West Culburra

Proposed Mixed Use Subdivision

Odour Impact Assessment

Report Number 660.10019-R1D2

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NSW 2000

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Proposed Mixed Use Subdivision

Odour Impact Assessment

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EXECUTIVE SUMMARY

SLR Consulting Australia Pty Ltd (SLR Consulting) has been commissioned by Allen, Price & Associates on behalf of Realty Realizations Pty Ltd (the proponent) to prepare an Odour Impact Assessment for a concept plan for a proposed mixed used subdivision in West Culburra, New South Wales.

It is SLR Consulting's understanding that the proposed subdivision may encroach on the established buffer zone around the neighbouring Culburra Sewage Treatment Plant (the Project Site) and that an odour assessment is required to determine whether the proposed subdivision will introduce incompatible land uses and investigate the application of the 400 m buffer distance as specified in Councils Development Control Plan (DCP 67).

The advanced atmospheric dispersion model CALPUFF was selected to carry out the dispersion modelling calculations. The NSW DECCW odour assessment criterion applicable to high density urban areas was used to assess the performance of the STP. This was based on the proposed number of dwellings in the surrounding area and the resultant population density of greater than 2,000 persons.

The results of the dispersion modelling for the Culburra STP suggested that no exceedance of the odour criterion of 2 odour units (2 OU) would occur beyond the 400 m buffer zone. The potential for exceedance of the odour criterion was predicted for an area to the southeast of the proposed site, to a distance of approximately 400 m, with the potential for introduction of incompatible land uses in the northwest corner of Area 1.

Commercial development of the area south of the STP, between Area 1 and 3 has been suggested in the draft concept drawings, with detailed plans yet to be finalised. Current NSW DECCW guidance does not differentiate between commercial and residential properties in terms of the potential for odour impacts. It is however expected that the tolerance for offensive odour is higher in commercial areas than in residential areas where people may be subjected to the odour for a longer period of time.

No exceedance of the odour criterion was detected for any of the remaining areas. The following points should be considered in relation to the odour assessment:

- Dispersion modelling was conducted using a range of odour emission rates obtained from STP sites which possessed a larger annual capacity than the Culburra STP. There is a high likelihood that the adopted odour emission rates have over accounted for the potential odorous emissions from sources at the Culburra STP. The quantification of site-specific odour emission rates from the operational STP would provide further clarity and certainty on this matter.

  Circumstantial evidence suggests that the odour emission rates for the STP may be over-estimated, with no odour being perceived during several site visits in the area surrounding the STP, and anecdotal evidence from existing commercial operators reporting no offensive odour.

- No odour mitigation technologies were applied to the odorous sources at the proposed STP. Such solutions may include those applied at source, including source covers and foul air extraction systems, or further afield, including tree barriers within the buffer zone to increase the turbulent mixing of odour emissions leaving the STP site.

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1.1 Study Overview

The scope of this assessment is to identify the potential odour impact from the Culburra Sewage Treatment Plant (STP), and determine constraints for development of the proposed mixed use subdivision. It is noted that at the present time, the development is at concept design stage, and that no fixed land-uses or residential densities have been provided.

The report comprises of:

- an overview of the regulatory framework as it pertains to odour;
- identification of sensitive receptors, in particular the proposed subdivision, which could potentially be impacted by the STP;
- identification and quantification of existing odour sources for the Culburra STP;
- dispersion modelling of existing operations at the Culburra STP to determine the level of impact on the surrounding area; and
- conclusions based on the results of this modelling in terms of constraints for development.

1.2 Process Overview

The Culburra STP consists of average dry weather flow (ADWF) of 1.5 million litres per day (ML/day). The main components of the plant are as follows:

- Pre-treatment by step screen and vortex grid arrestor with ultrasonic flow measurement and fume extraction. The inlet works have a flow bypass and a flow divider for distribution to the aerobic tanks (EATs). The inlet works is not enclosed;
- Two aerobic tanks (EATs) with intermittent aeration for removal of nitrogen (N) through oxidation and liquid aluminium dosage for enhancement of waste activated sludge settlement and phosphorous reduction. The sludge is allowed to settle in the aeration tanks and the effluent is decanted away into the flow equalisation basin;
- Wet weather storage pond for when flow to the inlet works exceeds 7 x ADWF;
- Flow equalisation basin for storage of effluent decanted from the EATs;
- Gravity filters for removal of remaining matter from the effluent;
- Disinfection by chlorination of the effluent before outfall and REMS (water recycling scheme that uses up to 80% of the effluent for local irrigation);
- Storage of treated effluent for site reuse;
- Three (3) sludge lagoons for storage and settlement of the waste activated sludge from the aeration tanks; and,

- Sludge dewatering in Council's trailer mounted mobile centrifuge, before storage in the sludge stockpile area.

