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KEMPSEY SHIRE COUNCIL

FREDERICKTON PLANNING REVIEW

ODOUR ASSESSMENT

DOCUMENT CONTROL

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EXECUTIVE SUMMARY

Airlabs Environmental Pty Ltd (Airlabs) was commissioned by Kempsey Shire Council (KSC) to undertake an Odour Assessment (the assessment) as a part of the Local Environmental Study (LES) for the Frederickton area which comes under the Kempsey Shire Council Local Government Area (LGA), located in the state of New South Wales (NSW). The aim of the LES is to undertake a review of the current land use zonings in an earmarked area for the provision of new residential and rural residential land releases, subject to a detailed planning proposal being developed. As a part of the LES process, KSC requested an odour study and as-such, this assessment aims to address that.

The re-zoning areas, which primarily comprise general residential (R1) and rural residential (R5) are adjacent to or "in the neighbourhood" of the existing Eversons Food Processors (EFP), which is a multi-species abattoir comprising an on-site rendering plant and the KSC owned and operated Frederickton Sewerage Treatment Plant (STP)

The objective of this assessment is to determine the magnitude and extent of odour impacts from the aforementioned sources on the proposed re-zones. To achieve this objective, odour dispersion modelling has been undertaken.

As per the NSW – Environment Protection Authority (EPA) *Technical Framework – Assessment and Management of Odour from Stationary Sources in NSW*, Department of Environment and Conservation, 2006, this assessment is a *Level 3* assessment as it uses at least one-year of hourly average site-representative meteorological data and the impacts are predicted using an appropriate odour emissions dispersion model. Furthermore, the odour assessment has been undertaken in accordance with the NSW – EPA *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, Department of Environment and Conservation, 2005.

When Airlabs was commissioned by KSC for undertaking this assessment, KSC informed Airlabs that the LES and the accompanying odour assessment would be considered as a feasibility / preliminary assessment at this stage of the process. Considering the preliminary nature of this assessment, it was mutually agreed that no site specific odour sampling would be undertaken either at EFP or at the Frederickton STP at this stage of the process. Odour emissions required for the dispersion modelling exercise would be sourced by drawing reference to literature data from facilities similar in operational nature to the EFP and the Frederickton STP. Subsequently, odour emission rates from the EFP and Frderickton STP have been determined by referencing literature data from similar facilities. The estimated odour emission rates were then fed into a dispersion model to predict odour impacts on the proposed re-zoning areas.

To determine odour impacts on the proposed re-zoning areas, an appropriate odour impact assessment criterion of 2.0 Odour Units (OU) was determined based on the existing environment and proposed population estimates provided by KSC.

To predict odour impacts on the proposed re-zoning areas, dispersion modelling was undertaken using the combination of the following mathematical models TAPM and CALMET / CALPUFF.

Dispersion modelling results suggested that a sizeable portion of the proposed R1 general residential could get affected due to odour impacts primarily from the operations at EFP, which included the abattoir, rendering plant and associated wastewater treatment plant. It is expected that odour impacts would stretch across a radius of 1000-1100m from the edge of the EFP facility boundary. The modelling results also suggest that a portion of existing residential development mainly to the south of the proposed R1 general residential re-zoning area could get affected due to odour impacts from the operations at EFP. No significant odour impacts are expected at the proposed R5 rural residential areas. The modelling also suggested that there would not be any adverse odour impacts from the Frederickton STP on the proposed R1 and R5 re-zoning areas. Furthermore, it was observed that the impacts from the Frederickton STP stretched to a maximum of 100-200m from the facility boundary.

Additionally, in order to undertake a comparative analysis of the modelled results, reference was drawn to buffer distances recommended by regulatory authorities. A review of the information suggested a strong agreement between the modelled results and the recommended separation distance guidelines for both EFP and the Frederickton STP.

Based on the modelling results and the guidance separation distances, Airlabs recommend that KSC undertake a review of their proposed re-zones areas (especially R1 general re-zoning area) so that it will not be adversely impacted by operations at EFP.

Although careful consideration has been given to the odour emission estimation methodology and the references cited for estimating odour emission rates, Airlabs recommend that a detailed site-specific odour sampling campaign be undertaken especially at EFP to determine site-specific odour emission rates and subsequently re-determine odour impacts on the KSC proposed re-zoning areas.

1. INTRODUCTION

Airlabs Environmental Pty Ltd (Airlabs) was commissioned by Kempsey Shire Council (KSC) to undertake an Odour Assessment (the assessment) as a part of the Local Environmental Study (LES) for the Frederickton area which comes under the Kempsey Shire Council Local Government Area (LGA), located in the state of New South Wales (NSW). The aim of the LES is to undertake a review of the current land use zonings in an earmarked area for the provision of new residential and rural residential land releases, subject to a detailed planning proposal being developed.

As a part of the LES process, the Council requires an Odour Study and as-such, this assessment aims to address that.

As per the NSW – Environment Protection Authority (EPA) *Technical Framework – Assessment and Management of Odour from Stationary Sources in NSW*, Department of Environment and Conservation, 2006 (hereafter 'the Odour Technical Framework'), this assessment is a *Level 3* assessment as it uses at least one-year of hourly average site-representative meteorological data and the impacts are predicted using an appropriate odour emissions dispersion model. Additional details of the model used and the modelling methodology are provided in the later sections of this report.

2. STUDY OBJECTIVE

The Council is undertaking an LES comprising a review of the land use zones in an earmarked area. The first phase of the review was undertaken throughout the second half of 2015 and involved carrying out initial investigations and community consultations to test the feasibility of a broader review of the current land use zonings. As of December 2015, it was resolved to proceed to the second stage of the review with the aim of preparing a series of environmental studies or reports to underpin the development and completion of an LES and Planning Quotation by early 2017.

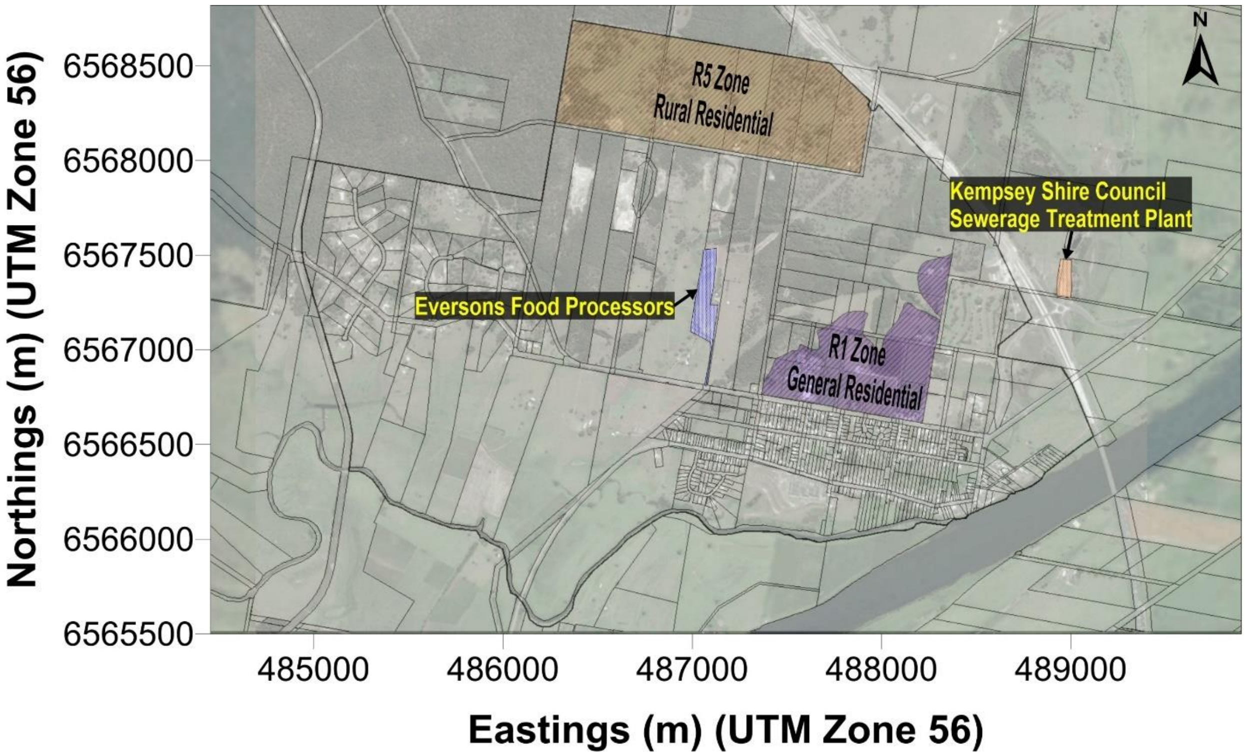
The re-zoning areas, which primarily comprise general residential (R1) and rural residential (R5) are adjacent to or "in the neighbourhood" of the existing Eversons Food Processors (EFP), which is a multi-species abattoir and comprises an on-site rendering plant and the Council owned and operated Frederickton Sewerage Treatment Plant (Frederickton STP)

The objective of this assessment was to determine the magnitude and extent of odour impacts from the aforementioned sources on the proposed re-zones. To achieve this objective, odour dispersion modelling was undertaken, where in odour emissions from the aforementioned sources were determined and fed into an appropriate dispersion model, which then predicted odour impacts at the proposed re-zoning areas. The predicted odour concentrations were then assessed against relevant odour assessment criteria, for identifying odour impacted areas.

It is to be noted that at the time of preparing the fee proposal (Q16025.1, 6th May, 2016) for the assessment, the Council informed Airlabs that the LES and the accompanying odour assessment would be considered as a feasibility / preliminary assessment at this stage of the process. Considering the preliminary nature of this assessment, it was mutually agreed that no site specific odour sampling would be undertaken either at EFP or at the Frederickton STP. Odour emissions required for the dispersion modelling exercise would be sourced by drawing reference to literature data from facilities similar in operational nature to the EFP and the Frederickton STP.

An aerial layout of the Council proposed re-zoning areas and the identified sources (i.e. EFP and Frederickton STP) are illustrated in **Figure 1**.

Figure 1: Aerial Overview of the Proposed Re-Zoning Areas and the Potential Sources of Odour



3. ASSESSMENT METHODOLOGY AND APPROACH

As mentioned earlier, this is a Level 3 assessment in accordance with the Odour Technical Framework document. Furthermore, the document states that odour dispersion modelling is to be undertaken in accordance with the NSW – EPA *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, Department of Environment and Conservation, 2005 (hereafter 'the Approved Methods')

Section 9 of the Approved Methods stipulates minimum requirements regarding information to be presented in an air quality assessment, which is outlined below. The relevant sections in this assessment, which provide details on the minimum requirements, are mentioned alongside:

- Site Plan / Study Area – **Section 2**;
- Project Description – **Section 2**;
- Detailed Description of Assessed Sources – **Section 7**
- Emissions Inventory – **Section 8**;
- Existing Environment and Meteorological Data – **Section 6** and **Section 9**;
- Dispersion Modelling – **Section 9**; and **Section 10**
- Bibliography – **Section 12**

In order to determine odour impacts from the identified sources (i.e. EFP and STP) on the proposed re-zoning areas (refer **Figure 1**), the following tasks have been undertaken:

- Identifying relevant regulatory framework;
- Characterising topographical features surrounding the sources and the proposed re-zoning areas;
- Characterising the existing environment – which includes local meteorological conditions;
- Estimating odour emission rates for the identified sources. As mentioned in **Section 1**, the odour assessment is a preliminary / feasibility stage assessment and as-such, odour emissions would be determined through a desktop approach, where in emission rates would be estimated by drawing reference to literature data from facilities similar in operational nature to the identified sources – i.e. EFP and STP;
- Predicting ground level odour concentrations through dispersion modelling for the identified sources in accordance with the Odour Technical Framework and the Approved Methods for Modelling and subsequently determining the level of odour impacts on the proposed re-zoning areas;
- Presentation of modelling results in the form of odour concentration isopleths.

4. PROJECT SETTING

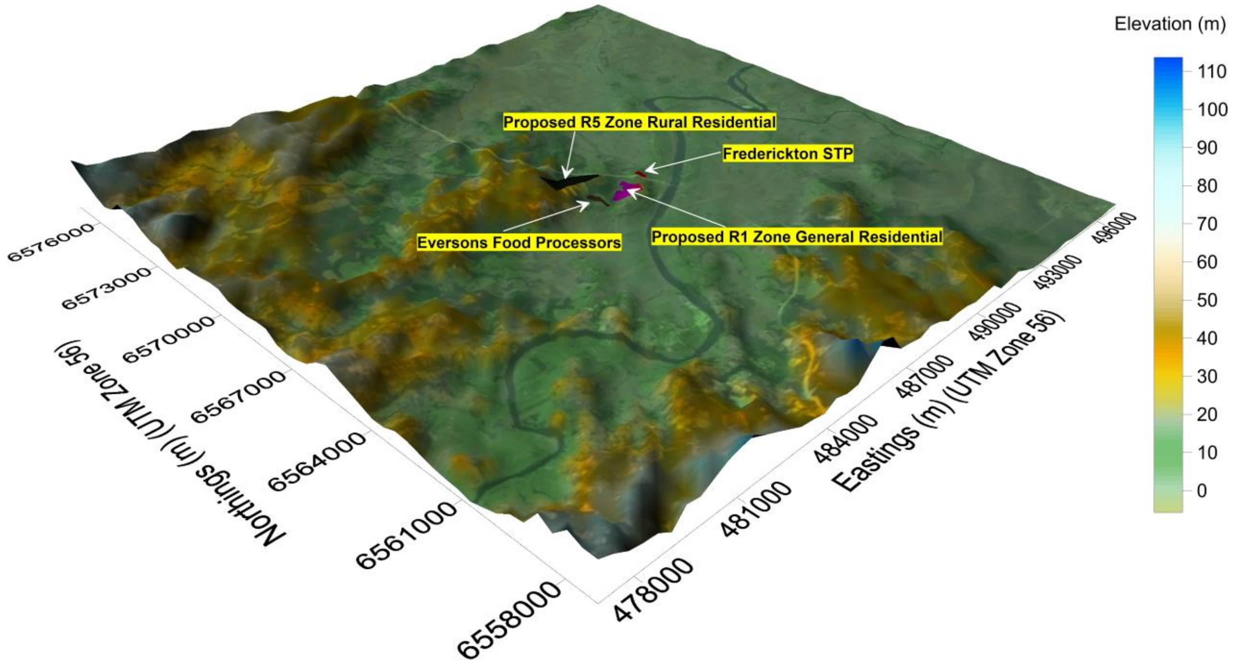
The proposed re-zoning area comprising the general residential (R1) and the rural residential (R5) along with the identified sources of odour are all located within the Frederickton Village.

As observed from **Figure 1**, there is existing residential development immediately south of the proposed general residential (R1), separated by the Great North Road. The proposed general residential (R1) zone is approximately 400-450m from the nearest site boundary of the EFP, whereas the rural residential (R5) is approximately 500m north from the closest site boundary. The STP is situated east of the Pacific Highway and is considerably separated from the proposed R1 general (circa. 600-650m) and R5 rural residential areas (circa. 1100-1150m). Based on Airlabs' experience in undertaking odour assessments, it is expected that there would not be significant odour impacts on the proposed re-zoning area exclusively from the STP owing to its separation distance, however, as per information provided to Airlabs by KSC, there exists a potential opportunity for residential development surrounding the STP which has not yet been identified / earmarked at this point of time and therefore in order to pre-empt potential odour impacts, the STP has been assessed as a source in this assessment.

Apart from the EFP and the Frederickton STP, no other sources of odour have been identified which could have a potential impact on the proposed re-zoning areas.

A 3-dimensional representation of topographical features surrounding the study area are illustrated in **Figure 2**. Topography can have a significant influence on air dispersion, especially during night-time and stable conditions when wind speeds are low, air tends to drain (katabatic drainage) towards low-lying areas. It is to be noted that the landforms surrounding the study area are relatively flat and undulating with the terrain gradually increasing towards the southern, western and north-western regions of the study area.

Figure 2: Topographical Features Surrounding the Re-Zoning Areas and the Potential Sources of Odour



5. REGULATORY FRAMEWORK

5.1 National Legislation

In June 1998 (revised in 2003), the National Environment Protection Council (NEPC) developed the Ambient Air Quality National Environmental Protection Measure (NEPM) which sets out uniform standards for air quality at the national levels and has included ambient air quality standards for carbon monoxide (CO), nitrogen dioxide (NO_2), photochemical oxidants (as ozone – O_3), sulfur dioxide (SO_2), lead and particulate matter with a nominal aerodynamic diameter of less than or equal to 10 microns (PM_{10}). The NEPM was revised in 2003 to include an advisory reporting goal for particulate matter with a nominal aerodynamic diameter of less than or equal to 2.5 microns ($PM_{2.5}$). It is to be noted that currently there are no national goals / guidelines regarding odour.

5.2 NSW Legislation

The *Protection of the Environment Operations Act 1997* (POEO 1997) and the *POEO Clean Air Regulations 2010 (Clean Air Regulations 2010)* set out the necessary frameworks and regulations for managing air emissions in NSW. The Act sets out provisions for issuing Environmental Protection Licences (EPLs) to control and limit air emissions. The Regulations prescribe emission limits based on the type of activity. The Regulations also stipulate that air quality assessments in NSW have to be undertaken in accordance with the Approved Methods.

