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SKM

AMCOR

# AMCOR Botany
# New Paper Mill EA

## AIR QUALITY ASSESSMENT

- Final Draft
- 5 December 2006

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# 1. Introduction

## 1.1 General Introduction

AMCOR Packaging are proposing to install a new paper making facility, utilising a 100% recycled waste paper fibrous furnish, at their Botany site, NSW. The New Paper Mill would replace the two existing papermaking machines (No. 7 and No. 8) at the site, increasing paper making capacity from the current 250,000 tonnes per year to around 345,000 tonnes per year.

Replacement of the two 1960's vintage paper machines with a single machine, incorporating modern technology, will result in significant increases in efficiency of the paper making process. The upgraded mill will reduce the quantities of solid waste sent to landfill per unit area of paper production, and improve the local amenity due to lower odour and noise emissions.

Services infrastructure on the south western boundary of the site would be demolished to make way for the New Paper Mill. Decommissioning of the existing paper making machines would occur following construction and successful commissioning of the new plant.

AMCOR Packaging is now seeking to gain development approval for the New Paper Mill at the Botany Site.

## 1.2 Site Location

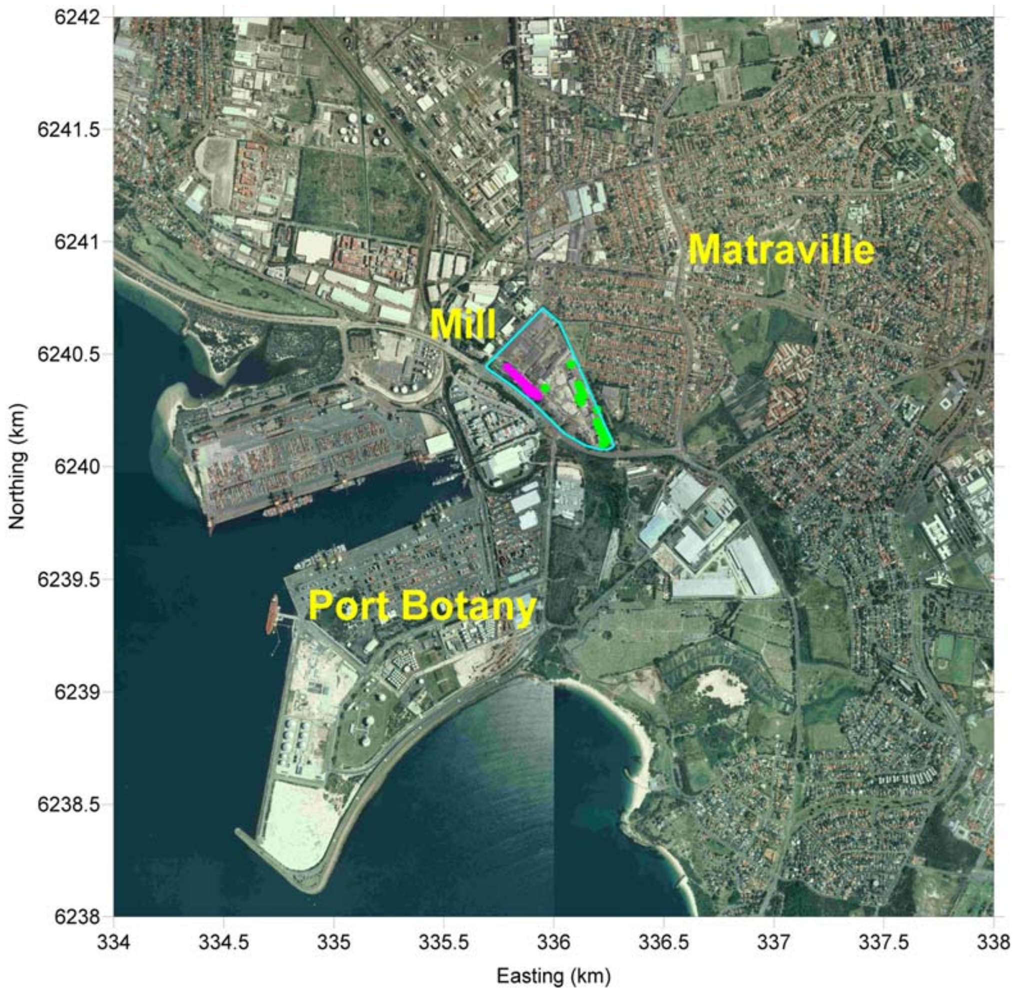
AMCOR Botany Mill is located on Botany Road, Matraville. It is located on a 15.5 hectare site within the Matraville Industrial Area. The land is owned by AMCOR. The site is bounded to the south by Botany Road, to the north by Australia Avenue, to the west by McCauley Street, and extends east to the end of Partanna Avenue. Surrounding land uses include residential uses to the north and east, and commercial and industrial uses to the west and south.

The nearest residential dwellings to the existing Botany Mill site boundary are located to the north and east of the site in Australia Avenue, Partanna Avenue, Moorina Avenue, Murrabin Avenue and McCauley Street. As shown in **Figure 1-1**, the nearest residences, located in Partanna Avenue and Australia Avenue, are approximately 30 m from the mill boundary. This area is zoned residential.

Commercial offices are located beyond the western boundary of the site, on the western side of McCauley Street, and immediately to the east. Industry associated with Port Botany, including the CTAL Container Terminal and Bulk Liquids Storage Area, the Patrick Container Terminal (Australian Stevedore), and the Caltex Oil Terminal are located to the south and south-east (refer to **Figure 1-1**).

The proposed New Paper Mill is to be located within the south-western area of the site, which is currently occupied by derelict buildings and derelict and active service infrastructure.

- **Figure 1-1: Location of AMCOR Botany Mill (blue), existing stack locations (green), proposed stack locations (pink)**




## 1.3 Study Objectives

This study assesses the impact of the New Paper Mill on local air quality. Specifically this assessment examines air quality issues associated with the construction of the upgrade, as well as operational impacts, mainly odours from the recycling of wastewater in the paper making process.

Specifically, this assessment includes:

- An overview of existing and proposed operations;
- A description of the relevant DEC criteria;
- A description of the local air quality and dispersion meteorology;
- A qualitative assessment of construction impacts and mitigation measures;

- A quantitative assessment of odour impacts using the CALPUFF and AUSPLUME dispersion models;
- Comparison of the modelled results with the relevant odour criteria; and
- A general discussion of results and conclusions.

# 2. Air Quality Issues

## 2.1 Overview

This section of the report identifies the major sources of existing and proposed emissions to air at the Paper Mill.

## 2.2 Existing Air Quality Issues

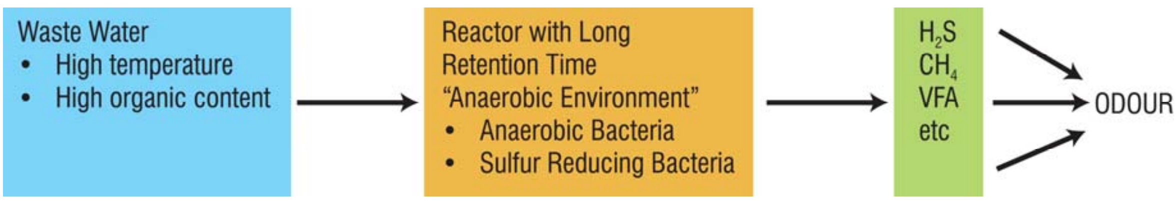
### 2.2.1 Dust Emissions

Airborne dust generation occurs at the Paper Mill site at times during periods of warm, dry and windy conditions. The main source of dust generation (specifically fibrous paper and board dust) is the waste paper storage area. Anecdotal evidence indicates that during hot dry periods within the summer months, occasional localised dust events can occur within the waste paper storage area, but do not generally extend outside this area. During humid or moist conditions following rain, dust generation is typically low. No community complaints relating to the transport of airborne waste paper dust from the Existing Paper Mill have been recorded.

### 2.2.2 Odour Emissions

With increased requirements for water conservation AMCOR has increased water recycling as part of their paper making operations. The reduced use of fresh water and the subsequent increased water recycling leads to increases in the system temperature and higher dissolved solids. Higher dissolved solids concentration and temperature (up to about 50 deg.C) are conducive to an increase in microbiological activity. Microbiological activity and higher temperature both act to reduce dissolved oxygen levels, in some instances depleting the available dissolved oxygen in the recycled water in as little as 5 minutes. This causes microbiological populations to shift from aerobic to anaerobic metabolism, resulting in the release of odorous Volatile Fatty Acids (VFAs) as metabolic-by-products. VFAs include acetic acid, butyric acid, propionic acid and valeric acid (Dexter and Bottjer, 1996) (refer to **Figure 2-1**).

- **Figure 2-1: Odour Generation Process in Waste Water**




Long retention times in tanks, "dead zones" in tanks or piping, and accumulation of sludge layers in the bottom of tanks and clarifiers all promote anaerobic environments and the formation of VFAs.

Another common odour generation mechanism in low effluent mills is the production of hydrogen sulfide by a group of anaerobic bacteria known as Sulphur (or sulphate) Reducing Bacteria (SRBs). The occurrence of SRBs and the attendant odour is most commonly found in areas of deposition or where sludge has settled out (Dexter and Bottjer, 1996).

Odour emission from the Existing Paper Mill is primarily from the evaporation of process water in the paper drying process in the No. 7 and No. 8 machines and associated building roof vents. The following process units are currently the major sources of odour at the Botany Mill:

- Waste Paper Plant Building;
- No.7 Pre Dryer Hood Exhaust (No. 1&2);
- No.7 Pre Dryer Hood Exhaust (No. 3&4);
- No.7 Pre Dryer Hood Exhaust (No. 5);
- No.7 Pre Dryer Hood Exhaust (No. 6);
- No.7 Pre Dryer Hood Exhaust (No. 7);
- No.7 Pre Dryer Hood Exhaust (No. 8);
- No.7 After Dryer Hood Exhaust (No. 9);
- No.7 After Dryer Hood Exhaust (No. 10);
- No.7 Machine Hall Exhaust (No. 1);
- No.7 Machine Hall Exhaust (No. 2);
- No.7 Machine Hall Exhaust (No. 3);
- No.7 Nash Vacuum Pump;
- No.7 Mill Starch Cooker;
- No.8 After Dryer Hood Exhaust (No. 1);
- No.8 After Dryer Hood Exhaust (No. 2);
- No.8 Pre Dryer Hood Exhaust (No. 3);
- No.8 Pre Dryer Hood Exhaust (No. 4);
- No.8 Pre Dryer Hood Exhaust (No. 5);
- No.8 Pre Dryer Hood Exhaust (No. 6);
- No.8 Pre Dryer Hood Exhaust (No. 7);
- No.8 Pre Dryer Hood Exhaust (No. 8);
- No.8 Mill Starch Cooker;
- No.8 Low Vacuum Fan Exhaust;
- No.8 Nash Vacuum Pump Exhaust;
- No.8 Machine Hall Exhaust (No. 8);
- No.8 Machine Hall Exhaust (No. 5);
- No.8 Machine Hall Exhaust (No. 7);
- No.8 Machine Hall Exhaust (No. 4);
- No.8 Machine Hall Exhaust (No. 3);
- No.8 Machine Hall Exhaust (No. 6);
- No.8 Machine Hall Exhaust (No. 10);
- No.8 Machine Hall Exhaust (No. 9).

A full set of odour emissions rates for the existing paper machines is included in **Appendix A**.

SKM has assessed odour impacts at the Existing Paper Mill since 2001 as part of a Pollution Reduction Program (PRP) imposed by the EPA on AMCOR for the purpose of odour reduction. Odour modelling undertaken in October 2001 showed that odour impacts at the nearest residence were of the order of 25 $OU/m^3$. Various odour reduction works have been implemented at the Existing Paper Mill since 2001, these include:

- decommissioning of the old clarifier;
- construction and operation of the new Dissolved Air Flotation (DAF) technology;
- increasing exhaust velocities on selected stacks;
- increasing the height of the No.8 mill low vacuum fan exhaust.

Recent modelling of odour impacts (November 2004) using the AUSLPUME dispersion model shows a reduction in odour concentration at the nearest residences to 10 OU/$m^3$. This level of odour reduction achieved the aim of the project as set out in the SKM report: AMCOR Pollution Reduction Program (PRP) – Odour Remediation Plan, March 2002. It is also noted that with an odour impact of 10 OU/$m^3$ within nearest residential areas, AMCOR through a community survey and records of complaints are currently demonstrating an acceptable level of odour impact within the local community.

A technical paper titled: 'AMCOR Botany Paper Mill – Odour Reduction Program 2000 – 2005' (SKM, 2005) which describes the odour reduction PRP process including a description of the odour remediation works, historic results of odour measurement and assessment as well as community survey results is included in **Appendix B**.

## 2.3 Proposed Expansion

The proposal is to install a new paper machine (B9) (i.e. New Paper Mill) located in the south western area of the site. Once the proposal is fully operational the existing B7 and B8 paper machines will be decommissioned.

### 2.3.1 Odour Emissions

Once fully operational potential odour emissions would be from the following processing units associated with the B9 machine:

| | |
|---|---|
| ▪ No.9 Pre Dryer Hood Exhaust (No.1)<br>▪ No.9 Pre Dryer Hood Exhaust (No.2)<br>▪ No.9 Pre Dryer Hood Exhaust (No.3)<br>▪ No.9 Pre Dryer Hood Exhaust (No. 4)<br>▪ No.9 After Dryer Hood Exhaust (No.1)<br>▪ No.9 After Dryer Hood Exhaust (No.2)<br>▪ No.9 After Dryer Hood Exhaust (No.3)<br>▪ No.9 Machine Room Exhaust (No.1)<br>▪ No.9 Machine Room Exhaust (No.2)<br>▪ No.9 Machine Room Exhaust (No.3)<br>▪ No.9 Machine Room Exhaust (No.4)<br>▪ No.9 Machine Room Exhaust (No.5)<br>▪ No.9 Machine Room Exhaust (No.6)<br>▪ No.9 Former Section (No.1)<br>▪ No.9 Former Section (No.2) | ▪ No.9 Sulzer Blower<br>▪ No.9 Low Vacuum Fan (No.1)<br>▪ No.9 Low Vacuum Fan (No.2)<br>▪ No.9 Low Vacuum Fan (No.3)<br>▪ No.9 Low Vacuum Fan (No.4)<br>▪ No.9 Vacuum Pump (No.1)<br>▪ No.9 Vacuum Pump (No.2)<br>▪ No.9 Vacuum Pump (No.3)<br>▪ No.9 Size Press Ventilation<br>▪ No.9 Pulper Hood (No.2)<br>▪ No.9 Pulper Hood (No.3)<br>▪ No.9 Pulper Hood (No.4)<br>▪ No.9 Pulper Hood (No.5)<br>▪ No.9 Starch Cooker Vent<br>▪ Waste Paper Plant Building |

A full set of forecast odour emissions rates for the proposed B9 machine is included in **Appendix A**. Ideally, odour emission rates for new facilities, e.g. B9 Paper Module, should be determined by direct measurement of odour concentrations from a very similar facility to that being assessed. This is not possible in the case of the B9 machine as there are no other modern paper machines like that proposed by AMCOR. As such, the odour emission rates for B9 machine have been determined from measurement of the existing B7 and B8 'worst case' assessment, as for reasons described later in this report, the B9 machine will have an improved odour performance compared with B7 and B8 machines.

The first step in estimating the odour emission rates for the B9 machine was to calculate the average odour concentrations as measured in B7 and B8 machines during November 2004 and March 2005, which are the most recent odour emission measurements following completion of the odour reduction PRP. Following this, like odour emission sources in the existing B7 and B8 machines were matched up with those proposed in B9 and the average B7 and B8 odour concentrations formed the basis for calculating B9 odour emission rates. For other discharge locations, assumptions were made based on changes to machine or process design, the assumption being that improved technology will yield lower odour emissions. The following are a list of process changes that will have a positive impact on odour generation. These process changes are the result of a well designed mill using modern technology:

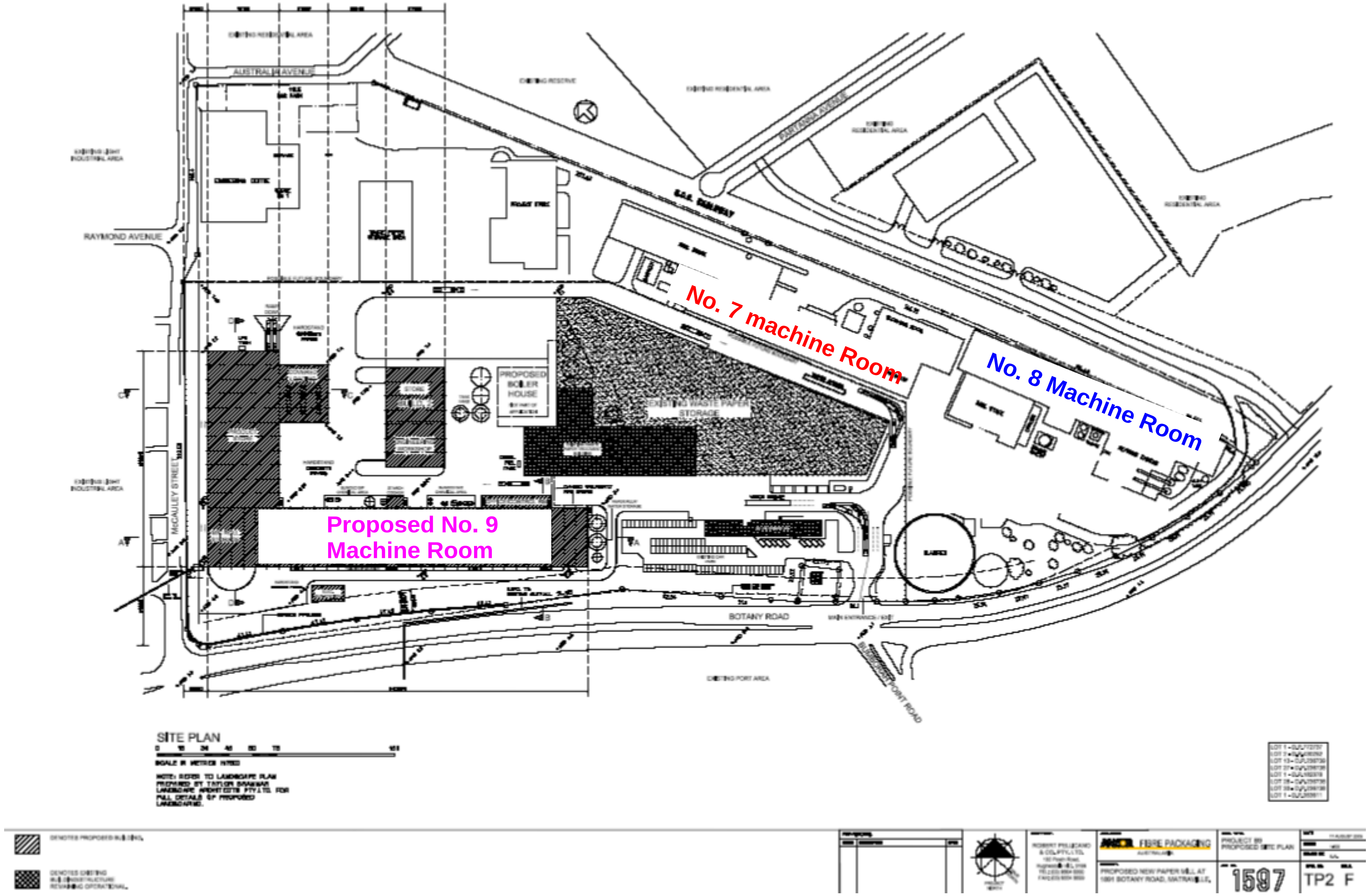
- balanced water system such that there is adequate water storage for the installed stock storage capacity.
- all tanks and chests containing process water, stock or rejects are agitated.
- the water system is operated at the highest practical temperature (nominally >50˚C).
- any process water storage is within the process water flow path – not external to this path.
- controlling and operating at the lowest practical SS & TDS levels in the process water loops to minimise the availability of food sources for microbiological organisms.

The locations of the new infrastructure are shown in **Figure 2-2**.

With respect to the nature of odour emissions the same Dissolved Air Flotation (DAF) system as recently installed in the Existing Paper Mill would be used in the New Paper Mill. DAF technology is considered best practice for primary water treatment at paper mills which are manufacturing recycled paper and its installation has resulted in a substantial reduction in odour impacts at the existing mill as discussed in the previous section. On this basis similar odour emissions would be expected from the New Paper Mill, however, further improvements are expected from the implementation of best engineering practice which will eliminate stagnant water sources contributing to odour, some of which may still exist in the B7 and B8 machines.

A literature review was commissioned by AMCOR into possible "end of the pipe" odour treatment options for wastepaper mills to further reduce odour emissions. This research undertaken by CSIRO is presented in **Appendix C**. The literature and best practice review concluded that there are no proven, economically feasible technologies for "end of the pipe" odour control for paper mills using waste paper.  This is primarily because of the large volumes of air and steam requiring treatment and the relatively low odour concentrations in the air and steam.  Standard industry practice for the control of odour is centred on minimising the potential for the generation of odour producing substances by effective design and management of the paper fibre and process water systems.

■ **Figure 2-2: Existing and Proposed Infrastructure**



# 3. Air Quality Criteria

## 3.1 Overview

This section of the report outlines the criteria as set out by the NSW DEC that are relevant to the proposed development. These include criteria for odour, particulate matter and dust which are considered most relevant to the project.

## 3.2 Odour Criteria

Odorous compounds or mixtures of compounds require an assessment of odour levels. The intensity of a particular odour as determined by olfactometry is described in terms of odour units (OU) which relate to the number of times odorous air must be diluted with odour-free air in order for 50% of a selected panel of ‘sniffers’ to detect a smell. Hence 1 $OU/m^3$ indicates that an equal volume of air is required to dilute a particular volume of odorous air to a level at which half the panel were able to detect the smell. The point at which only 50% of the panel can detect the smell is called the odour threshold.

The NSW DEC regulates air quality in NSW, with odour criteria objectives being set to minimise the adverse effects of dispersion of odorous emissions from odour-producing activities.