Figure 1 Flow Schematic of Culburra STP

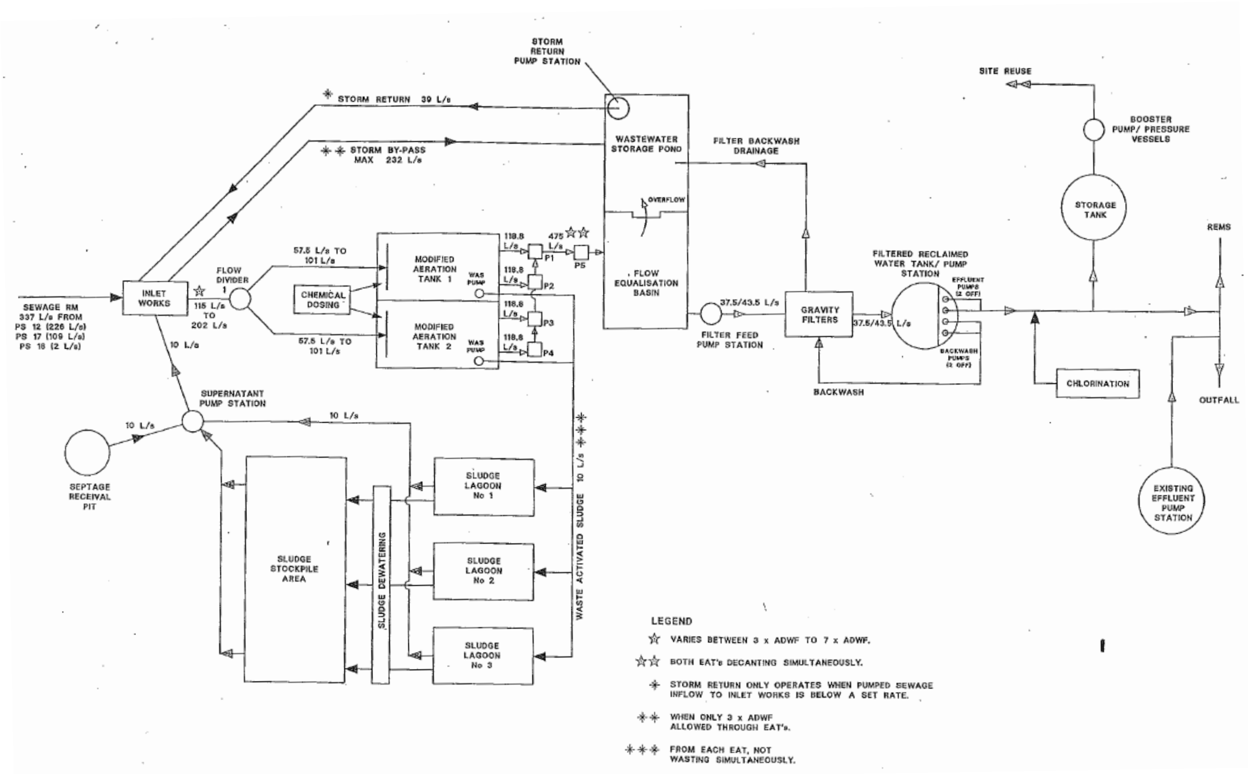


Image Source: Shoalhaven Water, 2010

1.3 Site Topography

The proposed mixed use subdivision will be located at West Culburra, which is situated in the Shoalhaven local government area. The subdivision consists of the following areas:

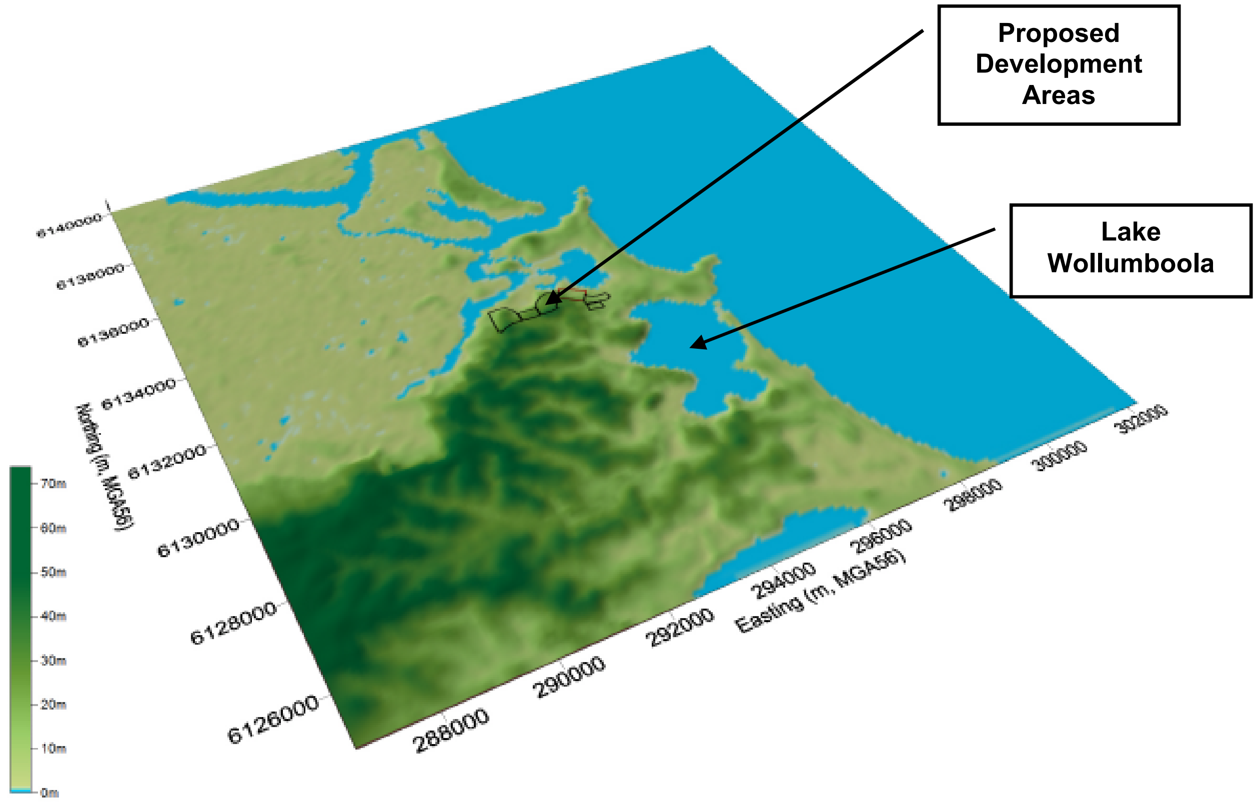
- Area 1 (situated within Lot 5 DP 1065111), approximately 8 ha;
- Area 2 (situated over potentially two unknown land parcels), approximately 5.5 ha;
- Area 3 (situated within Lot 6 DP 1065111), approximately 29 ha;
- Area 4 (situated within Lot 6 DP 1065111), approximately 11.5 ha; and
- Area 5 (situated over Lots 61 and 81 DP 755971 and Lot 7 DP 1065111), approximately 43 ha.

The project site and surrounding subdivisions are located in undulating coastal terrain with a high point of 35 m AHD.

Culburra Beach and the Tasman Sea are located 2 km to the east of the Culburra STP with Crookhaven Estuary to the north and Lake Wollumboola 1 km to the southeast.

A three dimensional representation of the area is given in **Figure 2**, with a vertical exaggeration of two applied to emphasise terrain features.

