphthalene

## Appendix C Assessment Criterion Derivation – Naphthalene

### Background

Naphthalene is an organic, crystalline solid, commercially produced from coal tar and petroleum, and used for the production of chemicals, dyes and as a moth-repellent. The compound is the most volatile polycyclic aromatic hydrocarbon. Naphthalene has a half-life of 3 – 8 hours in the atmosphere<sup>1</sup>.

### Health Effects

Naphthalene can be absorbed through inhalation, ingestion and dermal contact. Naphthalene is identified as a Hazardous Air Pollutant under the U.S. Clean Air Act Amendment (1990), and the adverse health effects of the compound have been recognised for some time<sup>2</sup>. While evidence suggests that naphthalene exposure can cause cancer in rats, evidence of cancers in humans caused by the compound is not conclusive. Naphthalene has, however, been classified as potentially or likely to be carcinogenic by a number of bodies:

- **National Toxicology Program (NTP) carcinogenic classification:** Reasonably Anticipated to be Human Carcinogen<sup>3</sup>;
- **International Agency for Research on Cancer (IARC) carcinogenic classification:** [Group 2B, Possibly Carcinogenic to Humans](#)<sup>2</sup>;
- **Environmental Protection Agency (EPA) carcinogenic classification:** [Group C, Possible Human Carcinogen](#)<sup>2</sup>;
- The State of California's Proposition 65 program listed naphthalene as a substance known to the State to cause cancer on April 19, 2002<sup>3</sup>.

The primary health issues associated with naphthalene exposure are lesions in the respiratory tract and haemolytic anaemia<sup>1</sup>. Short-term exposure can cause lesions of blood cells (haemolysis), while long-term exposure can result in chronic haemolytic anaemia. Inhalation can generate symptoms such as headache, confusion, nausea, vomiting and sweating. Skin irritation and dermatitis can result from dermal contact. Naphthalene exposure can cause cataracts in the eyes, while ingestion can cause abdominal cramps, nausea, vomiting, diarrhoea and death in young infants. The substance is very toxic to aquatic organisms, and may cause long-term effects in the aquatic environment<sup>4</sup>.

### Criteria

A number of criteria have been developed for naphthalene exposure as shown in the Table below. All criteria address the risks associated with indoor or employment-related exposure – none are directly relevant to ambient environmental pollutant concentrations. Only criteria relating to exposure via inhalation of air are shown. As indicated, the Australian occupational exposure criteria (TWA and STEL) are the same as those specified by the US EPA and other American authorities.

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<sup>1</sup> WHO. (2010). WHO Guidelines for Indoor Air Quality: Selected Pollutants. World Health Organization: Denmark.  
[http://www.euro.who.int/\\_data/assets/pdf\\_file/0009/128169/e94535.pdf](http://www.euro.who.int/_data/assets/pdf_file/0009/128169/e94535.pdf); accessed 19 April 2011.

<sup>2</sup> [http://oehha.ca.gov/air/hot\\_spots/pdf/naphth080304.pdf](http://oehha.ca.gov/air/hot_spots/pdf/naphth080304.pdf); accessed 15 April 2011

<sup>3</sup> [http://www.osha.gov/dts/chemicalsampling/data/CH\\_255800.html](http://www.osha.gov/dts/chemicalsampling/data/CH_255800.html); accessed 15 April 2011 Chemical Sampling Information – Naphthalene – United States Department of Labor, Occupational Safety and Health Administration (OSHA)

<sup>4</sup> International Programme on Chemical Safety Poisons Information Monograph 363;  
<http://www.inchem.org/documents/pims/chemical/pim363.htm>; accessed 19 May 2010