The objectives of reducing odour annoyance are regulated by the Protection of the Environment Operations (POEO) Act (1997) (NSW Government, 1997) . Section 129(1) of this Act states:

> *The occupier of any premises at which scheduled activities are carried on under the authority conferred by a licence must not cause or permit the emission of any offensive odour from the premises to which the licence applies.*
>
> The Act then defines an “offensive odour” as:
>
> *that, by reason of its strength, nature, duration, character, or quality, or the time at which it is emitted, or any other circumstances:*
>
> *(i) is harmful to (or is likely to be harmful to) a person who is outside the premises from which it is emitted, or*
>
> *(ii) interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted.*

The level at which an odour is perceived to be of nuisance depends on: the combination of odour quality; The sensitivity of the given population to odours, the background odour level, the tolerance of the community to odour, and the characteristic of the source.

### 3.2.1 Draft Odour Policy

The DEC in their Draft Policy: *Assessment and Management of Odour from Stationary Sources in NSW, January 2001* set odour performance criteria based on population density (NSW 2001a). These criteria which are reproduced in the DEC's *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW* (NSW 2001b) are displayed in **Table 3-1**. These criteria state that no individual should be exposed to ambient odour levels greater than 7 OU/m$^3$ and the level from which odours cause annoyance is 2 OU.

- **Table 3-1 Recommended Odour Performance Criteria**

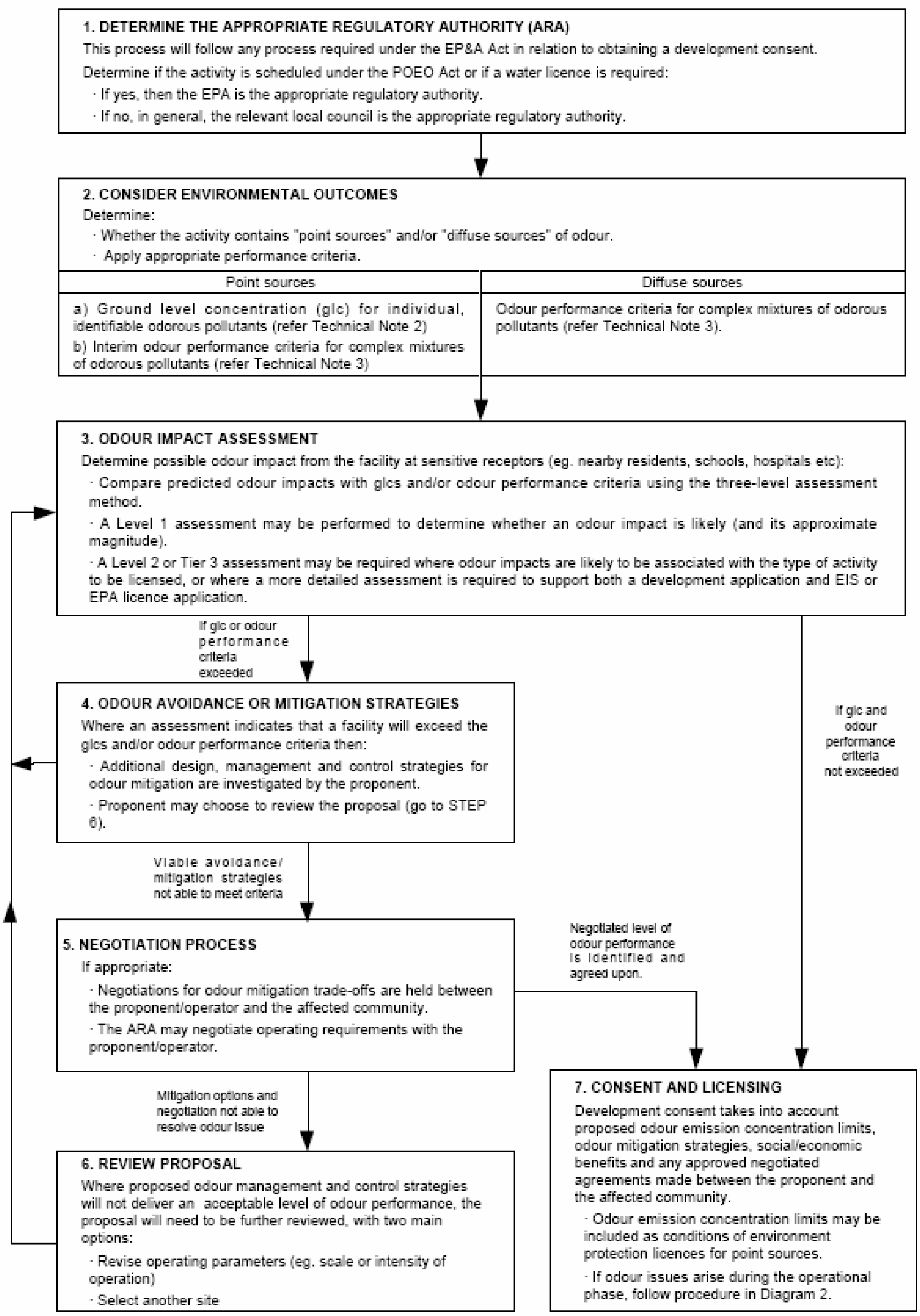
| Size of Affected Community | Odour Performance Criteria # (Odour Units) |
|---|---|
| Urban (Population ≥ ~ 2000) | 2.0 |
| Population ~ 500 | 3.0 |
| Population ~ 125 | 4.0 |
| Population ~ 30 | 5.0 |
| Population ~ 10 | 6.0 |
| Single Residence (≤ ~2) | 7.0 |

# nose-response time average, 99th percentile

**Figure 3-1** sets out a decision tree for establishing odour assessment criteria in accordance with the DEC's Draft Odour Policy.

- **Figure 3-1 Odour Assessment Criteria Decision Tree**

**Odour impact assessment and management for proposed facilities or expansions**



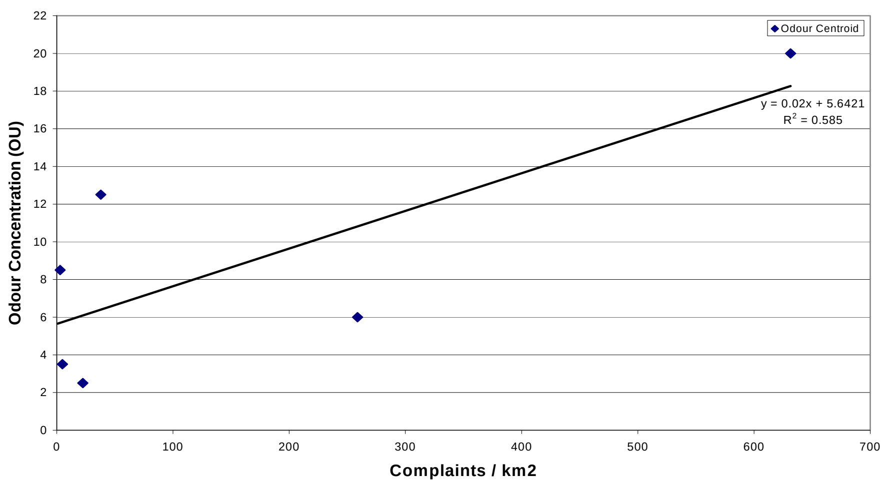
### 3.2.2 PRP Determination of Site Specific Odour Criteria

As per **Figure 3-1** the DEC Policy acknowledges that in some cases it may be appropriate to set industry specific odour criteria acknowledging that different industries emit different types of odour. As such, while 2 $OU/m^3$ may be an appropriate target for some industry, for industries where odour is considered less offensive a higher (less stringent) target may be appropriate.

As part of their Pollution Reduction Program (SKM, 2002) a site specific odour criterion was developed for the Existing Paper Mill. A community criterion was developed to provide a benchmark against which the impact of the proposed odour control could be measured. The methodology for developing such a criterion was as follows:

- using the AUSPLUME dispersion model contour plots representing 99th percentile odour concentrations were generated for the area surrounding the Mill;
- the plots are overlaid on an aerial photograph together with the location of validated complaints;
- the area of land occupied by residential dwellings between a plotted pair of isopleths, is computed, together with the number of dwellings in each band;
- the odour complaint density (complaints per square kilometre, complaints per number of dwelling) for each of the concentration bands is calculated with the process being repeated for each band;
- complaints per square kilometre and complaints per number of dwellings are graphed against the odour centroid for each concentration band. A relationship (ideally a line of best fit) is determined for the data and an odour criterion is established by reading off the odour concentration at a point corresponding to zero complaints (see **Figure 3-2**).

- **Figure 3-2: Community Criteria**



It can be seen from **Figure 3-2** that while there was only a limited set of data available for analysis, the results provided a method to set a site specific odour criterion of 6 $OU/m^3$. This was determined at the time as the level of odour impact required to achieve a situation of community acceptance where no valid odour complaints would be received.

A review of this criterion is made in the odour impact assessment provided in Section 5 to determine if this remains an acceptable criterion for the site, or should an alternate criterion be applied to the assessment of odours associated with operation of the New Paper Mill.

### 3.3 Particulate Matter

Air borne particulate matter is any material, except uncombined water, that exists in a solid or liquid state in the atmosphere or gas stream at standard condition. Air borne particles generally range in size from 0.001-500μm, with the bulk of the particulate mass in the atmosphere ranging from 0.1-10 μm. Common size related terms are the classes Total Suspended Particulates (TSP) and Particulate Matter 10 ($PM_{10}$). TSP refers to the concentration of all particles in the atmosphere, and $PM_{10}$ refers to all particles with aerodynamic sizes less than 10 μm.

Particulate matter is generated by industry, motor vehicles, refuse disposal, ocean salt, volcanic ash, products of wind erosion, roadway dust, bush fires and plant pollen and seed. Particulate matter presents a health hazard to the lungs, enhances chemical reactions in the atmosphere, reduces visibility, increases the possibility of precipitation, fog and clouds and reduces solar radiation.

The concentration based air quality criteria for particulate matter in NSW are provided in **Table 3-2**.

- **Table 3-2 NSW DEC Criteria for Particulate Matter**

| Pollutant | Averaging Period | Concentration (μg/m3) |
|---|---|---|
| $PM_{10}$ | 24-hour | 50 |
| | Annual | 30 |
| TSP | Annual | 90 |

Deposited dust, if present at sufficiently high levels, can reduce the amenity of an area. In NSW the DEC set limits on acceptable dust deposition levels.

**Table 3-3** shows the maximum acceptable increase in dust deposition over the existing dust levels.

- **Table 3-3 NSW DEC Criteria for Dust Fallout**

| Existing background dust fallout level (g/m2/month) | Maximum acceptable increase over existing fallout levels (g/m2/month) |
|---|---|
| 2 | 2 |
| 3 | 1 |
| 4 | 0 |

Dust deposition rates are assessed against the above criteria over an annual averaging period at the nearest off-site sensitive receiver.

# 4. Existing Air Quality and Meteorology

## 4.1 Overview

This section of the report describes existing air quality and dispersion meteorology in the area surrounding the Botany Paper Mill.

## 4.2 Existing Air Quality

In terms of existing odour sources in the Botany area odour surveys of the local community undertaken by SKM as part of AMCOR's Odour Reduction PRP indicate that, aside from historic impacts from the Existing Paper Mill, other sources include the SWSOOS sewer main which passes nearby to the site. This section of the SWSOOS is known to have significant odour problems due to sewage becoming septic. A dosing plant to control odour and concrete corrosion from the generation of $H_2S$ has been installed by Sydney Water approximately 2 km upstream of the Paper Mill.

Another source of odour identified by the community survey is the Kelloggs factory which is approximately 8.5 km to the north west of the Paper Mill.

Local industry also has the potential to influence local air quality, with emissions from ships and dockyard activities in Port Botany, aircraft movements at Sydney Airport, and the Caltex oil refinery in Kurnell.

The DEC operates air quality monitoring stations throughout the Sydney Region.

An air quality monitoring station is located at Sydney Airport. Particulate ($PM_{10}$) monitoring data shows that average $PM_{10}$ concentrations at Sydney Airport from 2000 to 2002 is in the order of 22.5 $\mu g/m^3$ which is below the annual criteria of 30 $\mu g/m^3$.

## 4.3 Dispersion Meteorology

The climatic environment at the Botany Paper Mill has been described using historical meteorological data recorded by the Bureau of Meteorology at Sydney (Kingsford-Smith) Airport, which is located approximately 5.5 km to the north west of the Botany Paper Mill. A summary of this data is provided in **Table 4-1** and discussed below.

## Table 4-1: Climatic Summary for Sydney Airport

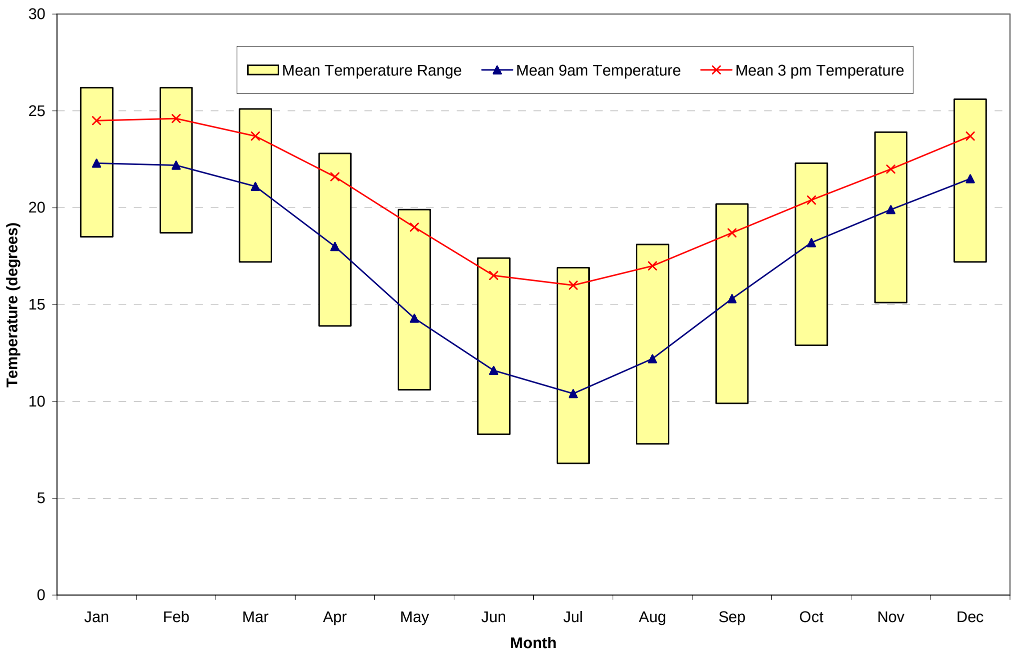
| Parameter | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean Daily Max Temp (°C) | 26.2 | 26.2 | 25.1 | 22.8 | 19.9 | 17.4 | 16.9 | 18.1 | 20.2 | 22.3 | 23.9 | 25.6 | 22 |
| Highest Max Temp (°C) | 43 | 42.6 | 41.2 | 35.7 | 30 | 26.8 | 26.7 | 31.1 | 35 | 38.2 | 43.4 | 43.2 | 43.4 |
| Mean Daily Min Temp (°C) | 18.5 | 18.7 | 17.2 | 13.9 | 10.6 | 8.3 | 6.8 | 7.8 | 9.9 | 12.9 | 15.1 | 17.2 | 13 |
| Lowest Min Temp (°C) | 9.7 | 11.2 | 7.4 | 6.1 | 3 | 1 | -0.1 | 1.2 | 2.3 | 4.8 | 5.9 | 8.2 | -0.1 |
| Mean 9am Air Temp (°C) | 22.3 | 22.2 | 21.1 | 18 | 14.3 | 11.6 | 10.4 | 12.2 | 15.3 | 18.2 | 19.9 | 21.5 | 17.2 |
| Mean 9am Dew Point Temperature (°C) | 12.7 | 13.5 | 11.9 | 9.1 | 6.5 | 3.8 | 2.7 | 4 | 6.2 | 8.3 | 9.9 | 11 | 8.1 |
| Mean 9am Relative Humidity (%) | 69 | 72 | 72 | 72 | 74 | 75 | 71 | 66 | 62 | 60 | 62 | 65 | 68 |
| Mean 3pm Air Temp (°C) | 24.5 | 24.6 | 23.7 | 21.6 | 19 | 16.5 | 16 | 17 | 18.7 | 20.4 | 22 | 23.7 | 20.6 |
| Mean 3pm Dew Point Temp (°C) | 16.1 | 16.7 | 15.5 | 12.6 | 9.8 | 7.6 | 5.5 | 5.6 | 7.5 | 9.8 | 12.1 | 14.3 | 11 |
| Mean 3pm Relative Humidity (%) | 61 | 62 | 61 | 58 | 57 | 57 | 51 | 48 | 49 | 52 | 55 | 57 | 56 |
| Mean Rainfall (mm) | 98.3 | 112.1 | 125.2 | 106.2 | 97 | 126.2 | 66.9 | 77.9 | 62.6 | 73.8 | 82.9 | 77.1 | 1106.4 |
| Mean no. of Raindays | 11.4 | 11.4 | 12.4 | 10.9 | 11.2 | 11.2 | 9 | 9.5 | 9.5 | 10.7 | 11.2 | 10.6 | 129 |
| Highest Monthly Rainfall (mm) | 400.4 | 596.9 | 393 | 476.2 | 421.7 | 465.9 | 253.7 | 387.8 | 249.4 | 271.3 | 396.1 | 359.2 | 596.9 |
| Lowest Monthly Rainfall (mm) | 5.4 | 2.5 | 6.4 | 12.1 | 2.9 | 2.5 | 0 | 0.2 | 1.6 | 0 | 5.7 | 4.8 | 0 |
| Highest Daily Recorded Rain (mm) | 157 | 216.2 | 202 | 174 | 165.9 | 151.2 | 132.6 | 207 | 115.4 | 112.3 | 143.3 | 182.1 | 216.2 |
| Mean no. of Clear Days | 4.8 | 4.3 | 5.8 | 7.2 | 7.8 | 8.1 | 10.9 | 11.4 | 8.8 | 6.1 | 4.9 | 4.5 | 84.6 |
| Mean no. of Cloudy Days | 10.9 | 9.9 | 9.1 | 7.8 | 8.1 | 8.4 | 6.1 | 5.6 | 6 | 8.9 | 8.8 | 9.6 | 99.1 |
| Mean Daily Evaporation (mm) | 7 | 6.4 | 5.2 | 4.1 | 2.9 | 2.5 | 2.7 | 3.7 | 4.7 | 5.7 | 6.5 | 7.4 | 4.9 |
| Mean Daily Sunshine (hrs) | 7.4 | 7.2 | 6.9 | 6.8 | 5.8 | 6 | 6.6 | 7.9 | 7.8 | 7.9 | 7.8 | 8.1 | 7.2 |
| Maximum wind Gust (km/hr) | 151.9 | 107.6 | 127.8 | 122.4 | 129.6 | 129.6 | 109.4 | 114.8 | 111.2 | 126 | 151.9 | 126 | 151.9 |

### 4.3.1 Temperature

Temperature has been recorded at Sydney Airport by the Bureau of Meteorology over a period of at least 65 years. As shown in **Figure 4-1**, the Botany area experiences a warm to mild climate with quite a mild range in temperatures throughout the year.

The 9 am mean daily temperature range is between 22.3°C in January and 10.4°C in July. The 3 pm mean temperature range is between 24.6 C in February and 16.0 C in July. Overall, the warmest months of the year are January and February, which receive mean daily maximum temperatures of approximately 26°C.

- **Figure 4-1: Mean Monthly Temperature**

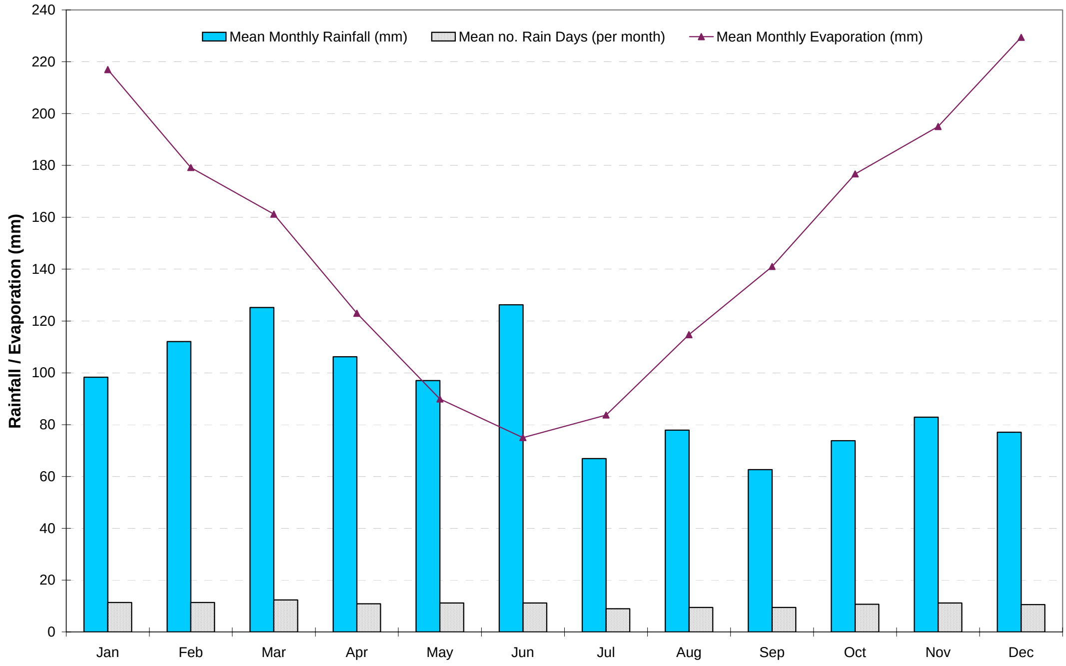



### 4.3.2 Rainfall and Evaporation

The rainfall data presented in **Figure 4-2** shows that the Botany area experiences a mild seasonal variation in the distribution of rain, with most rain falling during the late summer and autumn months. The mean annual rainfall at Sydney Airport is approximately 1,106 mm, which occurs over an average of approximately 129 days. The driest month is September, which receives a mean monthly rainfall of approximately 62 mm. The wettest months of the year are March and June, receiving approximately 126 mm. Rain typically falls on at least 9 days per month throughout the year, with the highest number of rain days (12) occurring during March.