Figure 2 Regional Topography Surrounding Project Site



Note: Topography shown with vertical exaggeration of 2

1.4 Sensitive Receptors

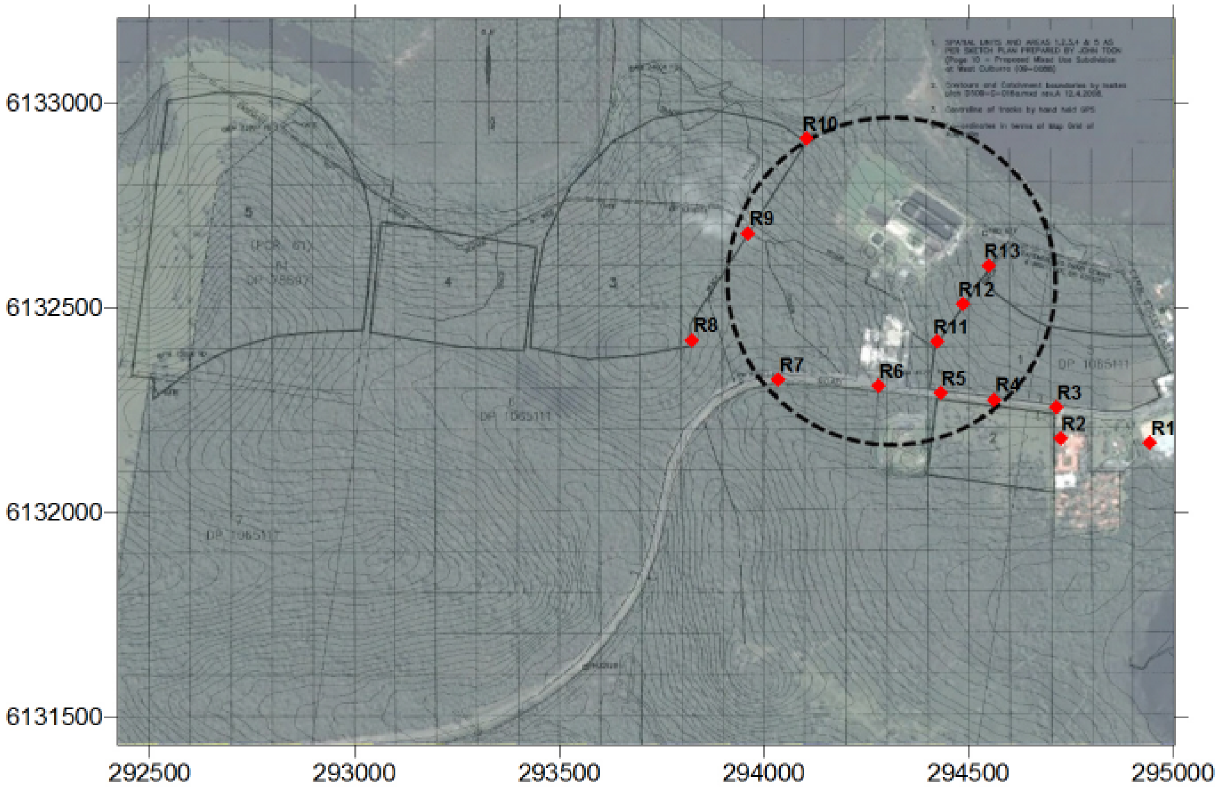
A number of residences are located in the area surrounding the Project Site. The nearest residences and commercial properties have been identified as sensitive receptor locations to be considered during the Odour Impact Assessment. Future residences as part of the DCP 67 subdivisions have also been identified as sensitive receptors. The nearest sensitive receptors in the vicinity of the Project Site (R1 to R13) are presented in **Table 1** and **Figure 3**. The recommended buffer distance (400 m) for the Project Site is also shown as a dotted line in **Figure 3**.

Table 1 Nearest Sensitive Receptors

Receptor ID	Location	Location (m, MGA56)		Elevation (m, AHD)
		Easting	Northing	
R1	Bowling club	294942	6132170	10.1
R2	Existing Retirement Village	294724	6132182	12.8
R3	Area2 Boundary N1	294713	6132258	12.5
R4	Area2 Boundary N2	294562	6132276	17.1
R5	Area 2 Boundary N3	294431	6132292	19.9
R6	Proposed Sports Complex	294279	6132309	24.1
R7	Proposed High School	294034	6132325	31.3
R8	Area3 Boundary E1	293824	6132421	34.7

Receptor ID	Location	Location (m, MGA56)		Elevation (m, AHD)
		Easting	Northing	
R9	Area3 Boundary E2	293960	6132682	26.8
R10	Area3 Boundary E3	294104	6132914	7.8
R11	Area1 Boundary W1	294424	6132418	18.3
R12	Area1 Boundary W2	294485	6132510	13.9
R13	Area1 Boundary W3	294548	6132603	8.5

Figure 3 Location of Sensitive Receptors



1.5 Existing Odour Environment

Odour from nearby Lake Wollumboola is a reoccurring problem when lake levels are low. The odour can be noticed even at long distances from the lake. The generation of odour is primarily caused by the release of hydrogen sulphide (H_2S) from sediments during periods of low water levels. Local odour can also be caused by decaying vegetation but the release of H_2S is the dominant source of local odour.

A Management Plan is currently being developed for the lake. The problem is periodic and cumulative effects have not been taken into account during this assessment. Only odour generating activities at the Project Site occurring as part of the sewage treatment have been assessed within this report.

2 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 per cubic metre (OU/m^3). An odour goal of less than 1 OU/m^3 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/m^3 to 10 OU/m^3 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 may contain.
- *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 DECCW 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 99^{th} 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.

Where a number of the factors above simultaneously contribute to making an odour "offensive", an odour goal of 2 OU at the nearest residence (existing or any likely future residences) is appropriate, which generally occurs for affected populations equal or above 2000 people.

The equation used by the NSW DECCW to determine the appropriate impact assessment criteria for complex mixtures of odorous air pollutants, as specified in the Approved Methods, 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 Approved Methods, is given in **Table 2**.

Table 2 NSW DECCW 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 (≥ 2000)	2.0
~300	3.0
~125	4.0
~30	5.0
~10	6.0
Single residence (≤ 2)	7.0

Source: The Approved Methods (DECCW, 2005)

The Approved Methods 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:

- 100^{th} percentile of dispersion model predictions for Level 1 impact assessments, or
- 99^{th} percentile of dispersion model predictions for Level 2 impact assessments.

