global environmental solutions

Odour Impact Assessment

North Orange 1 Sewage Pump Station

Report Number 610.11488

12 July 2012

Geolyse Pty Ltd c/o Orange City Council
PO Box 1963
Orange NSW 2800

Version: Revision 0

Odour Impact Assessment

North Orange 1 Sewage Pump Station

PREPARED BY:

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
2 Lincoln Street Lane Cove NSW 2066 Australia

(PO Box 176 Lane Cove NSW 1595 Australia)
T: 61 2 9428 8100 F: 61 2 9427 8200
E: sydney@slrconsulting.com www.slrconsulting.com

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the Client. Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of Geolyse Pty Ltd c/o Orange City Council. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR Consulting.

SLR Consulting disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
610.11488-R1	Revision 0	12 July 2012	Varun Marwaha	Martin Doyle	Martin Doyle

Table of Contents

1 INTRODUCTION 5

2 PROJECT OVERVIEW 6

2.1 Project Location 6

2.2 Project Scope 8
2.2.1 Stage One – Odour Monitoring 8
2.2.2 Stage Two – Dispersion Modelling and Odour Impact Prediction 8

2.3 Odour Emission Sources 8

2.4 Local Topography 9

3 ODOUR ASSESSMENT CRITERIA 11

3.1 Odour Impact Assessment Criteria for the Project 12

4 METEOROLOGICAL MODELLING 13

4.1 Selection of the Meteorological Year 13

4.2 TAPM 15

4.3 CALMET 15

4.4 Meteorological Data Used in Modelling 16

5 ODOUR EMISSIONS INVENTORY 20

5.1 Odour Monitoring Results 20

5.2 Calculated Odour Emission Rates 20

5.3 Comparison with Sewage Flow 21

6 DISPERSION MODELLING CONFIGURATION 23

6.1 CALPUFF 23

6.2 Odour Peak-to-Mean Ratios 23

6.3 Building Wake Effects 23

6.4 Odour Source Representation 24

7 DISPERSION MODELLING RESULTS 25

8 CONCLUSIONS AND RECOMMENDATIONS 29

8.1 Key Findings 29

Table of Contents

8.2 Recommendations 29
8.2.1 Odour Management and Mitigation 29

9 REFERENCES 30

10 ABBREVIATIONS AND ACRONYMS 31

TABLES

Table 1 NSW EPA Impact Assessment Criteria for Complex Mixtures of Odorous Air Pollutants (nose-response-time average, 99th percentile) 12
Table 2 Summary of Parameters for Determination of Representative Modelling Year 13
Table 3 Meteorological Parameters used for this Study (TAPM v 4.0.4) 15
Table 4 CALMET Configuration Used for this Study 16
Table 5 Description of Atmospheric Stability Classes 18
Table 6 Summary of the Monitoring Results 20
Table 7 Calculated Specific Odour Emission Rates (SOERs) – Vent Stack 21
Table 8 Calculated Specific Odour Emission Rates (SOERs) – Wet Well & Door Vent 21
Table 9 Building Characteristics and Coordinates 24
Table 10 Source Representation in the Modelling Setup 24

FIGURES

Figure 1 Location of the Project 6
Figure 2 Land Zoning Map – Orange Local Environmental Plan 2011 7
Figure 3 Location of the Odour Emission Sources – Pump Station 9
Figure 4 Regional Topographical Features 10
Figure 5 Comparison of Wind Roses - Long term and Selected year– Orange Airport 14
Figure 6 Seasonal Wind Roses for Pump Station (CALMET predictions, 2010) 17
Figure 7 Stability Class Frequencies at Pump Station (CALMET predictions, 2010) 18
Figure 8 Mixing Heights at the Pump Station (CALMET predictions, 2010) 19
Figure 9 22
Figure 10 Contour Plot for 99th Percentile Odour Concentrations 25
Figure 11 Contour Plot for Maximum Odour Concentrations due to Pump Station 26
Figure 12 Contour Plot of Number of Odour Events 27
Figure 13 Contour Plot of Number of Odour Events for Stack Vent 28

APPENDICES

Appendix A Odour Monitoring Report

1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR Consulting) has been commissioned by Geolyse Pty Ltd (Geolyse) on behalf of Orange City Council (the Council) to conduct an odour impact assessment for the North Orange No. 1 sewage pump station (hereafter, the pump station).

It is proposed by the Council that an area in the vicinity of the pump station is to be developed as a residential development site. Although in a rural setting, the Council is required to undertake an impact assessment to assess the potential for odour impacts on the proposed encroaching residential development.

The objectives of the study are to:

- Investigate and identify any sources of odour on or in the vicinity of the pump station.
- Investigate the implications of any existing odours for the staging of the development of surrounding proposed residential development.
- Provide odour contours from which practical distances to residential development can be derived.
- Recommend management strategies to maximise development opportunities both under the existing odour situation, and into the future.

The *"Technical framework: Assessment and management of Odour from stationary sources in NSW*" (DEC, 2006) (hereafter the Odour Framework) outlines the parameters that need to be determined in any odour impact assessment, as follows:

- All potential odour sources – materials, equipment or activities (including transport, waste management and maintenance) (**Section 2.3**)
- The location of the emission of each odour source as well as its characteristics and likely emission frequency, timing, duration, intensity, characteristics and chemical composition (**Section 2.3**)
- Operating hours and times when intermittent odour-generating activities are likely to occur (**Section 2.3**)
- Weather conditions particular to the site (including prevailing wind directions and the likelihood of inversions or katabatic drift) (**Section 4**)
- Site features that may affect odour propagation and dispersion, including topography, vegetation, buildings and surrounding land uses (**Section 2.4**)
- The odour assessment criteria that were used to assess the proposal under current and future circumstances (for example, where possibility of a change in land use exists) (**Section 3**)
- Likely odour impacts (predicted using level 1, 2 or 3 assessment) (**Section 7**)

Odour Impact Assessment studies are also generally required to assess odour at surrounding sensitive receptor locations. In this instance, impacts across an area of land are of primary concern, and odour impacts are predicted across this proposed residential land as identified in **Section 2.1**.

This study has been performed with reference to the *"Technical notes: Assessment and management of Odour from stationary sources in NSW*" (DEC, 2006) (hereafter the Odour Technical Notes).

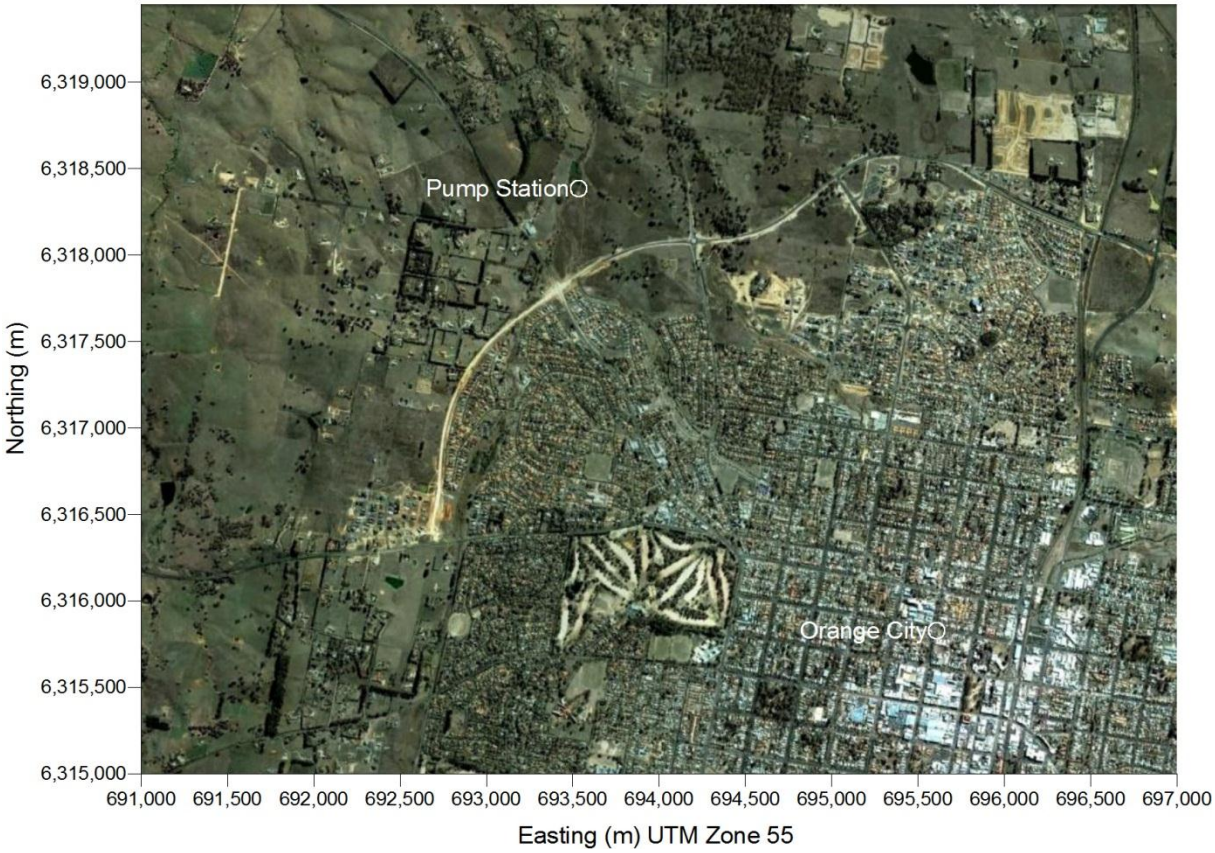
2 PROJECT OVERVIEW

2.1 Project Location

The pump station is located approximately 3 kilometres (km) northwest of Orange City.