The Odour Technical Framework provides guidance for industry, consent authorities, environmental regulators and odour specialists on assessing and managing activities that emit odour. The Framework provides:

- Legislation concerning odour assessment and management in NSW;
- A fair and transparent process for assessing odour impacts from new developments;

- Risk-based approaches and strategies for dealing with ongoing odour impacts from existing activities; and
- A technical reference document for proponents and regulators.

The Odour Technical Framework adopts the odour assessment criteria outlined in the Approved Methods. The assessment criteria are used to assess the likely performance of a project and acceptability of impacts at the nearest placed where people are likely to work or reside (both existing and any likely future sites).

5.3 Odour Impact Assessment Criteria

The detectability of an odour is a sensory property that refers to the theoretical minimum concentration which produces an olfactory response or sensation (PAE Holmes, 2009). That theoretical minimum concentration is referred to as the "odour threshold "and is also referred to as one (1) Odour Unit (OU). Therefore, an odour concentration of less than 1 OU would theoretically mean that there wouldn't be any odours perceived. Typically, the levels at which an odour is perceived to be a nuisance can range from 2 OU to 10 OU, depending on several factors, commonly referred to as the FIDOL factors. These factors determine whether an odour will result in a complaint or not. The FIDOL factors include:

- the **F**requency of the exposure;
- the **I**ntensity of the odour;
- the **D**uration of the odour episodes;
- the **O**ffensiveness of the odour; and
- the **L**ocation of the source.

The odour assessment criterion specified in the Odour Technical Framework is adopted within the Approved Methods. As per the Approved Methods, the assessment criterion is applicable at the nearest existing or likely future off-site sensitive receptors and is to be reported as the 99th percentile peak (1-second average) incremental (predicted impact due to the modelled sources alone) odour concentration.

It is to noted that the criterion is designed taking into account the range in sensitivities to odours within the community, and also provide additional protection for individuals with a heightened response to odours. As-such, the assessment criterion is directly linked to the population densities as shown in **Table 1** and is established through the below formula:

$$Impact\ assessment\ criterion\ (Odour\ Units) = \frac{log10\ (population) - 4.5}{-0.6}$$

In order to establish appropriate assessment criteria, population estimates were provided to Airlabs by KSC. It is expected that a total of 470 dwellings would be developed over a 20-year period within the identified re-zoning areas, in addition to the existing residential development. As per KSC provided average density of 2.4 persons per dwelling, it is estimated that the total population to be housed within the re-zoning areas would be approximately 1,316 people in addition to the existing community. Considering the existing and proposed residential developments, an odour impact assessment criterion of 2.0 OU, which according to **Table 1** is applicable for an urban community > 2,000 people was considered appropriate for this assessment.

As per the Approved Methods, the assessment criterion of 2.0 OU is applicable at the nearest existing or likely future off-site sensitive receptors and is to be reported as the 99th percentile peak (1-second average) incremental (predicted impact due to the modelled sources alone) odour concentration. The 99th percentile implies that the assessment criteria can be exceeded only for 1% of the entire year (i.e. 87 hours of the 8760 hours in a year).

Dispersion models typically predict concentrations valid for averaging periods of 1-hour or longer. As such, in order to determine peak (1-second) average concentrations, peak to mean factors (referred to as peak (1-second) to mean (1-hour) ratios) are applied to account for the odour fluctuation between the 1-second nose response time and the mean odour concentrations predicted over a 1-hour averaging period. The peak to mean ratios are dependent on the type of sources (e.g. point, area, volume etc.) and the atmospheric stability. Based on the modelled sources and the atmospheric stability, appropriate peak-to-mean factors have been determined and applied to 1-hour average concentrations to determine peak 1-second average odour concentrations. A summary of peak-to-mean factors for estimating odour concentrations are shown in **Appendix A**.

Table 1: Impact Assessment Criteria – Complex Mixtures of Odorous Air Pollutants

Population of Affected Community	Impact Assessment Criteria (Odour Units – OU)
Urban (≥~2000) and /or schools and hospitals	2.0
~500	3.0
~125	4.0
~30	5.0
~10	6.0
Single rural residence (≤~2)	7.0

6. EXISTING ENVIRONMENT

This section characterises the long-term climatic conditions and existing meteorological conditions.

6.1 Climate Statistics

Long-term climatic data from the Bureau of Meteorology (BoM) Kempsey Airport Automatic Weather Station (AWS) (Station No: 059007) (hereafter 'BoM Kempsey Airport AWS') were analysed to characterise the local climatic conditions. The key aspects that were analysed to understand the long-term climatic conditions were – mean minimum and maximum temperatures, mean 9AM and 3PM temperatures, rainfall data, mean 9AM and 3PM relative humidity (RH) levels and mean wind speeds. Analysed climate data is visually illustrated in **Figure 3** to **Figure 6**.

Figure 3: Long-Term Average Temperature Profile – BoM Kempsey Airport AWS

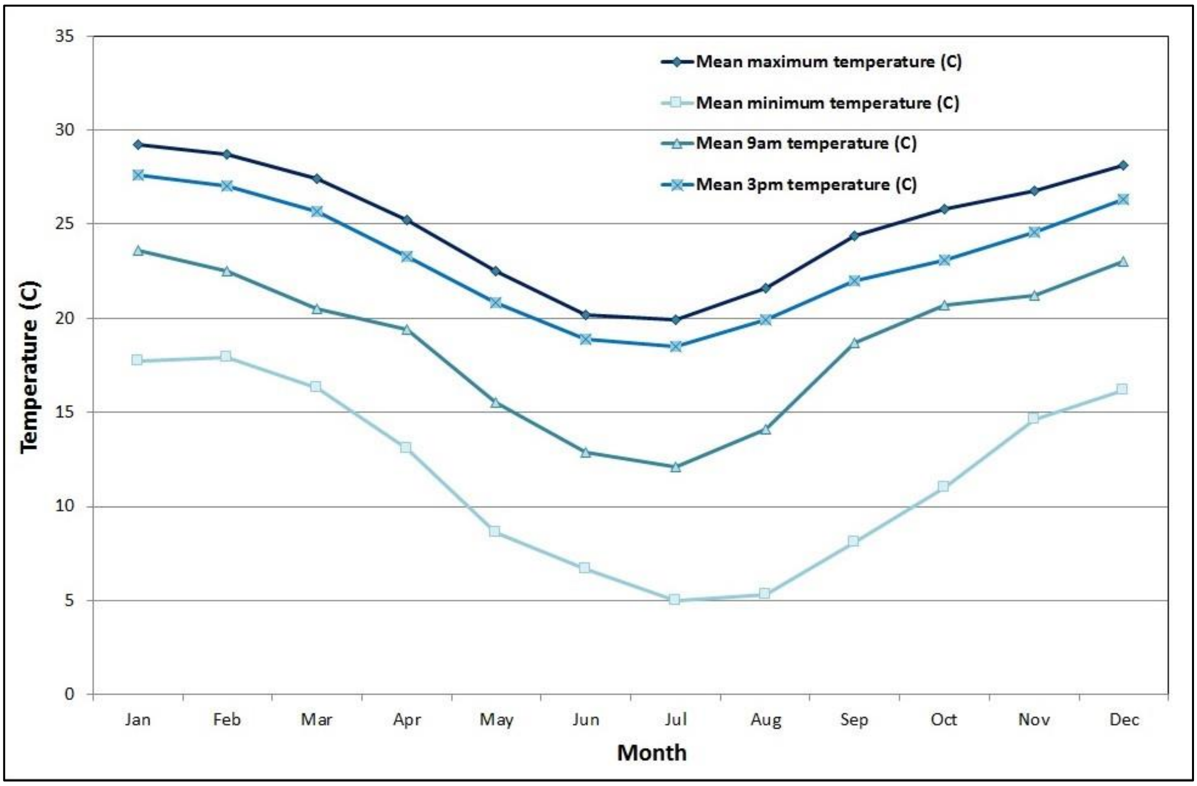


Figure 4: Long-Term Average Rainfall Data – BoM Kempsey Airport AWS

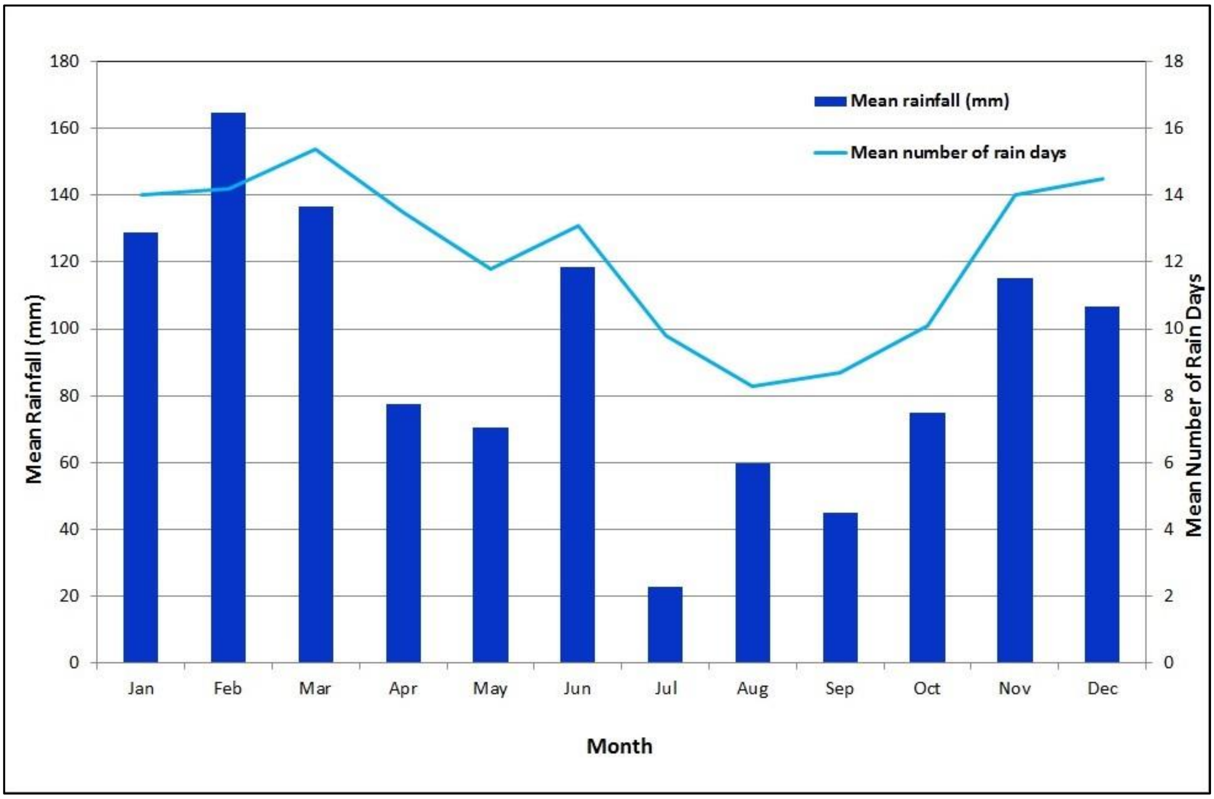


Figure 5: Long-Term Average 9AM and 3PM Mean Relative Humidity Levels – BoM Kempsey Airport AWS

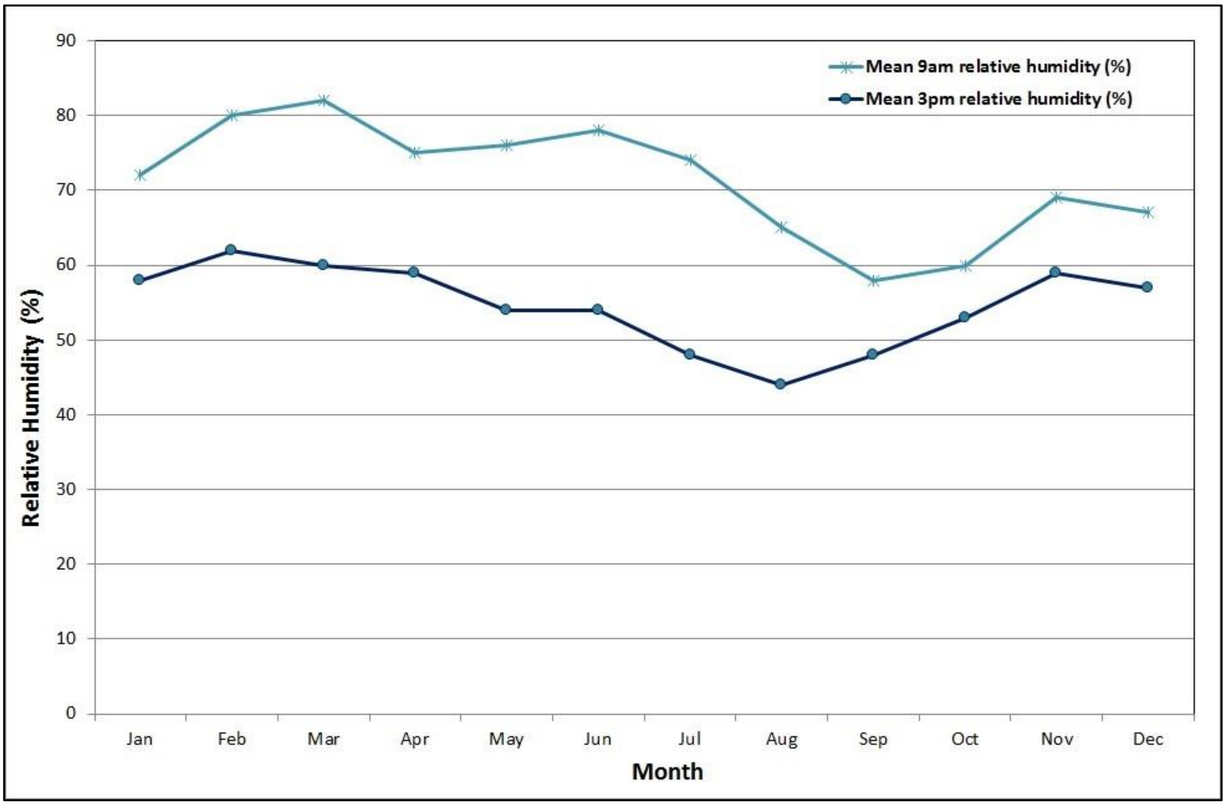
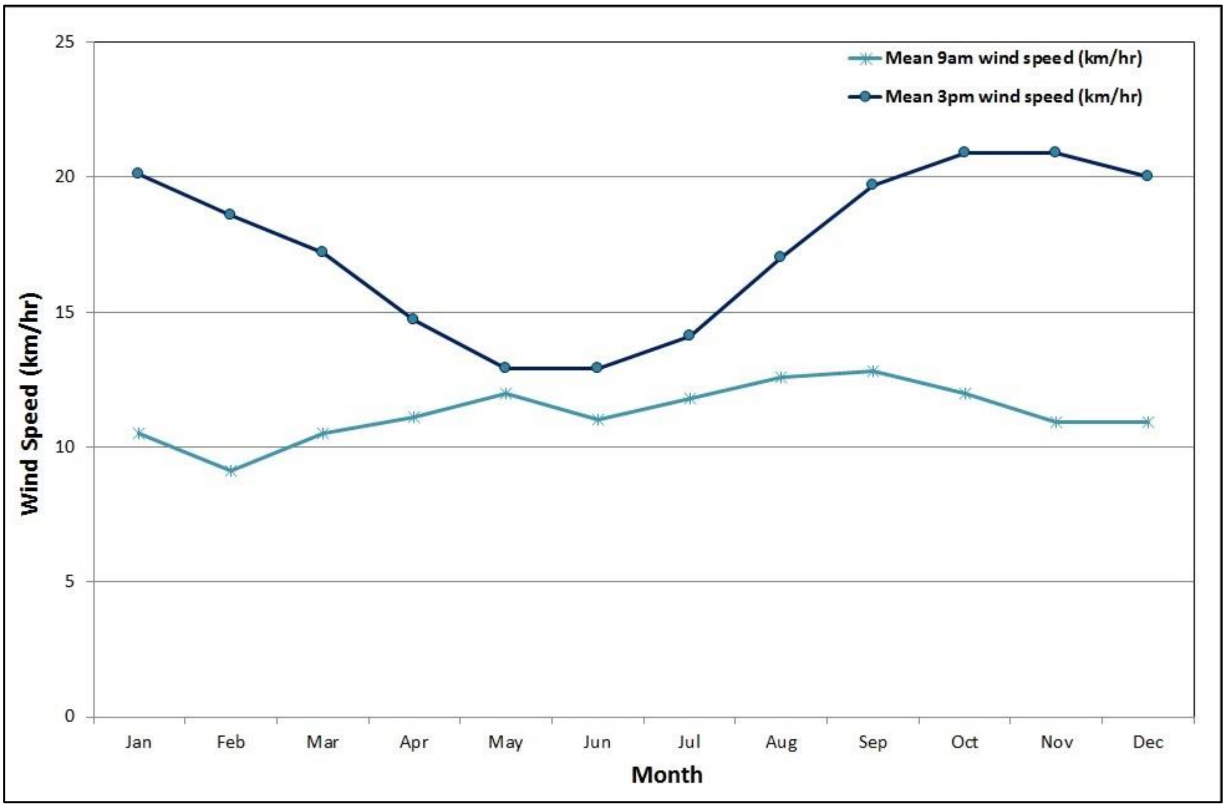


Figure 6: Long-Term Average 9AM and 3PM Mean Wind Speeds – BoM Kempsey Airport AWS



From the data illustrated in **Figure 3** to **Figure 6**, the following observations can be made:

- Highest mean maximum temperatures are observed during January with a mean maximum temperature of 29.2^0 C;
- July is observed to the coldest of all the months, with a mean minimum temperature of 5^0 C;
- High rainfall generally occurs during summer season, with the highest rainfall levels recorded in the month of February;
- There is a clear distinction between Relative Humidity (RH) levels recorded at 9AM and 3PM. The 9AM RH levels vary between 58-82% and the 3PM RH levels vary between 44-62%;
- Similarly, a clear distinction can be observed between the 9AM and 3PM wind speeds. The mean 9AM wind speed averaged over all months is 11.2km/hr whereas the mean 3PM wind speed averaged over all months is 17.4 km/hr.