**Published Assessment Criteria for Naphthalene**

Type	Value	Source
<b>Australian Standards</b>		
Time Weighted Average (TWA) (8 hours)	52 mg/m <sup>3</sup> (10 ppm)	NOHSC <sup>5</sup>
Short-Term Exposure Limit (STEL) (15 minutes)	79 mg/m <sup>3</sup> (15 ppm)	
<b>International Standards</b>		
Annual average exposure guideline	0.01 mg/m <sup>3</sup>	WHO <sup>6</sup>
Chronic Inhalation Reference Exposure Level (REL) (continuous exposures for up to a lifetime)	9 µg/m <sup>3</sup> (2 ppb)	OEHHA <sup>7</sup>
Reference concentration for Chronic Inhalation (daily inhalation exposure) <sup>^</sup> No Observed Adverse Effect Level (NOAEL) Lowest Observed Adverse Effect Level (LOAEL)	0.003 mg/m <sup>3</sup> None 9.3 mg/m <sup>3</sup>	USEPA <sup>8</sup>
Permissible Exposure Limit (PEL)	50 mg/m <sup>3</sup> (10 ppm)	OSHA <sup>8</sup>
Inhalation Minimal Risk Level (MRL) for chronic inhalation exposure (daily exposure)	0.003 mg/m <sup>3</sup> (0.0007 ppm)	ATSDR <sup>9</sup>
Recommended Exposure Limit (REL) –TWA	TWA 50 mg/m <sup>3</sup> (10 ppm) STEL 75 mg/m <sup>3</sup> (15 ppm)	NIOSH <sup>10</sup>
Immediately Dangerous to Life or Health Concentration (IDLH)	1,250 mg/m <sup>3</sup> (250 ppm)	
<p>It should be noted that the Australian standards used a slightly different conversion factor for ppm to mg/m<sup>3</sup> than the international standards.</p> <p><sup>^</sup> The inhalation Reference Concentration (RfC) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. In general, the RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily inhalation exposure of the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.</p> <p>Exposure timeframes are classified as acute (14 days or less), intermediate (15–364 days), and chronic (365 days or more).<sup>9</sup></p>		

<sup>5</sup> NOHSC. (1995). Adopted National Exposure Standards for Atmospheric Contaminants in the Occupational Environment. [NOHSC:1003(1995)] National Occupational Health and Safety Commission.

<sup>6</sup> WHO. (2010). WHO Guidelines for Indoor Air Quality: Selected Pollutants. World Health Organization: Denmark. [http://www.euro.who.int/\\_data/assets/pdf\\_file/0009/128169/e94535.pdf](http://www.euro.who.int/_data/assets/pdf_file/0009/128169/e94535.pdf); accessed 19 April 2011.

<sup>7</sup> California Office of Environmental Health Hazard Assessment; <http://oehha.ca.gov/air/allrels.html>; accessed 15 April 2011

<sup>8</sup> US EPA - <http://www.epa.gov/iris/subst/0436.htm>

<sup>9</sup> ATSDR. (2005). Toxicological profile for naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene. US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry.

<sup>10</sup> Chemical Sampling Information – Naphthalene – United States Department of Labor, Occupational Safety and Health Administration (OSHA); [http://www.osha.gov/dts/chemicalsampling/data/CH\\_255800.html](http://www.osha.gov/dts/chemicalsampling/data/CH_255800.html); accessed 15 April 2011

### **Criterion Derivation**

Due to the nature of the works and the relatively short half-life of the compound in the atmosphere, short-term averaging periods were considered most relevant for this pollutant. In accordance with the OEH's Approved Methods<sup>11</sup> for assessing toxic air pollutants on an hourly scale, an hourly assessment criterion was developed.

Following consultation, the Air Technical Advisory Services Unit (ATASU) of the Office of Environment and Heritage (OEH) suggested a methodology for determining an appropriate impact assessment criterion. This methodology involved converting a time weighted average (TWA), which is a workplace exposure criterion, to an ambient criterion; comparing the calculated ambient criterion to naphthalene's odour threshold; and using the more conservative value for an impact assessment criterion. The approach is further described below.