2.1 Odour Impact Assessment Criteria Applied to the Project

The size of the affected community has been based on indicative project uses and estimations of Equivalent Tenants (ET) made by Shoalhaven Water.. The likely population of each area impinged by the 400 m buffer zone specified in DCP 67 has been assumed to be potentially affected by odour emissions from the Project operations.

According to the Australian Bureau of Statistics, the average population per household for the years 2007-08 (the latest data available) is 2.56 persons per household[1]. It is assumed that the number of residencies within Area 1, Area 2 and Area 3 would be in the order of 1070 dwellings giving an approximate population density of marginally in excess of 2,000 persons, as presented in **Table 3**.

[1] http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4613.0Chapter20Jan+2010

Table 3 Approximate Population Density in Affected Community

Land Unit	Proposed Use	Capacity	Approximate Population
1	Commercial/mixed use - commercial or retail with units above - proposed hotel or motel	~378 ET	~968
2	3 and 6 storey units; some single lot subdivisions	~477 ET	~1,221
3	single lot subdivision	~216 ET	~553
Sum			**~2,742**

Source: The proponent

An odour impact assessment criteria of 2 OU applicable to an area with a population of more than 2,000 people (expressed as the 99th percentile for a nose response average, i.e. 1-second average) has been adopted for this assessment to assess the performance of the STP.

Similarly, if the Proponent were to submit a DA with lower population densities than has been assumed above, the relevant odour impact assessment criterion (as defined in **Table 2**) may alter, in accordance with NSW DECCW guidance.

3 PREVAILING DISPERSION METEOROLOGY

To adequately characterise the dispersion meteorology of the Project Site, information is needed on the prevailing wind regime, atmospheric stability, mixing depth and other meteorological parameters. The meteorology of the study area was characterised based on:

- Climate statistics obtained from the nearest Bureau of Meteorology (BoM) Automatic Weather Station (AWS) at Nowra RAN Air Station (Station Number 068072) and Culburra Treatment Works (Station Number 068083); and,
- Hourly meteorological data from the BoM AWS at Nowra RAN Air Station, Albion Park (Station Number 068241) and Kiama (Station Number 068242).

The locations of the monitoring stations situated in relatively close proximity to the Project Site for which data were obtained for analysis are summarised in **Table 4**. Monitoring data from these monitoring stations were used to characterise the local meteorology in the region of the Project Site. Annual and seasonal wind roses of recorded data at each station between 2001 and 2004 are presented **Appendix A**. It can be seen that, based on comparison with the three closest calendar years, data recorded during 2004 is representative of each location, with regards to wind speed and direction. It is considered that in the absence of site specific meteorological observations for the Project Site, the use of data from the nearest AWS is appropriately representative of meteorological conditions likely to be experienced at the Project Site and has been used to compare with modelled meteorological conditions.

Table 4 Meteorological Monitoring Station Details

Station Name	Location (m, MGA)		Distance (km) / Direction From Project Site	Elevation (m, AHD)
	Easting	Northing		
Nowra RAN Air Station	274,923	6,130,071	19.6 km / W	109 m
Albion Park	297,242	6,173,531	41.0 km / N	8 m
Kiama	303,877	6,163,687	32.3 km / NNE	16 m

Figure 4 Location of Closest Weather Stations

Image courtesy of Google Earth

3.1 Meteorological Modelling

Gaussian plume dispersion models such as Ausplume assume that the meteorological conditions are uniform spatially over the entire modelling domain for any given hour. While this may be valid for some applications, in complex flow situations, such as coastal environments, the meteorological conditions may be more accurately simulated using a wind field and puff model.

The assessment presented within this report utilises the CALPUFF (Version 6.1) modelling system. The CALPUFF modelling system comprises of three main components: CALMET, CALPUFF and CALPOST and a large set of pre-processing programs designed to interface the model to standard routinely available meteorological and geophysical databases.

In the simplest terms, CALMET is a meteorological model that develops hourly wind and other meteorological 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 hourly varying wind field thus reflects the influences of local topography and land uses.

The CALPUFF model makes use of wind fields generated by the CALMET model, and is discussed further in **Section 4**. CALPUFF can be used in screening mode, using a single meteorological input file, such as an Ausplume-style meteorological file. Using CALPUFF in screening mode assumes steady-state conditions with a single two dimensional wind field applied across the entire modelling domain. CALPUFF in screening mode is however not considered appropriate for non steady state conditions, such as in coastal locations or areas of complicated terrain.

As discussed in **Section 1.3**, and illustrated in **Figure 2**, the Project Site is situated in undulating coastal terrain, ranging from sea level to 35 m AHD. In view of the foregoing, the topography and land uses of the area have been considered in the atmospheric dispersion model.