SKM

▪ **Figure 4-2: Mean Monthly Rainfall and Evaporation**

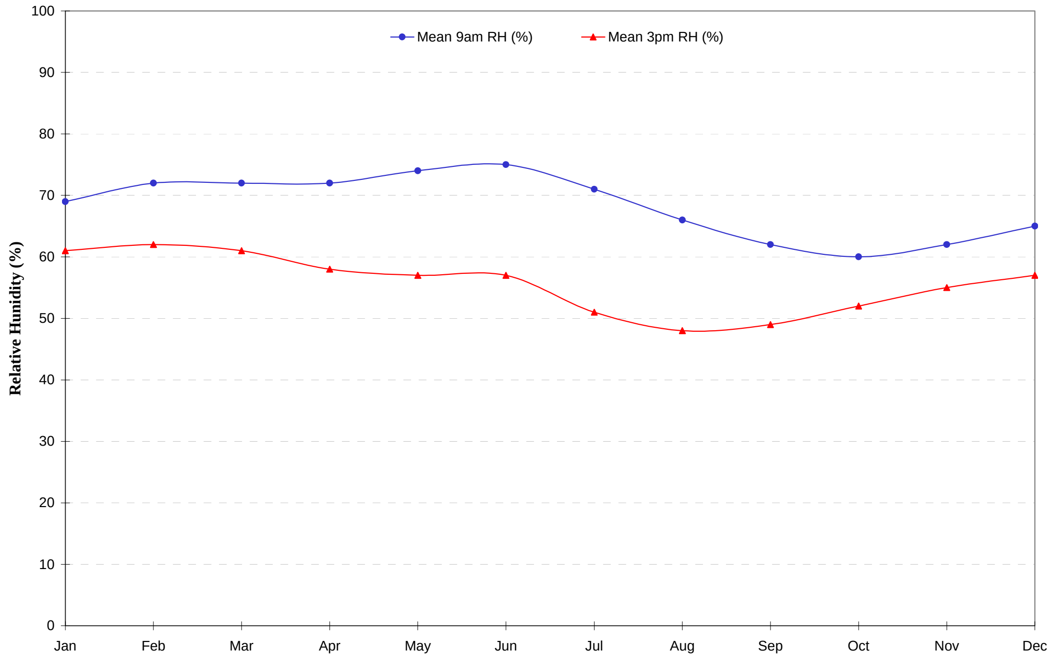



The monthly evaporation rates for Sydney Airport are also presented with the rainfall data in **Figure 4-2**. There is a strong seasonal pattern, with evaporation being strongest during the warm summer months and least during the cooler winter months. Mean monthly evaporation rates range from approximately 75 mm/month in June to 229 mm in December. Evaporation typically exceeds rainfall during all months except May and June.

### 4.3.3 Relative Humidity

The 9am and 3pm relative humidity readings recorded at Sydney Airport are shown in **Figure 4-3**. Relative humidity varies on both a daily and seasonal cycle. At 9 am humidity is highest during the cooler months from April to July. The annual range in 9am humidity is between 75% in June to 60% in October. The 3 pm relative humidity readings are typically lower than the 9 am values, and are generally greatest during the warmer summer months. The 3 pm readings range between 62% in February to 48% in August.

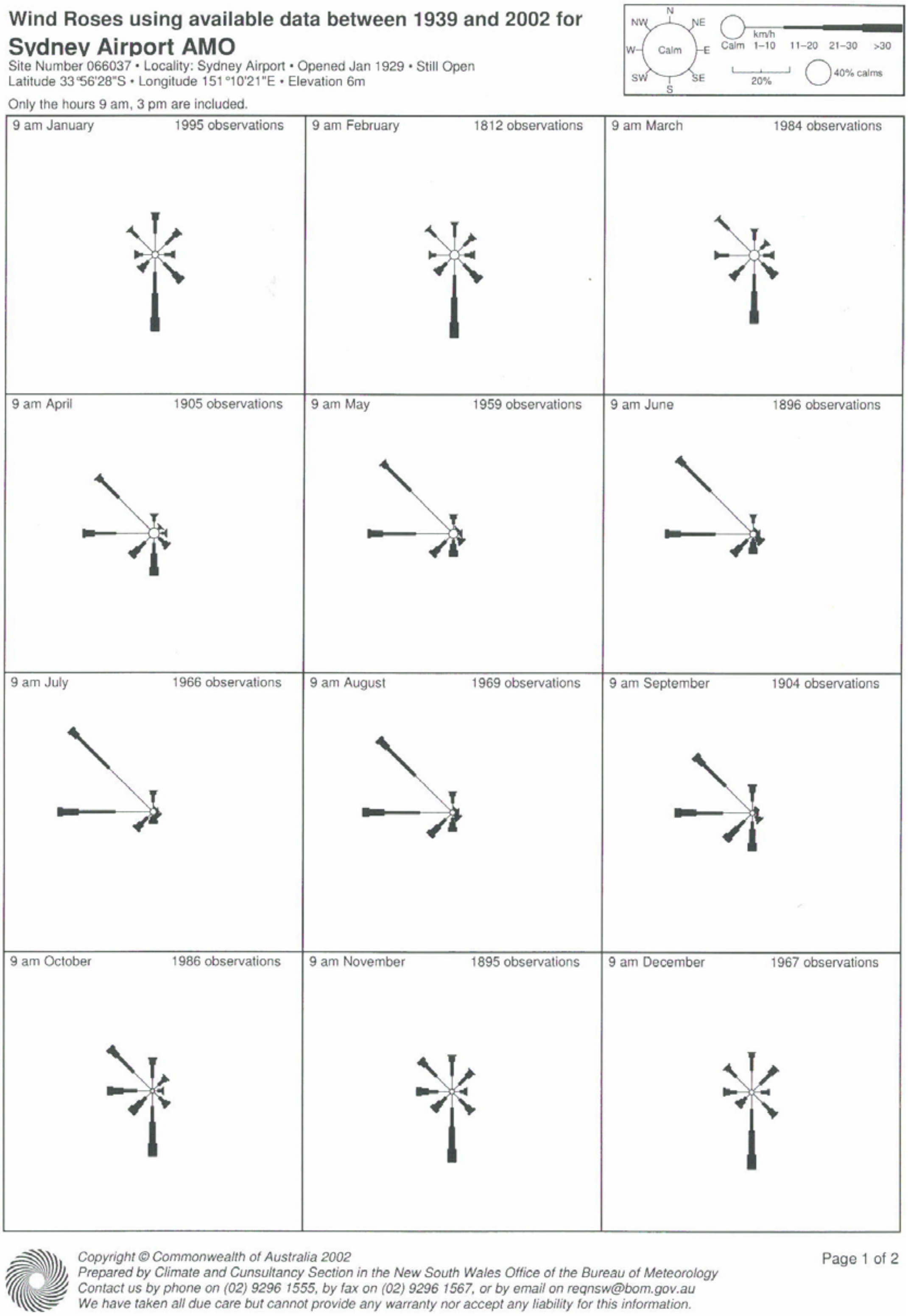
- **Figure 4-3: Mean Monthly Relative Humidity**



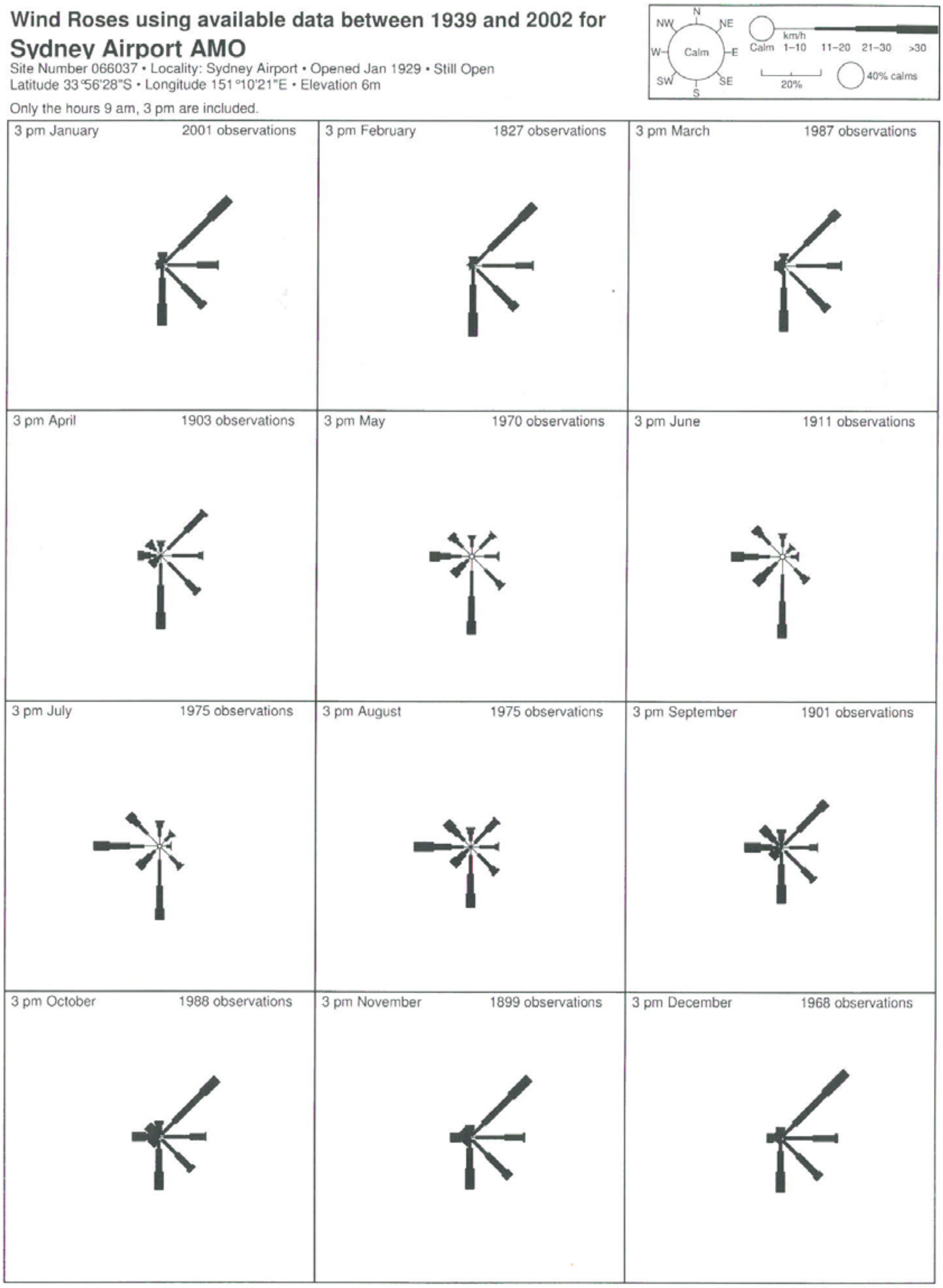

### 4.3.4 Wind Speed and Wind Direction

Long term windroses were obtained for Sydney Airport for both 9 am and 3 pm (refer to **Figure 4-4** and **Figure 4-5**) respectively. From November to March the predominant 9 am wind direction is from the south, with approximately 25% of winds from that direction. During April through to September, winds are generally from the west (28% of the time) and the north west (33% of the time). At 3 pm wind direction changes, and is predominantly from the north east through to the south during September through to April, while winds are predominantly from the south during May and June, and from the south and west during July and August.

- **Figure 4-4: Sydney Airport 9 am Windroses**



- **Figure 4-5: Sydney Airport 3 pm Windroses**



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# 5. Air Quality Impact Assessment

## 5.1 Overview

This section of the report provides a qualitative assessment of impacts associated with the construction phase of the proposed development. A quantitative assessment of impacts during the operational phase of this development is also provided. Here the CALPUFF and AUSPLUME dispersion models have been used to predict odour impacts in the area surrounding the Paper Mill.

## 5.2 Identification of Sensitive Receptors

The Paper Mill is located on Botany Road, Matraville. The nearest residences are located on the north and north eastern side of the Paper Mill. The nearest residence is approximately 30 m from the site boundary (refer to **Figure 1-1**).

## 5.3 Construction Phase Dust Assessment

During the construction phase of this development the main source of pollution would be air borne particulate matter. Particulate matter would be liberated during construction activities such as:

- demolition of existing buildings;
- excavation and levelling of the site by bulldozers, backhoes and excavators;
- Movement of soil/fill and demolition material by dump trucks and scrapers;
- Wind erosion from unsealed surfaces and stockpiles; and
- Wheel generated dust by construction vehicles travelling along unsealed roads/access tracks.

Standard mitigation measures can be used to minimise or prevent the dust impacts of these operations such as:

- Spraying water with watercarts and/or hand held hoses on a regular basis, particularly during dry or windy conditions;
- Stabilising disturbed areas;
- Installing cloth fencing around worksites;
- Stabilising or covering stockpiles;
- Spraying trafficable areas with water using a water cart;
- Covering all materials transported on and off site;
- Sweeping-up mud or soil tracked onto public roads;
- Ensuring adequate water supply is maintained on site for dust suppression;
- Minimising truck speeds on site; and

- Emissions generated by vehicles and machinery on site would be in accordance with EPA requirements.

### 5.4 Operational Phase Odour Assessment

The assessment of operational phase air quality impacts focuses on emissions of odour which are considered the only relevant emissions from the operation of the New Paper Machine.

This assessment considers two operational phase scenarios:

1) **Scenario 1 –** Existing B7 and B8 Paper machines (Existing Paper Mill); and
2) **Scenario 2** – Proposed B9 Paper Machine, where the new machine is fully commissioned and the existing B7 and B8 mill has been decommissioned but standing (New Paper Mill with Existing Paper Mill still standing).
3) **Scenario 3** – Proposed B9 Paper Machine, where the new machine is fully commissioned and the existing B7 and B8 infrastructure has been decommissioned and demolished as may happen in the future (New Paper Mill only).

As detailed in **Section 2.3**, with no other paper mill similar to the B9 machine in operation to allow odour emissions to be determined, the modelling assessment of B9 machine is based on odour emission concentrations measured in B7 and B8 machines, to model B9 impacts. This will provide a worst-case assessment as the modern design of B9 machines will provide significant improvements in odour performance. As such, it is not considered necessary, nor is it possible for this assessment to provide a sensitivity analysis associated with variable emissions. In short, the odour impacts presented here for B9 machine are a maximum and demonstrate a higher level of impact than that which would be expected from the future operation of B9 machine.

In accordance with the DEC's Draft Odour Policy, 2001, the modelling assesses the 99$^{th}$ percentile 1-hour average odour impacts, with emissions modified by peak-to-mean (P/M) factors to produce nose response (1-second) estimates of odour impacts.

It should also be noted that there will be a Transition Phase of up to nine months when the B9 Paper Machine will be commissioned progressively. During the Transition Phase one of the existing machines would be decommissioned while the other machine would operate to the extent required to maintain Mill output together with the B9 machine operating at reduced load. It is not possible to quantify odour emissions during this Transitional Phase as there is no odour emissions data available for paper machine operations at reduced loads. Hence it is not possible to undertake a quantitative assessment of odours for the Transition Phase. It should be noted, however, that at no time during the Transition Phase will the combined paper making capacity of the operating existing machine and B9 machines exceed the design capacity of the B9 machine.  AMCOR will commit to undertaking a full odour emissions measurement survey of the operating elements of the existing machine and B9 Machines during the Transition Phase to confirm odour emissions are not in excess of the existing (B7 and B8 Machine) or the proposed B9 machine.

The location of existing (B7 and B8) and future (B9) odour sources are shown **Figure 5-1**.

- **Figure 5-1: Location of Existing (green) and proposed (pink) stacks**

The modelling assessment of odour impacts has been undertaken using the CALPUFF and AUSPLUME dispersion models. CALPUFF was chosen for the assessment given it's high level sophistication (refer to **Section 5.4.1** to follow) while AUSPLUME results have been included to provide comparisons with the results of existing odour studies at the AMCOR Botany Mill.

### 5.4.1 Background to the CAMLET/CALPUFF Modelling Scheme

CALPUFF (Earth Tech, 1999) is a multi-vertical layer, multi-species non-steady-state puff dispersion model that simulates the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal. Puff models represent a continuous plume as a number of discrete packets of pollutant material and are represented in the model using an integrated sampling with modifications for near field applications.

As a result of this puff-based formulation, CALPUFF can account for a variety of effects such as spatial variability of meteorological conditions, causality effects, dry deposition and dispersion over a variety of spatially varying land surfaces, plume fumigation, low wind speed dispersion, pollutant transformation and wet removal. The model includes a resistance based dry deposition model for both gaseous pollutants and particulate matter. The model has detailed parameterisations of complex terrain effects, including terrain impingement, side-wall scraping, and steep walled terrain influences on lateral plume growth.

The meteorological fields used by CALPUFF are produced by CALMET, a meteorological pre-processor. CALMET produces hourly fields of 3 dimensional winds and various micrometeorological variables. CALMET includes a diagnostic wind field model containing objective analysis and parameterised treatments of slope flows, valley flows, terrain blocking effects and lake and sea breeze circulations.

One difficulty associated with CALPUFF is that to use it to its full extent requires detailed upper air meteorological information which is available as measured data in very few locations. While Sydney Airport take hourly readings, only two readings per day are made available to the public, therefore The Air Pollution Model (TAPMv3.0.5) – developed by the CSIRO and Atmospheric Research (CMAR), has been used to generate the upper air meteorological data required by CALMET. TAPM consists of coupled prognostic meteorological and air pollution concentration components, eliminating the need to have site specific meteorological observations.

TAPM is a three-dimensional prognostic meteorological and air pollution model. The meteorological component of TAPM is an uncompressible, optionally non-hydrostatic, primitive equation model with a terrain following vertical coordinate for three-dimensional situations. It predicts winds, temperature, pressure, water vapour, cloud/rain water and turbulence. The model also includes urban/vegetation canopy, soil effects and radiative fluxes The model is driven by sixhourly analysis fields of wind, temperature and specific humidity from the Bureau of Meteorology Limited Area Prediction System (LAPS) model, which account for the larger-scale synoptic variability (CSIRO, 2003; Hurley, 2002). TAPM also has the capability to assimilate meteorological observation data to 'nudge' the model to produce results closer to the observations. For this modelling project hourly observations of wind speed and direction from the Bureau of Meteorology station at Sydney Airport were used to nudge the TAPM solutions.

Meteorology for Botany Paper Mill was generated using TAPM for the period January 2000 to December 2000, and was configured with four nested grids of 25 x 25 x 25 points with grid spacing of 30,000, 10,000, 3,000 and 1,000m.

In the first instance the TAPM model was used to generate both surface and upper air meteorological data for CALMET. A third CALMET file was then generated using a 9 second (~250 m) digital elevation model (DEM) (Geoscience Australia, 1994). This surface data was then improved upon by comparing it with topographic maps and edited accordingly.

For the purpose of the CALPUFF modelling however, a terrain file was generated at 100 m contours and land use categories generated by SKM.

The meteorological modelling has sufficient complexity to capture the effects of the coastal environment of Port Botany. The sea breeze conditions have been captured in this way. First, as detailed above, a standard TAPM setup has been used to generate the surface and upper-air meteorological input data for CALPUFF. The TAPM model draws on meteorological data from a wide region surrounding the target site, and as such TAPM would have captured the sea breeze conditions. Further, TAPM was nudged by meteorological observations from the Bureau's Sydney Airport site, such that real sea breeze conditions would have been influenced by the modelling.

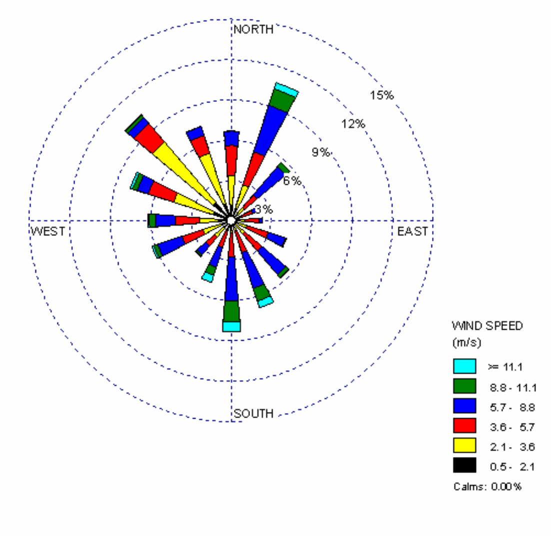
### 5.4.2 Comparison of TAPM Generated Meteorology

One criticism of the TAPM Model is that historically it has been known to underestimate low wind speed conditions and associated stable atmospheric conditions. This is an important consideration when undertaking odour assessments as commonly worst-case odour impacts occur as a result of low wind speeds or stable atmospheric conditions when plume dispersion is inhibited. The following provides a comparison of TAPM generated surface wind field conditions with measured wind data from Sydney Airport.

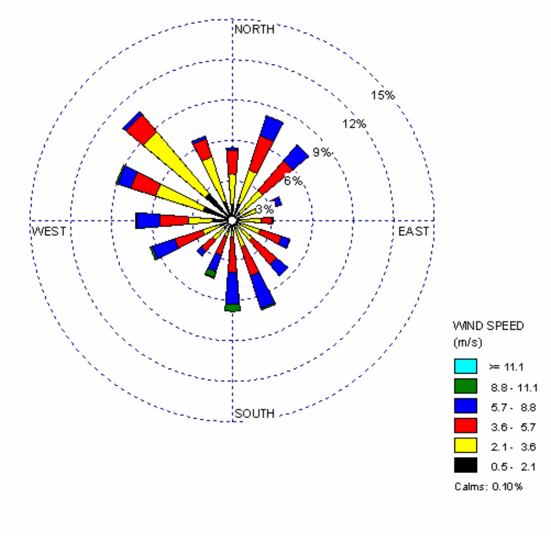
Wind roses generated for 2000 are displayed in **Figure 5-2**. These wind roses indicate that both the BOM and TAPM generated wind roses have a similar pattern in wind direction distribution.