6.2 Existing Meteorological Conditions – Wind Profile, Stability Class and Mixing Height

As no meteorological monitoring is undertaken at the proposed study area, hourly average weather monitoring data was sourced from the BoM Kempsey Airport AWS. Hourly averaged wind statistics (wind speed and wind direction) for a five (5) year (2011 through to 2015) were collated for Kempsey Airport AWS for generation of wind roses presented in **Figure 7**.

From the wind roses illustrated in **Figure 7**, the following observations are made:

- Prevailing winds on an annual basis are predominantly from the westerly direction;
- Seasonal variation is observed in the wind patterns especially during spring months as high speed easterly winds become more frequent.

Stability of the atmosphere is determined by a combination of horizontal turbulence caused by the wind and vertical turbulence caused by the solar heating of the ground surface. Stability cannot be measured directly; instead it must be inferred from available data, either measured or numerically simulated.

The Pasquill-Gifford scale defines stability on a scale from A to G, with stability class A being the least stable, occurring during strong daytime sun and stability class G being the most stable condition, occurring during low wind speeds at night. For any given wind speed the stability category may be characterised by two or three categories depending on the time of day and the amount of cloud present. In meteorological models such as CALMET, the stability classes F and G are combined.

A summary of the numerically simulated hourly stability class data for the five-year period (2011 through to 2015) is presented in

Figure 8. Stability class F is predicted to occur most frequently (46%), indicating that the dominant conditions are moderately to very stable, with very little lateral and vertical diffusion.

The mixing height quantifies the vertical height of mixing in the atmosphere and is a modelled parameter that is not able to be measured directly. Numerically simulated CALMET hourly mixing height data are presented in **Figure 9** for the five-year period (2011 through to 2015)

Figure 9 shows the mixing height as a function of the hour of the day at the study area. The graph represents the typical growth of the boundary layer, whereby the mixing height is generally lowest during the night and into the early morning and highest during the late afternoon. The mixing height decreases in the late afternoon, particularly after sunset, due to the change from surface heating from the sun to a net heat loss overnight. Low mixing heights typically translate to stagnant air with little vertical motion, while high mixing heights allow vertical mixing and good dispersion of pollutants.

Figure 7: Annual and Seasonal Wind Roses – Kempsey Airport AWS (2011 – 2015)

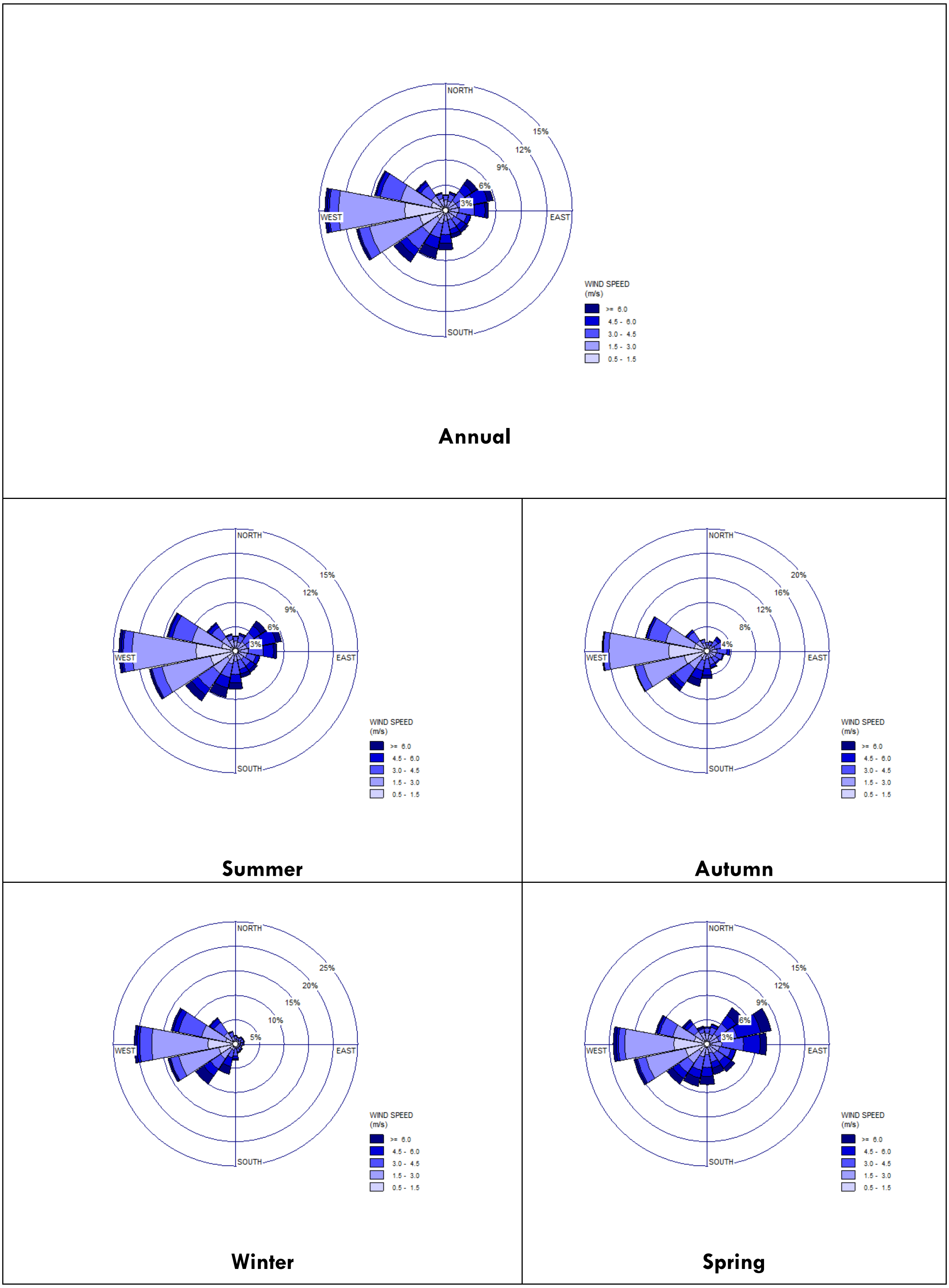


Figure 8: Frequency of Stability Class – CALMET (2011 – 2015)

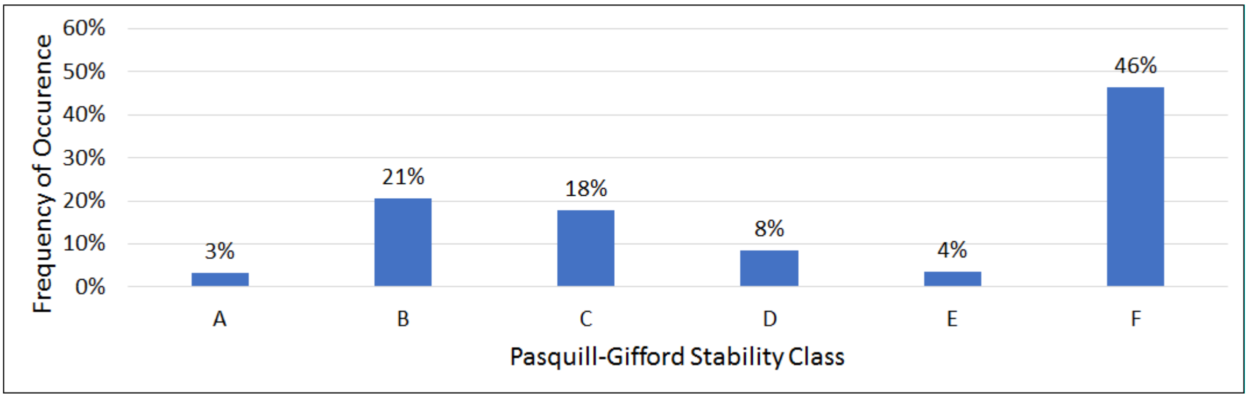
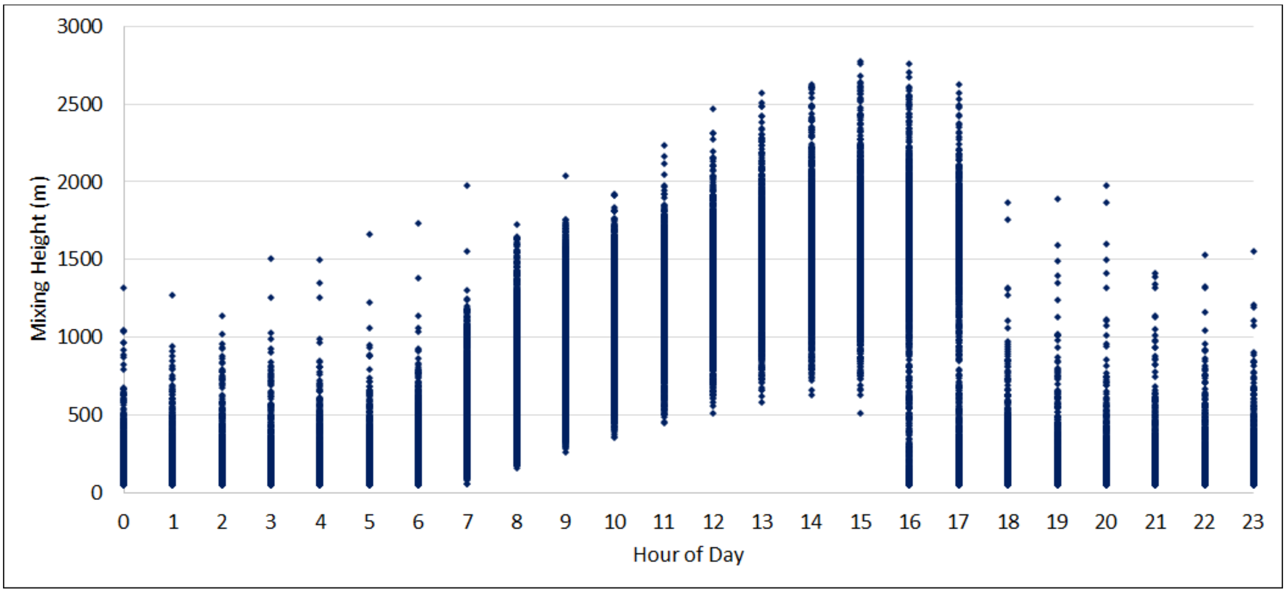


Figure 9: CALMET Predicted Diurnal Variation in Mixing Heights (2011 – 2015)



7. SOURCE DESCRIPTION

As mentioned in **Section 2**, the general residential (R1) and rural residential (R5) re-zoned areas are adjacent to or "in the neighbourhood" of the existing Eversons Food Processors (EFP), which is a multi-species abattoir and comprises an on-site rendering plant and the Council owned and operated Frederickton Sewerage Treatment Plant (Frederickton STP).

A detailed understanding of the operations and activities undertaken at the EFP and the Frederickton STP is required to comprehensively characterise odour emissions and subsequently predict their impacts on the proposed re-zoned areas. A site inspection was undertaken by Airlabs personnel in June, 2016. Information gathered during the site inspection and a detailed review of provided literature including previous assessments enabled a comprehensive understanding of the EFP and STP, which is summarised in this section. As mentioned in **Section 4**, no other sources of odour have been identified which could have a potential impact on the proposed re-zoning areas.

7.1 Overview of Operations – Eversons Food Processors (EFP)

Macleay River Meats (MRM) trading as Eversons Food Processors (EFP) is a family owned and managed multi-species abattoir located at 60 Collombatti Road, Frederickton, NSW operational since 1974.

MRM is the largest domestic multi-species abattoir in Australia and has been owned and operated by the Eversons family since 1998. Based on a review of information provided and site inspection undertaken by Airlabs personnel, it is noted that principal operations include stock washing, livestock slaughtering, boning, chilled storage, sheep skin salting, cattle hide brining/drying and rendering.

MRM wholesales its own meat products and also operate a service kill for wholesale butchers, who in turn sell to retailers. Livestock is generally delivered to the abattoir by wholesale butchers. The delivered livestock is then processed and stored by MRM before delivery to customers. Livestock currently processed at MRM includes – cattle, calves, sheep, lamb, pigs, goats and water buffaloes.

Macleay River Proteins (MRP) is the on-site rendering plant which has been operational since 1984 processing all production waste including fat, bone and inedible offal from the MRM to produce tallow and meat meal. The MRP also provides a daily fat and bone waste collection service to butcher's shops and supermarkets. A detailed description of operations at MRP is provided in the subsequent sections of this report.

The MRM and MRP operate on a Monday-Friday (5 days a week) cycle from 5AM to 10PM.

Wastewater from MRM and MRP is treated through a three-pond treatment system. Treated water is recycled to irrigation, cattle and stockyard washing and to MRP where it cools and processes cooking odours.

Since the time of commissioning, the abattoir has undergone significant upgrades, with major changes occurring in 1994 (expansion of the abattoir), 2004 (application to process small stock) and 2008 (design and commissioning of the wastewater treatment system)

In order to gain a comprehensive understanding of the process and odour management at the abattoir, and the rendering plant, a review of all major modifications and their corresponding environmental assessments was undertaken. Key documents that have been reviewed as a part of this study include:

- *Air Quality Impact Assessment of the Frederickton Abattoir*, Environmental Impact Statement (EIS), Proposed Expansion of Abattoir at Frederickton, Katestone Environmental, 1994;
- *Environmental Impact Statement (EIS)*, Eversons Food Processors - Proposed Abattoir Wastewater Treatment System, Environmental Resources Management (ERM), 2006;
- *Air Quality Assessment*, Environmental Impact Statement (EIS), Eversons Food Processors - Proposed Abattoir Wastewater Treatment System, Environmental Resources Management (ERM), 2006;

- *Biofilter Remediation Strategy*, Macleay River Proteins, PAE Holmes, April 2012; and
- *Ongoing Biofilter Operation and Maintenance Strategy*, Macleay River Proteins, PAE Holmes, May 2012.

Based on a review of the aforementioned documents, information gathered by Airlabs during the site inspection and correspondence with staff at EFP, a detailed description of operations at MRM, MRP and treatment of wastewater has been determined which is outlined below.

7.1.1 Macleay River Meats (MRM)

As mentioned earlier, principal operations at the abattoir include stock washing, livestock slaughtering, boning, chilled storage, sheep skin salting, cattle hide brining/drying and rendering.

The processing capacities (head count) were referenced from the National Greenhouse Energy Reporting (NGER) calculator for EFP. From the NGER calculator, the total head killed for all species for each of the last five (5) financial years, the number of operational days for those corresponding years and an estimated average head killed per day have been determined and are presented in **Table 2**.

Table 2: EFP Processing Capacities 2011-16

Financial Year	Total Head Killed (All Species)	Total Working Days	Estimated Average Head Killed (All Species) per day
2011-12	499,714	251	1,991
2012-13	548,491	250	2,194
2013-14	609,384	252	2,418
2014-15	643,600	253	2,544
2015-16	599,132	257	2,331
AVERAGE	**580,064**	**253**	**2,296**

Based on review of the aforementioned previous assessments, an overview of the operations undertaken at the abattoir has been determined and is presented below:

- Livestock are received in a designated unloading area, which is next to the stock holding yards. Received livestock are unloaded from transport vehicles and are directly placed into the holding yards;
- Livestock that has been washed is directed to the knocking box. Post knocking, they are placed in a cradle and hooked onto the moving conveyor for processing;
- The livestock is then bled with over 90% of the blood captured and processed at MRP;
- After bleeding, the horns and heals are removed along with the hides. The horns and heals are sent to MRP for processing, whereas the hides are preserved through salting and drying before being exported;
- The carcass is sawn in half with the stomach, excess fat and offal processed at MRP. The carcasses are washed and sent to the chillers for dispatch to customers;
- Majority of the trimmings are collected and sent to the rendering plant for further processing thereby eliminating excess fat entering the wastewater system;
- Blood recovered from the slaughter room floor is drained and collected into a blood receival pit, from where it is collected and processed at MRP.

The operations in the abattoir are not considered to be a high impact source of odour as freshly butchered meat is not highly odorous and moreover, the abattoir is enclosed during operational hours. The livestock holding area characterised by a typical livestock odour is considered a continuous source of odour, although, not as offensive as the odours generated from rendering operations.

7.1.2 Macleay River Proteins (MRP)

As mentioned earlier, the MRP is the on-site rendering plant which has been operational since 1984 processing all production waste including fat, bone and inedible offal from the MRM to produce tallow and meatmeal. Rendering is the process undertaken to convert by-products into value added products such as tallow and meatmeal.