The Air Pollution Model (TAPM) meteorological model Version 4 was used to generate three-dimensional predictions over the 1-year modelling period (2004), which were subsequently used as input to the CALTAPM software. TAPM software, 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, with no local data inputs required. The CALTAPM software, provided by the CALPUFF model developers, allows TAPM prognostic output to be converted into a format which can be read directly by the CALMET diagnostic meteorological model as an initial guess field, rather than as an observational field, which provides the CALMET model greater freedom to calculate the effects of the complicated local topography on the input wind field.

The 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.

Table 5 details the parameters used in the meteorological modelling to drive the CALPUFF model.

Table 5 Meteorological Parameters used for this Study

TAPM (v 4.0)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grids point	25 x 25x 25
Year of analysis	2004
Centre of analysis	Culburra STP (35^{o}4’ S, 149^{o}34’ E)
Data assimilation	Not used
CALMET (v 6.1)	
Meteorological grid domain	20 km x 20 km
Meteorological grid resolution	0.2 km
Surface and Upper Air data	3-dimensional data from TAPM model as initial guess field

3.2 Meteorological Conditions

3.2.1 CALMET Predicted Wind Regime

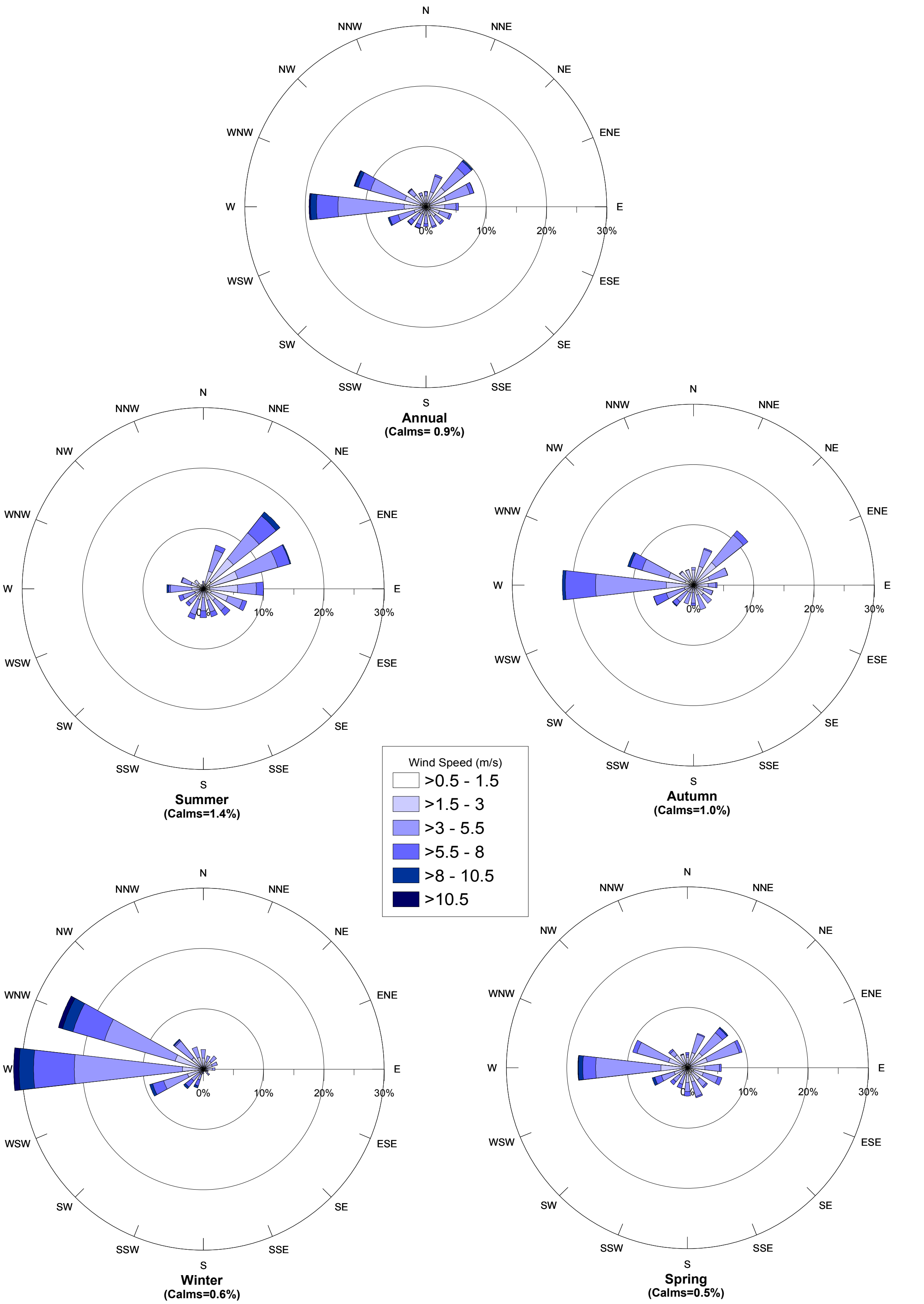
2004 was chosen to represent the local meteorology in the region, as previously discussed in more detail in **Section 3.** A summary of the 2004 annual and seasonal wind behaviour predicted by CALMET for the site is presented as wind roses in **Figure 5**.