In the absence of other guidance, the New Zealand Government<sup>12</sup> advocates the amendment of TWAs for assessment criteria where appropriate. TWAs are workplace exposure standards designed to protect healthy people with a potential exposure of eight hours per day, five days per week. Conversely, impact assessment criteria are designed to protect all members of the community (including the elderly and children, who are often more sensitive to exposure than healthy workers). The TWA must, therefore, be converted to a more generic protection level, which can be achieved as follows.

For low or moderately toxic hazardous air pollutants, the TWA is converted to a generic protection level by dividing the TWA by 50. This divisor both converts the eight-hour TWA to a 24-hour average and incorporates a further safety factor of 10 to account for the potentially more sensitive receptors in the environment. For highly toxic, bioaccumulative or carcinogenic hazardous air pollutants, the TWA is converted to a generic protection level by dividing the TWA by 100. The divisor of 100 again converts the TWA to a 24-hour average, but also incorporates an increased safety factor (20) to account for either more toxic pollutants or more long-term chronic effects. Although the generic protection criteria are theoretically 24-hour averages, the New Zealand Government recommends that the criteria are compared to the maximum one-hour average concentrations predicted by CALPUFF (or three-minute averages generated by modelling using AUSPLUME).

The above methodology was used with the National Australian Standard (NOHSC) TWA of 10 ppm (52 mg/m<sup>3</sup>). Based on naphthalene's classification as a potential carcinogen, a divisor of 100 was used. An ambient 1 hour criterion for naphthalene of 0.01 ppm (0.52 mg/m<sup>3</sup>) was subsequently calculated.

As described above, naphthalene is a strongly odorous compound. Offensive odours can adversely affect people's health and well-being, causing stress and other physical symptoms. Published data indicate that naphthalene is detectable at very low concentrations, with an average air odour threshold of 0.084 ppm<sup>13</sup> (0.44 mg/m<sup>3</sup>).

Assessment criteria for pollutants that are both toxic and odorous must protect against impacts associated with both properties. The odour threshold of 0.44 mg/m<sup>3</sup> was, therefore, selected as the assessment criterion for naphthalene as it was the more stringent of the two criteria. This value is well below the LOAEL for naphthalene of 9.3 mg/m<sup>3</sup>; as such, no adverse effects on sensitive receptors are expected to occur should concentrations at Barangaroo fall below this assessment criterion.

### **Conclusion**

An assessment criterion of 0.44 mg/m<sup>3</sup> was adopted for assessing 1 hour maximum naphthalene concentrations for the assessment. The criterion relates to the published average odour threshold for the compound, which was the more stringent of the two criteria developed for this toxic, potentially carcinogenic, odorous pollutant.

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<sup>11</sup> DEC. (2005). Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales.

<sup>12</sup> Good Practice Guide for Assessing Discharges to Air from Industry, June 2008, Ministry for the Environment: Wellington.

<sup>13</sup> Amoores & Hautala. (1983). Odour as an aid to chemical safety: odour thresholds compared with threshold limit values and volatilities for 214 industrial chemicals in air and water dilution. Journal of Applied Toxicology, 3:272–290. Conversion to mg/m<sup>3</sup> performed assuming 1 ppm = 5.24 mg/m<sup>3</sup> (CDC NIOSH) (<http://www.cdc.gov/niosh/npg/npgd0439.html>).

## Appendix D

# Typical Fuel Composition from NPI

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Typical Fuel Composition Percentages from NPI (2012)

VOC	Typical Fuel Composition from NPI (%)		
	Diesel	Unleaded Gasoline	Jet Kerosene
Benzene	0.030	0.933	0.367
Cumene	0.975	0.100	2.830
Cyclohexane	0.010	0.765	1.200
Ethylbenzene	0.110	1.533	0.517
n-Hexane	0.010	1.830	4.650
PAH	0.360	0.610	0.985
Toluene	0.100	5.603	0.180
Xylenes	0.345	7.747	1.880

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