Wind speed and wind direction has also been compared graphically in **Figure 5-3** and **Figure 5-4** respectively. It appears that TAPM overestimates the percentage of time where low wind speeds are recorded, with wind speeds of 5.7 m/s or less predicted for 81% of time, compared to the BOM records of 64% of time. It can also be seen in **Figure 5-5** that TAPM represents wind speed below 1 m/s well.

- **Figure 5-2: 2000 Annual Windrsoes – BOM vs TAPM Generated**

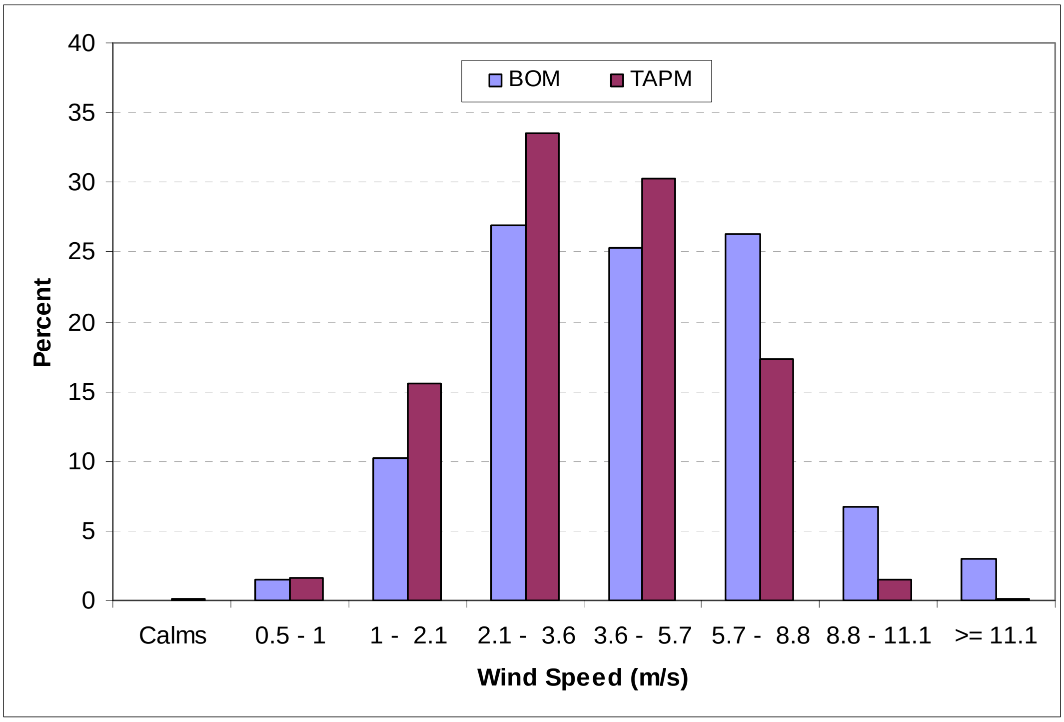



**a) 2000 Windrose – Sydney Airport – BOM Monitoring Data**

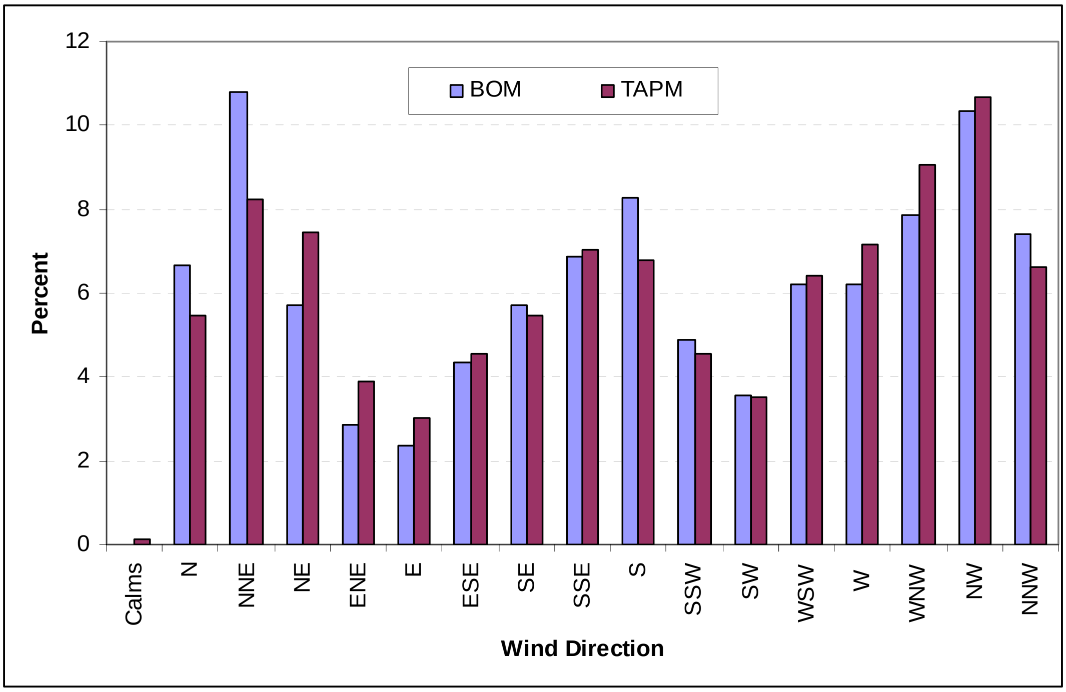



**b) 2000 Windrose – Sydney Airport – TAPM Generated**

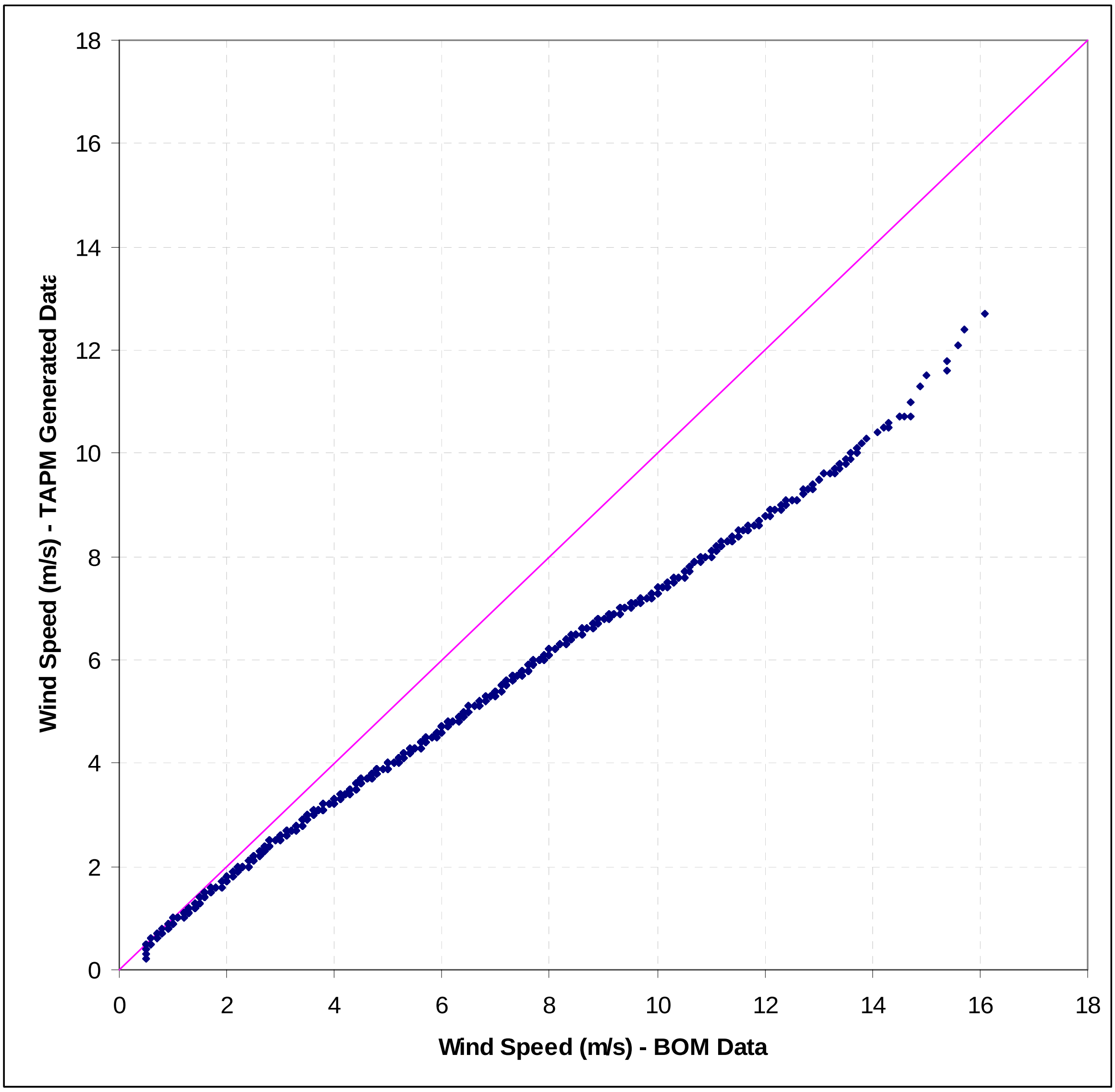
- **Figure 5-3: Comparison of Wind Speed**




- **Figure 5-4: Comparison of Wind Direction**



- **Figure 5-5: Wind Speed Comparison**




### 5.4.3 Exhaust Stack Parameters and Odour Emission Data

The Existing Paper Mill has been modelled using the parameters as outlined in **Appendix A.1** and **Appendix A.2**. This data were collected by Environ Odour in November 2004.

Proposed stack parameters and odour emission data are set out in **Appendix A.3** and **Appendix A.4**.

It should be noted that all stack heights associated with B9 machine will be 35m.

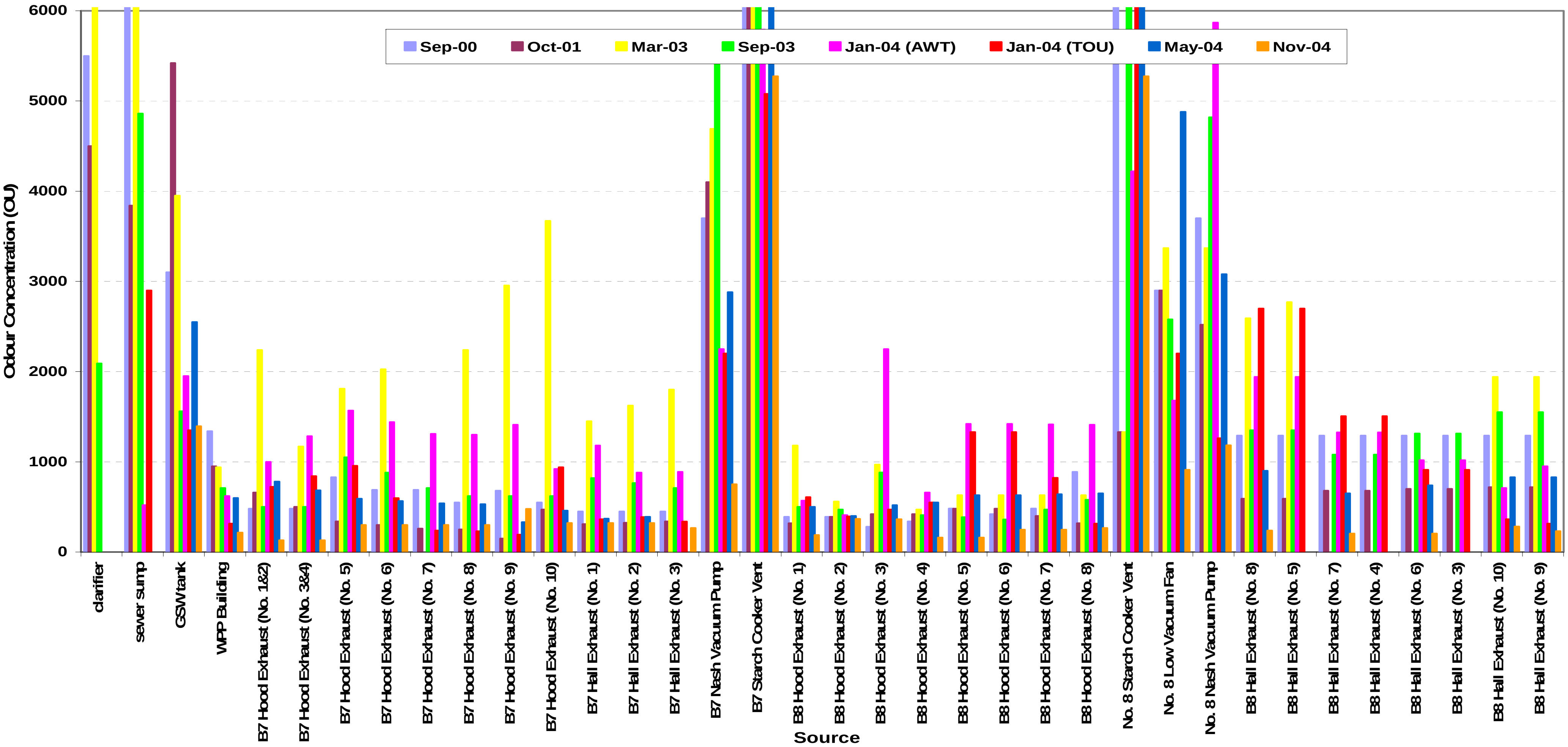
The current total odour emission rate for B7 and B8 machines as at November 2004 was 198,560 OU.$m^3$/s and total proposed emission rate for the B9 machine is estimated to be 186,154 OU.$m^3$/s; based on estimated odour emissions supplied by AMCOR.

Since September 2000, odour concentrations have generally decreased at the Existing Paper Mill. In particular, the clarifier and sewer sump have been decommissioned. Historic odour concentrations are displayed graphically in **Figure 5-6**.

It should be noted that the odour emission data is based on measurements made at the existing B7 and B8 machines during periods of continuous operation and at full capacity. The paper making process is intended to be a continuous process with no significant variations associated with feed stock, water supply and recycling of paper output. As such basing the odour assessment to follow on data collected while the existing machines are operating on a continuous basis and at full capacity will ensure the predicted odour impacts are representative of impacts that could be expected for the majority of the time.

It is acknowledged that the existing paper making process is disrupted from time to time at the B7 and B8 Mills, and such disturbances may impact on odour emissions and impacts. The variations generally result from the aging infrastructure and technology within the existing Mill, which at times can be unreliable. The proposed B9 Machine will use the latest technology providing for higher levels of reliability and more continuous operations. As such odour emissions and impacts will be less variable than those existing, hence providing further justification of odour emission estimates used here for assessment purposes.

▪ **Figure 5-6: Historic Odour Concentrations**

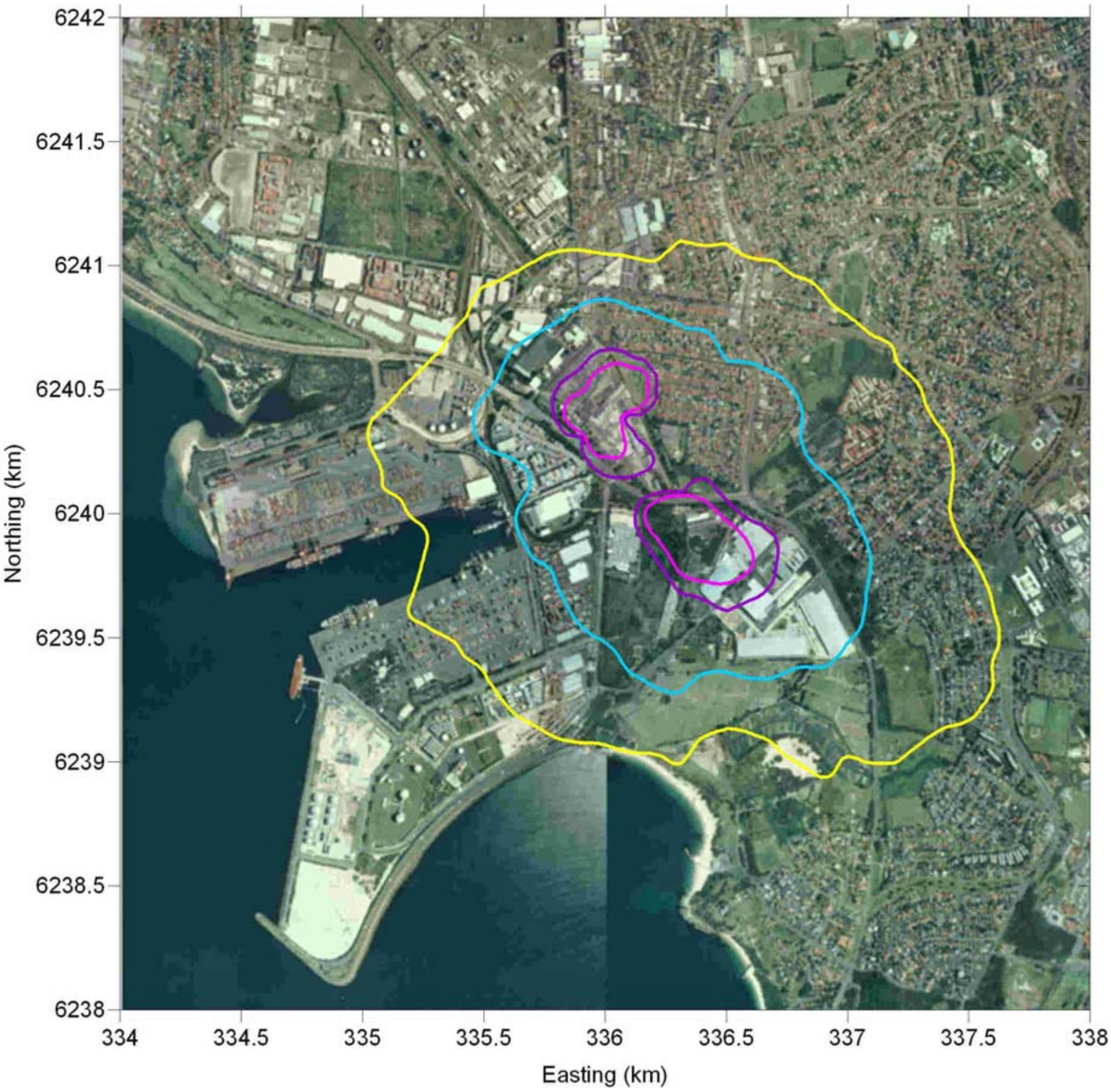


## 5.5 Odour Dispersion Modelling Results

### 5.5.1 Scenario 1 – Existing B7 and B8 Machine Odour Impacts

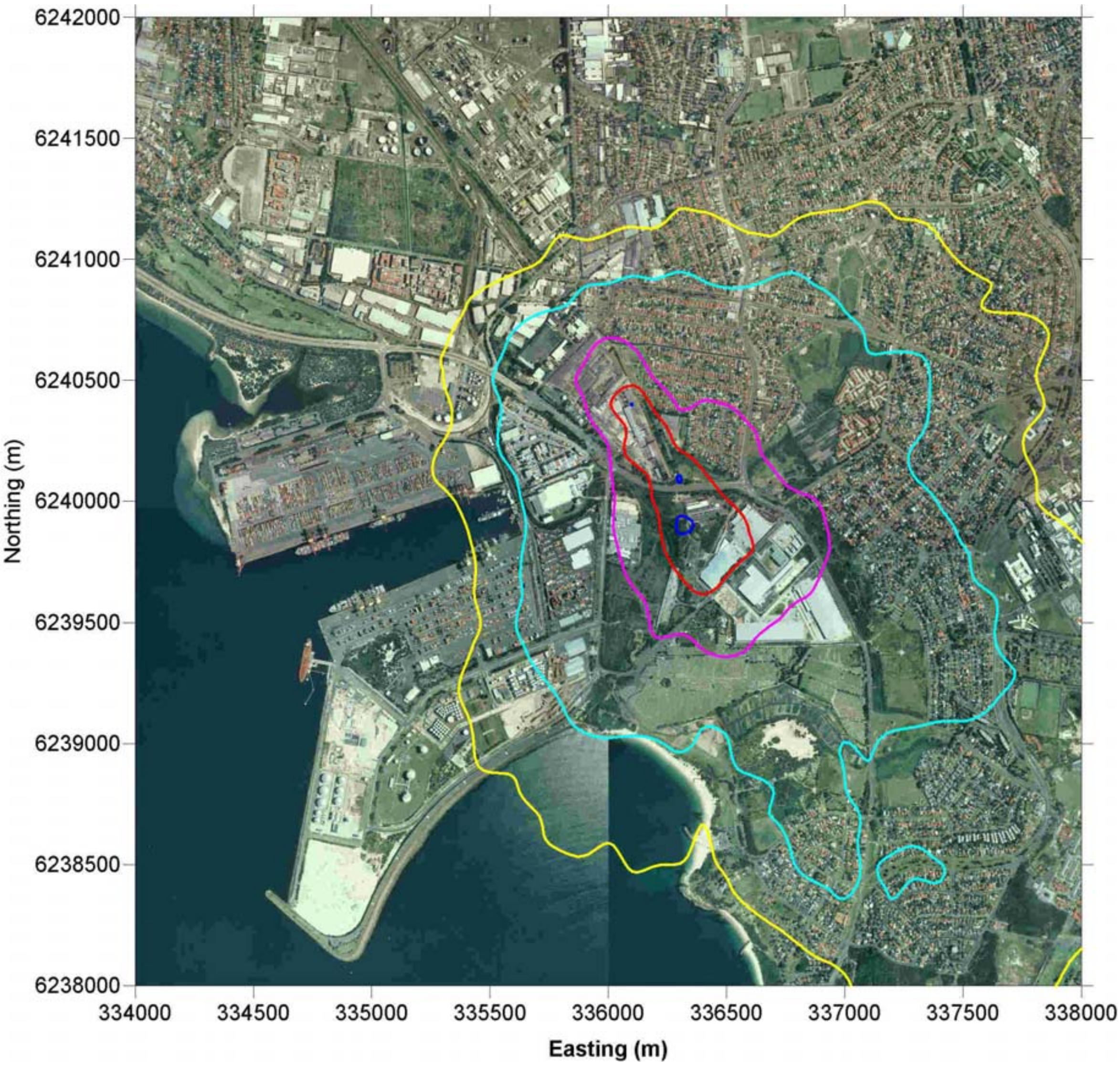
CALPUFF modelled odour impacts of the Existing Paper Mill, based on November 2004 odour measurements, and results are shown in **Figure 5-7**. Here it can be seen that impacts at the nearest residence are in the order of 5 - 6 OU/m$^3$.