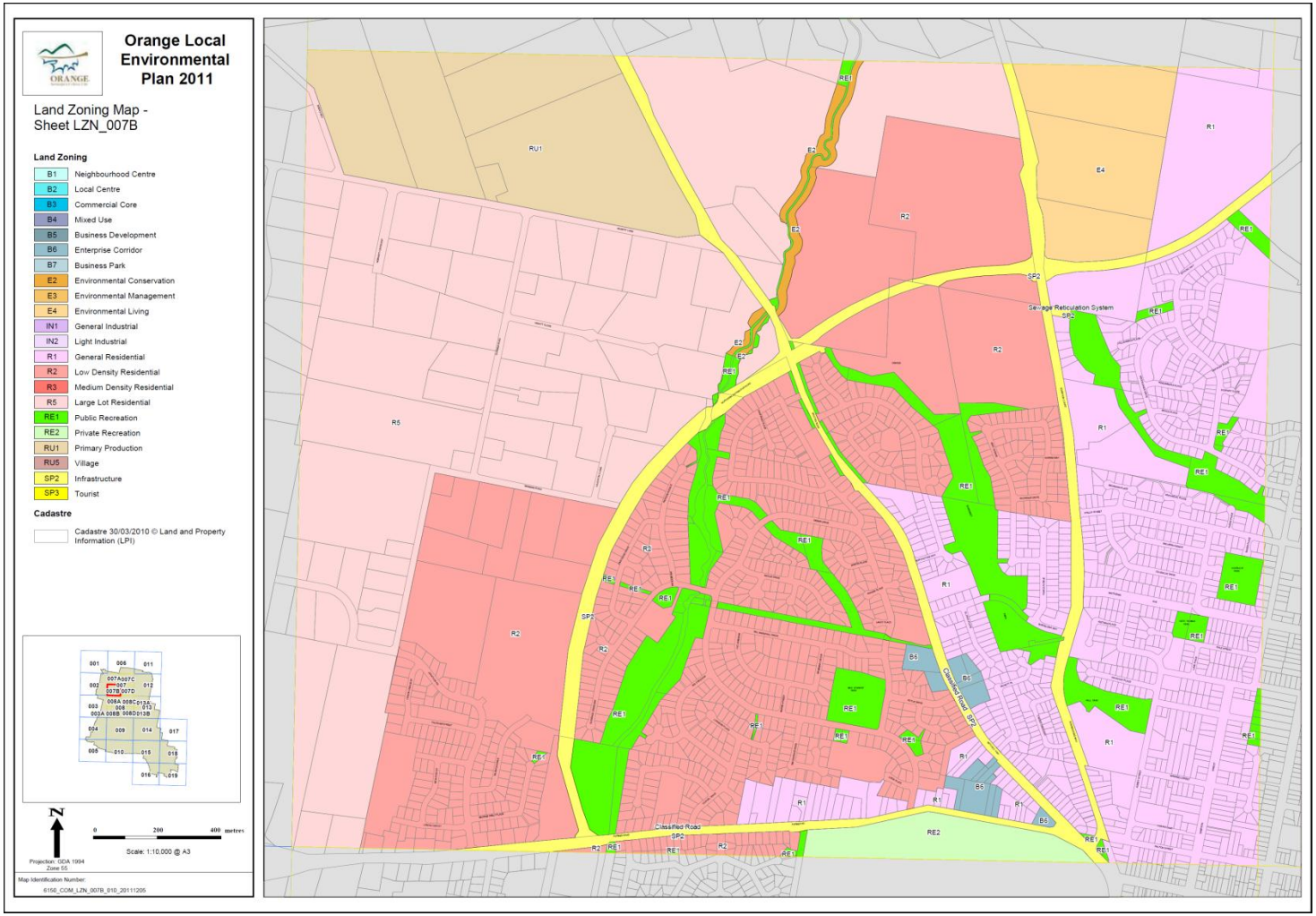
The land surrounding the pump station is proposed to be subdivided into low to medium density residential lots with the possibility of a small number of local-needs service orientated developments. **Figure 1** shows the location of the pump station in comparison to the location of Orange City.

Figure 1 Location of the Project



The proposed land zoning map is shown in **Figure 2**.

Figure 2 Land Zoning Map – Orange Local Environmental Plan 2011



2.2 Project Scope

The odour impact assessment has been divided into two stages. Stage one was concerned with the collection of odour data and the derivation of odour emission rates relating to the pump station operation. Stage two of the assessment is concerned with the modelling of odour emissions and the prediction of odour dispersion and resulting odour concentrations across the surrounding land. The detailed scope of each stage of the assessment has been summarised below.

2.2.1 Stage One – Odour Monitoring

- Site visit and investigation of the area surrounding the proposed residential development to identify potential odour sources.
- Collection of triplicate odour samples using the 'lung-in-a-drum' method as per *AS4323.3:2001 Stationary Source Emissions Part 3: Determination of odour concentration by dynamic olfactometry (AS4323.3.2001)*. The samples were collected during three distinct time periods to allow variations in odour concentrations during the day:
  - Off-Peak – 11pm – 1am
  - Peak – 7am – 9am
  - Off-Peak – 11am – 1pm
- Collection of data on source dimensions and other details.
- Analysis of odour samples based on AS4323.3.2001.

A detailed report for Stage One can be found in **Appendix A**.

2.2.2 Stage Two – Dispersion Modelling and Odour Impact Prediction

As part of the Stage Two assessment (this report), the following tasks have been undertaken:

- Quantification of odour emissions from all sources using monitored odour emissions data.
- Atmospheric dispersion modelling to determine the resultant impact of the odour emissions.
- Undertake a Level 3 Odour Impact Assessment in accordance with the Odour Framework and Odour Technical Notes.

2.3 Odour Emission Sources

The odour monitoring report identified the following odour emission sources from the pump station:

- Stack Vent
- Door Vent
- Wet Well

The location of the identified odour emission sources is shown in **Figure 3**.