The rendering plant is located immediately adjacent to the abattoir. Abattoir and butcher waste are conveyed to the cooker. Cooked solids are passed through a perforated screen to remove any gross material and pressed to remove tallow. The tallow is passed through screening prior to decanting in a centrifuge. The tallow is bulked for off-site distribution while the backwash from the centrifuge is sent to the wastewater system.

A detailed description of operations and odour abatement measures currently implemented at the MRP are summarised below:

- Raw materials from the abattoir enters a hopper at the eastern part of the building and is transferred by a screw conveyor to the top of the three ovens in operation;
- There is a separate blood collection vessel and processing units (blood dehydrator) to the right of the raw material hopper. Processed – heated and centrifuged solids from the blood dehydration process are transferred to one of the screws that feed to the ovens;
- The material is cooked in batches and an operator decides when the material is to be removed from the oven;
- The ovens are manually opened by the operator and the contents fall out to a collection vessel beneath the open door. Solid material and tallow are partially separated by a percolator;
- A screen conveyor transfers the remainder of the material to the presses to remove the remainder of the tallow from the protein solids;
- The tallow is further processed to remove solids and water. It is then considered ready to be transferred to the tallow tanks;
- The solid residue following tallow extraction is the metameral or also known as the pressed cake. The pressed cake is milled (via a hammer mill) to a coarse powder and transferred to the meatmeal storage hopper;
- The MRP has a coal-fired boiler which is used for generating steam for the cooking operation and hot water for the abattoir;

Odours generated from rendering operations are a major source. In order to effectively manage and minimise odour emissions from the MRP, the following abatement measures are implemented:

Odour Abatement Measures:

- The raw material brought from the abattoir is processed immediately and maintained in a fresh condition prior to rendering;
- Odours generated from the rendering process including cooking of animal by-products and blood processing are mitigated using a combination of condensation, wet scrubbing (using water) and biofiltration;

- At the MRP, the cooking air is extracted through a heat exchanger to capture heat from the process. The non-condensable gases are then ducted into a water scrubber before biofiltration. Based on information provided to Airlabs, the condensate derived from the cooking will be diverted to the save-all;
- The biofilter ultimately treats the process air generated from the cookers, the area around the cookers, the press area and the blood processing area before it is discharged to the atmosphere. This system has been designed in 2004, but has been operational since 2008. This system has been designed to capture and extract the emissions from the cooking process which are considered to be the most odorous. Odorous air that is treated by the biolfilters is extracted from the following places at the MRP:
    - The hood above the cooker discharge points;
    - The ducts above each of the three cookers that transfer the cooker vapours to the heat exchanger;
    - The screw mechanism that transfers blood solids to the raw material screw conveyor; and
    - Air from the general cooking area.
- A typical operation of the biofilter is provided below:
    - Air entering the biofilter initially passes through a wet scrubber so that the air is near 100% saturated. This is done to ensure that the air is fully saturated so that it doesn't dry out the media in the biofilter;
    - The biofiltration process involves absorption of odorous compounds into a biologically active membrane (i.e. bacteria on the biofilter media). The odorous compounds from the cooking process are oxidised by the bacteria in the media to odourless compounds as the micro-organisms on surface of the materials in a biofilter bed have the capacity to break down a wide variety of organic and inorganic odorous compounds (pp 157-162 *Odour Abatement by Biofiltration and Dispersion*, CSIRO). Aerobic microbial activity only occurs in damp conditions and requires a film of water on the surface of the particles of materials in the bed. Oxygen is also required for the process. The odours, oxygen and vapours are transferred to the very thin film of water that adheres to the surface of the solid material in the biofilter medium. If the moisture content in the media is insufficient, it has the potential to reduce the proliferation of microorganisms that oxidises the odorous compounds as there is a reduction in the aqueous layer. In rendering operations, the moisture in the media is removed in the air passing through the media and through evaporation. As well as saturating the air that enters the biofilter, irrigation of the media is required to ensure that the correct moisture content is maintained. However, application of excessive water is counterproductive as it can lead to non-uniform saturation of the media leading to channelling of air (potentially without any removal of odorous compounds) and enhance degradation and wash the biofilm of the media which will reduce the efficiency of the biofilter.
- A review of the operation of the biolfilter installed at MRP was undertaken by PAE Holmes in 2012 (PAE Holmes, 2012). The study was commissioned after the NSW-EPA requested that a report be prepared which included – a detailed description of the condition of the existing biofilter, recommendations of necessary remediation works to optimise the performance of the biofilter and demonstrate that all recommended measures have been implemented;
- As a part of the study, Airlabs have been provided a copy of the *Biofilter Remediation Strategy* (PAE Holmes, April 2012) and the *Ongoing Biolfilter Operation and Maintenance Strategy* (PAE Holmes, May 2012) reports which were issued as a part of the biofilter

review. The aforementioned documents were reviewed by Airlabs and the key findings are provided below:

- o The biofilter media (woodchips) does allow the biofilter to operate effectively to remove odours from the airstream;
- o Character of the odour coming from the biofilter was typical of what is expected of a woodchip biofilter operating at a rendering plant;
- o No strong odours were observed while standing at various places on and downwind of the biolfilter indicating that there wasn't significant air channelling;
- o The air appeared to be passing through the surface of the biofilter uniformly, evidenced based on observation of water vapour in the air coming from the surface of the biofilter;
- o No subsidence of the biofilter media was observed;
- o The biofilter media which was replaced in January 2011 was considered adequate at the time of this review and as-such, no remediation of the biofilter media was recommended;
- o It is noted that the biofilter had no roof on it up till the time that the NSW-EPA officials visited the facility in January 2012. Since then, a roof has been commissioned and this has been evidenced by site inspection undertaken by personnel from Pacific Environment and during the site inspection undertaken by Airlabs personnel. Having a roof over a biofilter ensures that moisture content in the media is not affected by precipitation or excessive evaporation;
- o Moisture content in the media was well managed, regularly measured and the surface of the media irrigated using a sprinkler system to maintain the moisture content;
- o As a part of the review of the performance of the biofilter, PAE Holmes recommended management strategies which included a prescriptive moisture determination methodology, a methodology for monitoring the odours from the biofilter on a daily basis and containment of the fugitive odorous emissions from the production area in the MRP.

- As mentioned above, Airlabs undertook a site inspection of the MRM and MRP in June 2016. The observations made during the site inspection in June 2016 are similar to the observations made by PAE Holmes in 2012, especially in relation to the functioning of the biofilter, which effectively captures and treats odorous emissions discharged from the MRP.

A layout of the MRP and a picture of the biofilter in operation is illustrated in **Figure 10** and **Figure 11**. An enlarged layout of the MRP along with MRM is provided in **Appendix B**.

Figure 10: Layout of the Macleay River Proteins (MRP)

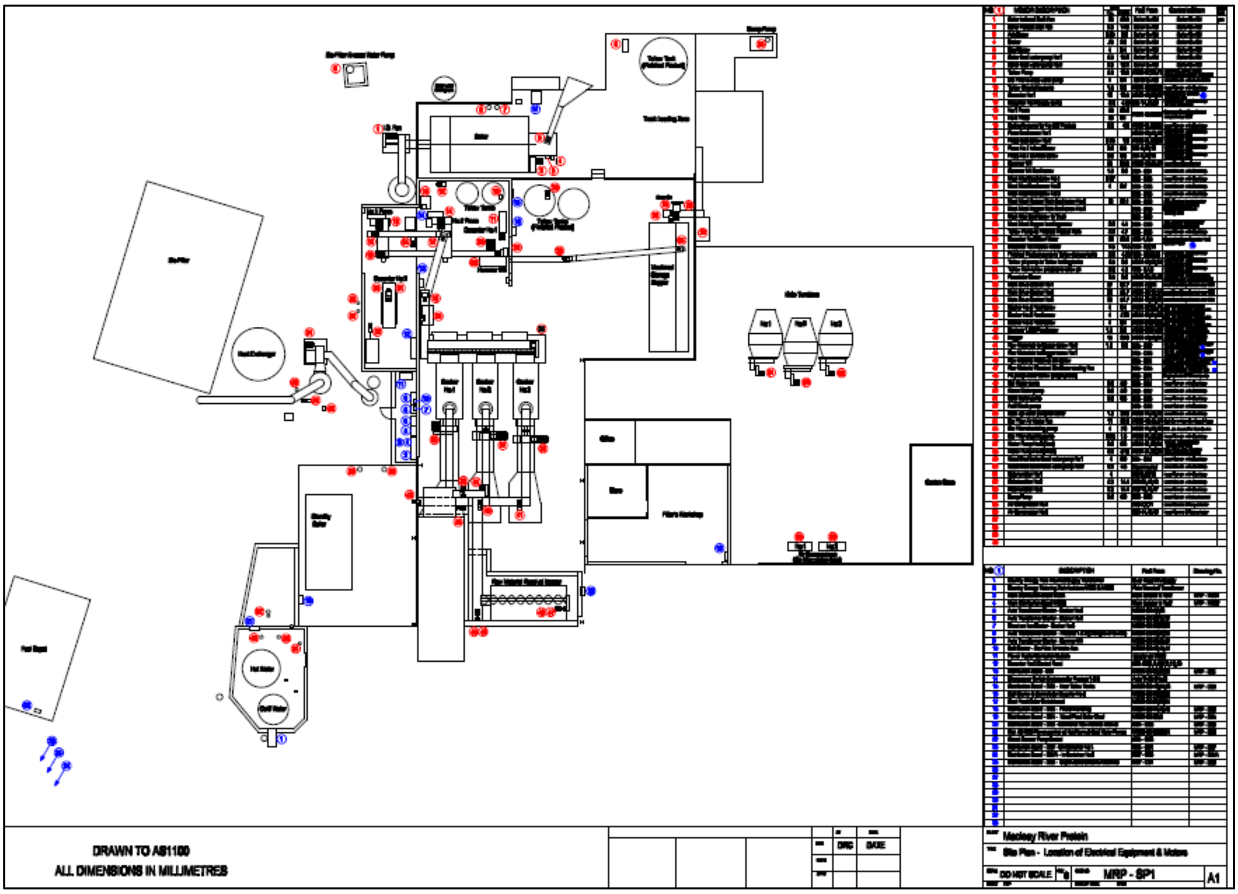
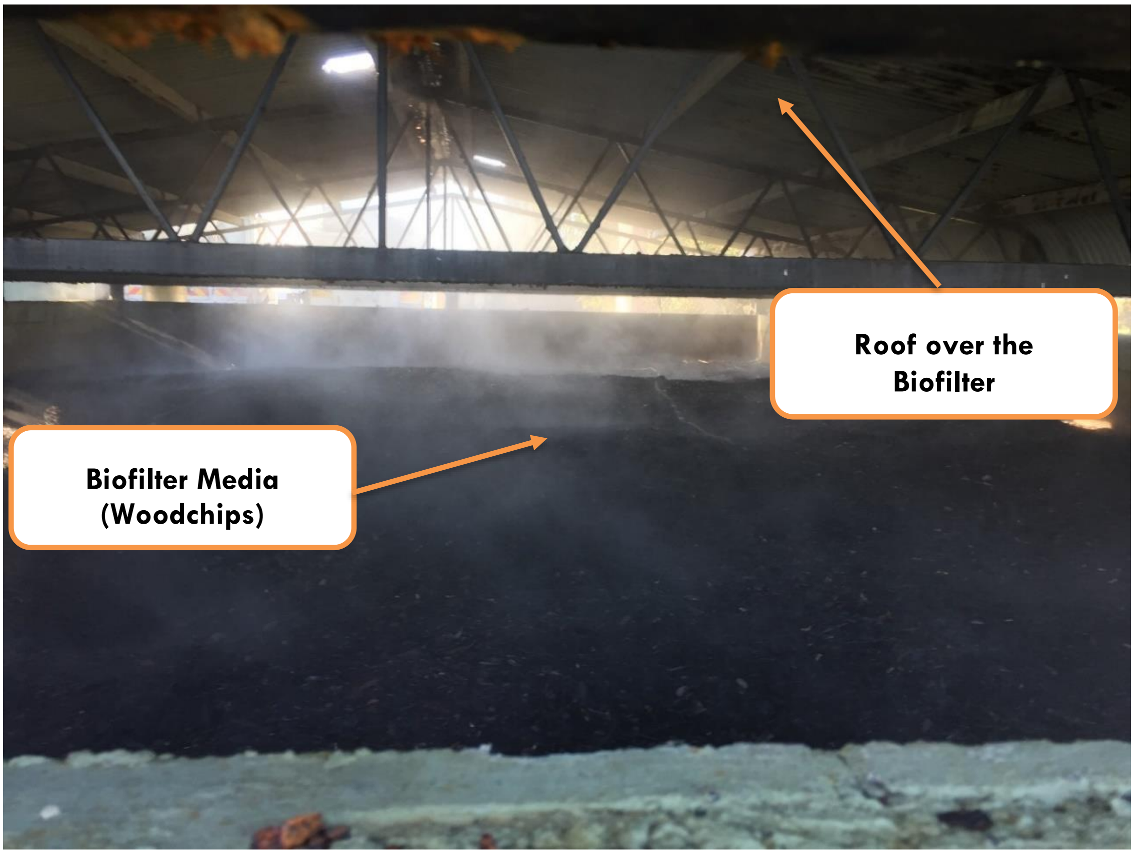


Figure 11: Visual Illustration of the Biofilter



7.1.3 Wastewater Treatment System

Abattoirs and rendering plants generate a significant volume of biological waste. The generated effluent is typically high in both suspended solid, degradable organic matter expressed as biochemical oxygen demand (BOD) and fatty material.

As mentioned earlier, wastewater from MRM and MRP is treated through a three-pond treatment system. Treated water is recycled to irrigation and for cattle and stockyard washing.

A three-pond treatment system was commissioned in 2008 to complement the existing primary 'saveall'. As a part of the Development Application (DA) supporting the three-pond treatment system, an Environmental Impact Statement (EIS) accompanying an Air Quality Assessment was undertaken in 2006 (ERM, 2006), copies of which have been provided to Airlabs for review.

Based on information provided in the EIS, prior to the three-pond treatment system, the method of wastewater disposal via flood irrigation of primary treated effluent over various adjoining grazing properties was considered to be unsustainable, therefore the commissioning of the three-stage wastewater system.

The wastewater treatment plant is used for treating red and green waste from MRM and MRP. The effluent typically comprises – runoff from stock holding yards, wash down water from the livestock processing floor, paunch waste and residual water and wash down water from the rendering plant.

The current wastewater treatment process at EFP is as follows:

- The bulk solid materials from the abattoir processing floor are captured in an inception pit for disposal;
- The remaining solid materials from various sources along with the effluent are collected in the existing saveall;
- Removal of solids at the saveall is achieved through an Archimedes Screw type separator from a secondary tank receiving paunch and kill floor flows;
- Remaining minor solids are pumped to secondary treatment ponds via a macerating pump;
- The three (3)-pond system comprises two (2) aerated ponds and one (1) wet weather storage pond;
- The first pond is an *Aeration and Biological Treatment Pond* (Pond 1):
    - Effluent will enter Pond 1, which has a holding capacity of 4.23ML (Mega Litres) where it is dosed with a biological treatment agent;
    - The aerobic treatment process, incorporating mechanical aeration would be benefitted by the addition of the biological treatment agent;
    - *Ultrazyme* is the biological treatment agent used at EFP and is added into the treatment train at controlled dosage rates to breakdown and decompose waste under aerobic conditions.
- The second pond is the *Aerated Polishing Pond* (Pond 2):
    - Pond 2, which has a holding capacity of 1.28ML receives treated water from Pond 1allowing for the prescribed retention period for treatment;
    - Water in the second pond also undergoes mechanical aeration and is expected to continue to be biologically treated as a result of the initial dosing rates.
- The third pond is the *Wet Weather Storage* (Pond 3) – The treated water is stored in a shallow 1.43ML storage pond prior to being irrigated on surrounding pasture lands. The pond is sufficiently shallow to enable ultra-violet light penetration and further aeration. The treated effluent is disposed onto surrounding pasture lands;

- Based on information gathered by Airlabs, it is understood that the two aerated ponds and one wet weather storage pond configuration has been operational since 2008 and has been effective in managing odour emissions from wastewater.

7.2 Overview of Operations – KSC –Frederickton Sewerage Treatment Plant (STP)

In addition to the EFP, the other source that is being assessed for odour impacts on the proposed re-zoning areas is the KSC owned and operated Frederickton STP. As mentioned earlier in **Section 4,** the STP is situated east of the Pacific Highway and is considerably separated from the proposed R1 general (circa. 600-650m) and R5 rural residential areas (circa. 1100-1150m) and as-such, it is expected that there would not be significant odour impacts on the proposed re-zoning area from the STP owing to its separation distance, however, there exists a potential opportunity for residential development surrounding the STP which has not yet been identified / earmarked at this point of time and therefore in order to pre-empt potential odour impacts, the Frederickton STP has been considered as a source of odour. A brief overview of the STP and its workings are provided below.

The Frederickton STP was constructed in 1980 and is bounded by Christmas Creek to the south, the Macleay River to the east and rural lands to the west and north. The effluent transportation system consists of 4 KSC owned pumping stations and 1 privately owned pumping station, all discharging into the inlet works at the Frederickton STP.