Figure 5 indicates that winds experienced at the STP are predominantly moderate to fresh (between 3 m/s and 10.5 m/s) from the west and west-northwest (approximately 32% combined). Calm wind conditions (wind speed less than 0.5 m/s) were predicted to occur less than 1% of the time throughout 2004.

The seasonal wind roses indicated that:

- In summer, the prevailing wind directions are from the east-northeast to northeast;
- In autumn, the prevailing wind directions are from the west and northeast;
- In winter, the prevailing wind directions are from the west and west-northwest; and,
- In spring, the prevailing wind direction is from the west.

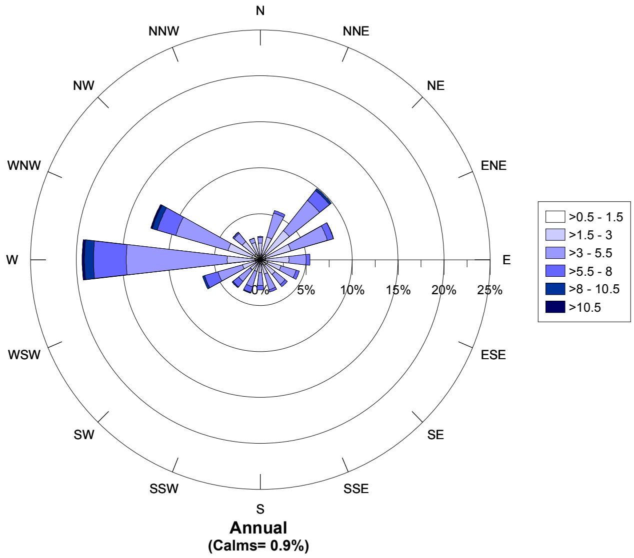
Figure 5 CALMET predicted Annual and Seasonal Wind Roses for Project Site, 2004



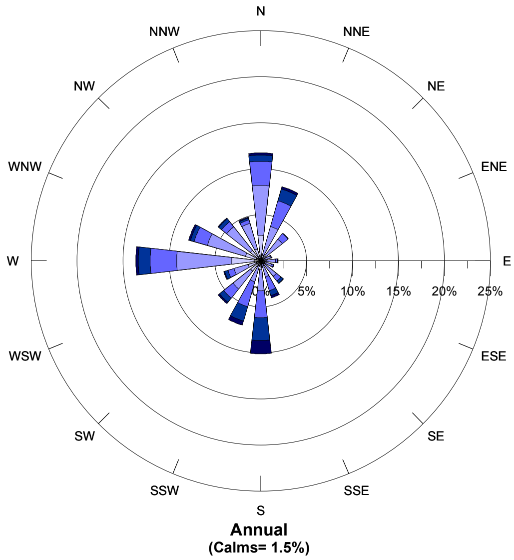
Comparison with wind roses constructed for Nowra RAN, Albion Park and Kiama 2004 indicate a reasonable agreement between the modelled and observed meteorology, as presented in **Figure 6** and **Appendix A**, with all locations experiencing predominantly west quadrant winds. Wind directions for the Project Site show reasonable agreement with the closest located AWS (Nowra RAN). Predicted wind speeds and calms for the Project Site and Kiama are comparable, which can be expected given that both sites are located in close proximity to the coast.

It is considered that the CALMET generated meteorology represents a good approximation of the wind regime likely to be experienced at the Project Site, given the absence of local observations.

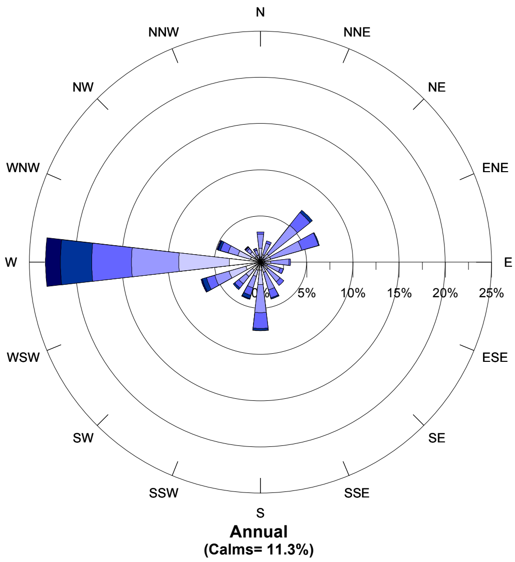
Figure 6 Comparison CALMET Predicted Annual Wind Roses