Figure 3 Location of the Odour Emission Sources – Pump Station

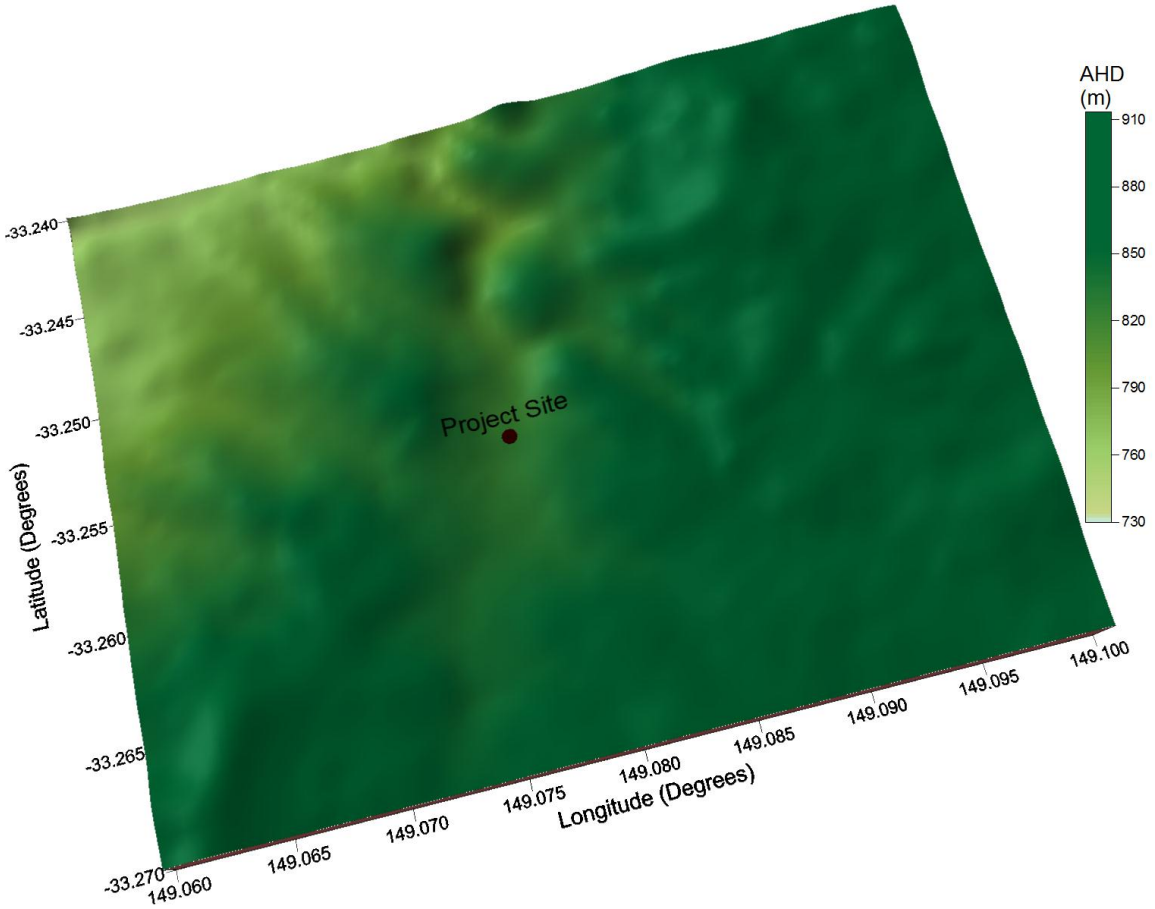
2.4 Local Topography

Figure 4 illustrates the topography of the region surrounding the pump station.

The topographical data used in the modelling assessment was sourced from the United States Geological Service's Shuttle Radar Topography Mission database that has recorded topography across Australia with a 3 arc second (~90 m) spacing.

The pump station itself is located within relatively flat terrain. However, the topography of the region surrounding the pump station is characterised by gently undulating terrain, with an approximate range of 730 m to 910 m Australian Height Datum (AHD).

Figure 4 Regional Topographical Features



Note: Vertical exaggeration of 11 applied.

3 ODOUR ASSESSMENT CRITERIA

Impacts from odorous air contaminants are often nuisance-related rather than health-related. Odour performance goals guide decisions on odour management, but are generally not intended to achieve "no odour". The detectability of an odour is a sensory property that refers to the theoretical minimum concentration that produces an olfactory response or sensation. This point is called the *odour threshold* and defines one odour unit (OU). An odour goal of less than 1 OU would theoretically result in no odour impact being experienced.

In practice, the character of a particular odour can only be judged by the receiver's reaction to it, and preferably only compared to another odour under similar social and regional conditions. Based on the literature available, the level at which an odour is perceived to be a nuisance can range from 2 OU to 10 OU depending on a combination of the following factors:

- **Odour quality**: whether an odour results from a pure compound or from a mixture of compounds. Pure compounds tend to have a higher threshold (lower offensiveness) than a mixture of compounds.
- **Population sensitivity**: any given population contains individuals with a range of sensitivities to odour. The larger a population, the greater the number of sensitive individuals it contains.
- **Background level**: whether a given odour source, because of its location, is likely to contribute to a cumulative odour impact. In areas with more closely-located sources it may be necessary to apply a lower threshold to prevent offensive odour.
- **Public expectation**: whether a given community is tolerant of a particular type of odour and does not find it offensive, even at relatively high concentrations. For example, background agricultural odours may not be considered offensive until a higher threshold is reached than for odours from a landfill facility.
- **Source characteristics**: whether the odour is emitted from a stack (point source) or from an area (diffuse source). Generally, the components of point source emissions can be identified and treated more easily than diffuse sources. Emissions from point sources can be more easily controlled using control equipment. Point sources tend to be located in urban areas, while diffuse sources are more often located in rural locations.
- **Health effects**: whether a particular odour is likely to be associated with adverse health effects. In general, odours from agricultural activities are less likely to present a health risk than emissions from industrial facilities.

Experience gained through odour assessments from proposed and existing facilities in NSW indicates that an odour performance goal of 7 OU is likely to represent the level below which "offensive" odours should not occur (for an individual with a 'standard sensitivity' to odours).

The NSW Environment Protection Authority (EPA) recommends within the Odour Framework that, as design goal, no individual be exposed to ambient odour levels of greater than 7 OU. This is expressed as the 99th percentile value, as a nose response time average (approximately one second).

Odour performance goals need to be designed to take into account the range in sensitivities to odours within the community, and provide additional protection for individuals with a heightened response to odours, using a statistical approach which depends on the size of the affected population. As the affected population size increases, the number of sensitive individuals is also likely to increase, which suggests that more stringent goals are necessary in these situations. In addition, the potential for cumulative odour impacts in relatively sparsely populated areas can be more easily defined and assessed than in highly populated urban areas. It is often not possible or practical to determine and assess the cumulative odour impacts of all odour sources that may impact on a receptor in an urban environment. Therefore, the proposed odour performance goals allow for population density, cumulative impacts and anticipated odour levels during adverse meteorological conditions and community expectations of amenity.

The equation used by NSW EPA to determine the appropriate impact assessment criteria for complex mixtures of odorous air pollutants, as specified in the Odour Framework, is expressed as follows:

$$\text{Impact assessment criterion (OU)} = (\log_{10}(\text{population})-4.5)/-0.6$$

A summary of the impact assessment criteria given for various population densities, as drawn from the Odour Framework is given in **Table 1**. This factor has been used to derive a project specific odour criterion in **Section 3.1**.

Table 1 NSW EPA Impact Assessment Criteria for Complex Mixtures of Odorous Air Pollutants (nose-response-time average, 99th percentile)

Population of Affected Community	**Impact Assessment Criteria for Complex Mixtures of Odours (OU)**
Urban area ($\geq$ 2000)	2.0
~300	3.0
~125	4.0
~30	5.0
~10	6.0
Single residence ($\leq$ 2)	7.0

Source: Odour Framework (DEC, 2006)

The Odour Framework states that the impact assessment criteria for complex mixtures of odorous air pollutants must be applied at the nearest existing or likely future off-site sensitive receptor(s).

The incremental impact (predicted impact due to the pollutant source alone) must be reported in units consistent with the impact assessment criteria (OU), as peak concentrations (i.e. approximately 1 second average) and as the:

- 100th percentile of dispersion model predictions for Level 1 impact assessments.
- 99th percentile of dispersion model predictions for Level 2 impact assessments (this is also appropriate for Level 3 impact assessments).

3.1 Odour Impact Assessment Criteria for the Project

Given the assumed population of potential sensitive receptor locations in the immediate vicinity of the pump station it is expected that an odour impact assessment criterion of 2 OU (expressed as the 99th percentile for a nose response average, i.e. 1-second average) would appropriately characterise the odour impact from the pump station.

The area surrounding the pump station comprises a significant amount of agricultural land incorporating pastoral farming. Although the background odour environment may be significantly affected by agricultural odours, these may not be considered offensive until a higher threshold is reached than for odours from sewerage. Additionally, public expectation may be such that 'natural' odours may be less offensive than those from human waste. This reports only considers odour impacts from the pump station.

4 METEOROLOGICAL MODELLING

Meteorological mechanisms govern the dispersion, transformation and eventual removal of pollutants from the atmosphere. The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. Dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction, and the variability in wind direction, determines the general path pollutants will follow, and the extent of crosswind spreading.

Pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field (Oke, 2004).

To adequately characterise the dispersion meteorology of the study site information is needed on the prevailing wind regime, mixing depth and atmospheric stability and other parameters such as ambient temperature, rainfall and relative humidity.

4.1 Selection of the Meteorological Year

The Bureau of Meteorology (BoM) maintains a network of automatic weather stations (AWS) across Australia, which record meteorological data. The closest such station to the Project location is identified as Orange Airport AWS (Station Number 063303).