- **Figure 5-7: CALPUFF Modelled Existing Odour Impacts (2 OU/m$^3$– Yellow; 3 OU/m$^3$ – Blue; 5 OU/m$^3$ – Purple; 6 OU/m$^3$ – Pink)**



Extensive AUSPLUME modelling of odour impacts from the Existing Paper Mill have also been conducted in the past as part of the AMCOR PRP. The results of recent (November 2004) AUSPLUME modelling can be seen in **Figure 5-8**. Here the impacts at the nearest residence are of the order of 10 OU/$m^3$.

- **Figure 5-8: AUSPLUME Modelled Existing Odour Impacts (2 OU/$m^3$ – Yellow; 3 OU/$m^3$ – Blue; 6 OU/$m^3$ – Pink, 10 OU/$m^3$ – Red; 15 OU/$m^3$ – Dark Blue)**

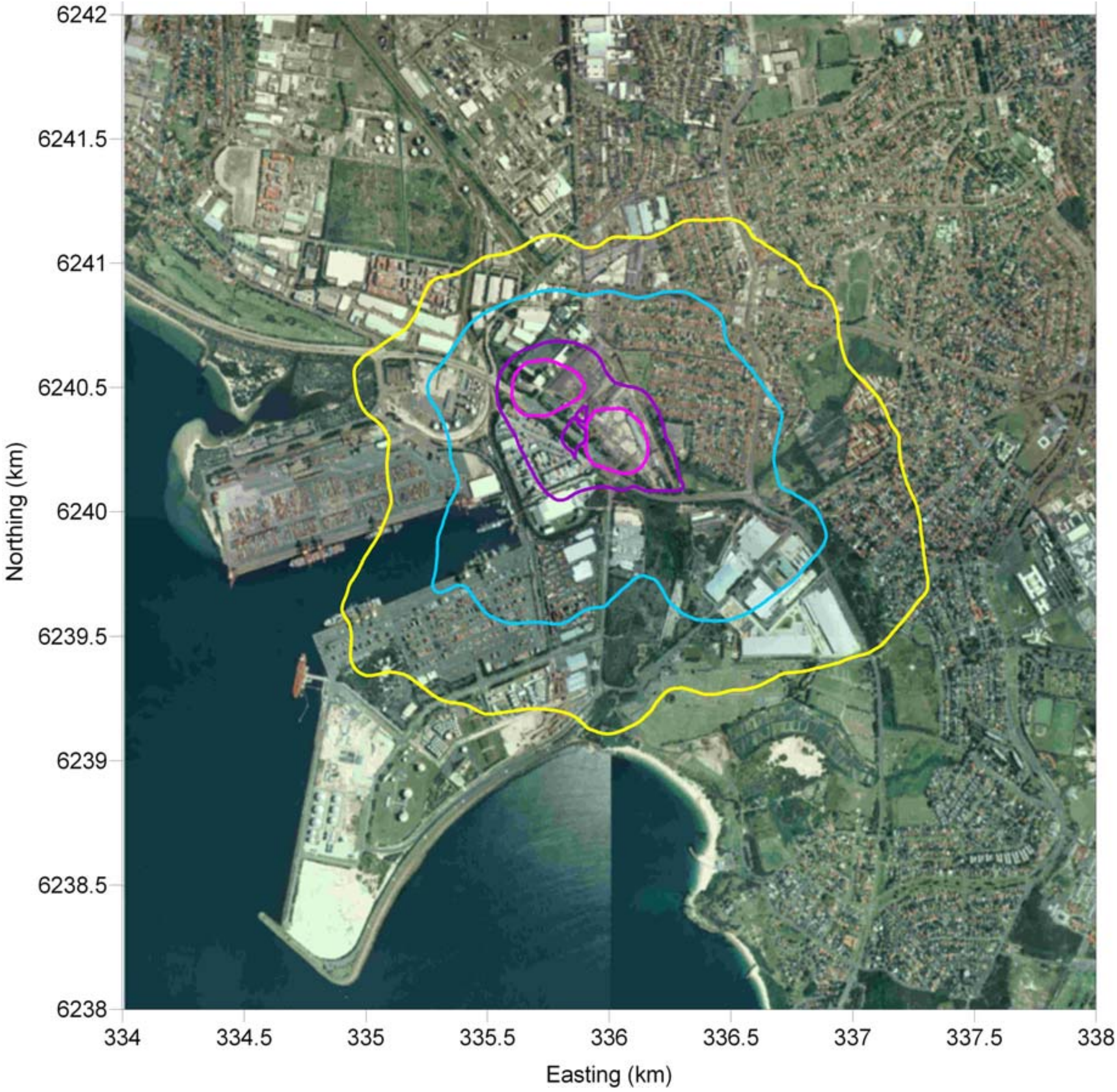



When comparing the AUSPLUME results with CALPUFF it can be seen that AUSPLUME predicts higher odour concentrations than CALPUFF. It is noted that in the period since November 2004, which is represented by this modelling, basically no odour complaints were received by AMCOR and the community surveys completed during this time period also report an improvement in odour impact. This level of community acceptance is considered to reflect a low level of impact, possibly more accurately reflected by CALPUFF when compared to AUSPLUME.

### 5.5.2 Scenario 2 – Proposed B9 Machine Odour Impacts Including B7, B8 and B9 Building Wake Effects

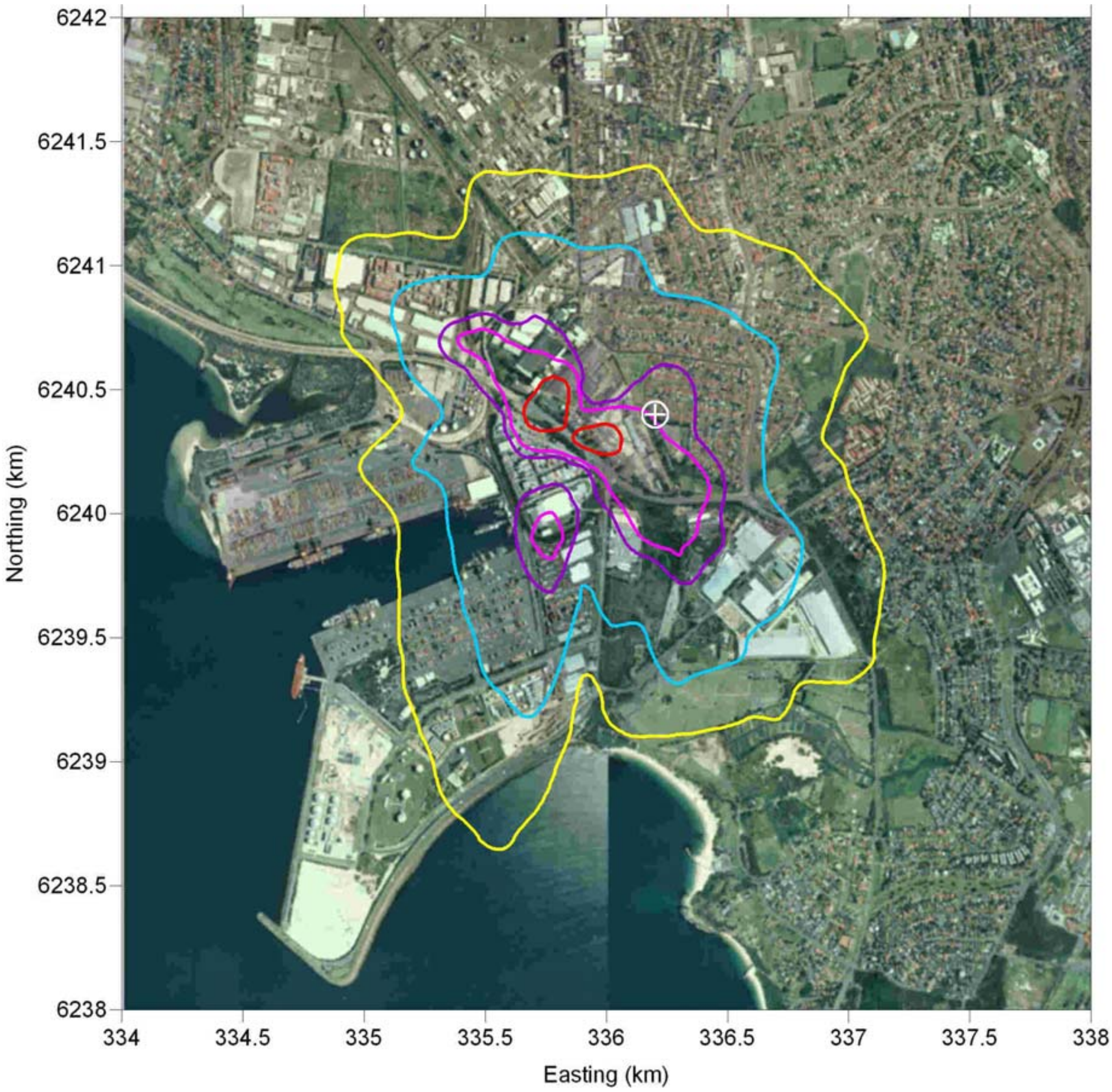
Modelled odour impacts of the New Paper Mill with CALPUFF are shown in **Figure 5-9**. Here it can be seen that impacts at the nearest residence are of the order of less than 5 OU/m$^3$.

- **Figure 5-9: CALPUFF Modelled Proposed Odour Impacts Including B7, B8 and B9 Buildings (2 OU/m$^3$ – Yellow; 3 OU/m$^3$ – Blue; 5 OU/m$^3$ – Purple; 6 OU/m$^3$ – Pink)**



AUSPLUME modelling of Scenario 2 are displayed in **Figure 5-10**. Here it can be seen that impacts at the nearest residence are in the order of 6 OU/$m^3$.

- **Figure 5-10: AUSPLUME Modelled Proposed Odour Impacts – B7, B8 and B9 Buildings (2 OU/$m^3$ – Yellow; 3 OU/$m^3$ – Blue; 5 OU/ $m^3$ – Purple, 6 OU/$m^3$ – Pink, 10 OU/$m^3$ – Red; including location of discrete receptor)**



### 5.5.3 Scenario 3 - Proposed B9 Machine Odour Impacts Including B9 Building Wake Effects Only

It should be noted that the impact represented in **Section 5.5.2** includes the influence of building wake affects from the B7, B8 and B9 mill buildings. As it is likely in the future that B7 and B8 mill buildings will be demolished, a model was also generated including only the building wake affects of the B9 mill building. This model generated an almost identical odour impact footprint to that shown by **Figure 5-9** and **Figure 5-10**.

This demonstrates that building wake affects on plume dispersion will be minimal with or without the B7 and B8 mill buildings in place and that no change in odour impacts would be expected at such time in the future when the buildings are demolished.

### 5.5.4 Relative Contribution of Industrial Odour Sources

In order to understand the individual impact of different odour emission sources within B9 Mill, the results from each source group were extracted from the AUSPLUME modelling and the odour impacts as determined, for a single discrete sensitive receptor, immediately adjoining the northern boundary of Botany Mill (refer to **Figure 5-10**) were determined as follows:

| | **Individual Odour Concs (OU/m$^3$)** |
|---|---|
| ▪ Pre-dryer hood exhausts: | 0.56 |
| ▪ After-dryer hood exhausts: | 0.27 |
| ▪ Machine room exhausts: | 0.88 |
| ▪ Former section exhausts: | 0.93 |
| ▪ Waste paper building: | 2.57 |
| ▪ Balance of plant: | 0.70 |

These odour impact results are generally consistent with the relative strength of the odour emission sources for the B9 Mill, which are detailed in **Table A.4**. The results are considered useful for the future management of odour impacts after the B9 machine becomes operational.

### 5.5.5 Comparison of Modelling Results and Discussion

With respect to the Existing Paper Mill, AUSPLUME predicts larger impacts than does CALPUFF, with impacts at the nearest residence in the order of 10 OU/$m^3$ (refer to **Figure 5-8**) and 5-6 OU/$m^3$ (refer to **Figure 5-7**) respectively.

The AUSPLUME model predicts a reduction in odour impacts as a result of the upgrade. This is particularly evident to the south and south east of the Mill (refer to **Figure 5-8** and **Figure 5-10**).

CALPUFF results for the Existing Mill show that odour concentrations at the most affected residence are in the order of 5-6 OU/$m^3$ (refer to **Figure 5-7**). CALPUFF predicted that the proposed impacts from the B9 Mill are slightly decreased, to less than 5 OU/$m^3$ within nearest sensitive receiver areas to the north-east (refer to **Figure 5-9**). This decrease is attributable to the location of the B9 mill adjacent to Botany Road (i.e. further away from residences) and improvements in dispersion from the increased airflows and stack heights.

In terms of the extent of odour impact, the CALPUFF predicted 2 OU/$m^3$ contour is smaller for B9 mill (refer to **Figure 5-9**) than it is for the existing B7 and B8 mills (refer to **Figure 5-7**), and, importantly the impacts are generally shifted towards the south-west, which has the effect to reduce the number of residential locations contained within the 2 OU/$m^3$ contour for the B9 machine impacts. The marginally increased impact of low level odours over Port Botany from B9 machine will not result in increased odour annoyance to these industrial receivers.

## 5.6 Odour Impact and Site Criteria for the Proposed B9 Mill

A maximum off-site odour impact of less than 5 OU/$m^3$ predicted by CALPUFF and less than 6 OU/$m^3$ predicted by AUSPLUME for the New Paper Mill are above the DEC criteria of 2 OU/$m^3$ that would normally be applied to industry co-located with sensitive receiver areas within an urban environment. However, as was the case with the Odour Reduction PRP undertaken for the Existing Mill, where AUSPLUME predicted 10 OU/$m^3$ as achievable by the proposed odour reduction works, it is considered appropriate that a site specific criterion be adopted for the New Paper Mill in consideration of predicted impacts.

In lieu of the new paper mill being constructed and commissioned, it is not possible to state either specifically what the exact impact will be, or the specific community response.

The important points are:

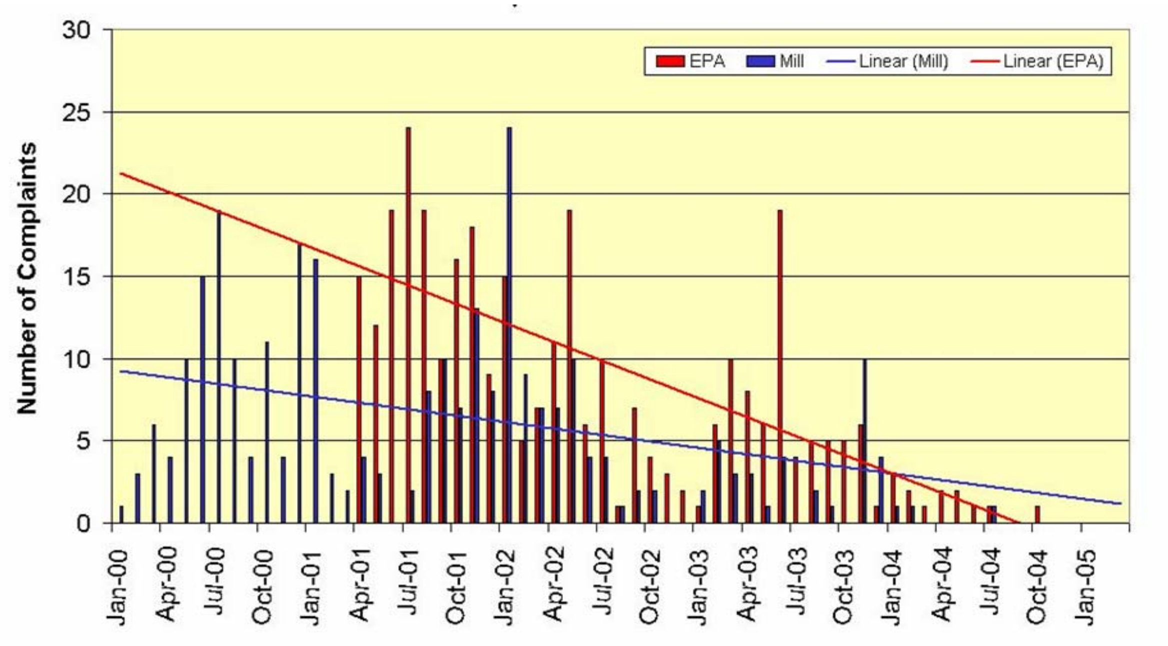
- first, that emissions be minimised as far as possible; and
- second, where existing odour impacts are shown to be acceptable, the new mill as a minimum needs to be designed such that odour impacts are no greater that those being experienced currently.

These issues are discussed in **Section 5.6.1** to follow.

### 5.6.1 Odour Annoyance and Complaints

Presently odour complaints made to the DEC and the Paper Mill are very much lower than they have been in the past as shown by **Figure 5-11** which demonstrates a downward trend in odour complaints made to both the Paper Mill and EPA (now DEC) since January 2000.

- **Figure 5-11: Odour Complaint Data**




In considering this complaints data, as stated above in recent times (since the end of 2004 / start of 2005) there have been very few complaints with respect to odour, probably reflecting an acceptable level of impact within the community. Hence, in view of the fact that the New Paper Mill based on Calpuff results is shown to have a similar odour impact and in the case based on AUSPLUME results a marginally improved odour impact compared with the existing situation, it could be deduced that the New Paper Mill will also be acceptable.

It is acknowledged, however, that odour complaints data is not always a sound means of determining impact. For this reason and as part of the Odour Reduction PRP detailed community surveys were undertaken and a summary of results are set out in the following section.

### 5.6.2 Odour Annoyance and Community Odour Surveys

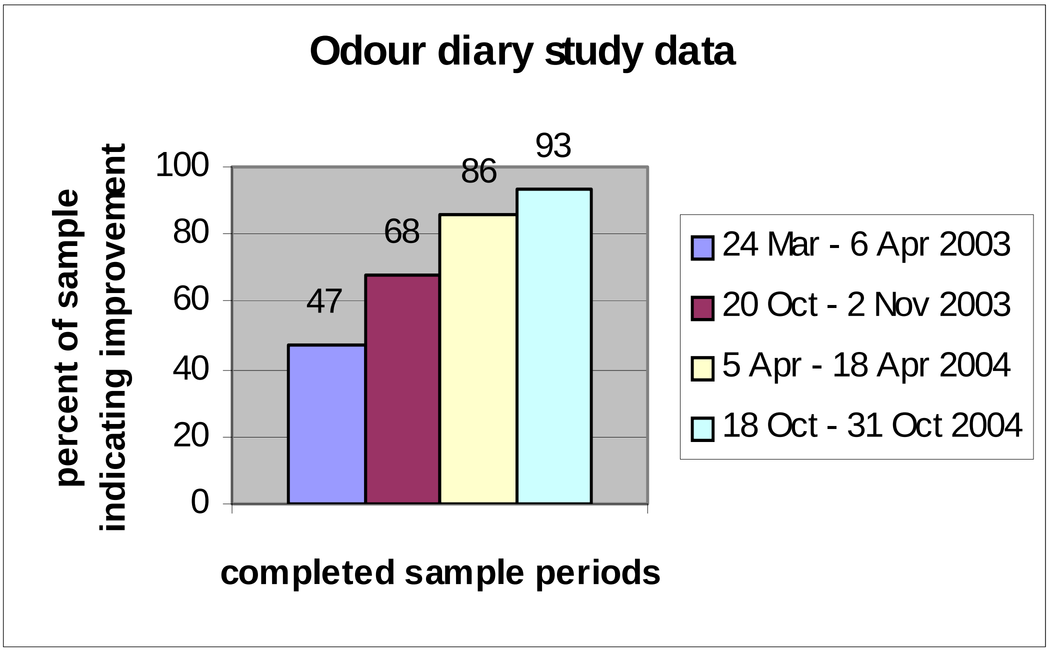
As part of the Odour Reduction PRP SKM and AMCOR completed a study investigating community perceptions to changes in odour as a result of the odour reduction works completed on the Existing Paper Mill. The study included written surveys to 5500 households and businesses in the local area. Along with questions about the local environment, the survey also called for volunteers to participate in a long-term Odour Diary project.

The study area for the Diary project was determined through odour modelling, with a boundary drawn at the October 2001 Base Case 2 OU/m$^3$ contour band.

Data was collected during each of the five Diary sample periods, which were timed to be shortly after each stage of the odour reduction works were completed. The Diaries are tracked to determine whether residents perceive any improvement to their odour experiences as a result of the works. Participants recorded their odour experiences over a two week period, providing information on the time of day the entry was made, odour type, strength and perceived source.

Corresponding to the decrease in measured odour concentrations and impacts predicted by modelling at the same time as the Diaries were completed, there was a gradual improvement in Diary responses to odour, with less people recording odours where the Existing Paper Mill was the perceived source of annoyance. This is demonstrated in **Figure 5-12** which shows the improvement in the Existing Paper Mill odour impact reported by the Odour Diaries.

- **Figure 5-12 Odour Diary Response**




Considering the results of the Diary surveys and the reduced number of complaints received from the general community regarding odour from the Existing Paper Mill, it is considered that the Existing Paper Mill has an acceptable level of odour impact.

On the basis that the CALPUFF modelling for the New Paper Mill shows a smaller impact to the existing mill, which as stated above we determine to be acceptable with respect to odour impacts within residential areas immediately to the north of the Paper Mill site, it is determined that the odour impact from the New Paper Mill will also be acceptable, and further improved. Specifically the CALPUFF modelling shows a reduction in odour impact within nearest sensitive receptors for the B9 machine (less than 5 $OU/m^3$) compared to B7 and B8 machines (5-6 $OU/m^3$).