The Frederickton STP consists of one 1,000 Equivalent Population (EP) pasveer channel with excess sludge from the treatment process being stored in two (2) sludge lagoons and the displaced supernatant liquor being returned to the pasveer channel. Tertiary treatment is provided in the form of three (3) effluent ponds before being discharged into the Macleay River. The sludge lagoons used for storing excess sludge would be emptied through a mobile dewatering plant approximately once every 18-24 months. The dewatering campaign which takes place over a 4 to 5-week period once every 18-24 months is expected to generate odour emissions but considering the infrequent nature of this operations, the dewatering process and its associated odour emissions have not been considered in this assessment. A schematic layout of the Frederickton STP is provided in **Figure 12.**

7.3 Identified Key Sources of Odour

Based on observations made during the site inspection, review of the provided information and Airlabs' previous experience in undertaking odour assessments for abattoirs and wastewater treatment plants, key sources of fugitive odour emissions for the EFP and STP have been identified, which are listed below:

MRM and MRP:

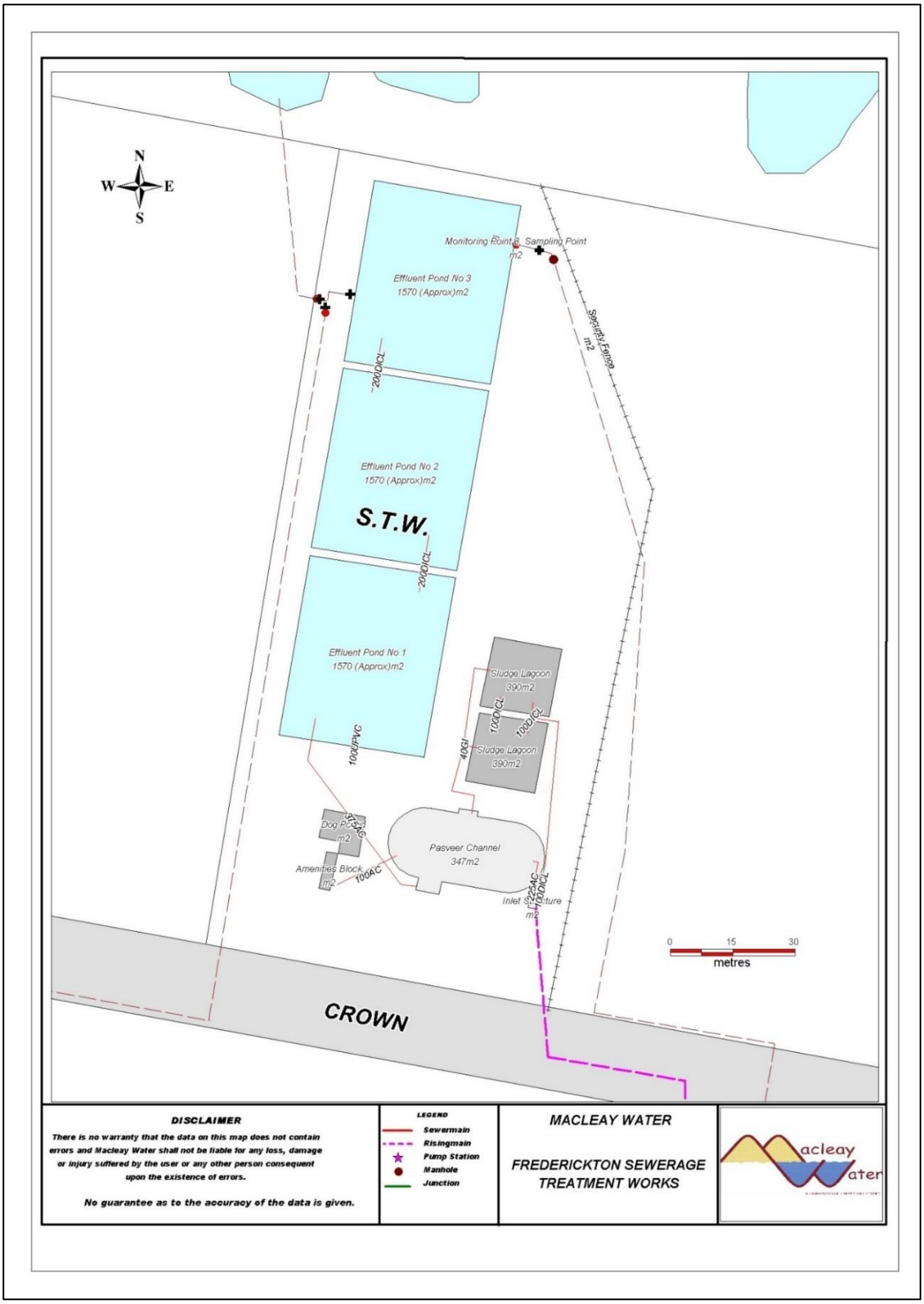
- Open and covered stock yards;
- Kill Floor;
- Non-edible / Offal area;
- Paunch / Tripe area;
- Saveall;
- Skin Salting, Hide Brining / Drying;
- Biofilter;
- Fugitive odours from Rendering Plant; and
- Wastewater Treatment Plants

Frederickton STP:

- Inlet Works;

- Pasveer Channel;
- Sludge Lagoons – 1 and 2;
- The three (3) Effluent Ponds.

Figure 12: Schematic Layout of the Frederickton STP



8. ODOUR EMISSION ESTIMATION

This section provides details on estimating odour emission rates for the identified key sources of odour. As mentioned in **Section 1**, the nature of this odour assessment is a preliminary / feasibility stage assessment and as-such, odour emissions were determined through a desktop approach. Odour emission rates were estimated by drawing reference to literature data from facilities similar in operational nature to the EFP (i.e. MRM and MRP) and the Frederickton STP.

8.1 Basis of Odour Emission Estimates – MRM and MRP

To estimate odour emissions, an extensive desktop literature search of odour impact assessments for facilities similar in nature to the MRM and MRP was undertaken. Specific Odour Emission Rates (SOERs) expressed as (OU.m^3/m^2/sec) for the identified key sources at the MRM and MRP (refer **Section 7.3**) were referenced from these carefully selected odour impact assessments available on the public domain. The SOERs were then adjusted based on the processing capacities (i.e. head counts) of EFP and the referenced facility to determine an adjusted SOER. Although, a careful consideration has been given to this method of estimating odour emission rates from similar facilities and subsequently adjusting it based on processing capacities, it is to be noted that each facility is different and would have a unique odour profile, which would be ascertained / determined through an extensive odour monitoring campaign. However, considering that the assessment is in a preliminary stage at this point of time, this approach is considered appropriate.

As noted earlier, the EFP is a multi-species abattoir, where in live-stock including – cattle, calves, sheep, lamb, pigs, goats and water buffaloes are killed and processed. A review of information provided within EFPs National Greenhouse and Energy Reporting Calculator (NGER) and the 2015-16 Kill Weights data was undertaken to understand the type of livestock that is processed. Based on reviewing the total heads killed over the last five (5) financial years and the number of corresponding operational days, it is noted that approximately 2,300 heads per day are killed and processed, which includes all species. Furthermore, the review suggested that majority of the livestock (approximately 85%) killed and processed is small stock, which includes – sheep, hogget, rams, goats, pigs, bobby calves etc. and the remaining 15% comprise large stock, including – cattle and buffaloes. Of the 85% of small stock, 83% comprises lamb, sheep, hogget, rams and pigs and the remaining 2% are goats and bobby calves. This estimation of the percentages of small and large stock was provided by the staff at EFP during personal communication over the course of the assessment. As-such, in order to estimate odour emissions, emphasis was laid on searching literature data for emissions associated primarily with small stock abattoirs.

8.1.1 Stockyards – Covered and Open

To estimate odour emissions from covered and open stockyards, reference was drawn to *Air Quality Impact Assessment – Proposed Bourke Small Stock Abattoir* (SLR, 2016). This abattoir proposes to process 6,000 heads per day of small stock, primarily comprising – sheep, lambs and goats. In context to EFP, the total numbers of heads processed per day is approximately 2,300 (1,900 small stock and the remaining large stock). SLR (2016) provides an SOER of 1.81 OU.m^3/m^2/sec for soiled holding pens containing sheep, which was considered representative for the holding pens at MRM. An adjusted SOER was determined based on the processing capacities. In addition, SLR (2016) provides an exclusive SOER for goat odour – 42 OU.m^3/sec/goat, with a goat density of 1.12 goats/m^2. Based on the number of goats killed and processed and their estimated densities, an adjusted SOER was determined. The adjusted SOERs for stockyards is provided in **Table 3**.

8.1.2 Kill Floor

As per Airlabs' experience in undertaking odour assessments, the kill floor is not considered a major source of odour as the operations are fully enclosed and freshly butchered meat is not highly odorous in nature. This observation is agreed in SLR (2016). However, to be conservative odour emissions from the kill floor were quantified for the assessment. SLR (2016) estimates an SOER of 0.53 OU/m^3/m^2/sec representative of operations inside the kill floor. To be further conservative, no adjustments to this SOER has been made despite significant differences in the processing capacities.

8.1.3 Non-Edible / Offal

SLR (2016) provides an SOER of 15.8 $OU.m^3/m^2/sec$ for fresh side products obtained from the abattoir. This SOER has been used to determine non-edible / offal odour emission rates. Similar to the kill floor odour emission estimation approach, no adjustments to this SOER has been made.

8.1.4 Paunch / Tripe

SLR (2016) provides an SOER of 15.8 $OU.m^3/m^2/sec$ for fresh side products obtained from the abattoir. This SOER has been used to determine non-paunch /tripe emission rates. It is to be noted that no adjustments to this SOER has been made.

8.1.5 Saveall

SLR (2016) provides an SOER of 2.73 $OU.m^3/m^2/sec$ for Dissolved Air Flotation (DAF) Systems. An odour assessment of the Wagga Wagga abattoir undertaken by The Odour Unit (The Odour Unit, 2001) notes that the odour character of the wastewater saveall at the Wagga Wagga abattoir is similar to the odour character of the DAF. Taking this into consideration, the SLR (2016) SOER for DAF system is considered representative and has been applied for the saveall. It is to be noted that no adjustments to this SOER has been made.

8.1.6 Skin Salting Hide Brining / Drying

Based on the findings of the site inspection and Airlabs' previous experience in undertaking odour assessments at abattoirs and rendering plants, the salting, brining and drying of skins and hides are not considered to be a major source of odour when compared to other sources. Therefore, no odour emissions have been estimated for this process.

8.1.7 Biofilter

The biofilter is one of the key components of the MRP. As described in **Section 7.1.2**, the biofilter treats the odours generated from the rendering plant before discharging into the atmosphere. A review of the biofilter undertaken by PAE Holmes in April 2012 noted that it was operating effectively to remove odours from the incoming air stream, which was also observed by Airlabs personnel during the site inspection. In order to determine odour emissions from the biofilter, reference was drawn to the *Odour Impact Assessment, Swift Australia Pty Ltd – King Island, Tasmania* undertaken by EML Air in 2010 (EML Air, 2010). This abattoir site comprises rendering operations where the odours are treated through a biofilter. The EML (2010) odour assessment focused on determining odour emissions and impacts from a proposed wastewater treatment plants and the existing biofilter on site. The King Island abattoir kills and processes large stock, approximately 180 head of cattle per day. Odour emissions from the biofilter were determined through odour sampling undertaken by EML Air between December 2008 and August 2010. Based on the measured data and the dimensions of the biolfilter, an SOER of 1,829 $OU.m^3/min/m^2$ (30.5 $OU.m^3/m^2/sec$) was determined. It is to be noted that the King Island abattoir processes large stock (i.e. cattle), whereas EFP is a multi-species abattoir primarily processing small stock (approximately 85%). However, based on previous experiences, it is expected that biofilter odour character wouldn't alter significantly between small and large stocks and as-such, this SOER was used to determine odour emissions from the biofilter. It is to be noted that no adjustments to this SOER has been made.

8.1.8 Fugitive Odours from Rendering Plant

As mentioned earlier, the biofilter treats the odours generated from the rendering plant before discharging into the atmosphere. At MRP, odorous air that is treated by the biofilter is extracted from all the key sources of odour, including – the hood above the cooker discharge points, the ducts above each of the three cookers that transfer the cooker vapours to the heat exchanger, screw mechanism that transfers blood solids to the raw material screw conveyor and air from the general cooking area. Thereby, the potential for fugitive odour emissions to be released from the rendering plant is minimal as most of the key odours are captured and treated by the biofilter. However, as a conservative approach, fugitive odour emissions from the rendering plant have been determined. For this exercise, reference was drawn to the odour assessment undertaken by The Odour Unit (2001) for the Wagga Wagga abattoir, which processes approximately 4,250 large cattle per week. The Odour Unit (2001) estimates odour emissions from the rendering plant to be in the order of 18,000 OU.m^3/sec. This SOER is considered very conservative, as it is noted that most of the odours generated from the MRP are captured and treated by the biofilter before releasing to the atmosphere. As-such, applying this SOER would not be considered representative. Therefore, to provide a realistic estimate, it was assumed that 80% of the odours generated from the MRP would be captured and treated by the biofilter and the remaining 20% would be released as untreated fugitive emissions. Based on this assumption and the referenced SOER from The Odour Unit (2001), the adjusted SOER representing fugitive odour emissions from the rendering plant was estimated to be in the order of 3,600 OU.m^3/sec (5.3 OU.m^3/m^2/sec)

8.1.8 Wastewater Treatment Plant

As mentioned in **Section 7.1.3**, a three-pond treatment system comprising two (2) aerated ponds and one (1) wet weather storage pond was commissioned in 2008 to complement the existing primary 'saveall'. As a part of the Development Application (DA) supporting the three-pond treatment system, an Environmental Impact Statement (EIS) accompanying an Air Quality Assessment was undertaken in 2006 (ERM, 2006), copies of which have been provided to Airlabs for review.

ERM (2006) quantified odour emissions from the three pond treatment system and as-such that information has been used to determine odour emissions for the wastewater treatment plants. ERM (2006) estimated odour emissions for the aerobic wastewater treatment system by referencing an air quality assessment for a proposed abattoir and a saleyard facility in Ballarat, Victoria. This assessment used odour emission rates for wastewater treatment sources obtained from odour sampling undertaken at the Southern Meats abattoir located in Goulburn, NSW. The Southern Meats abattoir had a throughput of approximately 4,000 sheep per day, which is approximately twice the throughput rates at EFP. Based on information provided within the Ballarat and the Southern Meats abattoir odour assessment, ERM (2006) estimated the odour emission for the ponds to be 9,520 OU.m^3/second. As noted earlier, the source of information from which this odour emission rate was determined had a processing capacity, which was twice the capacity at EFP. Furthermore, it is noted that the biological treatment agent – *Ultrazyme* is added into the treatment train to breakdown and decompose waste under aerobic conditions. Therefore, taking into consideration the processing capacities and the application of *Ultrazyme*, it was assumed that the odour emissions profile at the EFP wastewater treatment plant would be about 50% of the odour emissions measured at the Southern Meats abattoir wastewater treatment system. Therefore, the SOER for the wastewater treatment system was estimated to be approximately 4,760 OU.m^3/second. It is to be noted that this SOER is applicable in total to Pond 1, which is the aeration and biological treatment pond and Pond 2, which is the aeration polishing pond. No odours are expected from the third pond, which is a wet weather storage pond.

8.2 Basis of Odour Emission Estimates – Frederickton STP

Odour emissions from the Frederickton STP, were determined by undertaking an extensive desktop literature search of odour impact assessments for facilities similar in nature. Specific Odour Emission Rates (SOERs) expressed as (OU.m^3/m^2/sec) for the identified key sources at the Frederickton STP (refer **Section 7.3**) were referenced from these carefully selected odour impact assessments available on the public domain. The SOER's were then adjusted based on the processing capacities / Equivalent Populations (EP) (i.e. head counts) of the Frederickton STP and the referenced facility to determine an adjusted SOER. Although, a careful consideration has been given to this method of estimating odour emission rates from similar facilities and subsequently adjusting it based on processing capacities, it is to be noted that each facility is different and would have a unique odour profile, which would be ascertained / determined through an extensive odour monitoring campaign. However, considering that the assessment is in a preliminary stage at this point of time, this approach is considered appropriate.

8.2.1 Inlet Works

To determine odour emissions from the inlet works, reference was drawn to the *Buffer Zone Odour Impact Assessment for the South West Rocks STP*, undertaken by SKM in 2008 (SKM, 2008). The South West Rocks STP comes under the KSC Sewage Scheme similar to the Frederickton STP. The South West Rocks STP has a processing capacity of 6,000 EP, which is about six (6) times higher than the processing capacity of the Frederickton STP. SKM (2008) estimated the odour emission rate for the inlet works at the South West Rocks STP to be 0.17856 OU.m^3/m^2/sec. Based on the SOER and the difference in the EP, the SOER was adjusted by a factor of six (6) and the resultant adjusted SOER for the inlet works at the Frederickton STP was estimated to be 0.03 OU.m^3/m^2/sec.

8.2.2 Pasveer Channel

SOER for the pasveer channel / aeration ponds at the South West Rocks STP were estimated to be 0.0384 OU.m^3/m^2/sec by SKM (2008). Based on the SOER and the difference in the EP between the Frederickton STP and the referenced South West Rocks STP, the SOER was adjusted by a factor of six (6). The resultant adjusted SOER for the pasveer channel / aeration pond at the Frederickton STP was estimated to be 0.01 OU.m^3/m^2/sec.