In order to determine a representative meteorological year for modelling of emissions from the pump station, a selection of parameters were analysed for the last five meteorological years. A summary of the analysis on meteorological data for years 2007, 2008, 2009, 2010 and 2011 is presented in **Table 2**.

The parameters identified in determining the representative meteorological year for modelling have been identified as:

- Percentage of hourly average wind speed events with wind speeds less than 0.5 m/s (i.e. calm conditions). Calm wind conditions are conducive to higher concentrations of odour due to poor dispersion of the pollutant plume.
- Percentage of hourly wind direction events with wind directions between 315° (Northwest) and 45° (Northeast). These wind events are conducive to higher odour impacts at the proposed encroaching residential development site (see **Figure 1**).

Table 2 Summary of Parameters for Determination of Representative Modelling Year

Year	Percentage of WS (<0.5 m/s)	Percentage of WD (b/w 315° & 45°)
2007	9.2	33.8
2008	7.1	30.3
2009	7.6	33.7
2010	9.1	34.8
2011	9.3	30.6

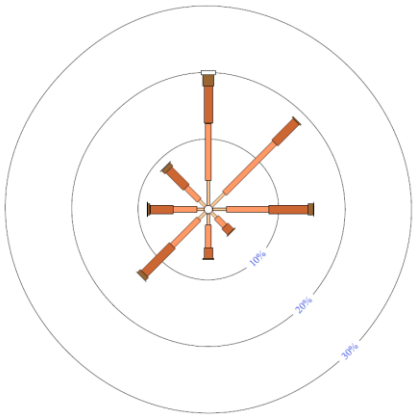
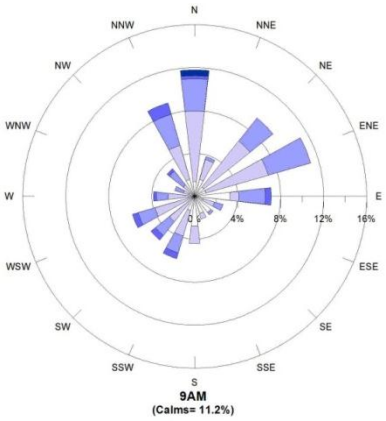
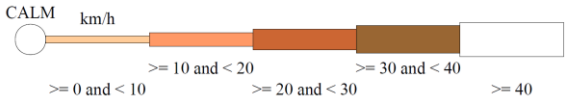
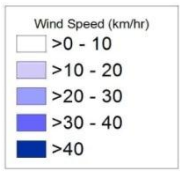
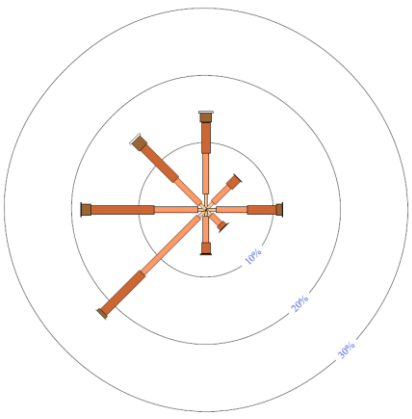
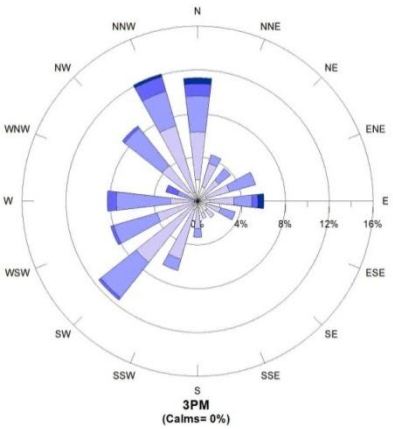
From **Table 2**, it is noted that:

- The percentage of calm wind speed events was highest for the year 2011, although only marginally above the year 2007 and 2010; and
- The percentage of hourly wind direction events with wind directions between 315° (Northwest) and 45° (Northeast) were highest for the year 2010.

Although the percentage of calm wind speed events were marginally lower in the year 2010, based on the high percentage of wind direction events conducive to higher odour impacts, the year 2010 is chosen as the representative year for meteorological modelling.

Further, in order to validate a representative meteorological year for the Project, long term meteorological data from Orange Airport AWS were analysed. A comparison of the long term meteorological conditions with the meteorological conditions for the selected year 2010 was performed in the form of a wind rose and is shown in **Figure 5**.

Figure 5 Comparison of Wind Roses - Long term and Selected year– Orange Airport

Long Term Wind Rose (1996-2010)	**Selected Year Wind Rose (2010)**
	
9:00 am; Calm: 3%	9:00 am; Calm: 11.2%
	
	
3:00 pm; Calm: <0.5%	3:00 pm; Calm: 0%

It is concluded that conditions in the year 2010 are in general agreement with the long term wind conditions at Orange Airport.

4.2 TAPM

In order to calculate all required meteorological parameters required by the dispersion modelling process, meteorological modelling using The Air Pollution Model (TAPM, v 4.0.4) has been performed. TAPM, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a prognostic model which may be used to predict three-dimensional meteorological data and air pollution concentrations.

TAPM model predicts wind speed and direction, temperature, pressure, water vapour, cloud, rain water and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate site-specific hourly meteorological observations at user-defined levels within the atmosphere.

Additionally, the TAPM model may assimilate actual local wind observations so that they can optionally be included in a model solution. The wind speed and direction observations are used to realign the predicted solution towards the observation values.

Table 3 outlines the input data used in determining the 3-dimensional meteorology of the area surrounding the Project site.

Table 3 Meteorological Parameters Adopted (TAPM v 4.0.4)

Modelling Period	1 January 2010 to 31 December 2010
Centre of analysis	693,535 E, 6,318,445 N (UTM Coordinates)
Outer grid spacing	30 km x 30 km x 4 km
Number of grids (spacing)	5 (30 km, 10 km, 3 km, 1 km, 300 m)
Data assimilation	Orange Airport AWS (2010)
Terrain	AUSLIG 9 second DEM

TAPM data on a 3-dimensional grid was output and configured for input into the diagnostic meteorological model, CALMET.

4.3 CALMET

CALMET is a meteorological model that develops wind and temperature fields on a three-dimensional gridded modelling domain. Associated two-dimensional fields such as mixing height, surface characteristics, and dispersion properties are also included in the file produced by CALMET. The interpolated wind field is then modified within the model to account for the influences of topography, as well as differential heating and surface roughness associated with different land uses across the modelling domain. These modifications are applied to the winds at each grid point to develop a final wind field. The final wind field thus reflects the influences of local topography and land uses.

Table 4 details the parameters used in the CALMET meteorological modelling. No surface or upper air observations were used in the CALMET model ('No-Obs Mode' hereafter). This approach is recommended by Scire et al, 2011 as:

- No-Obs mode allows the important benefits of the non-steady-state approach in CALPUFF to be included in the dispersion modelling (e.g., spatially varying meteorology and dispersion, causality, recirculation, stagnation, pollutant build-up, fumigation, etc.).

- No-Obs mode makes use of three-dimensional, hourly prognostic meteorological data often available at high resolution to drive CALMET and CALPUFF (TAPM output).
- No-Obs mode greatly simplifies the preparation of the CALMET inputs because a large number of input variables dealing with observational data are not required and the difficulties of dealing with potentially incomplete observational datasets are eliminated.
- No-Obs mode provides a relatively straightforward approach that facilitates agency review and approval of the CALMET/CALPUFF simulations.