### 5.6.3 Odour Intensity

To further quantify the odour impact in determining acceptability it is important to also consider odour intensity.

Odour intensity is the perceived strength of an odour above its threshold, as “not perceivable”, then “very weak”, through to “extremely strong” (WA EPA, 2002). Odour intensity is commonly cited as one of the important dimensions of odour that determine odour annoyance (Welchman *et al.*, 2005).

At the Existing Paper Mill odour intensity was measured in November 2004 and March 2005. The results of these measurements can be seen in **Table 5-1**.

- **Table 5-1: Odour Intensity**

| Date | Source | OCI Relationship# | DOC ($OU/m^3$)## | $r^3$ |
|---|---|---|---|---|
| Nov 2004 | GSWT | I = 2.42 OC + 0.48 | 11.0 | 0.393 |
| Nov 2004 | No. 7 Pre Dryer Exhaust 7 | I = 4.24 OC + -1.77 | 13.3 | 0.968 |
| Nov 2004 | No. 8 Pre Dryer Exhaust 3 | I = 2.97 OC + 0.05 | 9.9 | 0.934 |
| Mar 2005 | GSWT | I = 1.75 OC + 0.43 | 29.5 | 0.936 |
| Mar 2005 | No. 7 Pre Dryer Exhaust 7 | I = 2.49 OC + 0.01 | 15.9 | 0.953 |
| Mar 2005 | No. 8 Pre Dryer Hood Exhaust 8 | I = 2.58 OC + 0.08 | 13.6 | 0.934 |

# OCI – Odour Concentration Intensity relationship is reported as a linear regression equation

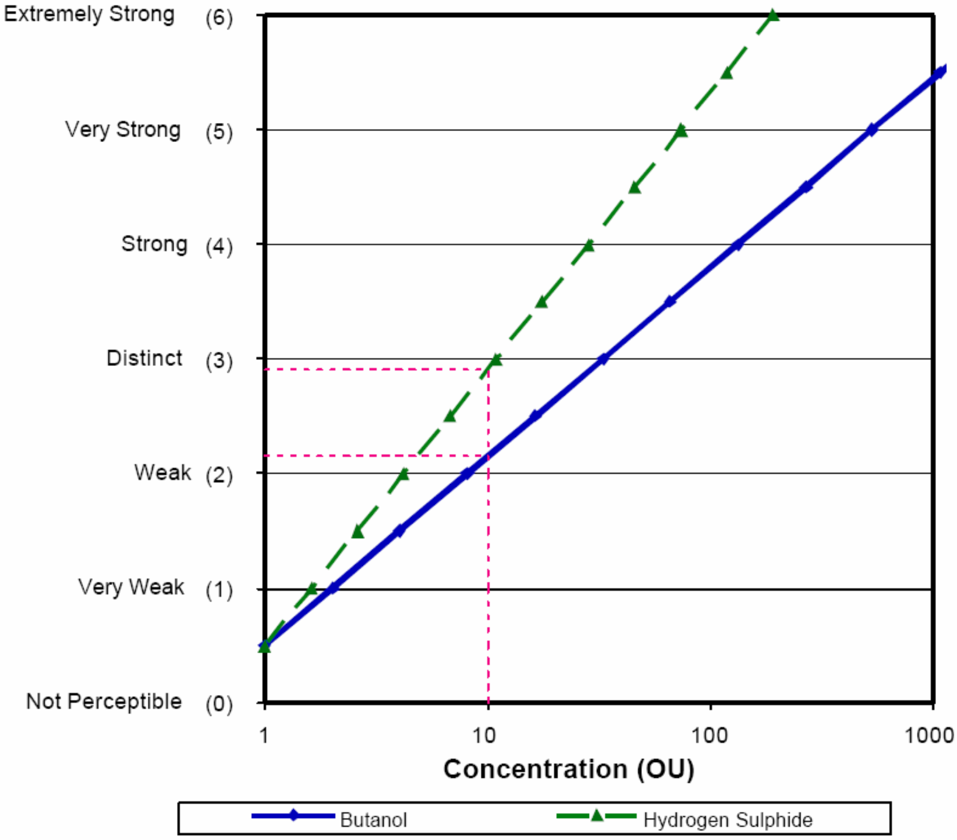
## DOC – Distinct Odour Concentration at which odour intensity index is distinct

The relationship between odour concentration and odour intensity is important when assessing the impact of nuisance odours. Odour intensity is useful because some odours are perceived as being stronger than others ie. all odours are just detectable at 1 $OU/m^3$, however, at 2 $OU/m^3$ some odours may be perceived as very weak, while others may be perceived as distinct. At 10 $OU/m^3$ one odour may be perceived as distinct, while others may be perceived as strong (WA DEP, 2002).

This means that defining an odour criterion based on odour concentration will result in different perceived odour strengths for different odour types. The only exception being when the odour criterion is equal to the odour detection threshold (ie 1 $OU/m^3$), which is essentially a “no impact” criterion (WA DEP, 2002).

An example of the relationship between odour concentration and odour intensity for butanol and hydrogen sulphide is illustrated in **Figure 5-13**. Here is can be seen that if an odour concentration of 10 OU/m3 was chosen as the criterion for both butanol and hydrogen sulphide the odour intensity, and hence annoyance, is very different. To have equivalent protection from odour annoyance for the two substances a different level of criterion would be required. For example, if the criterion of a “distinct” odour impact was chosen, an odour concentration of 11 OU/m3 would be required for hydrogen sulphide, while a criterion of 33 OU/m3 would be required for butanol.

- **Figure 5-13: The Relationship Between Odour Intensity and Odour Concentration for Butanol and Hydrogen Sulphide(as reported in the German Standard VDI 3882) using the Weber-Fechner Law (WA DEP, 2002)**




Results of odour concentration and odour intensity measurements taken from the Existing Paper Mill during November 2004 and March 2005 provide an average "Distinct" odour intensity of 15 OU/m$^3$. The current maximum odour impacts of 5-6 OU/m$^3$ and the predicted maximum odour impacts for the New Paper Mill of the order of less than 5 OU/m$^3$ as predicted by CALPUFF which is much less than 15 OU/m$^3$.

Therefore, considering the nature of odour from the New Paper Mill will be similar to that currently associated with the improved Existing Paper Mill, the odour intensity data impacts suggest an acceptable impact for the proposed operations. This supports the same assertion drawn from the CALPUFF modelling and the acceptable level of impacts determined with respect to complaints data and the Diary surveys.

## 5.7 Odour Emission Comparison with German Paper Mills

In order to provide a higher degree of certainty to the preceding assessment of odour impacts associated with AMCOR Botany's proposed B9 paper machine a review of international literature was undertaken to compare forecast odour emissions from the B9 paper machine with other similar installations overseas, acknowledging the fact that there are no other similar paper machines in Australia.

This review included the commissioning of a German consultant Muller-BBM (M-BBM) to review the assessment of odours presented here by SKM and to provide odour emission data for similar German paper machines. A full copy of the M-BBM report is provided in **Appendix D**.

The scope of the M-BBM report was to:

- provide a comparison of odour assessment criteria in Germany and that used in NSW;
- compare odour emission data between that forecast for the B9 paper machine and similar German paper machines; and to
- provide a summary of odour management techniques within the paper manufacturing industry in Germany.

### 5.7.1 German Odour Criteria

With respect to the first dot-point, M-BBM advise that in Germany regulations set out by Geruchs-Immissionsrichtlinie (GIRL) generally apply to odours emitted from paper mills. The following frequencies of odour perception (as odour hours) apply to different land-uses as follows:

- residential and mixed areas: 0.10 (10%);
- industrial and commercial areas: 0.15 (15%);
- villages and livestock farming: 0.15 (15%);
- outskirts and rural areas (odour from farming): 0.15 to 0.20 (15 % to 20 %)

Assuming "odour perception" is defined as 1 $OU/m^3$, then a 10 % exceedance criterion of this threshold within residential and mixed areas is not really comparable with the DEC criteria in NSW of 2 $OU/m^3$ as a 1 % exceedance criteria. This is agreed by M-BBM who apply a dispersion modelling experiment to demonstrate this.

### 5.7.2 Comparison of Odour Emissions

With respect to odour emissions as forecast for AMCOR's B9 machine, M-BBM provide odour emission rates for two German paper Mill's namely "Mill A" and "Mill B". It is considered appropriate to compare odour emissions between Australian and German facilities as the method of dynamic olfactometry used in NSW e.g. AS4323.3(2001): Determination of Odour Concentration by Dynamic Olfactometry is based on the European CEN method which is also the basis of the German VDI 3945 method.

It is acknowledged that the German Mills A and B are not as modern as AMCOR's proposed B9 machine, however, they are similar to AMCOR's B7 and B8 machines, which have been used to represent worst impacts from the B9 machine. While it is not possible to directly compare measured odour emission rates or emission concentrations between the German Mills A / B and Botany Mill (B9 machine) in general the emission concentrations reported by M-BBM for machine hood and hall exhausts averaged 650 to 750 OU/m$^3$ which is comparable to the average odour emission concentrations forecast for the B9 machine of approximately 680 OU/m$^3$. This result provides an enhanced level of certainty for the forecast odour emission concentrations determined for the B9 machine as detailed in **Appendix A**.

### 5.7.3 Odour Management in German Paper Mills

In terms of odour management within the German paper industry M-BBM reconfirm the conclusions by CSIRO (refer to **Section 2.3.1** and **Appendix C**) that "due to the relatively low concentrations, there is no paper plant in Germany that treats its waste gases in a purifier."

Generally the successful management of odours in German paper mills has been realised through:

- elimination and substitution of sulphur-containing chemicals in the process;
- reducing remaining times in all production connected silos, specifically in the broke and pulper system;
- collecting and burning the exhaust air of the most intensive smelling sources in the power station;
- testing the entire water and paper circuit to see if there are any "dead zones" that are not flushed regularly;
- widening the water/product ratio;
- reducing filling heights in all production connected silos and tanks to a minimum;
- regular flushing of all pulpers;
- waste paper: First-in-First-out stock rotation;
- circulating of silos and tanks in the production process; and
- frequent cleaning of channels, pipes and exhaust channels.

Many of these odour management techniques are already in place at AMCOR's existing Botany Paper Mill (B7 and B8 machines), with some having been implemented as part of the recent odour reduction PRP. In addition to these, the more modern design of the new B9 machine will further assist in managing odour generating processes and further minimise adverse odour impacts.

### 5.8 Ongoing Odour Management AMCOR Botany Mill

The odour emission rates forecast for the New Mill are considered conservative for the reasons discussed in **Section 2.3.1**. Hence the odour impacts predicted by the modelling presented in this assessment are considered to represent the worst case scenario and it is anticipated that once the New Mill is fully operational under steady state conditions the odour impact will be significantly less than it is currently.

In the unlikely event, that the emissions to air from the New Mill are determined to contain unacceptable levels of odorous compounds AMCOR would commit to undertake a further sequence of additional mitigation measures to minimize their generation and therefore impact. At this stage it is not possible to detail the nature of these measures, as any controls required would be specific to the source of odour problem that occurs. As can be appreciated this cannot be forecast at this stage. It is generally accepted that the odour causing compounds in the emissions to air from recycled paper based Mills are volatile fatty acids and/or reduced sulphur compounds generated by biological activity as described in **Section 2.2.2**. As there are no proven technologies available for "end-of-pipe" control of odour emissions, further mitigation measures would be targeted at management or elimination of biological activity in the process.

The appropriate mitigation measures to employ would depend on the source of the biological activity generating the odorous compounds. Hence, if necessary, Amcor would implement an exhaustive survey of the Mill process systems to identify the sources, mechanisms and process factors that were responsible for the biological activity.

The range of potential mitigation measures available to address odour generating biological activity would include:

- Correction of any mechanical deficiencies resulting in stagnant pockets in the process circuits;
- Adjustment of the biological control program to specifically target identified problem areas;
- Optimisation of the paper machine wet end retention system to minimize total dissolved solids (TDS) and biological oxygen demand (BOD) levels in the Paper Machine water loop; and
- Controlling and operating the process water loops at the lowest practical TDS level to minimize the availability of food sources for microbiological organisms.

After implementation of any further odour mitigation measures the survey would be repeated to verify the effectiveness of the odour reduction measures. In summary, AMCOR are committing that the odour impact of the B9 machine will not result in any offensive odour as defined by Section 129 of the POEO Act (NSW Government, 1997).

# 6. Conclusions and Recommendations

## 6.1 General Conclusions

AMCOR are proposing to install a new paper making facility at their Botany Mill. The New Paper Mill would increase the paper making capacity from the current 250,000 tonnes per year to around 345,000 tonnes per year.

This assessment has qualitatively assessed construction impacts, and quantitatively assessed operational impacts from the Existing and New Paper Mills.

Particulate matter would be liberated during various construction activities. However, the impact of air borne particulate matter will be minimised by implementing standard mitigation measures.

Once fully operational, it is anticipated that the New Paper Mill would result in a decreased total odour emission from the current (November 2004) rate of 198,560 $OUm^3/s$ to about 186,154 $OUm^3/s$. Correspondingly, odour impacts in the near vicinity of the New Paper Mill are predicted by CALPUFF modelling to reduce to less than 5 $OU/m^3$ for the New Paper Mill compared to 5-6 $OU/m^3$ for the Existing Paper Mill.

On the basis that the odour impact from the Existing Paper Mill is considered acceptable, it can be deduced that an equivalent or similar emission from the New Paper Mill is also acceptable. This assessment is supported by consideration of complaints data, detailed Odour Diary Surveys and measurement of odour intensity.

It is also noted that the technology being installed at the New Paper Mill, e.g. Dissolved Air Flotation (DAF) for primary water treatment, is considered “Best Practice” for the type of recycled paper mill proposed. A report prepared by CSIRO to investigate additional means of odour control, e.g., “end of pipe” solutions determined that there are no proven, economically feasible technologies for “end of the pipe” odour control for paper mills using waste paper. This is primarily because of the large volumes of air and steam requiring treatment and the very low odour concentrations in the air and steam.

## 6.2 Recommendations

With respect to odour management it is recommended that on commissioning of the New Paper Mill odour emissions measurement and modelling are undertaken to confirm the results of this assessment.

AMCOR should also engage the community in a similar consultation process to that undertaken as part of the Odour Reduction PRP for the Existing Paper Mills to confirm community acceptance with respect to odour impacts from the New Paper Mill.

# References

Department of Environment Protection, WA (2002) *Odour Methodology Guideline*, Perth.

Environment Protection Authority, NSW (2001a) *Draft Policy: Assessment and Management of odour from Stationary Sources in New South Wales*, Environment Protection Authority, Sydney.

Environment Protection Authority, NSW (2001b), *Approved methods and Guidance for the Modelling and Assessment of Air Pollutants in New South Wales*, Environment Protection Authority, Sydney.

New South Wales Government, (1997), Protection of Environment Operations Act 1997, NSW Government, Sydney

Sinclair Knight Merz (2004) *AMCOR Community Odour Annoyance Study Project*

Welchman, S., Brooke, A., Best, P. (2005) 'Is Odour All It's Cracked Up to Be?', *17th Iinternational Clean Air and Environment Conference Hobart*, May 2005.

# Appendix A Exhaust Stack Parameters

## A.1 Exhaust Velocity and Flow – November 2004

| Source | Temp (°C) | Duct Area ($m^2$) | Vel (m/s) | Flow @ stack cond ($m^3$/s) | Flow @ STP ($m^3$/s) |
|---|---|---|---|---|---|
| No. 7 Pre Dryer Hood Exhaust (No. 1&2) | 62 | 11.0 | 10.7 | 118.1 | 96.2 |
| No. 7 Pre Dryer Hood Exhaust (No. 3&4) | 51 | 11.6 | 11.4 | 132.6 | 111.8 |
| No. 7 Pre Dryer Hood Exhaust (No. 5) | 62 | 3.0 | 13.7 | 41.5 | 33.9 |
| No. 7 Pre Dryer Hood Exhaust (No. 6) | 54 | 3.0 | 13.5 | 40.9 | 34.1 |
| No. 7 Pre Dryer Hood Exhaust (No. 7) | 59 | 3.0 | 12.7 | 38.5 | 31.6 |
| No. 7 Pre Dryer Hood Exhaust (No. 8) | 64 | 3.0 | 14.0 | 42.3 | 34.3 |
| No. 7 After Dryer Hood Exhaust (No. 9) | 54 | 1.8 | 16.0 | 28.7 | 24.0 |
| No. 7 After Dryer Hood Exhaust (No. 10) | 47 | 1.8 | 15.2 | 27.3 | 23.3 |
| No 7 Machine Hall Exhaust (No. 1) | 38 | 1.1 | 10.0 | 11.3 | 9.9 |
| No 7 Machine Hall Exhaust (No. 2) | 44 | 1.1 | 11.2 | 12.7 | 10.9 |
| No 7 Machine Hall Exhaust (No. 3) | 45 | 1.1 | 9.0 | 10.2 | 8.7 |
| No. 7 Nash Vacuum Pump | 43 | 0.1 | 14.7 | 1.0 | 0.9 |
| No. 7 Starch Cooker Vent | 97 | 0.0 | 2.0 | 0.0 | 0.0 |
| No. 8 After Dryer Hood Exhaust (No. 1) | 55 | 1.8 | 20.8 | 36.8 | 30.6 |
| No. 8 After Dryer Hood Exhaust (No. 2) | 55 | 1.8 | 18.3 | 32.3 | 26.9 |
| No. 8 After Dryer Hood Exhaust (No. 3) | 64 | 1.8 | 14.2 | 25.1 | 20.3 |
| No. 8 Pre Dryer Hood Exhaust (No. 4) | 64 | 1.5 | 12.2 | 18.2 | 14.8 |
| No. 8 Pre Dryer Hood Exhaust (No. 5) | 63 | 1.5 | 16.0 | 23.9 | 19.4 |
| No. 8 Pre Dryer Hood Exhaust (No. 6) | 70 | 1.8 | 16.0 | 28.3 | 22.5 |
| No. 8 Pre Dryer Hood Exhaust (No. 7) | 65 | 1.8 | 16.0 | 28.3 | 22.8 |
| No. 8 Pre Dryer Hood Exhaust (No. 8) | 39 | 1.8 | 14.7 | 26.0 | 22.7 |
| No. 8 Starch Cooker Vent | 99 | 0.0 | 2.4 | 0.0 | 0.0 |
| No. 8 Low Vacuum Fan Exhaust | 53 | 1.8 | 15.2 | 26.9 | 22.5 |
| No. 8 Nash Vacuum Pump Exhaust | 40 | 0.5 | 14.7 | 7.9 | 6.9 |
| No.8 Machine Hall Exhaust (No.8 CE-VA40) | 33 | 1.1 | 9.0 | 10.2 | 9.1 |
| No.8 Machine Hall Exhaust (No.5 CE-VA37) | - | 1.1 | - | - | 0.0 |
| No.8 Machine Hall Exhaust (No.7 CE-VA39) | 36 | 1.1 | 10.2 | 11.5 | 10.2 |
| No.8 Machine Hall Exhaust (No.4 CE-VA36) | - | 1.1 | - | - | 0.0 |
| No.8 Machine Hall Exhaust (No.6 CE-VA38) | 33 | 1.1 | 13.3 | 15.0 | 13.4 |
| No.8 Machine Hall Exhaust (No.3 CE-VA35) | - | 1.1 | - | - | 0.0 |
| No.8 Machine Hall Exhaust (No.10 CE-VA44) | 35 | 1.1 | 11.9 | 13.5 | 11.9 |
| No.8 Machine Hall Exhaust (No.9 CE-VA43) | 38 | 1.1 | 8.9 | 10.1 | 8.8 |

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## A.2 Source Odour Emission Rates – November 2004

| Source | Odour Conc ($OU/m^3$) | Surface Area ($m^3$) | Emission Rate (Oum/s) | Flow Rate @STP ($m^3/s$) | SOER ($OUm^3/s$) | Contrib (%) |
|---|---|---|---|---|---|---|
| General Service Water Tank | 1395 | 102.6 | 0.48 | | 48.9 | 0.02 |
| Sewer Sump | - | - | - | - | - | 0.00 |
| Waste Paper Plant Building | 215 | | - | | 3762.5 | 1.89 |
| No.7 Pre Dryer Hood Exhaust (No. 1&2) | 130 | 11.0 | - | 96.2 | 12511.7 | 6.30 |
| No.7 Pre Dryer Hood Exhaust (No. 3&4) | 216 | 11.6 | - | 111.8 | 24138.2 | 12.16 |
| No.7 Pre Dryer Hood Exhaust (No. 5) | 302 | 3.0 | - | 33.9 | 10223.0 | 5.15 |
| No.7 Pre Dryer Hood Exhaust (No. 6) | 301 | 3.0 | - | 34.1 | 10271.0 | 5.17 |
| No.7 Pre Dryer Hood Exhaust (No. 7) | 300 | 3.0 | - | 31.6 | 9485.2 | 4.78 |
| No.7 Pre Dryer Hood Exhaust (No. 8) | 300 | 3.0 | - | 34.3 | 10279.0 | 5.18 |
| No.7 After Dryer Hood Exhaust (No. 9) | 478 | 1.8 | - | 24.0 | 11465.0 | 5.77 |
| No.7 After Dryer Hood Exhaust (No. 10) | 322 | 1.8 | - | 23.3 | 7497.6 | 3.78 |
| No.7 Machine Hall Exhaust (No. 1) | 322 | 1.1 | - | 9.9 | 3196.8 | 1.61 |
| No.7 Machine Hall Exhaust (No. 2) | 294 | 1.1 | - | 10.9 | 3207.2 | 1.62 |
| No.7 Machine Hall Exhaust (No. 3) | 266 | 1.1 | - | 8.7 | 2324.4 | 1.17 |
| No.7 Nash Vacuum Pump | 751 | 0.1 | - | 0.9 | 674.2 | 0.34 |
| No.7 Mill Starch Cooker | 5273 | 0.0 | - | 0.0 | 61.1 | 0.03 |
| No. 8 After Dryer Hood Exhaust (No. 1) | 188 | 1.8 | - | 30.6 | 5751.5 | 2.90 |
| No.8 After Dryer Hood Exhaust (No. 2) | 367 | 1.8 | - | 26.9 | 9878.2 | 4.97 |
| No.8 Pre Dryer Hood Exhaust (No. 3) | 363 | 1.8 | - | 20.3 | 7379.0 | 3.72 |
| No.8 Pre Dryer Hood Exhaust (No. 4) | 161 | 1.5 | - | 14.8 | 2379.9 | 1.20 |
| No.8 Pre Dryer Hood Exhaust (No. 5) | 248 | 1.5 | - | 19.4 | 4822.2 | 2.43 |
| No.8 Pre Dryer Hood Exhaust (No. 6) | 248 | 1.8 | - | 22.5 | 5581.0 | 2.81 |
| No.8 Pre Dryer Hood Exhaust (No. 7) | 257 | 1.8 | - | 22.8 | 5869.1 | 2.96 |
| No.8 Pre Dryer Hood Exhaust (No. 8) | 266 | 1.8 | - | 22.7 | 6046.2 | 3.04 |
| No.8 Mill Starch Cooker | 5273 | 0.0 | - | 0.0 | 71.4 | 0.04 |
| No.8 Low Vacuum Fan Exhaust | 913 | 1.8 | - | 22.5 | 20536.8 | 10.34 |
| No.8 Nash Vacuum Pump Exhaust | 1182 | 0.5 | - | 6.9 | 8183.6 | 4.12 |
| No.8 Machine Hall Exhaust (No.8 CE-VA40) | 239 | 1.1 | - | 9.1 | 2170.4 | 1.09 |
| No.8 Machine Hall Exhaust (No.5 CE-VA37) | - | 1.1 | - | 0.0 | - | 0.00 |
| No.8 Machine Hall Exhaust (No.7 CE-VA39) | 204 | 1.1 | - | 10.2 | 2079.2 | 1.05 |
| No.8 Machine Hall Exhaust (No.4 CE-VA36) | - | 1.1 | - | 0.0 | - | 0.00 |
| No.8 Machine Hall Exhaust (No.6 CE-VA38) | 243 | 1.1 | - | 13.4 | 3261.0 | 1.64 |
| No.8 Machine Hall Exhaust (No.3 CE-VA35) | - | 1.1 | - | 0.0 | - | 0.00 |
| No.8 Machine Hall Exhaust (No.10 CE-VA44) | 282 | 1.1 | - | 11.9 | 3364.0 | 1.69 |
| No.8 Machine Hall Exhaust (No.9 CE-VA43) | 231 | 1.1 | - | 8.8 | 2041.1 | 1.03 |
| **Total** | | | | | **198560.30** | |