8.2.3 Sludge Lagoons – 1and 2

South West Rocks STP has two (2) sludge lagoons. As per SKM (2008), the maximum SOER estimated across the two (2) sludge lagoons was 0.339 OU.m^3/m^2/sec. Based on the maximum SOER and the difference in the EP between the Frederickton STP and the referenced South West Rocks STP, the SOER was adjusted by a factor of six (6). The resultant adjusted SOER for both the sludge lagoons at the Frederickton STP were determined to be 0.06 OU.m^3/m^2/sec.

8.2.4 Effluent Ponds

Tertiary treatment at Frederickton STP is provided in the form of three (3) effluent ponds before discharging the treated water into the Macleay River. The effluent treatment ponds are not expected to be a major source of odour as they are well oxygenated without the presence of any anaerobic activity. However, to be conservative, an SOER has been nominated for the three (3) effluent ponds. To determine odour emissions, reference was drawn to emission rates presented in the Frechen (2002), *Odour Abatement Strategies at Wastewater and Waste Facilities in Germany*, presented in the *Clean Air and Environmental Quality Journal, Volume 36, Number 3, August 2002*. This publication presents odour emission rates emitted from various processes involved in wastewater treatment. As per Frechen (2002), aerobic tanks at wastewater treatment facilities had an average SOER of 510 OU.m^3/m^2/hour (0.14 OU.m^3/m^2/sec). No further adjustments were made and this SOER was used to estimate odour emissions from the three (3) effluent treatment ponds.

Table 3 and **Table 4** presents a summary of the desktop referenced odour emission rates from the EFP and the Frederickton STP respectively. These emission rates would be used in the dispersion modelling exercise to predict odour impacts on the proposed re-zoning areas.

Table 3: Modelled Odour Sources – Eversons Food Processors (EFP)

Source Name	Approximate Area (m^2) (a)	Frequency	SOER ($OU.m^3/m^2/sec$)
Covered Stock Yards	648	Continuous	1.4
Open Stock Yards	3,076	Continuous	1.4
Kill Floor	382	5AM to 10PM, Monday-Friday	0.53
Non-edible / Offal	29	5AM to 10PM, Monday-Friday	15.8
Paunch / Tripe	26	5AM to 10PM, Monday-Friday	15.8
Save All	130	5AM to 10PM, Monday-Friday	2.73
Biofilter	91	Continuous	30.5
Wastewater Treatment Ponds (Pond 1 and Pond 2)	7,112	Continuous	0.7
Rendering Plant – Fugitive (b)	683	5AM to 10PM, Monday-Friday	15.8

(a) Areas estimated from aerial imagery

(b) Fugitives from rendering plant were modelled as a volume source

Table 4: Modelled Odour Sources – Frederickton Sewerage Treatment Plant (STP)

Source Name	Approximate Area (m^2) (a)	Frequency	SOER ($OU.m^3/m^2/sec$)
Inlet Works	4	Continuous	0.03
Pasveer Channel	523	Continuous	0.01
Sludge Lagoon 1	333	Continuous	0.06
Sludge Lagoon 2	289	Continuous	0.06
Effluent Pond 1	1369	Continuous	0.14
Effluent Pond 2	1517	Continuous	0.14
Effluent Pond 3	1500	Continuous	0.14

(a) Areas estimated from aerial imagery

9. DISPERSION MODELLING METHODOLOGY

In order to predict odour impacts on the proposed re-zoning areas, air dispersion modelling was undertaken using the combination of the following mathematical models TAPM and CALMET / CALPUFF.

- **TAPM**: The Air Pollution Model (TAPM) is a prognostic meteorological model that generates three-dimensional (3D) meteorological data and air pollution concentrations;
- **CALMET**: CALMET is the meteorological pre-processor for the dispersion model CALPUFF. Using geophysical information and observed/simulated surface and upper air data as inputs, hourly wind fields and temperature fields are generated on a three-dimensional (3-D) gridded modelling domain. Associated two-dimensional (2-D) fields such as mixing height, surface characteristics, and dispersion properties are also included in the field produced by CALMET (SRC, 2000);
- **CALPUFF**: CALPUFF is the dispersion model that calculates the dispersion of plumes within the three-dimensional (3D) meteorological field calculated by CALMET. CALPUFF is a non-steady state US-EPA approved dispersion model which "advects" puffs of material emitted from modelled sources, simulating dispersion and transformation processes along the way. In doing so, it typically uses the wind fields generated by CALMET. Temporal and spatial variations in the meteorological fields selected are explicitly incorporated in the resulting distribution of puffs throughout a simulation period (SRC, 2011)

9.1 Dispersion Meteorology

Meteorological mechanisms govern the generation, dispersion, transformation and eventual removal of pollutants from the atmosphere. The local meteorology at the site plays a significant role in understanding the pollutant transport and dispersion mechanisms, and in order to adequately characterise the local meteorological conditions, information is needed on key parameters such as prevailing wind regime, mixing depth, atmospheric stability, ambient temperatures, rainfall and relative humidity. The following sections outline the methodology for characterising the local meteorological conditions at the study area.

9.1.1 TAPM

For this assessment, the meteorological model 'The Air Pollution Model (TAPM) (Version 4.0.5)' was used to generate the prognostic output. TAPM, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a prognostic model which is used to predict three-dimensional meteorological data and air pollution concentrations. TAPM allows users to generate synthetic observations by referencing in-built databases (e.g. terrain information, synoptic scale meteorological observations, vegetation and soil type etc.) which are subsequently used in generating site-specific hourly meteorological data.

TAPM includes the option to assimilate local observations (of wind speed and wind direction) in order to nudge the predicted solution towards the observed records. Local observations 10 km southwest (SW) of the study area were available from the BoM Automatic Weather Station (BoM – AWS), which is the Kempsey Airport AWS (Station No: 059007). However as only the upper air data of TAPM will be used in CALMET, the data assimilation functionality of TAPM was not used. Instead, the surface observations from Kempsey Airport AWS were used in the next step of meteorological modelling (CALMET). Technical details of the model equations, parameterisations and numerical methods are described in Hurley (2008)

For the Project, TAPM simulation was run for five calendar year 2011 through to 2015 and was setup using four (4) nested 25 x 25 grids, (30km, 10km, 3km and 1km) centred on latitude 33°, 2.0' south, longitude 152°, 51.5' east, which is within 300 m from the centre of the study area. Thirty (30) vertical levels were used with the lowest level being 10m and the highest level being 8km.

9.1.2 CALMET

CALMET is a diagnostic three-dimensional meteorological pre-processor for the CALPUFF modelling system (developed by Earth Tech, Inc.). CALMET was run in Hybrid Mode (Prognostic Model Data + Observations). The meteorological modelling domain for CALMET for the calendar years 2011 through to 2015 consisted of a grid extending 20km east-west and 20km north-south, with a grid spacing of 400m. The meteorological grid domain was located in the centre of the Project Site bearing Easting coordinates 487047 m and Northing coordinates 6567131 m, located in the Universal Transverse Mercator (UTM) Zone 56.

Prognostic output from TAPM for the five years was converted to 3D.Dat using the CALTAPM utility program.

Surface observations from the Kempsey Airport AWS (Station No: 059007) were collated for year 2011 through to 2015 and used as input in CALMET. Assimilation of surface observations in CALMET requires that at least one station has a non-missing value for wind speed and wind direction for each hour of simulation. Values of wind speed and wind direction from the TAPM generated surface station location were only used in the absence of observational data from the Kempsey Airport AWS.

The Geophysical dataset for CALMET contain terrain and land use information for the modelling domain. For this assessment, the terrain for the CALMET grid was extracted from 3- arc second (90m) spaced elevation data obtained via NASA's Shuttle Radar Topography Mission (SRTM) in 2000 (downloaded from USGS website). The land use or land cover data for the modelling domain was based on the USGS Global Land Cover Classification (USGS GLCC). The geotechnical parameters for the land use classification were adopted from the default CALMET corresponding land use categories.

Using geophysical datasets, prognostic and surface observational data, CALMET then develops the higher resolution flow fields to include (in general) the kinematic effects of terrain, slope flows, blocking effects and 3-dimensional divergence minimisation as well as differential heating and surface roughness associated with variations in land use categories across the modelling domain.

The CALMET model settings were in accordance with the '*Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the* '*Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia*' (OEH, 2011)

9.2 Inter-Annual Variability in CALMET Generated Meteorological Dataset

CALMET output was extracted at the centre of the study area for the five years (2011 through to 2015) and was analysed to compare the inter-annual variability in winds, stability classes and mixing height.

Inter-annual comparison of CALMET wind rose is presented in **Figure 13**. Inter-annual comparison of percentage of calm wind speeds, frequency of stability class and frequency of mixing heights is presented in **Figure 14**, **Figure 15** and **Figure 16** respectively.

Based on the analysis, 2015 was considered to be a representative year, as the data compares well with the previous years and no distinct anomalies have been identified for the 2015 dataset and as-such, meteorological data from the 2015 calendar year was considered for the dispersion modelling.

It is also noted that, of the five years of CALMET meteorological dataset, year 2015 contained highest percentage of calm wind conditions (7.2%) of the analysed five years.

Figure 13: Comparison of Annual Wind Rose – CALMET (2011 to 2015)

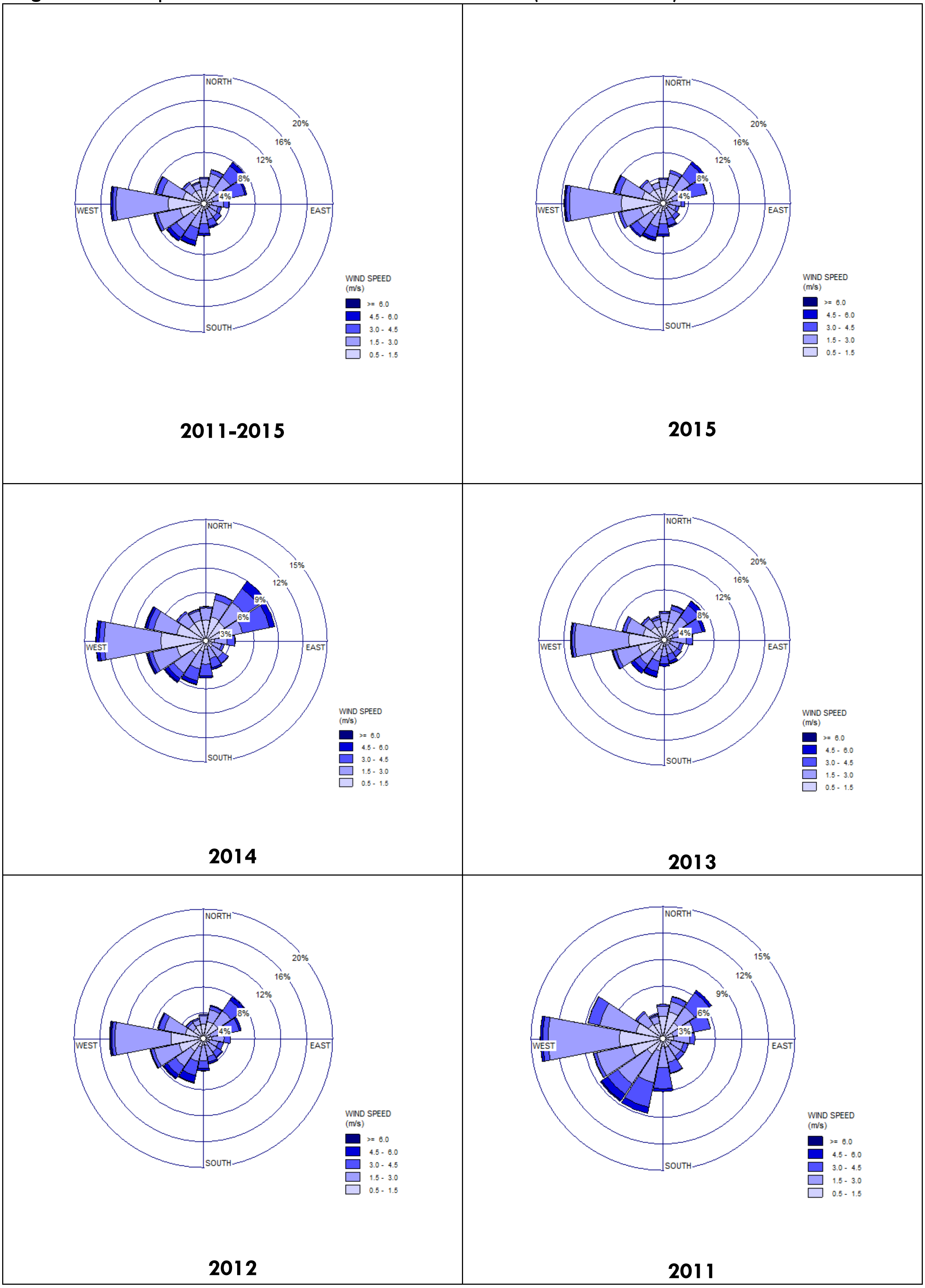


Figure 14: CALMET 2011 to 2015 – Comparison of Calm Percentages

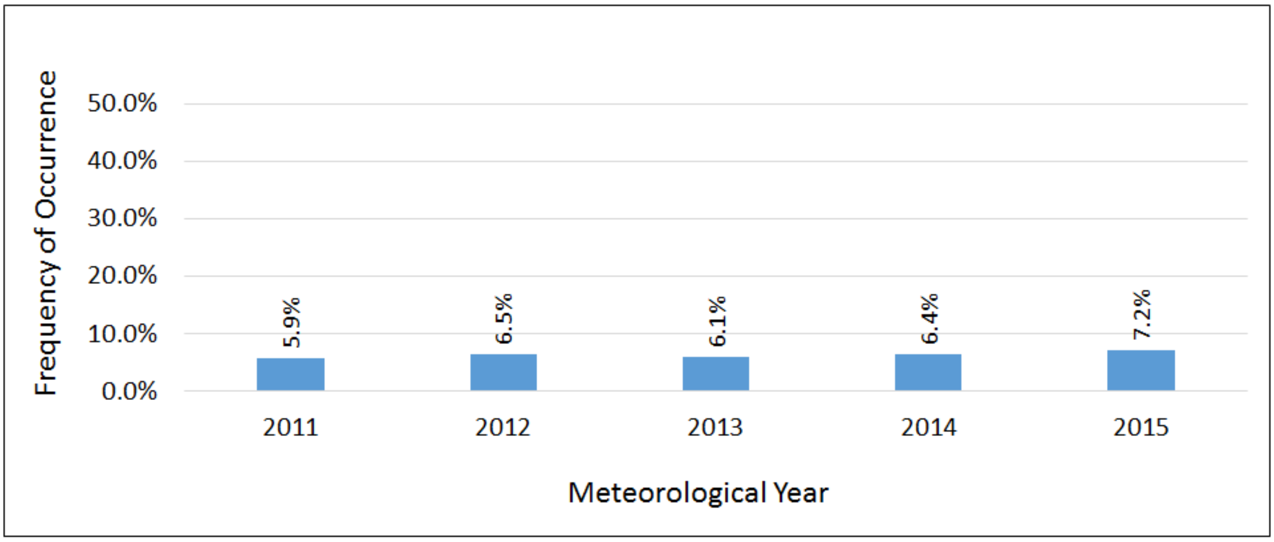


Figure 15: CALMET 2011 to 2015 – Comparison of Frequency of Stability Class

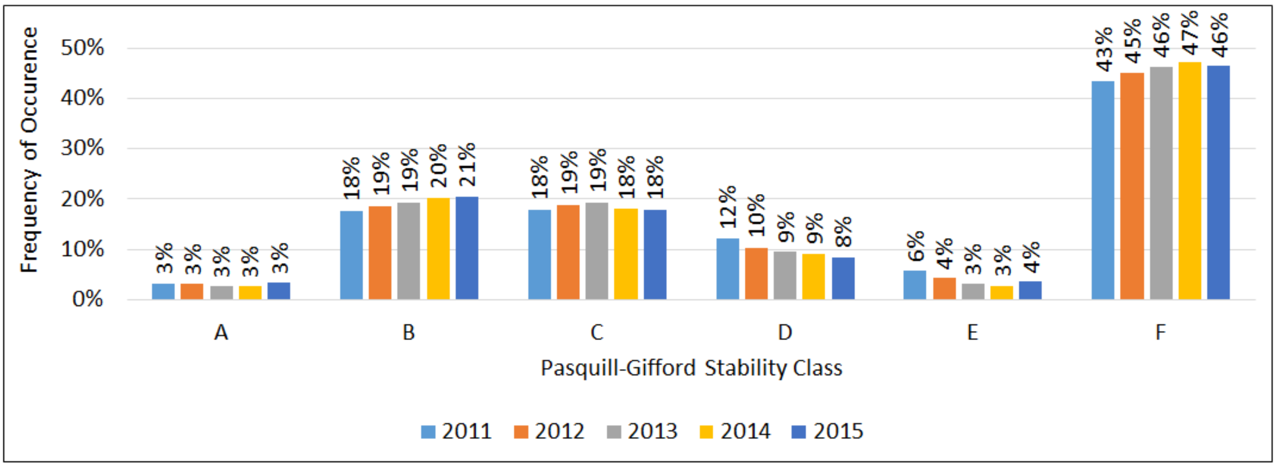
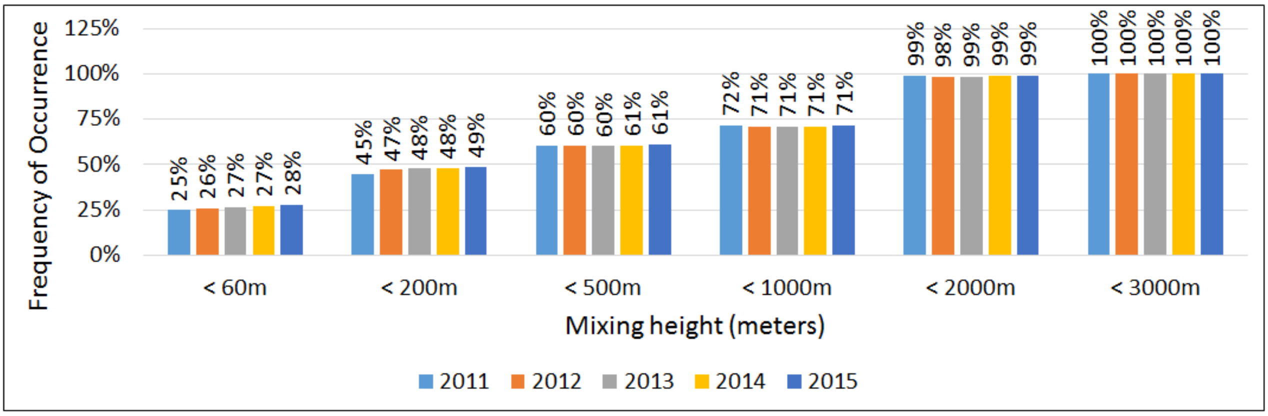


Figure 16: CALMET 2011 to 2015 – Comparison of Frequency of Mixing Heights



9.3 Comparison of Observed BoM (Kempsey AWS) and CALMET Generated Data - 2015

Comparison was made between the simulated data from CALMET and observed meteorological data at BoM operated Kempsey Airport AWS for the year 2015 and is shown in **Table 5**. Approximately 2.4% of meteorological data was missing from the Kempsey Airport AWS 2015 yearly dataset.