Table 4 CALMET Configuration Used for this Study

Meteorological grid domain	12 km x 12 km
Meteorological grid resolution	100 m
TERRAD Value	0.4 km
Vertical Resolution (Cell Heights)	11 (0 m, 20 m, 40 m, 80 m, 160 m, 320 m, 640 m, 1200 m, 2000 m, 3000 m, 4000 m)
Modelling Year	2010

4.4 Meteorological Data Used in Modelling

Wind Speed and Direction

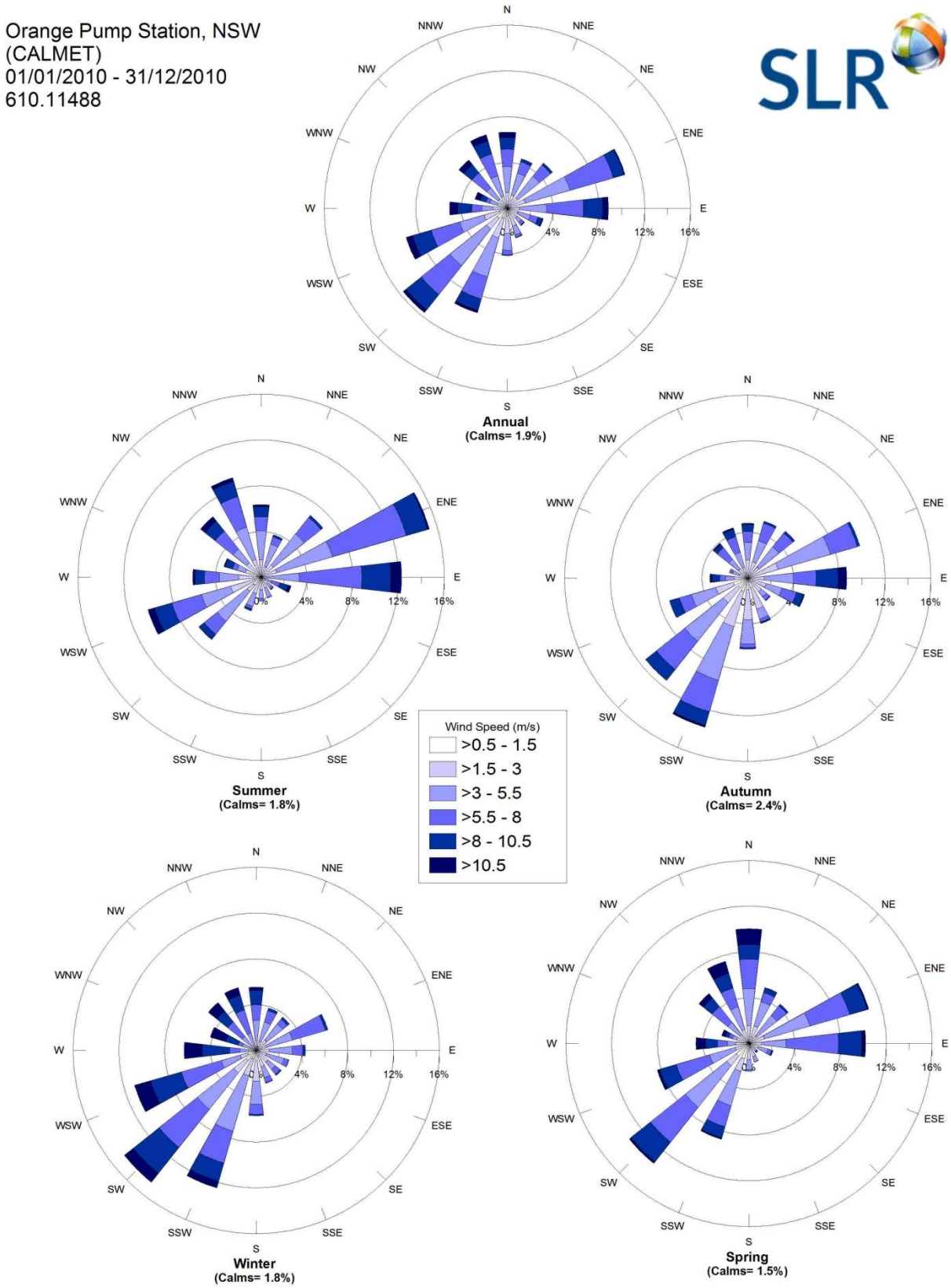
A summary of the annual wind behaviour predicted by CALMET at the pump station is presented as wind roses in **Figure 6**.

Figure 6 indicates that winds experienced at the sites are predominantly moderate to heavy (between 3 m/s and 10.5 m/s) and wind direction is seasonally dependent. Winds occur reasonably evenly from all quadrants except the south-eastern quadrants. Calm wind conditions (wind speed less than 0.5 m/s) were predicted to occur approximately 2 % of the time throughout the modelling period.

The seasonal wind roses indicate that typically:

- In summer, winds are moderate to heavy predominantly from east northeast and west southwest quadrant (approximately 58 % combined) with very few light winds.
- In autumn, winds are light to moderate predominately from south southwest and east northeast (approximately 51% combined), with very few light winds.
- In winter, winds are moderate to heavy and are experienced predominantly from the southwest quadrant (approximately 38 % combined), with very few light winds.
- In spring, winds are moderate to heavy predominately from the southwest, east northeast and northern quadrant (approximately 51 % combined) with very few light winds.

Figure 6 Seasonal Wind Roses for Pump Station (CALMET predictions, 2010)



Atmospheric Stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Turner assignment scheme identifies six Stability Classes, A to F, to categorise the degree of atmospheric stability (see **Table 5**). These classes indicate the characteristics of the prevailing meteorological conditions and are used as input into various air dispersion models.

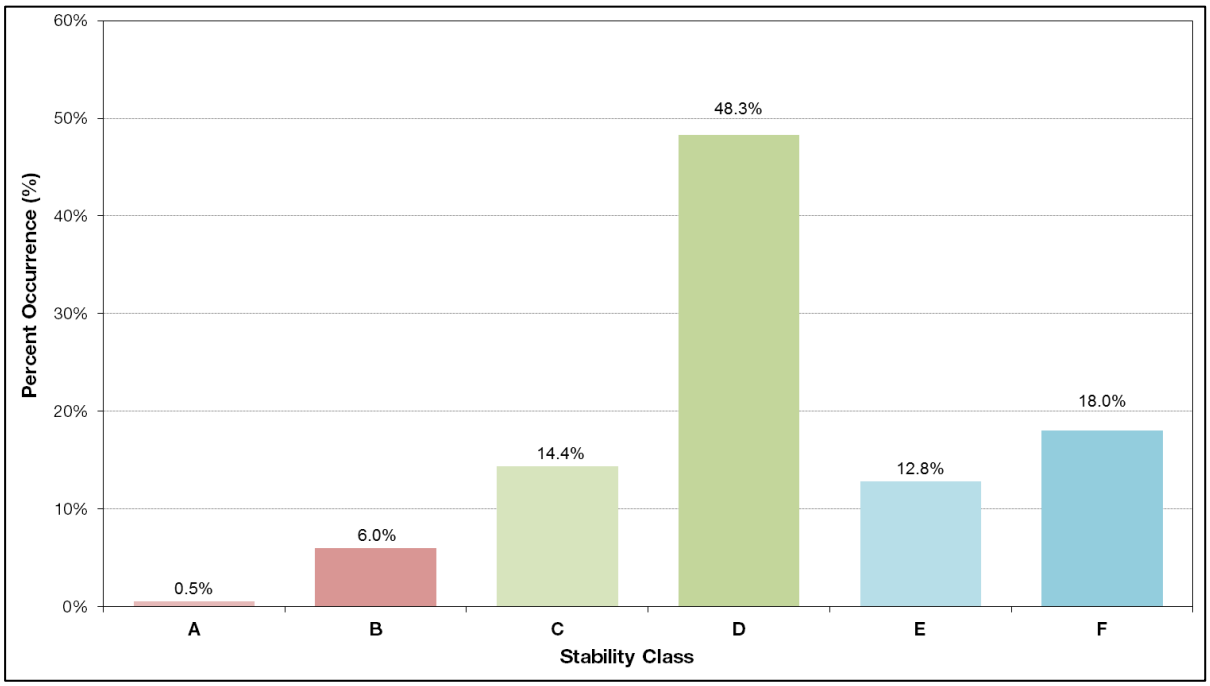
Table 5 Description of Atmospheric Stability Classes

Atmospheric Stability Class	Category Description
A	Very unstable Low wind, clear skies, hot daytime conditions
B	Unstable Clear skies, daytime conditions
C	Moderately unstable Moderate wind, slightly overcast daytime conditions
D	Neutral High winds or cloudy days and nights
E	Stable Moderate wind, slightly overcast night-time conditions
F	Very stable Low winds, clear skies, cold night-time conditions

The frequency of each stability class predicted by CALMET, extracted at the pump station during the modelling period is presented in **Figure 7**. The results indicate a high frequency of conditions typical to Stability Class D and F.

Stability Class D is indicative of neutral conditions, conducive to a moderate level of pollutant dispersion due to mechanical mixing. Stability Class F is indicative of stable night time conditions, which will inhibit pollutant dispersion.