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## A.3 Exhaust Velocity and Flow – Proposed

| Source | Temp ($^oC$) | Duct Area ($m^2$) | Vel (m/s) | Flow @ stack cond ($m^3/s$) | Flow @ STP ($m^3/s$) |
|---|---|---|---|---|---|
| No.9 Pre Dryer Hood Exhaust (No.1) | 65 | 1.96 | 15 | 29.4 | 24.1 |
| No.9 Pre Dryer Hood Exhaust (No.2) | 65 | 1.96 | 15 | 29.4 | 24.1 |
| No.9 Pre Dryer Hood Exhaust (No.3) | 65 | 1.96 | 15 | 29.4 | 24.1 |
| No.9 Pre Dryer Hood Exhaust (No. 4) | 65 | 1.96 | 15 | 29.4 | 24.1 |
| No.9 After Dryer Hood Exhaust (No.1) | 65 | 2.04 | 15 | 30.6 | 25.1 |
| No.9 After Dryer Hood Exhaust (No.2) | 65 | 2.04 | 15 | 30.6 | 25.1 |
| No.9 After Dryer Hood Exhaust (No.3) | 65 | 2.04 | 15 | 30.6 | 25.1 |
| No.9 Machine Room Exhaust (No.1) | 30 | 1.28 | 15 | 19.2 | 17.3 |
| No.9 Machine Room Exhaust (No.2) | 30 | 1.28 | 15 | 19.2 | 17.3 |
| No.9 Machine Room Exhaust (No.3) | 30 | 1.28 | 15 | 19.2 | 17.3 |
| No.9 Machine Room Exhaust (No.4) | 30 | 1.28 | 15 | 19.2 | 17.3 |
| No.9 Machine Room Exhaust (No.5) | 30 | 1.28 | 15 | 19.2 | 17.3 |
| No.9 Machine Room Exhaust (No.6) | 30 | 1.28 | 15 | 19.2 | 17.3 |
| No.9 Former Section (No.1) | 40 | 3.36 | 15 | 50.4 | 44.0 |
| No.9 Former Section (No.2) | 40 | 3.36 | 15 | 50.4 | 44.0 |
| No.9 Sulzer Blower | 60 | 0.96 | 15 | 14.4 | 11.8 |
| No.9 Low Vacuum (No.1) | 45 | 0.34 | 15 | 5.16 | 4.4 |
| No.9 Low Vacuum (No.2) | 60 | 0.18 | 15 | 2.64 | 2.2 |
| No.9 Low Vacuum (No.3) | 45 | 0.30 | 15 | 4.56 | 3.9 |
| No.9 Low Vacuum (No.4) | 45 | 0.30 | 15 | 4.56 | 3.9 |
| No.9 Vacuum Pump (No.1) | 40 | 0.20 | 15 | 3 | 2.6 |
| No.9 Vacuum Pump (No.2) | 40 | 0.20 | 15 | 3 | 2.6 |
| No.9 Vacuum Pump (No.3) | 40 | 0.20 | 15 | 3 | 2.6 |
| No.9 Size Press Ventilation | 30 | 0.88 | 15 | 13.2 | 11.9 |
| No.9 Pulper Hood (No.2) | 40 | 0.80 | 15 | 12 | 10.5 |
| No.9 Pulper Hood (No.3) | 40 | 0.80 | 15 | 12 | 10.5 |
| No.9 Pulper Hood (No.4) | 40 | 0.80 | 15 | 12 | 10.5 |
| No.9 Pulper Hood (No.5) | 40 | 0.80 | 15 | 12 | 10.5 |
| No.9 Starch Cooker Vent | 97 | 0.01 | 2.2 | 0.017 | 0.01 |

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## A.4 Source Odour Emission Rates – Proposed

| Source | Odour Conc ($OU/m^3$) | Surface Area ($m^2$) | Total Flow Rate @STP ($m^3/s$) | Source Odour Emission Rate ($Oum^3/s$) | Contrib'n (%) |
|---|---|---|---|---|---|
| No.9 Pre Dryer Hood Exhaust (No.1) | 350 | 1.96 | 24.1 | 8,436 | 4.53 |
| No.9 Pre Dryer Hood Exhaust (No.2) | 350 | 1.96 | 24.1 | 8,436 | 4.53 |
| No.9 Pre Dryer Hood Exhaust (No.3) | 350 | 1.96 | 24.1 | 8,436 | 4.53 |
| No.9 Pre Dryer Hood Exhaust (No. 4) | 350 | 1.96 | 24.1 | 8,436 | 4.53 |
| No.9 After Dryer Hood Exhaust (No.1) | 300 | 2.04 | 25.1 | 7,526 | 4.04 |
| No.9 After Dryer Hood Exhaust (No.2) | 300 | 2.04 | 25.1 | 7,526 | 4.04 |
| No.9 After Dryer Hood Exhaust (No.3) | 300 | 2.04 | 25.1 | 7,526 | 4.04 |
| No.9 Machine Room Exhaust (No.1) | 325 | 1.28 | 17.3 | 5,622 | 3.02 |
| No.9 Machine Room Exhaust (No.2) | 325 | 1.28 | 17.3 | 5,622 | 3.02 |
| No.9 Machine Room Exhaust (No.3) | 325 | 1.28 | 17.3 | 5,622 | 3.02 |
| No.9 Machine Room Exhaust (No.4) | 325 | 1.28 | 17.3 | 5,622 | 3.02 |
| No.9 Machine Room Exhaust (No.5) | 325 | 1.28 | 17.3 | 5,622 | 3.02 |
| No.9 Machine Room Exhaust (No.6) | 325 | 1.28 | 17.3 | 5,622 | 3.02 |
| No.9 Former Section (No.1) | 500 | 3.36 | 44.0 | 21,980 | 11.81 |
| No.9 Former Section (No.2) | 500 | 3.36 | 44.0 | 21,980 | 11.81 |
| No.9 Sulzer Blower | 750 | 0.96 | 11.8 | 8,854 | 4.76 |
| No.9 Low Vacuum (No.1) | 750 | 0.34 | 4.4 | 3,322 | 1.78 |
| No.9 Low Vacuum (No.2) | 750 | 0.18 | 2.2 | 1,623 | 0.87 |
| No.9 Low Vacuum (No.3) | 750 | 0.30 | 3.9 | 2,936 | 1.58 |
| No.9 Low Vacuum (No.4) | 750 | 0.30 | 3.9 | 2,936 | 1.58 |
| No.9 Vacuum Pump (No.1) | 1250 | 0.20 | 2.6 | 3,271 | 1.76 |
| No.9 Vacuum Pump (No.2) | 1250 | 0.20 | 2.6 | 3,271 | 1.76 |
| No.9 Vacuum Pump (No.3) | 1250 | 0.20 | 2.6 | 3,271 | 1.76 |
| No.9 Size Press Ventilation | 350 | 0.88 | 11.9 | 4,163 | 2.24 |
| No.9 Pulper Hood (No.2) | 350 | 0.80 | 10.5 | 3,663 | 1.97 |
| No.9 Pulper Hood (No.3) | 350 | 0.80 | 10.5 | 3,663 | 1.97 |
| No.9 Pulper Hood (No.4) | 350 | 0.80 | 10.5 | 3,663 | 1.97 |
| No.9 Pulper Hood (No.5) | 350 | 0.80 | 10.5 | 3,663 | 1.97 |
| No.9 Starch Cooker Vent | 5250 | 0.01 | 0.015 | 78 | 0.04 |
| Waste Paper Plant Building | 215 | | | 3763 | 2.02 |
| **Total** | | | | **186,154** | |

# Appendix B AMCOR – Odour Reduction Program

# Pollution studies and reduction programs

## PRP 1 ODOUR MITIGATION WORKS

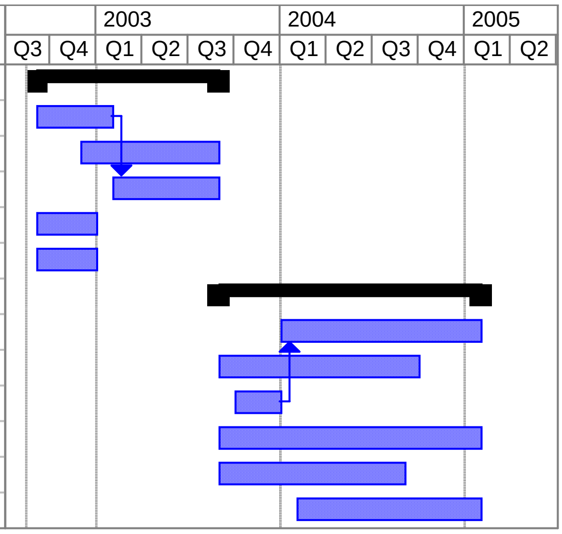
### 1.1 OBJECTIVE

The aim of this PRP is to reduce odour emissions from the premises.

### 1.2 REQUIRED WORKS

1.2.1 The licensee must implement works outlined in the document titled "Amcor Pollution Reduction Program (PRP), Odour Remediation Plan Final March 2002". Each stage of works must be installed and made operational at the premises by the dates specified in the following table:

| ID | Task Name | Start | Finish |
|---|---|---|---|
| 1 | **Stage 1 - August 2002 to August 2003** | **Mon 02/09/02** | **Fri 29/08/03** |
| 2 | Install & operate white water tank, pipes, and pumps | Mon 02/09/02 | Fri 31/01/03 |
| 3 | Waste Paper Plant DAF installed and operating | Mon 02/12/02 | Fri 29/08/03 |
| 4 | Install & operate 31m exh stack for B8 low vac fans | Mon 03/02/03 | Fri 29/08/03 |
| 5 | No. 7 BW pump upgrade operational | Mon 02/09/02 | Tue 31/12/02 |
| 6 | No. 8 BW pump upgrade operational | Mon 02/09/02 | Tue 31/12/02 |
| 7 | **Stage 2 - September 2003 to February 2005** | **Mon 01/09/03** | **Tue 01/02/05** |
| 8 | Install & operate B7 DAF, piping, and pumps | Thu 01/01/04 | Tue 01/02/05 |
| 9 | Install & operate B8 DAF, piping, and pumps | Mon 01/09/03 | Thu 30/09/04 |
| 10 | Decommission clarifier | Wed 01/10/03 | Wed 31/12/03 |
| 11 | Mill water distribution change- pumps and pipework | Mon 01/09/03 | Tue 01/02/05 |
| 12 | Install M/C vents and exhaust stacks Group 1 | Mon 01/09/03 | Tue 31/08/04 |
| 13 | Install M/C vents and exhaust stacks Group 2 | Mon 02/02/04 | Tue 01/02/05 |




| INDICATIVE ODOUR REDUCTIONS FOR EACH STAGE* | | |
|---|---|---|
| **Stage 1** | **3.5** | **30/06/2005** |
| **Stage 2** | **4.5** | **30/06/2005** |

These Odour Reductions are indications only, and are based on Ausplume modelling using 2000 metrological data.

### 1.3 MONITORING AND RECORDING

1.3.1 The following points referred to in the table below are identified for the purposes of monitoring and/or the setting of limits for the emission of pollutants to the air from the point.

| EPA identification point | Type of monitoring point | Type of discharge point | Description of location |
|---|---|---|---|
| 1 | Air emissions monitoring | Discharge to air | Clarifier |

| | | | |
|---|---|---|---|
| 2 | Air emissions monitoring | Discharge to air | General service water tank |
| 3 | Air emissions monitoring | Discharge to air | Sewer sump |
| 4 | Air emissions monitoring | Discharge to air | Waste paper plant building |
| 5 | Air emissions monitoring | Discharge to air | No. 7 mill pre dryer exhaust 1 & 2 |
| 6 | Air emissions monitoring | Discharge to air | No. 7 mill pre dryer exhaust 3 & 4 |
| 7 | Air emissions monitoring | Discharge to air | No. 7 mill pre dryer exhaust 5 |
| 8 | Air emissions monitoring | Discharge to air | No. 7 mill pre dryer exhaust 6 |
| 9 | Air emissions monitoring | Discharge to air | No. 7 mill pre dryer exhaust 7 |
| 10 | Air emissions monitoring | Discharge to air | No. 7 mill pre dryer exhaust 8 |
| 11 | Air emissions monitoring | Discharge to air | No. 7 mill after dryer exhaust 9 |
| 12 | Air emissions monitoring | Discharge to air | No. 7 mill after dryer exhaust 10 |
| 13 | Air emissions monitoring | Discharge to air | No. 7 machine hall exhaust 1 |
| 14 | Air emissions monitoring | Discharge to air | No. 7 machine hall exhausts 2 |
| 15 | Air emissions monitoring | Discharge to air | No. 7 machine hall exhaust 3 |
| 16 | Air emissions monitoring | Discharge to air | No. 7 mill nash vacuum pump exhaust |
| 17 | Air emissions monitoring | Discharge to air | No. 7 mill starch cooker exhaust |
| 18 | Air emissions monitoring | Discharge to air | No. 8 mill after dryer exhaust 1 |
| 19 | Air emissions monitoring | Discharge to air | No. 8 mill after dryer exhaust 2 |
| 20 | Air emissions monitoring | Discharge to air | No. 8 mill pre dryer exhaust 3 |
| 21 | Air emissions monitoring | Discharge to air | No. 8 mill pre dryer exhaust 4 |
| 22 | Air emissions monitoring | Discharge to air | No. 8 mill pre dryer exhaust 5 |
| 23 | Air emissions monitoring | Discharge to air | No. 8 mill pre dryer exhaust 6 |
| 24 | Air emissions monitoring | Discharge to air | No. 8 mill pre dryer exhaust 7 |
| 25 | Air emissions monitoring | Discharge to air | No. 8 mill pre dryer exhaust 8 |
| 26 | Air emissions monitoring | Discharge to air | No. 8 mill starch cooker exhaust |
| 27 | Air emissions monitoring | Discharge to air | No. 8 mill low vacuum fan exhaust |

| | | | |
|---|---|---|---|
| 28 | Air emissions monitoring | Discharge to air | No. 8 mill nash vacuum pump exhaust |
| 29 | Air emissions monitoring | Discharge to air | No. 8 mill machine hall exhaust 1 |
| 30 | Air emissions monitoring | Discharge to air | No. 8 mill machine hall exhaust 2 |
| 31 | Air emissions monitoring | Discharge to air | No. 8 mill machine hall exhaust 3 |
| 32 | Air emissions monitoring | Discharge to air | No. 8 mill machine hall exhaust 4 |
| 33 | Air emissions monitoring | Discharge to air | No. 8 mill machine hall exhaust 5 |
| 34 | Air emissions monitoring | Discharge to air | No. 8 mill machine hall exhaust 6 |
| 35 | Air emissions monitoring | Discharge to air | No. 8 mill machine hall exhaust 7 |
| 36 | Air emissions monitoring | Discharge to air | No. 8 mill machine hall exhaust 8 |

1.3.2 For each monitoring/discharge point or utilisation area specified below (by point number), the applicant must monitor (by sampling and obtaining results by analysis) the concentration of each pollutant specified in Column 1. The applicant must use the sampling method, units of measure and sample at the frequency, specified opposite in the other columns.

1.3.3 A test on one (1) point is deemed valid for other nominated test points, where it can be demonstrated that the air discharges into this point are representative of that of the nominated points.

EPA identification point 1 to 3

| Pollutant | Units of measure | Method | Frequency |
|---|---|---|---|
| Odour | $OU/m^3$ | OM-7 & OM-8 | Within a month of completion date for each stage of work specified by condition 1.2.1 |

EPA identification point 4 to 36

| Pollutant | Units of measure | Method | Frequency |
|---|---|---|---|
| Odour | $OU/m^3$ | OM-7 | Within a month of completion date for each stage of work specified by condition 1.2.1 |

EPA identification point 5 to 36

| Parameter | Units of measure | Method | Frequency[1] |
|---|---|---|---|
| Carbon dioxide | % | TM-24 | Within a month of completion date for each stage of work specified by condition 1.2.1 |
| Dry gas density | $Kg/m^3$ | TM-23 | Within a month of completion date for each stage of work specified by condition 1.2.1 |
| Moisture | % | TM-22 | Within a month of completion date for each stage of work specified by condition 1.2 |
| Molecular weight of stack gases | g/g.mol | TM-23 | Within a month of completion date for each stage of work specified by condition 1.2.1 |
| Oxygen | % | TM-25 | Within a month of completion date for each stage of work specified by condition 1.2 |
| Temperature | °C | TM-2 | Within a month of completion date for each stage of work specified by condition 1.2.1 |
| Velocity | m/s | TM-2 | Within a month of completion date for each stage of work specified by condition 1.2.1 |
| Volumetric flow rate | $m^3/s$ | TM-2 | Within a month of completion date for each stage of work specified by condition 1.2.1 |

EPA identification point 5 to 36

| Other | Units of measure | Method | Frequency |
|---|---|---|---|
| Selection of sampling positions | - | TM-1 | - |

## 1.4 COMMUNITY ODOUR ANNOYANCE SURVEY

1.4.1 The licensee must engage an independent consultant to develop a community odour annoyance survey in consultation with the impacted community (as defined in Figure 4-3 of the submitted document entitled "Amcor Pollution Reduction Program (PRP) Odour Remediation Plan, Final, March 2002) and the EPA.

1.4.2 The community odour annoyance survey developed in accordance with item 1.4.1 must be undertaken to indicate the effectiveness of each stage of works required by condition 1.2.1 within 2 months following completion of each stage of works.

Note: If, after the completion of works required by item 1.2, the EPA considers offensive odours (as defined by the POEO Act) are being emitted from the premises, the EPA will require further odour mitigation works.

**1.5 PROGRESS REPORTS**

The licensee must submit a progress report to the EPA within 2 months of the completion date of each stage of works as specified by item 1.2.1. The report must include details of the progress of required works and the results of monitoring required by item 1.3. The results of the community odour annoyance survey required by item 1.4 must be submitted to the EPA within 5 months of the completion date of each stage of works specified by item 1.2.1.

**1.6 Extension of Time – Installation of B8 Low vacuum exhaust stack**

Due to delays in obtaining Council approval for the installation of the B8 low vacuum exhaust stack, this work is not due to be completed before 28 November 2003.

**1.7 Deletion of No 7 Mill DAF Plant from PRP Works**

Line item ID 8 titled “Install and operate B7 DAF, piping and pumps” is removed from the Table in Pollution Reduction Program (PRP) Condition 1.2.

**1.8 Additional Round of Odour Monitoring and Reporting of Results**

By 1 December 2004, a further series of odour samples must be collected and analysed from each of the odour sources as listed in PRP Condition 1.3.

A report of the results of the odour monitoring must be submitted to the EPA’s Manager Sydney Industry at PO Box 668 Parramatta NSW 2124 by 1 January 2005.

**1.9 Additional Community Odour Annoyance Survey and Reporting of Results**

By 1 December 2004 (and not before 1 October 2004), a further round of the odour community odour diaries must be completed as specified in PRP Condition 1.4.

A report of the results of the community odour annoyance survey must be submitted to the EPA’s Manager Sydney Industry at PO Box 668 Parramatta NSW 2124 by 1 January 2005.

**1.10 Extension of time for Installation of extension stacks**

1.10.1 The extension stacks for Group 1 discharges identified in Condition 1.2 of the PRP were required to be completed by 31 August 2004. This completion date is extended to

1 April 2005.

1.10.2 The extension stacks for Group 2 discharges identified in Condition 1.2 of the PRP were required to be completed by 1 February 2005. This completion date is extended to 1 September 2005.

## PRP 2 Additional Odour Reduction Works

### U2.1 Objective

The aim of this PRP is to achieve additional odour reduction from the premises.