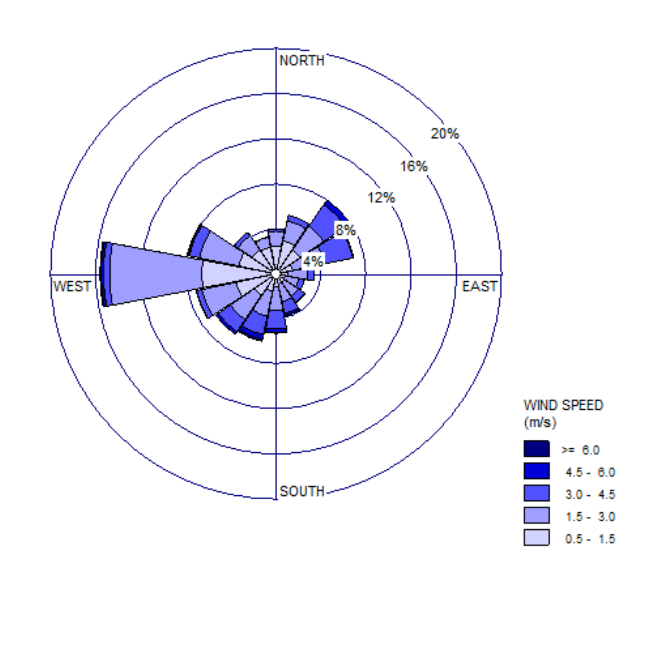
On an annual basis, percentage of calms (wind speed <0.5 m/s) in CALMET simulated dataset for year 2015 matches closely to that of observed data considering the fact that the study area is approximately 10 km from the location of observed dataset (Kempsey Airport). Furthermore, it is noted that percentage of calms is slightly higher in observed data at BoM Kempsey Airport AWS compared to the simulated CALMET dataset.

Table 5: Comparison of Calm Conditions – Observed BoM Kempsey AWS and CALMET 2015

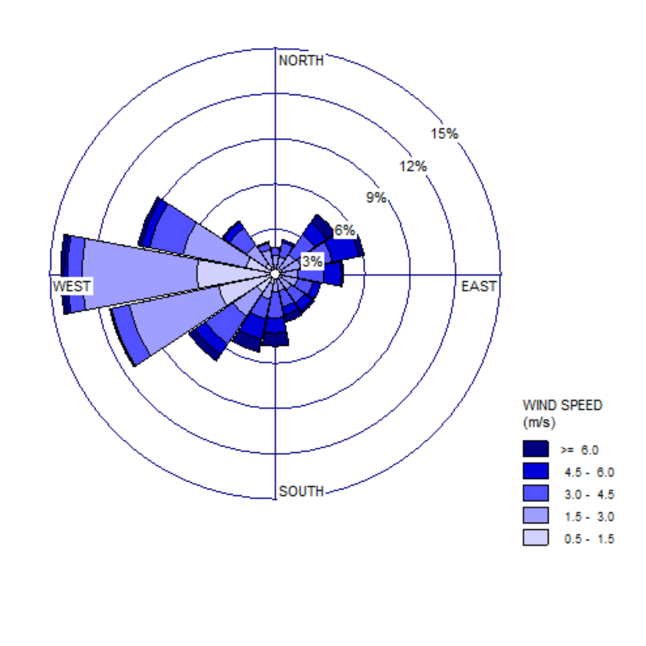
Period	% Missing		% Calms		% Non-Calms		% Total	
	BoM	CALMET	BoM	CALMET	BoM	CALMET	BoM	CALMET
Annual	2.4%	0.0%	9.5%	7.1%	88.1%	92.9%	100%	100%
Summer	0.0%	0.0%	11.2%	11.2%	88.8%	88.8%	100%	100%
Autumn	5.1%	0.0%	8.2%	7.1%	86.6%	92.9%	100%	100%
Winter	4.2%	0.0%	4.7%	2.9%	91.1%	97.1%	100%	100%
Spring	0.0%	0.0%	14.0%	7.4%	86.0%	92.6%	100%	100%

Comparison of CALMET generated and Kempsey Airport AWS wind roses show similarity in wind directions, however, higher wind speeds are observed at Kempsey Airport AWS when compared to the CALMET generated winds at the study area as shown in **Figure 17**. It is noted that the distance of circa. 10km between the observed data and simulated data could be the reason for the deviation in wind speeds.

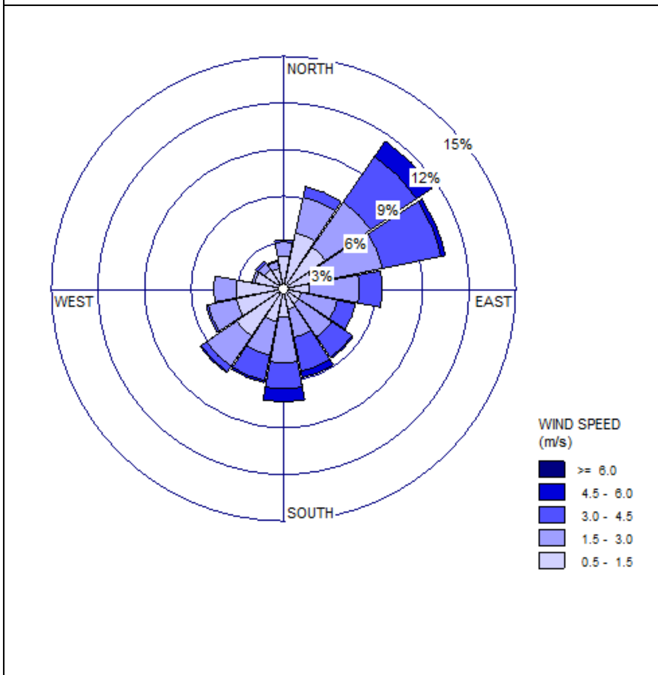
Figure 17: Comparison of Wind Rose – Observed BoM Kempsey AWS and CALMET 2015



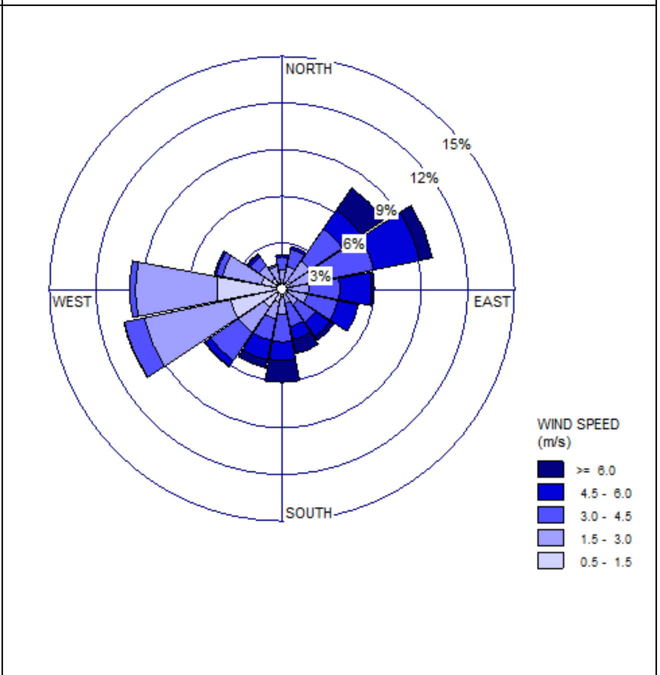
CALMET – Annual 2015



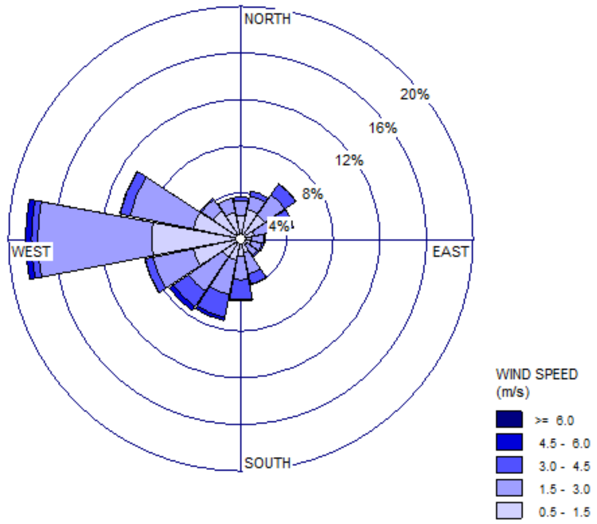
BoM – Annual 2015



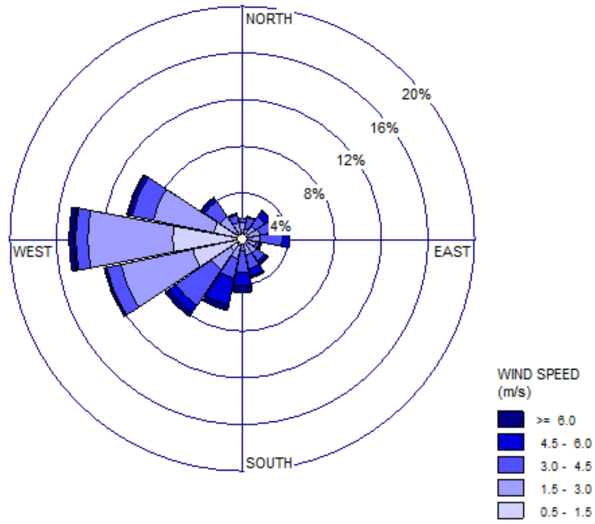
CALMET – Summer 2015



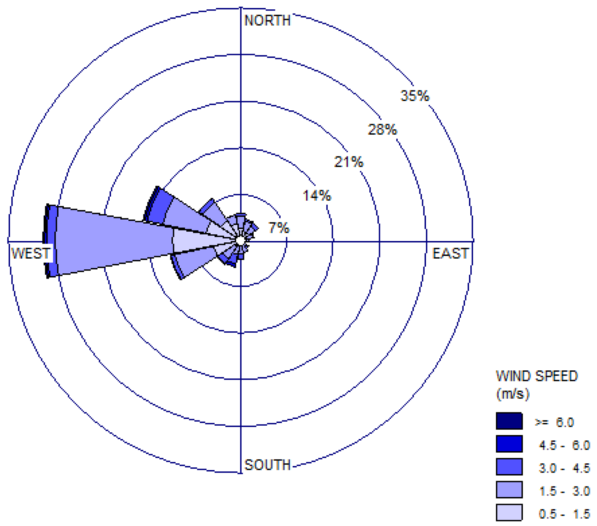
BoM – Summer 2015



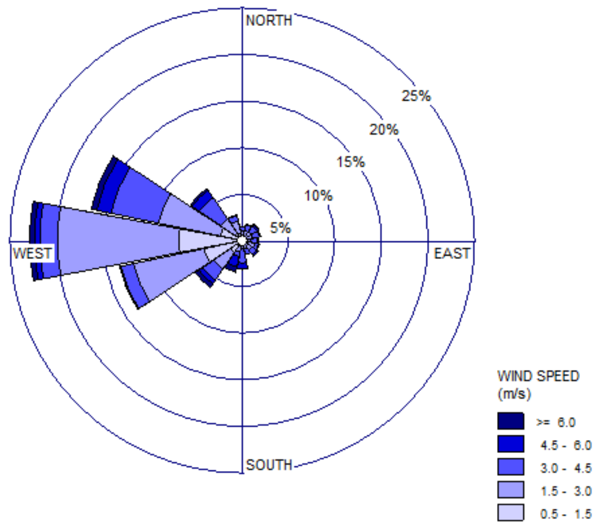
CALMET – Autumn 2015



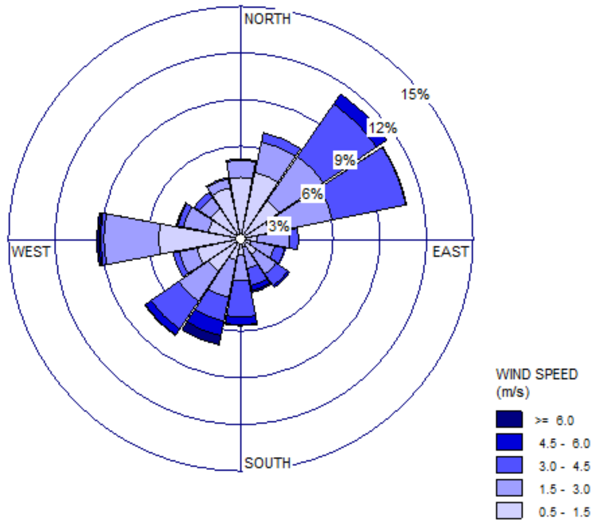
BoM – Autumn 2015



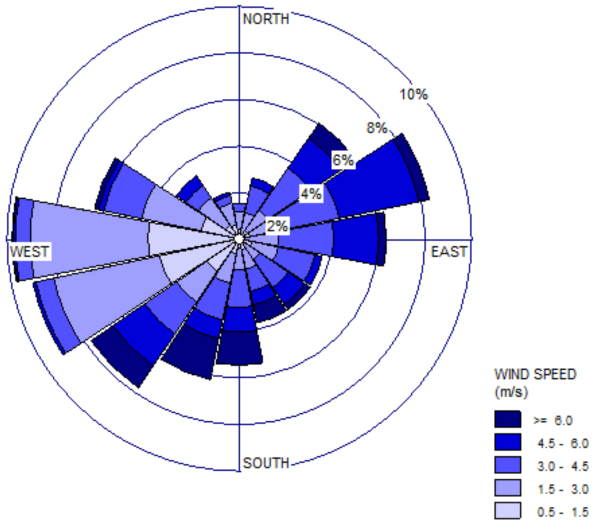
CALMET – Winter 2015



BoM – Winter 2015



CALMET – Spring 2015



BoM – Spring 2015

9.4 CALPUFF Model Configuration

The CALPUFF model domain was set as a sub-set of the CALMET model domain, with the sampling grid extending 6 km east-west and 6 km north-south with a grid spacing of 100 m (using a nesting factor of 4 on the 400m CALMET resolution)

All other CALPUFF model settings were referenced from the Generic *Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia*' (OEH, 2011)

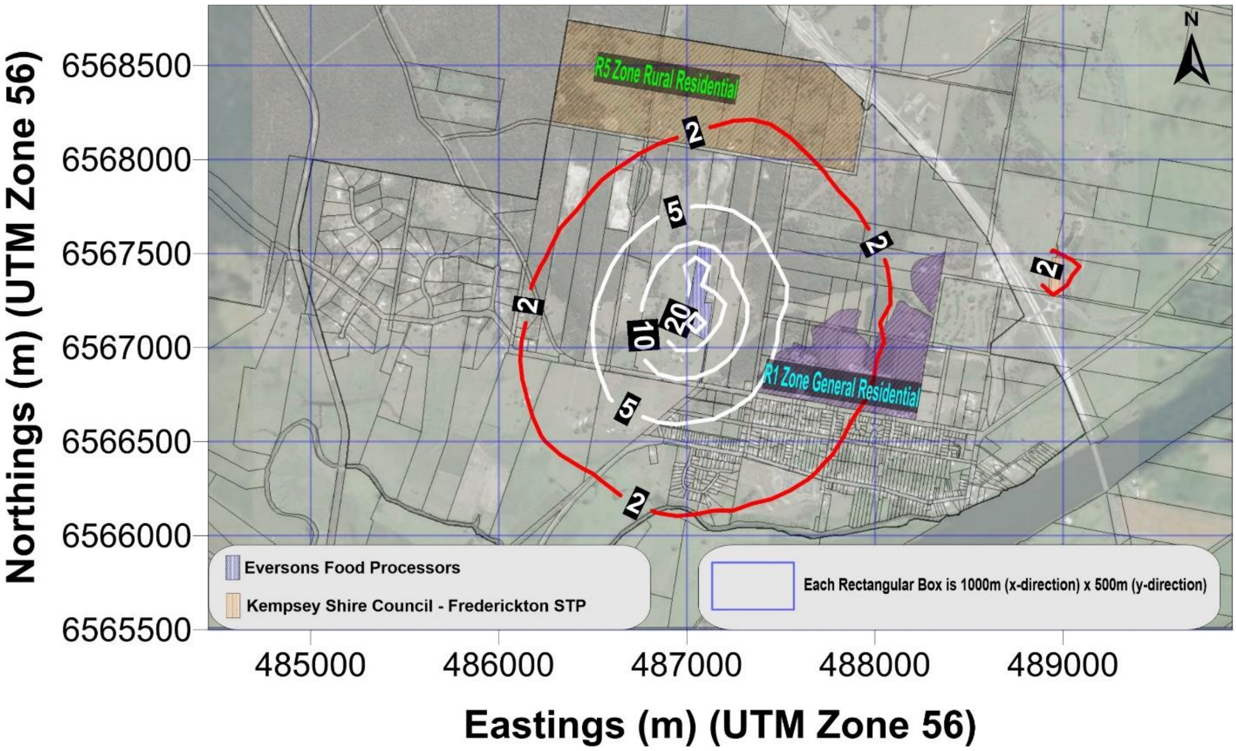
Except the fugitive odour emissions from the rendering plant which was modelled as a volume sources, all other sources (refer **Table 3** and **Table 4**) were modelled as area sources.