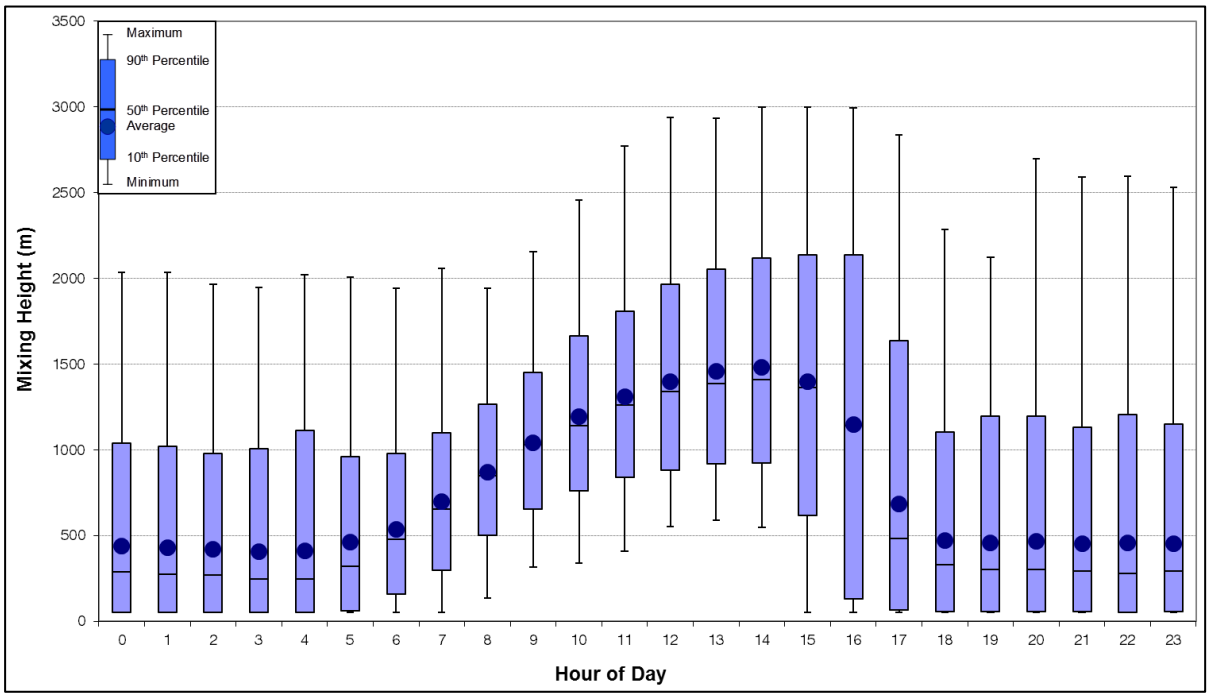
Figure 7 Stability Class Frequencies at Pump Station (CALMET predictions, 2010)



Mixing Heights

Diurnal variations in maximum and average mixing depths predicted by CALMET at the pump station during the 2010 modelling period are illustrated in **Figure 8**. As would be expected, an increase in mixing depth during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground based temperature inversions and growth of the convective mixing layer.

Figure 8 Mixing Heights at the Pump Station (CALMET predictions, 2010)



5 ODOUR EMISSIONS INVENTORY

5.1 Odour Monitoring Results

SLR Consulting conducted a monitoring campaign at the pump station in June 2012. A summary of the results from the odour monitoring campaign is shown in **Table 6**. A detailed monitoring report is presented in **Appendix A**.

Table 6 Summary of the Odour Monitoring Results

Location	Sample ID	Monitoring Date	Sampling Time	Velocity (m/s)	Volumetric Flow Rate (Nm^3/s)	Odour Concentration (OU)[1]
Vent stack	1233	12/6/2012	2335-2350	0.96	0.05	1,688
Vent stack	1234	12/6/2012	2350-0005	0.96	0.05	2,526
Vent stack	1235	13/6/2012	0005-0020	0.96	0.05	1,237
Vent stack	1239	13/6/2012	0758-0812	1.34	0.07	495
Vent stack	1240	13/6/2012	0814-0828	1.34	0.07	1,148
Vent stack	1241	13/6/2012	0835-0850	1.34	0.07	1,053
Wet well	1242	13/6/2012	0800-0815	ND	ND	603
Door vent	1243	13/6/2012	0825-0840	ND	ND	20
Vent stack	1244	13/6/2012	1217-1230	1.36	0.07	1,148
Vent stack	1245	13/6/2012	1230-1243	1.36	0.07	1,341
Vent stack	1246	13/6/2012	1245-1258	1.36	0.07	896

ND No Data – no flow could be measured from these locations.

[1] Source: ORLA, 2012a, ORLA 2012b

It is noted that for the wet well and door vent, the volumetric flowrate measurements could not be recorded because of the limitation of the manometer to record low measurements.

5.2 Calculated Odour Emission Rates

An Odour Emission Rate (OER) is the product of the odour concentration (OU) and the volumetric flow rate (m^3/s or m^3/min), and is often annotated as $OU.m^3/s$, or $OU.m^3/min$. An odour emission rate can be thought of as the volume of clean air that would be required to dilute the concentration of odorous gas emitted per unit time down to 1 OU.

The Specific Odour Emission Rate (SOER) may be defined as the quantity of odour emitted per unit time from a unit surface area. The quantity of odour emitted is not determined directly by olfactometry, but is calculated from the concentration of odour (as measured by olfactometry) which is then multiplied by the volume of air passing through the measurement system per unit time. SOERs are often annotated as $OU.m^3/m^2/s$, or $OU.m^3/m^2/min$.

$SOER\ (OU.m^3/m^2/s) = OC \times Q/A$

Where:

OC= odour concentration of compound from air in the chamber (OU)

Q = sweep gas flow rate into chamber (m^3/s)

A = sample source total surface (m^2)

Based on the site specific monitoring data presented in **Table 6**, the specific odour emission rates from the stack vent have been calculated and are presented in **Table 7**.

Table 7 Calculated Specific Odour Emission Rates (SOERs) – Vent Stack

Source	Sample ID	Sampling Time	SOER - Dry ($OU.m^3/s$)
Vent stack	1233	2335-2350	86
Vent stack	1234	2350-0005	129
Vent stack	1235	0005-0020	63
Vent stack	1239	0758-0812	33
Vent stack	1240	0814-0828	77
Vent stack	1241	0835-0850	71
Vent stack	1244	1217-1230	78
Vent stack	1245	1230-1243	91
Vent stack	1246	1245-1258	61

In the absence of volumetric flowrate data for the wet well and door vent, it has been assumed that volumetric flowrate from these sources is equal to the maximum flowrate from the vent stack (0.07 Nm^3/s). This assumption is considered to be appropriate given that all emissions at the pump station are generally governed by the displacement of air, rather than the active (forced) emission from a source.

The calculated specific odour emission rates for the wet well and door vent are presented in **Table 8**.

Table 8 Calculated Specific Odour Emission Rates (SOERs) – Wet Well & Door Vent

Source	Sample ID	Sampling Time	SOER - Dry ($OU.m^3/s$)
Wet well	1242	0800-0815	42.2
Door vent	1243	0825-0840	1.4