### U2.2 Works

The following works must be completed by the specified dates:

| ID Number | Details | Completion date |
|---|---|---|
| 1 | Install effluent pit at B8 Mill | 1 October 2004 |
| 2 | Clean and empty clarifier surge tank | 1 November 2004 |
| 3 | Redirect screenings from paper machine backwater to WPP through 3mm screen | 1 December 2004 |
| 4 | Redirect WPP sump from interceptor pit to 3mm screen | 31 December 2004 |
| 5 | Modify B7 effluent pit to reduce the size of stagnant areas | 15 January 2005 |
| 6 | Redirect flow from interceptor pit to the WPP through the 3mm screen | 31 January 2005 |

## PRP 3 Noise Reduction Works

### U3.1 Objective

The aim of this PRP is to implement a program of works to achieve compliance with the noise limit.

### U3.2 Submission of Noise Reduction Works Program

By 1 October 2004 the licensee must submit an acoustical report to the EPA’s Manager Sydney Industry at PO Box 668, Parramatta NSW 2124.

The acoustical report required by condition U3.2 must be prepared by a suitably qualified person.

The acoustical report required by condition U3.2 must:

a) Recommend options for noise reduction measures to ensure that noise levels emitted from operations of the premises achieve compliance with the limits specified in Condition L6.1; and

b) Provide a timetable for the implementation of those options so that the noise emitted from the premises achieves compliance.

**U3.3 Undertaking noise reduction works**

The works specified in the report submitted in accordance with Condition U3.2 must be completed in accordance with the timetable specified in that report.

# Appendix C CSIRO "End-of-Pipe" Literature Review

THE JOINT FORCES OF CSIRO & SCION

# A REVIEW OF THE WORLDWIDE SCIENTIFIC AND TECHNICAL LITERATURE DESCRIBING METHODS FOR END-OF-PIPE CONTROL OF ODOUR EMISSIONS FROM PAPER MILLS MANUFACTURING BROWN PAPER GRADES FROM RECYCLED FIBRE

Dr Warwick Raverty B Sc (Hons), Ph D

Senior Principal Research Scientist

October 2005

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THE JOINT FORCES OF CSIRO & SCION

# A Review of The Worldwide Scientific and Technical Literature Describing Methods for End-of-Pipe Control of Odour Emissions from Paper Mills Manufacturing Brown Paper Grades from Recycled Fibre

Dr Warwick Raverty B Sc (Hons), Ph D

Senior Principal Research Scientist

October 2005

## EXECUTIVE SUMMARY

### Objective

The objective of this review was to list available "end-of-pipe" technologies for controlling, or reducing odour emitted to the air during the manufacture of brown papers and paperboards from recycled fibre, including the routine monitoring of odour emissions.

### Key Results

1. The result of this search of the premier electronic database[1] that comprehensively abstracts the world's scientific and technical literature, indicates that there are no "end-of-pipe" technologies available for treating odour emitted to the air during the manufacture of brown papers and paperboards from recycled fibre.

2. No "end-of-pipe" methods for removing odour from paper machine vents have even been proposed, presumably because of the enormous flows of air and steam involved and the consequently prohibitive quantities of energy and materials that would be required to heat this flow to a temperature at which the odour-causing compounds would be spontaneously oxidized. Similarly, attempts to absorb these materials from the gaseous emissions would involve prohibitively large absorption vessels and prohibitively large quantities of solid or liquid absorbants that would then require regular regeneration or disposal.

3. The widely accepted modern technologies for control of odours generated during the manufacture of brown papers and paperboards from recycled fibre involve a suite of individual technologies and best management practices that are applied to steps within the manufacturing process. These include:
   3.1. Detailed monitoring of the number and type of microorganisms present in the paper machine backwater circuit, so that application of antibacterial biocides (and necessary pH adjustments) can be tailored to be more effective at lower dosage rates.
   3.2. Detailed attention to pH, flocculant and nutrient dosage rates in clarifiers and or dissolved air flotation cells (and aeration lagoons where these are employed).
   3.3. Good housekeeping within the mill.

### Application of Results

The results of this investigation demonstrate that there is no proven, economically feasible technology for "end-of-pipe" odour control in paper mills using waste paper. Nor do there appear to be any under development. The accepted control measures in developed countries involve application of best practice process and environmental management to unit processes within the mill.

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A Review of The Worldwide Scientific and Technical Literature Describing End-of-Pipe Methods for Controlling Odour Emissions from Paper Mills Manufacturing Brown Paper Grades from Recycled Fibre

Dr Warwick Raverty B Sc (Hons), Ph D

Senior Principal Research Scientist

October 2005

# INTRODUCTION

All paper mills around the world that make brown paper grades and that use waste paper as their primary raw material emit odours to the atmosphere. Ensis has been asked by Amcor to conduct a comprehensive review of the published scientific and technical literature in order to establish whether there are any "end-of-pipe" technologies, apart from the best practice process management that Amcor practises within its mills, that will reduce the odour emitted from the proposed mill. Ensis' Senior Principal Research Scientist, Dr Warwick Raverty, who has over 25 years experience in both the public and private sectors of the pulp and paper industry, with extensive experience in odour chemistry, control and reduction, has conducted this review and has prepared this report based on that review.

In any paper mill processing waste paper there are many sources of odour emissions. This odour arises primarily from the action of micro-organisms (principally bacteria and fungi) on starch (a normal component of many paper grades), and on food and beverage remnants with which the waste paper is contaminated – unwashed milk cartons being a prime example. Depending on the availability of oxygen either aerobic bacteria and fungi, or anaerobic bacteria will grow most rapidly. In general, anaerobic bacteria produce larger quantities of malodorous by-product chemicals (such as hydrogen sulfide, methyl mercaptan, and a number of volatile fatty acids (VFA), including butanoic and pentanoic and hexanoic acids), however anaerobes also produce part per billion levels of VFA which dissolve in the water used to process the recycled paper making fibre and form it into a new sheet. VFA are then volatilized spontaneously from mill tankage and clarifiers and with the water during forming and drying of the sheet and are emitted into the atmosphere around the mill. Because the human nose has evolved to detect VFA at part per billion levels in air (as a protection against eating food and drinking water contaminated with high levels of bacteria) these compounds often cause unpleasant, but otherwise unharmful, odours around recycled paper mills. The principal sources of odour within the mill are normally (in order of decreasing intensity):

i. The vents that take water vapour and steam away from the paper machine. For every tonne of paper manufactured, approximately 800 – 1000 kg of water is removed from the sheet as steam during the manufacturing stage in which the pressed, but still wet paper sheet is dried, before being wound into machine reels.
ii. Clarifiers used to remove solids from the mill water before it is recycled or discharged.
iii. Bins containing contrary materials (such as plastic, wire, glue etc.) removed from the fibre during screening and cleaning.

It is widely accepted best practice environmental management to dose the mill process water with low levels of biocides to control the level of micro-organisms growing in the mill water circuit[2]. This dosing must be controlled both for reasons of cost, and because the mill water will eventually be discharged to some form of biological treatment plant (either on the mill site, or at a sewerage works) and too high a residual level of some biocides will reduce the efficiency of biological treatment and may even be harmful to final receiving waters if levels are too high. As long as levels of micro-organisms are monitored regularly and biocide dosing is adjusted appropriately (and regular cleaning of equipment is carried out to prevent anaerobic fibre deposits building up), odour emissions can be kept to acceptable levels. Good internal house keeping within the mill is the key to odour minimization in recycled paper mills.

Information for Ensis abstracting:

| | |
|---|---|
| Contract number | FFP05/197 |
| Products investigated | Odour reduction, recycled fibre, linerboards, mediums |
| Wood species worked on | N/A |
| Other materials used | Literature review |
| Location | Sydney |

## CONCLUSIONS AND RECOMMENDATIONS

1. The result of this search of the premier electronic database that comprehensively abstracts the world's scientific and technical literature[1], indicates that there are no "end-of-pipe" technologies available for treating odour emitted to the air during the manufacture of brown papers and paperboards from recycled fibre.

2. No "end-of-pipe" methods for removing odour from paper machine vents have even been proposed, presumably because of the enormous flows of air and water vapour involved and the consequently prohibitive quantities of energy and materials that would be required to heat this flow to a temperature at which the odour-causing compounds would be rapidly oxidized. Similarly, attempts to absorb these materials from the gaseous emissions would involve prohibitively large absorption vessels and prohibitively large quantities of solid or liquid absorbants that would then require regular regeneration.

   Ozone is a powerful oxidant that is widely used to remove traces of odorous and tainting compounds from drinking water. There is one very brief reference in 1975[3] to use of ozone to destroy odour compounds in mill emissions, however no record of this technique being used commercially in the late 1970s, or since, can be found. Ozone is itself toxic above levels of 0.5 parts per million in air and also has an irritating odour at these low concentrations. On this basis, the need to constantly adjust the amount of ozone injected into the steam vents from the vents on the paper machine, so that the amount of ozone added was just sufficient to destroy the odour could presumably not be overcome in the late 1970s and the author can see no way of achieving this in a practical way in 2005.

   Another method of controlling odour in some enclosed areas, principally retail environments such as shopping malls, is to add odour suppressants to the stream of air being circulated. Odour suppressants do not destroy the VFA (present in human sweat among other sources), but merely mask them by overloading the olfactory receptors in the human nose (see Appendix 1). All of the known odour suppressants are essential oils that are expensive and would, if released into the air in the volumes required for a typical paper mill, contribute as do all volatile organic compounds (VOC) to generation of photochemical smog in the atmosphere. It is therefore not recommended that odour suppressants be used in paper mill applications for odour control.

   A third technology that is not used in recycled paper mills, but which is used in some areas of the petrochemical, pharmaceutical and food processing industries is

Regenerative Thermal Oxidation (RTO)[4]. In this process the odour containing air is heated to 300 – 400$^{o}$C and passed over a catalyst that absorbs and oxidizes the odour compounds to compounds that have less odour. The catalyst must be regenerated periodically by heating it to temperatures over 500$^{o}$C to keep it active. While this technology is appropriate for more concentrated odour streams having relatively low volumes compared to the volume of air passing through a paper machine vent, the energy input required to heat the vented air from its normal range of 80-90$^{o}$C to 300$^{o}$C would be quite uneconomic and totally out of keeping with current requirement to reduce energy usage in all manufacturing operations.

3. The accepted modern technologies for control of odours generated during the manufacture of brown papers and paperboards from recycled fibre involve a suite of individual technologies and best management practices that are applied to steps within the manufacturing process. These include:
   3.1. Detailed monitoring of the number and type of microorganisms present in the paper machine backwater circuit, so that application of antibacterial biocides[2] (and necessary pH adjustments) can be tailored to be more effective at lower dosage rates.
   3.2. Detailed attention to pH, flocculant and nutrient dosage rates in clarifiers and or dissolved air flotation cells (and aeration lagoons where these are employed).
   3.3. Good housekeeping within all areas of the mill.

# METHODS

## Search strategy

Because nuisance odours are a common by-product of many manufacturing industries, including recycled paper, it can be stated with confidence that any known technology for reducing odour emissions will be described in the open scientific literature, including the patent literature. The financial and public relations rewards that arise when nuisance odours are successfully reduced make this fact inevitable – there is simply no conceivable advantage in keeping such a development secret. The published scientific literature is therefore a comprehensive source of any such technologies and it can be searched efficiently using modern electronic information storage and retrieval services.

The search of the published scientific and technical literature was divided into two sections:

A. Technologies and methods employed or investigated within the worldwide paper industry to reduce, or control odourous substances emitted into the air during the manufacture of papers and paperboards from recycled fibre; and technologies, and
B. methods employed or investigated within the worldwide manufacturing industry to reduce, or control odourous substances emitted into the air during the production of energy, forest products, petroleum products, food, textiles, leather, chemicals and metals.

Search A, relating to the paper industry was conducted using the world's pre-eminent electronic database Paper Village 2®[1], operated by the American Engineering Institute in conjunction with the publishing company, Elsevier. The search terms were selected to reveal technical and scientific articles in the scientific and technical literature (including patents) relating to odour control during the processing of waste paper, and during the subsequent conversion of the recycled fibre that results into papers, or paperboards. The following search terms were selected:

Odour and waste paper and end-of-pipe
Odour and recycled fibre and end-of-pipe
Odour and paper machine and end-of-pipe
Odour reduction and waste paper and end-of-pipe

Odour reduction and recycled fibre and end-of-pipe
Odour control and paper machine and end-of-pipe

These combinations can be all covered in the one statement, using the term "odour* or odor*" (the * being the symbol used in these databases to cover anywords containing the letters preceding the asterisk – for example “odour*” will pick up odours, odourous, odour reduction, or odour control) combined with “paper” and paper machin* and recycled fib* and end-of-pipe and pipe.

Three searches were conducted:
Searching article title only for the years 1990-2005 with paper as a stand alone term
Searching article title only for the years 1990-2005 with paper combined with paper machin*)
Searching article title, article abstract and keywords in the article for the years 1990-2005 with all terms – with the intention of capturing as wide a range of relevant papers as possible.

The results of these searches were zero articles that included these terms, compared to 278 articles when the terms end-of-pipe and pipe (to cover unhyphenated “end of pipe”) were excluded. Detailed examination of the 278 articles discovered, revealed that 193 described odour control measures that were only applicable to non-condensable gas streams in kraft pulp and paper mills and therefore not relevant to recycling mills. 85 articles related to odour control measures in recycled paper mills that were exclusively standard “in-process” methods of the type described in section 3 of the Conclusions and Recommendations section above. There were no end-of-pipe methods for odour control described, either as fully-developed technologies, or as semi-developed laboratory research studies.

There were no descriptions of technologies or methods in regular use in recycled paper mills for quantifying and monitoring odour levels.

Search B of other (non pulp and paper) industries was conducted by referring to the comprehensive Kirk-Othmer Encyclopedia of Chemical Technology (4th edition, 24 volumes + supplements, 2000)[5] under the headings “Odor Control” and “Odor Modification”.

The results of this Search B are detailed in Appendix 1. There are no technologies described that are suitable for end-of pipe treatment of air emissions with the flow rates, temperatures and low contaminant levels of those encountered in a recycled paper mill.

# APPENDIX 1: Search of The Encyclopedia of Chemical Technology

## Odor Control

Odor is a subjective perception of the sense of smell. Its study is still in a developmental stage: information including a patent index has been compiled (310); 124 rules of odor preferences have been listed (311); detection and recognition threshold values have been given (312); and odor technology as of 1975 has been assessed (313). Odor control involves any process that gives a more acceptable perception of smell, whether as a result of dilution, removal of the offending substance, or counteraction or masking (see Odor modification; Perfumes).

8.1. Odor Measurement
Both static and dynamic measurement techniques exist for odor. The objective is to measure odor intensity by determining the dilution necessary so that the odor is imperceptible or doubtful to a human test panel, ie, to reach the detection threshold, the lowest concentration at which an odor stimulus may be detected. The recognition threshold is a higher value at which

the chemical entity is recognized. An odor unit (o.u.) has been widely defined in terms of 0.0283 $m^3$ (1 $ft^3$) of air at the odor detection threshold. It is a dimensionless unit representing the quantity of odor which when dispersed in 28.3 L (1 $ft^3$) of odor-free air produces a positive response by 50% of panel members. Odor concentration is the number of cubic meters that one cubic meter of odorous gas will occupy when diluted to the odor threshold. Selection of people to participate in an odor panel should reflect the type of information or measurement required, eg, for evaluation of an alleged neighborhood odor nuisance, the test subjects should be representative of the entire neighborhood. However, threshold determinations may be done with a carefully screened panel of two or three people (314). A general population test panel of 35 people has been described (315).

8.1.1. Static Dilution Methods

A known volume of odorous sample is diluted with a known amount of nonodorous air, mixed, and presented statically or quiescently to the test panel. The ASTM D1391 syringe dilution technique is the best known of these methods and involves preparation of a 100-mL glass syringe of diluted odorous air which is allowed to stand 15 min to assure uniformity. The test panel judge suspends breathing for a few seconds and slowly expels the 100-mL sample into one nostril. The test is made in an odor-free room with a minimum of 15 min between tests to avoid olfactory fatigue. The syringe dilution method is reviewed from time to time by the ASTM E18 Sensory Evaluation Committee, who suggest and evaluate changes. Instead of a syringe, a test chamber may be used which can be as large as a room (316, 317). A technique to make threshold determinations for 53 odorant chemicals has been described (316). The test room consisted of two chambers: an antechamber and the actual test chamber. The air in each chamber was circulated through activated carbon to provide a controlled, odor-free background for sample dilution.

8.1.2. Dynamic Dilution Methods

In this method, odor dilution is achieved by continuous flow. Advantages are accurate results, simplicity, reproducibility, and speed. Devices known as dynamic olfactometers control the flow of both odorous and pure diluent air, provide for ratio adjustment to give desired dilutions, and present multiple, continuous samples for test panel observers at ports beneath odor hoods. The Hemeon olfactometer (318, 319) uses three ports, each designed as a face piece which surrounds the lower half of the face loosely, and allows three panelists to judge simultaneously. The Hellman odor fountain (320–322) is a similar device. An olfactometer based on forced-choice-triangle statistical design has been constructed (323). To distinguish dynamically obtained group threshold values from ASTM odor units, the $ED_{50}$ (effective dose, 50%) designation may be used. $ED_{50}$ is the concentration at which half the panelists begin to detect odor in a dynamic test. $ED_{50}$ values are 5% higher at the 1000 o.u. level than ASTM odor unit values, 20% higher at 100 o.u. level, and 33% higher at the 20 o.u. level (323). Similar but greater deviations have been obtained when the Hemeon odor meter results have been compared to results of the ASTM static syringe method (323).

Another dynamic instrument, the Scentometer, is the basis for odor regulations in the states of Colorado, Illinois, Kentucky, Missouri, Nevada, and Wyoming, and in the District of Columbia (324). The portable Scentometer (Barneby-Cheney) can produce dilution ratios up to 128:1 in the field. The Scentometer blends two air streams, one of which has been deodorized with activated carbon. The dilution ratio is decreased until the odor becomes detectable (325). Improvements to dynamic methods have been recommended (326).

8.2. Odor Control Methods

Absorption, adsorption, and incineration are all typical control methods for gaseous odors; odorous particulates are controlled by the usual particulate control methods. However, carrier gas, odorized by particulates, may require gaseous odor control treatment even after the particulates have been removed. For oxidizable odors, treatment with oxidants such as hydrogen peroxide (qv), ozone (qv), and $KMnO_4$ may sometimes be practiced; catalytic oxidation has also been employed (see Exhaust control, industrial). Odor control as used in rendering plants (327), spent grain dryers (328), pharmaceutical plants (329–331), and cellulose pulping (332) has been reviewed (333–335); some reviews are presented in two symposium volumes (336, 337) from APCA Specialty Conferences. The odor-control performances of activated carbon and permanganate—alumina for reducing odor level of air streams containing olefins, esters, aldehydes, ketones, amines, sulfide, mercaptan, vapor from decomposed crustacean shells, and stale tobacco smoke have been compared (338). Activated carbon produced faster deodorization in all cases. Activated carbon adsorbers have been used to concentrate odors and organic compounds from emission streams, producing fuels suitable for incineration (339). Both air pollution control and energy recovery were accomplished.

## Odor Modification

4. Modification

4.1. Masking

Masking can be defined as the reduction of olfactory perception of a defined odor stimulus by means of presentation of another odorous substance without the physical removal or chemical alteration of the defined stimulus from the environment. Masking is therefore hyperadditive; it raises the total odor level, possibly creating an overpowering sensation, and may be defined as a reodorant, rather than a deodorant. Its end result can be explained by the simple equation of $1 + 1 = > 2$(Fig. 2**a**).

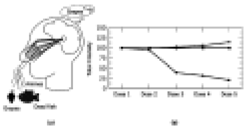

**Figure 2.** Odor masking: (**a**) how masking agents work, and (**b**) masking curve for tobacco odor, where ( ▾) is perceived odor strength (treated); ( ▪) is perceived odor strength (untreated); and (•) is tobacco odor, malodor reduction.
[Full View]

An olfactive evaluation of this phenomenon produces the following outcome:

**intensity rating malodor = 6 (moderately strong)**

**intensity rating malodor + odorous material = 8 (strong)**

**degree of modification = 8 (good masking agent)**

Odor masking does little or nothing to control malodors; it merely covers them up (Fig. 2**b**). Many materials used in masking odors are aldehydes, which are very chemically reactive and usually comprise the top note of a fragrance. Odor masking has had a long and colorful history. It gave birth to eau de cologne, devised to mask the malodor that was presumed to carry the plague. Odor masking is used in many areas of household, industrial, and institutional use via products that mask such malodors as pet smells, smoke, cooking, and numerous other odors. The forms by which masking is executed vary, and can be solid, liquid, and aerosol.

4.2. Counteraction

Counteraction, sometimes referred to as neutralization, occurs when two odorous substances are mixed in a given ratio and the resulting odor of the mixture is less intense than that of the separate components. The acceptable term to describe this occurrence is compensation. Materials that can accomplish this are basically organic odors which are highly polarized, have a strong affinity for each other, and may also have a low vapor pressure. Some of these molecules have the ability to compensate physiologically for certain malodor materials; others to react chemically with them. Counteraction occurs when the compensating substrate is able to form a coordinate bond with osmophoric sites unique to malodor molecules, such as amino- and thio- moieties. The result is overall reduction in odor; the malodor is transformed into an acceptable state, often with some residual freshening odor. This result lowers the total odor perception and can be exemplified by $1 + 1 = <2$(Fig. 3.

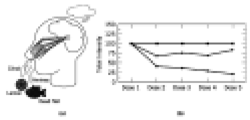

**Figure 3.** Odor counteraction: (**a**) how odor counteraction works, and (**b**) counteraction curve, where (▾) is perceived odor strength (treated); (▪) is perceived odor strength (untreated); and (•) is kitchen odor, malodor reduction.
[Full View]

An olfactive evaluation of this phenomenon produces the following outcome:

**intensity rating malodor = 6 (moderately strong)**

**intensity rating malodor + odorous material = 8 (strong)**

**degree of modification = 8 (good counteractancy agent)**

It is unlikely that two odors when combined will cancel each other and result in no odor, ie, $1 + 1 = 0$; there is always some residual odor. However, reduction of an odor by an oxidation process can destroy the odor molecule permanently and leave no residual odor.

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# Appendix D Muller BBM Expert Report