10. DISCUSSION OF ODOUR IMPACTS AND RECOMMENDATIONS

The 99th percentile peak (1-second) average odour concentrations predicted at the KSC proposed re-zoning areas due to odour emissions from the EFP (refer **Table 3**) and STP (refer **Table 4**) are presented in **Figure 18**. From the odour concentration isopleth, it is observed that a sizeable portion of the proposed R1 general residential could get affected due to odour impacts primarily from the operations at EFP. On the contrary, no significant odour impacts are expected at the proposed R5 rural residential areas. Furthermore, as observed from **Figure 13**, the prevailing winds on annual basis are predominantly from the west which potentially drive the odour emissions from the EFP towards the proposed R1 re-zoning area. Based on a closer investigation of the odour concentration isopleth in **Figure 18**, it is observed that the 2.0 OU contour (i.e. the assessment criterion contour highlighted in red ink) stretches to a distance of approximately 1000-1100m from the edge of the EFP facility boundary, implying that adverse odour impacts could be perceived by the community within this radius. The modelling results also suggest that a portion of existing residential development mainly to the south of the proposed R1 general residential re-zoning area could get affected due to odour impacts from the operations at EFP.

As seen in **Figure 18**, the Frederickton STP is not a significant source of odour as it is not expected to have an adverse impact on the proposed R1 and R5 re-zoning areas. Furthermore, the 2.0 OU contour (i.e. the assessment criterion contour highlighted in red ink) stretches to a distance of only 100-200m from the edge of the STP facility boundary, which is typically expected for wastewater treatment plants similar in nature to the Frederickton STP. As-such, KSC can use this buffer distance to plan and develop residential developments in the future surrounding the Frederickton STP.

Figure 18: 99th Percentile Peak (1-second) Average Odour Concentrations on the Proposed Re-Zoning Areas (Criterion: 2.0 OU)



10.1 Review of Separation Distances

As mentioned earlier, the modelling exercise has been based on estimating odour emissions rates by drawing reference to literature data from facilities similar in operational nature to the EFP and Frederickton STP. To undertake a comparative analysis of the modelled results, especially with reference to the main source of odour (i.e. EFP), reference was drawn to buffer distances recommended by regulatory authorities.

According to the Department of Environment Regulation (DER), Western Australia - *Separation distances are the estimated distances recommended to separate premises and their emissions from sensitive land uses to preserve the beneficial use of the environment.* Buffer / separation distances provide a valuable screening tool in situations where the details and specifics of the development are unknown. Reference has been drawn to the following information documented by regulatory agencies to determine the recommended separation distances for abattoirs and rendering plants and sewerage treatment plants.

- Recommended Separation Distances for Industrial Residual Air Emissions, EPA Victoria, 2013
- Guidance Statement – Separation Distances (DRAFT), Division 3, Part V, Environmental Protection Act 1986, Department of Environment Regulation, Western Australia, 2015
- Consultation Draft – Guidelines for Separation Distances, Environment Protection Authority, South Australia, 2000
- Abattoir buffer zones, NSW EPA (http://www.epa.nsw.gov.au/mao/abattoirs.htm)

Based on a review of the aforementioned guidance documents, recommended separation distances have been identified and summarised in **Table 6** specifically for abattoirs, rendering plants and sewerage treatment plants which would reflect the operations at EFP and Frederickton STP.

Table 6: Summary of Recommended Separation / Buffer Distances

Industry	Regulatory Department	Recommended Buffer / Separation Distances (m)
Abattoirs, including rendering operations	Environment Protection Authority (EPA) Victoria	1,000 m (a)
	Department of Environment Regulation (DER) Western Australia	1,000 m (b)
	Environment Protection Authority (EPA) South Australia	1,000 m
	Environment Protection Authority (EPA) New South Wales	1,000 m
Mechanical / Biological Wastewater plants	Environment Protection Authority (EPA) Victoria	100-150m (c)
	Environment Protection Authority (EPA) South Australia	100m -200m (d)

(a) For rendering operations > 200 tonnes per year

(b) For rendering operations > 100 tonnes per year

(c) Estimated using a formula of 10n1/3, where n is the Equivalent Population (EP)

(d) For 1000-5000 Equivalent Population (EP)

There appears to be a strong agreement between the modelled results and the recommended separation distance guidelines as evidenced by the 2.0 OU contour (i.e. the assessment criterion contour highlighted in red ink) shown in **Figure 18** which stretches to a distance of 1000-1100m from the edge of the EFP facility boundary. This is similar to the separation distances (1000m) recommended by regulatory authorities. A similar agreement between the modelled results and the recommended separation distance guidelines is observed for the Frederickton STP.

10.2 Recommendations

Based on the modelling results presented in **Figure 18** and the recommended separation distances summarised in **Table 6**, Airlabs recommend that KSC undertake a review of their proposed re-zones areas (especially R1 general re-zoning area) so that it will not be adversely impacted by operations at EFP.

Although careful consideration has been given to the odour emission estimation methodology and the references cited for estimating odour emission rates, Airlabs recommend that a detailed site-specific odour sampling campaign be undertaken especially at EFP to determine site-specific representative odour emission rates and subsequently re-determine odour impacts on the KSC proposed re-zoning areas.

11. CONCLUSION

Airlabs was commissioned by KSC to undertake an odour assessment as a part of the Local Environmental Study (LES) for the Frederickton area. The aim of the LES is to undertake a review of the current land use zonings in an earmarked area for the provision of new general residential and rural residential land releases.

The re-zoning areas, which primarily comprise general residential (R1) and rural residential (R5) are adjacent to or "in the neighbourhood" of the existing Eversons Food Processors (EFP), which is a multi-species abattoir and comprises an on-site rendering plant and KSC owned and operated Frederickton Sewerage Treatment Plant (STP)

The objective of this assessment is to determine the magnitude and extent of odour impacts from the aforementioned sources on the proposed re-zones. To achieve this objective, odour dispersion modelling has been undertaken.

The odour assessment has been undertaken in accordance with the NSW – Environment Protection Authority (EPA) *Technical Framework – Assessment and Management of Odour from Stationary Sources in NSW*, Department of Environment and Conservation, 2006 and the NSW – EPA *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, Department of Environment and Conservation, 2005.

An appropriate odour impact assessment criterion of 2.0 OU was determined based on the existing environment and proposed population estimates provided by KSC.

As the nature of this odour assessment is a preliminary / feasibility stage assessment, odour emission rates from the EFP and Frderickton STP have been determined by referencing literature data from similar facilities. The estimated odour emission rates were then fed into a dispersion model to predict odour impacts on the proposed re-zoning areas.

To predict odour impacts on the proposed re-zoning areas, dispersion modelling was undertaken using the combination of the following mathematical models TAPM and CALMET / CALPUFF.

99^{th} percentile, peak 1-second average modelled odour concentrations suggested that a sizeable portion of the proposed R1 general residential could get affected due to odour impacts primarily from the operations at EFP, which included the abattoir, rendering plant and associated wastewater treatment plant. Odour impacts, would stretch across a radius of 1000-1100m from the edge of the EFP facility boundary. The modelling results also suggest that a portion of existing residential development mainly to the south of the proposed R1 general residential re-zoning area could get affected due to odour impacts from the operations at EFP. However, no significant odour impacts are expected at the proposed R5 rural residential areas. The modelling suggested that there would not be any adverse odour impacts from the Frederickton STP on the proposed R1 and R5 re-zoning areas. Furthermore, it was observed that the impacts from the Frederickton STP stretched to a maximum of 100-200m from the facility boundary. Additionally, in order to undertake a comparative analysis of the modelled results, reference was drawn to buffer distances recommended by regulatory authorities. A review of the information suggested a strong agreement between the modelled results and the recommended separation distance guidelines for both EFP and the Frederickton STP.

Based on the modelling results and the guidance separation distances, Airlabs recommend that KSC undertake a review of their proposed re-zones areas (especially R1 general re-zoning area) so that it will not be adversely impacted by operations at EFP. Although careful consideration has been given to the odour emission estimation methodology and the references cited for estimating odour emission rates, Airlabs recommend that a detailed site-specific odour sampling campaign be undertaken especially at EFP to determine site-specific odour emission rates and subsequently re-determine odour impacts on the KSC proposed re-zoning areas.

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13. GLOSSARY

Airlabs	Airlabs Environmental Pty Ltd
Approved Methods	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW
AQ	Air Quality
AQIA	Air Quality Impact Assessment
AWS	Automatic Weather Station
Biofilter	Absorption of odorous compounds into a biologically active membrane (i.e. bacteria on the biofilter media). Odorous compounds are oxidized by the bacteria to odourless compounds
BoM	Bureau of Meteorology
CALMET	California Meteorological Model
CALPUFF	California Puff Dispersion Model
CO	Carbon Monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DA	Development Application
DAF	Dissolved Air Flotation
EFP	Eversons Food Processors
EML	EML Air Pty Ltd
EP	Equivalent Population
EPA	Environmental Protection Authority
ERM	Environmental Resources Management
FIDOL	Frequency, Intensity, Duration, Offensiveness and Location of Odours
GLCC	Global Land Cover Classification
KSC	Kempsey Shire Council
LES	Local Environment Study
MRM	Macleay River Meats
MRP	Macleay River Proteins
NASA	National Aeronautics and Space Administration
NEPC	National Environment Protection Council
NEPM	National Environmental Protection Measure
NGER	National Greenhouse Energy Reporting
NO_2	Nitrogen Dioxide
NSW	New South Wales
NSW EPA	New South Wales Environment Protection Authority
NSW- OEH	New South Wales Office of Environment and Heritage
O_3	Ozone
The Odour Unit	The Odour Unit Pty Ltd

Odour Technical Framework	Technical Framework – Assessment and Management of Odour from Stationary Sources in NSW, NSW-EPA
OU	Odour Unit
$PM_{2.5}$	Particulate matter less than 2.5 µm
PM_{10}	Particulate matter less than 10 µm
POEO	Protection of the Environment Operations Act
RH	Relative Humidity
SA	South Australia
SLR	SLR Consulting Australia Pty Ltd
SO_2	Sulfur Dioxide
SOER	Specific Odour Emission Rate
SRC	Sigma Research Corporation
SRTM	Shuttle Radar Topography Mission
STP	Sewerage Treatment Plant
Study Area	Area focusing on the assessed sources and the Council proposed re-zoning areas
TAPM	The Air Pollution Model
TSP	Total suspended particulates
Ultrazyme	Biological treatment agent used at the wastewater treatment system at EFP. The agent is added into the treatment train at controlled dosage rates to breakdown and decompose waste under aerobic conditions
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
Vic	Victoria
WA	Western Australia
Wind Roses	A wind rose is a graphical tool used to show wind speed and wind direction for a particular location over a specified period of time. The wind rose is divided into a number of spokes which represent the frequency of winds blowing from a particular direction

APPENDIX A

Peak to Mean Ratios – Table 6.1 – Approved Methods

Table 6.1: Factors for estimating peak concentrations in flat terrain (Katestone Scientific 1995 and 1998)

Source type	Pasquill–Gifford stability class	Near-field P/M60*	Far-field P/M60*
Area	A, B, C, D	2.5	2.3
	E, F	2.3	1.9
Line	A–F	6	6
Surface wake-free point	A, B, C	12	4
	D, E, F	25	7
Tall wake-free point	A, B, C	17	3
	D, E, F	35	6
Wake-affected point	A–F	2.3	2.3
Volume	A–F	2.3	2.3

* Ratio of peak 1-second average concentrations to mean 1-hour average concentrations

APPENDIX B

Layout of MRM and MRP

Figure B-1: Layout of the Macley River Meats (MRM)

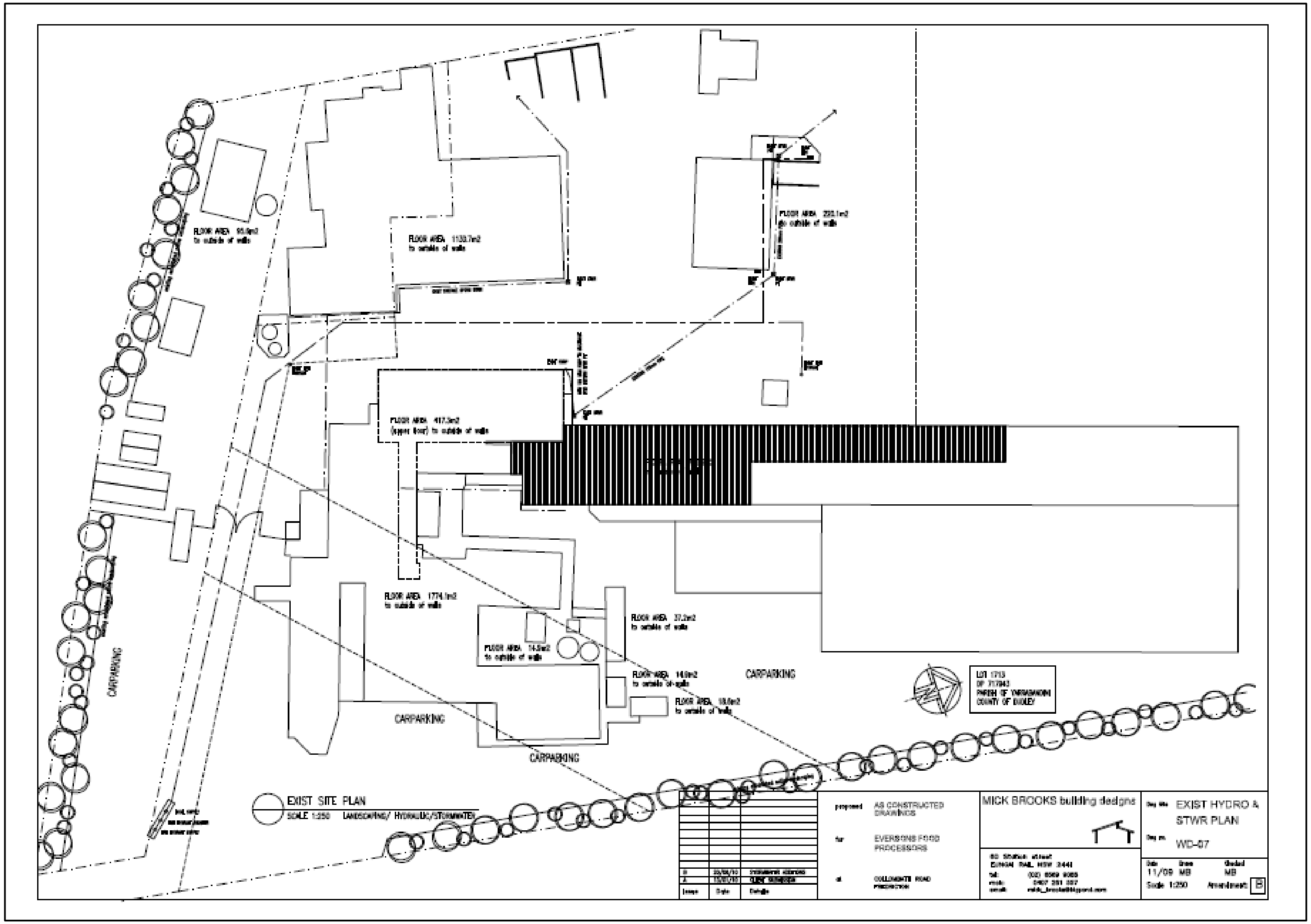

Figure B-2: Layout of the Macley River Proteins (MRP)