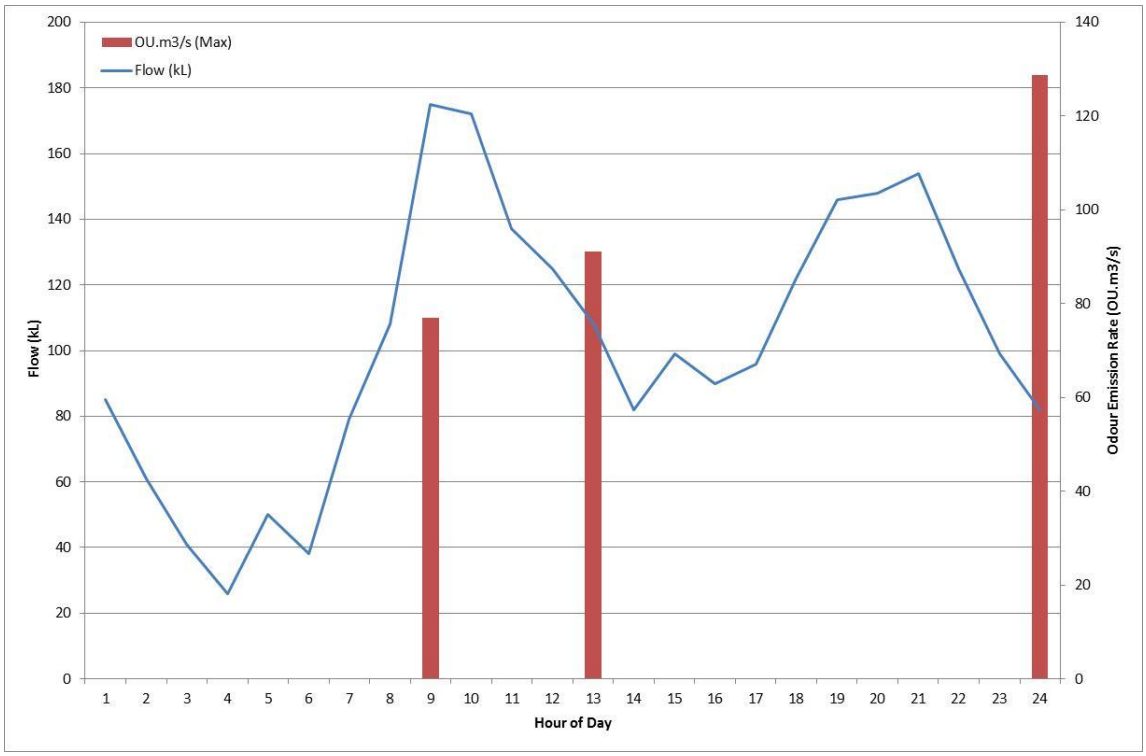
5.3 Comparison with Sewage Flow

Odour emissions were sampled at various time of the day (refer **Section 2.2.1**) to assess whether any relationship between sewage flow and odour emissions was apparent. Information of the annual average hourly flow through the pump station was provided by Orange City Council.

It can be noted from **Table 7** that maximum odour emissions from the vent stack are observed during periods of lower sewage flow, as shown in **Figure 9**. The higher odour emissions during the night-time period are most likely due to the material releasing odour which is allowed to 'pool'. In periods of higher flow, material would not be allowed to remain stationary for periods of time, with the added effect of material movement removing odours into the system itself, rather than allowed to exit via the vent stack.

Higher odour emission rates have been applied across all hours within this assessment to allow a conservative assessment of likely odour impacts to be performed.

Figure 9 Annual Average Daily Sewage Flow and Monitored Odour Emission Rates



6 DISPERSION MODELLING CONFIGURATION

6.1 CALPUFF

Odour emissions from the pump station have been modelled using the US EPA's CALPUFF (Version 6) modelling system, as recommended by the NSW EPA. CALPUFF is a transport and dispersion model that ejects "puffs" of material emitted from modelled sources, simulating dispersion and transformation processes along the way. In doing so it typically uses the fields generated by a meteorological pre-processor CALMET, discussed in **Section 4.3**. The primary output files from CALPUFF contain either hourly concentration or hourly deposition fluxes evaluated at selected receptor locations. The CALPOST post-processor is then used to process these files, producing tabulations that summarise results of the simulation for user-selected averaging periods.

The advantages of using CALPUFF (rather than using a steady state Gaussian dispersion model such as Ausplume) is its ability to handle calm wind speeds (<0.5 m/s), complicated terrain and cumulative pollution impacts. Steady state models assume that meteorology is unchanged by topography over the modelling domain and may result in significant over or under estimation of air quality impacts.

More advanced dispersion models (such as CALPUFF) are approved for use by many regulatory authorities in situations where these models may be more appropriate than use of the Ausplume model. Such situations include those noted above (i.e. high frequency of calm wind conditions and/or complicated terrain). Given the amount of calm wind conditions experienced across the region, the CALPUFF modelling system was selected for use in place of Ausplume.

6.2 Odour Peak-to-Mean Ratios

The NSW EPA document "*Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales"* (DEC, 2005) (hereafter Approved Methods) states that Peak-to-Mean ratios should be incorporated when conducting atmospheric dispersion modelling of odour.

It is commonly recognised that dispersion models such as CALPUFF need to be supplemented to accurately simulate atmospheric dispersion of odours. This is because the instantaneous perception of odours by the human nose typically occurs over a time scale of approximately one second but dispersion model predictions are typically valid for time scales equivalent to ten minutes to one hour averaging periods. To estimate the effects of plume meandering and concentration fluctuations perceived by the human nose, it is possible to multiply dispersion model predictions by a correction factor called a "peak-to-mean ratio". The peak to mean ratio (P/M60) is defined as the ratio of peak 1-second average concentrations to mean 1-hour average concentrations.

To estimate peak concentrations, this assessment has used data presented in Table 6.1 of the Odour Framework. Specifically, to establish a conservatively high estimate of peak odour concentrations, the following peak to mean ratio (P/M60) has been adopted, corresponding to near-field receptors:

- A Peak-to-Mean Ratio (P/M60) of 2.5 has been applied to the emission rate for area sources during periods where atmospheric stability class is between A and D.
- A Peak-to-Mean Ratio (P/M60) of 2.3 has been applied to the emission rate for area sources during periods where atmospheric stability class is E or F.

A Peak-to-Mean Ratio (P/M60) of 2.3 has been applied to the emission rates for point sources and volume sources modelled within this assessment.

6.3 Building Wake Effects

Plumes trapped in building wakes can either be recirculated in the cavity region immediately downwind of a building or subjected to plume downwash and enhanced horizontal or vertical spreading due to the turbulent zone that exists further downwind.

Buildings generate downwind wake effects up to 5 times the lesser of the building height or projected building width. If there are stacks less than approximately 2.5 times the building height within this zone, then the effect of building wakes should be considered.

Building wake effects were included in the dispersion modeling in relation to the pump station building.

Wake effects from the pump station house were included for the stack vent and the building locations used in this assessment are shown in **Table 9**.

Table 9 Building Characteristics and Coordinates

Building	**Height (m)**	**Easting (m)**	**Northing (m)**
Pump station house	3	607,132.7	5,933,536.6

The easting and northing coordinates of the pump house represents the southwest corner of the building.

6.4 Odour Source Representation

The identified sources of odour emissions from the pump station have been modelled and have been setup in the dispersion model as shown in **Table 10**.

Table 10 Source Representation in Dispersion Modelling

Source	**Source Type**	**Diameter (m)**	**Height (m)**	**Exit Velocity (m/s)**	**Exit Temperature (K)**	**Dimensions (m x m)**	**SOER – Dry ($OU.m^3/s$)**
Vent stack	Point	0.27	5	1.34	285.5	NA	296.7
Door vent	Volume	NA	2.5	NA	NA	5 x 5	3.2
Source	**Source Type**	**Diameter (m)**	**Height (m)**	**Exit Velocity (m/s)**	**Exit Temperature (K)**	**Dimensions (m x m)**	**SOER – Dry ($OU.m^2/s$)**
Wet well	Area	NA	0.1	NA	NA	3.3 x 2.3	5.6

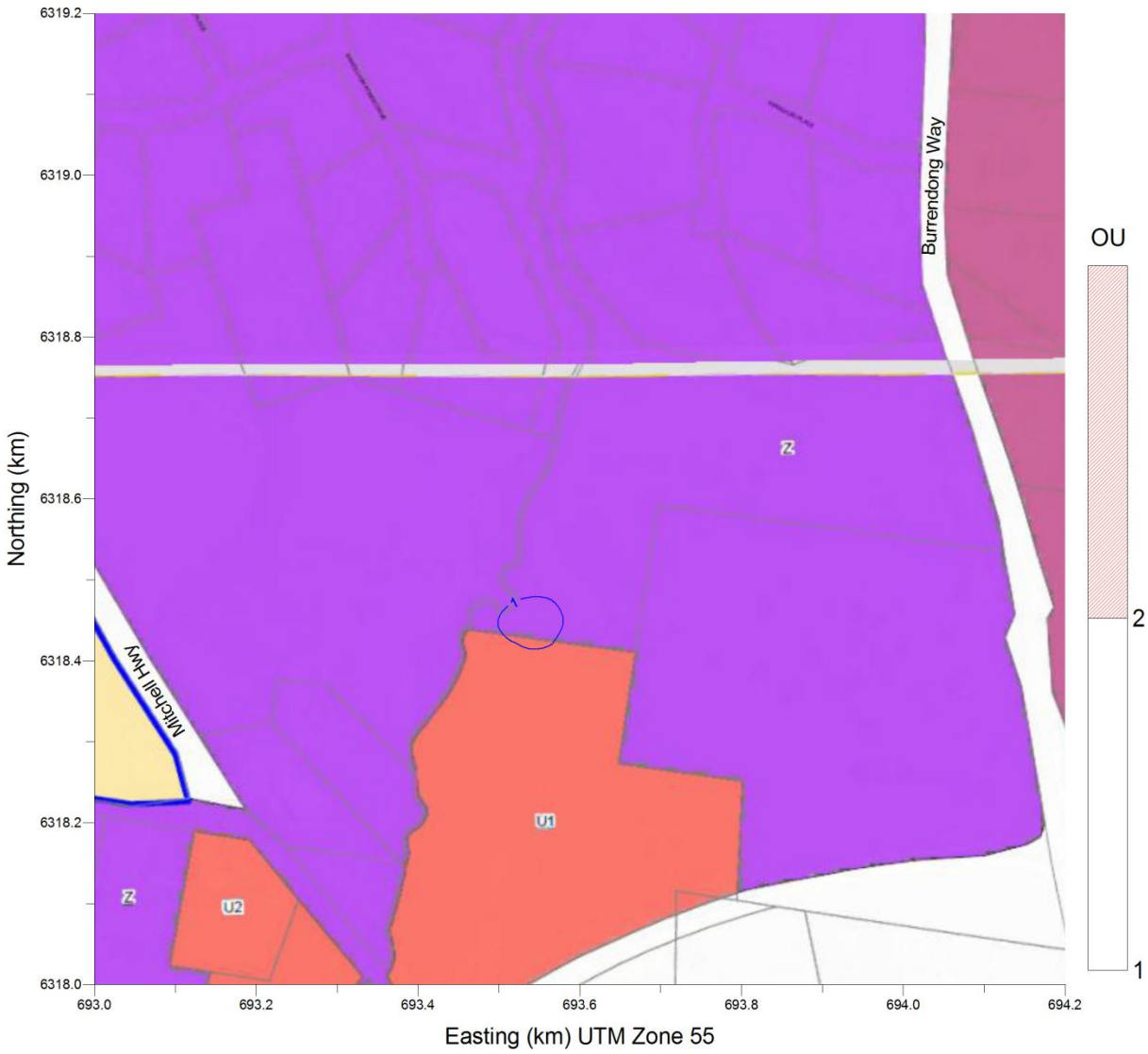
It is noted that the source representation shown in **Table 10** represents a conservative approach as:

- The pump house building is assumed to emit odour as a volume source whereas in reality the odour is being emitted only from the door vent of the pump house building.
- The wet well area is assumed to emit odour as an area source whereas in reality the wet well is covered and the odour is being emitted only because the cover is not airtight.

7 DISPERSION MODELLING RESULTS

The predicted 99th percentile odour concentrations (for nose-response time, 1-second average) output by CALPUFF are presented in **Figure 10**.

Figure 10 Predicted 99th Percentile Odour Concentrations



It is noted that the predicted 99th percentile odour concentration does not exceed the Project odour criterion of 2 OU within any area of proposed redevelopment or at any nearby sensitive receptor.

The odour contour plots do not reflect odour concentrations occurring at any particular instant in time, but rather illustrate the predicted 99th percentile odour concentration taking into account all combinations of meteorological conditions modelled across the entire year.

It is predicted that the most stringent odour criterion will be achieved within close proximity to the pump station. However, following residential development, this may not necessarily result in no odour complaints being received by council. The percentile approach to odour assessment means that odour can be experienced at high concentrations in an area over short periods of time, but may not result in exceedances of the odour criterion.

Further analysis of the maximum predicted odour concentrations has therefore been performed to identify the likelihood that odour complaints may be received by Council from any residential development in the area. Maximum predicted odour concentrations are presented in **Figure 11**.

Figure 11 Predicted Maximum Odour Concentrations

It is noted from **Figure 11** that the theoretical odour threshold of 1 OU is predicted to be experienced across an area of approximately 10% of the proposed residential subdivision. This identifies that the potential for odour complaints exists in the north eastern area of the proposed subdivision, although the odour criterion is not anticipated to be exceeded.

An analysis of the number of 'odour events' has also been performed with results presented in **Figure 12**. For the purpose of this assessment, an 'odour event' is defined as a period when odour concentrations exceed 1 OU (the theoretical odour detection threshold). This is presented to allow identification of the number of potential odour complaints in each year.

It is identified from **Figure 12** that within approximately 10% of the proposed subdivision, at least one odour event per year is predicted.

Figure 12 Predicted Number of Odour Events (above 1 OU)

It is anticipated that with appropriate mitigation measures applied to the wet well and the door vent, the number of odour events can be reduced further. A dispersion model run with stack vent as the only source was run, and the results are presented in **Figure 13**.

7.1 Odour Management and Mitigation

During the odour monitoring campaign, potential odour mitigation measures were identified. These are:

- sealing of the wet well cover; and
- sealing of the concrete channel housing electrical cables to the pump house (this will effectively mean that there will be no odour emissions from the pump house).

It is considered that these mitigation measures will be easy to implement and at low cost. The resultant impacts of these mitigation measures on the number of exceedances of the theoretical odour detection threshold (1 OU) is presented in **Figure 13**.

Further reductions in odour may be achieved by the installation of vegetated buffers between the proposed residential subdivision and the pump station. However, the resulting odour reduction within the subdivision cannot be quantified through the dispersion modelling exercise.

Figure 13 Predicted Number of Odour Events (above 1 OU) – Odour Mitigation Applied

It can be seen that the application of odour mitigation measures on the wet well and pump house result in a reduction in the number of odour events in the proposed subdivision.

8 CONCLUSIONS AND RECOMMENDATIONS

An odour impact assessment was performed to assess the potential odour impact of the operation of the North Orange sewage pump station on a proposed residential subdivision. Results of an odour monitoring and dispersion modelling assessment identify that odour is predicted to be within criteria limits usually reserved for high density residential development. The main findings of the assessment and recommendations made in respect of such findings are presented below.

8.1 Key Findings

The Project odour criterion of 2 OU (as a 99th percentile, nose response time average) is not predicted to be exceeded within the proposed subdivision, or at any existing sensitive receptors. However, from examination of the maximum predicted odour concentrations and the analysis of number of 'odour events', it is concluded that odour is predicted to be experienced within approximately 10% of the proposed subdivision. Although the odour criterion is predicted to be achieved across all parts of the proposed subdivision, there may be occasions when odour may be experienced above threshold concentrations, and therefore the risk of Council receiving odour complaints may be increased.

With the installation of appropriate odour mitigation measures for the wet well and door vent at the pump station, the number of odour events is predicted to be reduced and the area in which the odour is experienced is minimised to an area in the immediate northwest of the proposed subdivision.

8.2 Recommendations

8.2.1 Odour Management and Mitigation

Mitigation measures could be applied within the pump station, the aim of which would be to reduce exposure to odour. Specifically, the options are described as follows:

- sealing of the wet well cover;
- sealing of concrete channel housing electrical cables to pump house (this will effectively mean that there will be no odour emissions from the pump house) ; and
- installation of buffers (vegetated) between residences and pump station.

9 REFERENCES

- AS4323.3.2001, Stationary Source Emissions Part 3: Determination of odour concentration by dynamic olfactometry.
- DEC 2005, Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales, 2005, Department of Environment and Conservation NSW, August 2005.
- DEC 2006, Technical framework: assessment and management of odour from stationary sources in NSW, Department of Environment and Conservation NSW, November 2006.
- ORLA 2012a, Olfactometry Test Report, ORLA Report Number 5101/ORLA/01/Revision B, 13 June 2012.
- ORLA 2012b, Olfactometry Test Report, ORLA Report Number 5101/ORLA/02/Revision B, 14 June 2012.
- Scire et al 2011, Generic Guidance and Optimum Model Settings for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia', Atmospheric Studies Group, TRC Environmental Corporation, March 2011.

10 ABBREVIATIONS AND ACRONYMS

AWS	Automatic Weather Station
BoM	Bureau of Meteorology
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EPA	NSW Environment Protection Authority
SLR Consulting	SLR Consulting Australia Pty Ltd
TAPM	The Air Pollution Model
µm	Micrometre or micron (metre x 10^{-6})
m^3	Cubic metre
OU	Odour Units; concentration of odorous mixtures in odour units. The number of odour units is the concentration of a sample divided by the odour threshold or the number of dilutions required for the sample to reach the threshold. This threshold is equivalent to when 50% of a testing panel correctly detect an odour
SOER	Odour Emission Rate ($OU.m^3/s$)
OUV	Odour Unit Volumes; odour units are not concentrations but are a ratio. As such, they may not be used to represent an odour emission. It is necessary to multiply the source odour level (OU) by the volume of air emitted per second, to produce an odour emission rate. Typically odour emission rates may be expressed as OUV/s (point/volume sources) and $OUV/m^2/s$ (area sources) with units of $OU.m^3/s$ and $OU.m^3/m^2/s$ respectively.