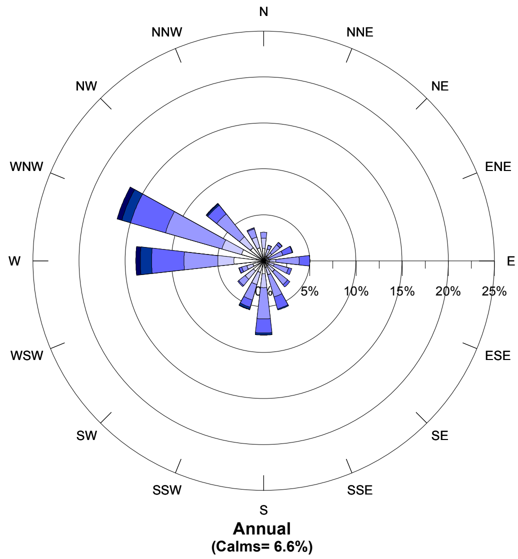
CALMET Predicted Annual Wind Rose 2004



Kiama Annual Wind Rose 2004



Albion Park Annual Wind Rose 2004



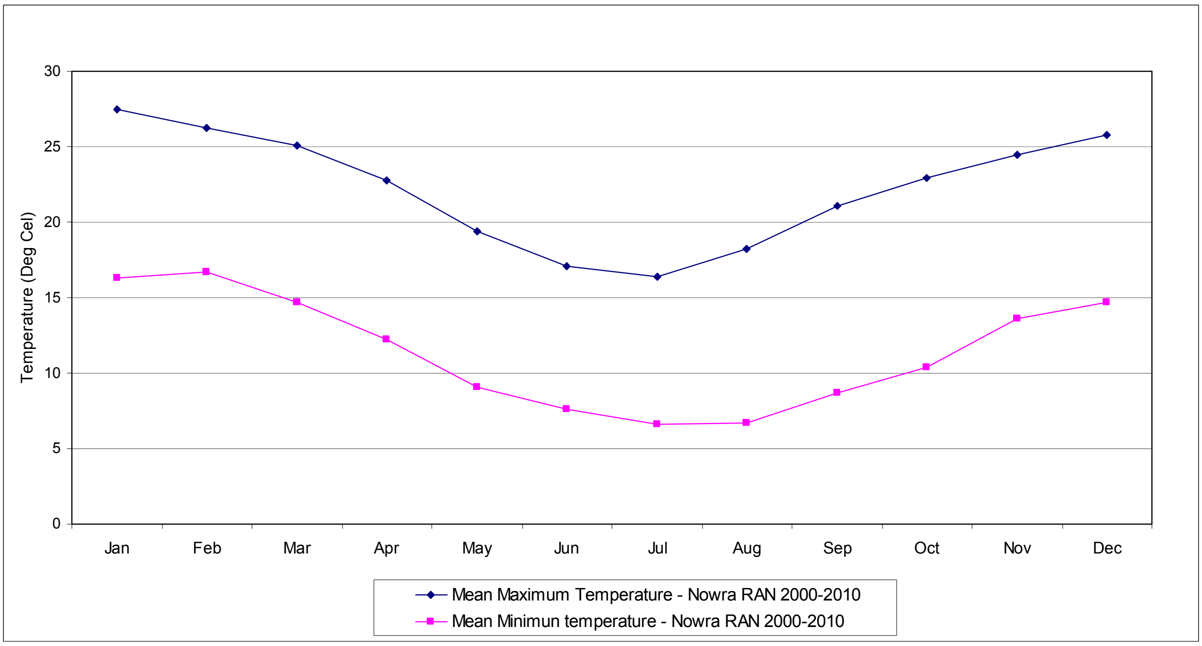
Nowra RAN Annual Wind Rose 2004

3.2.2 Temperature

Historic mean maximum/minimum temperatures recorded at the Nowra RAN AWS between 2000 and 2010 (BoM, 2010) are shown in **Figure 7**.

From analysis of the recorded historic data at Nowra RAN AWS, the daytime temperature of the greater region surrounding the Project Site may be described as cool to hot, with average air temperatures during the day varying between 16.4 degrees Celsius (°C) in winter and 27.5ºC in summer. Average air temperatures during the night tend to be cold to mild, varying between 6.6ºC in winter and 16.7ºC in summer.

Figure 7 Historic Monthly Temperature Variance at Nowra RAN AWS between 2000 and 2010



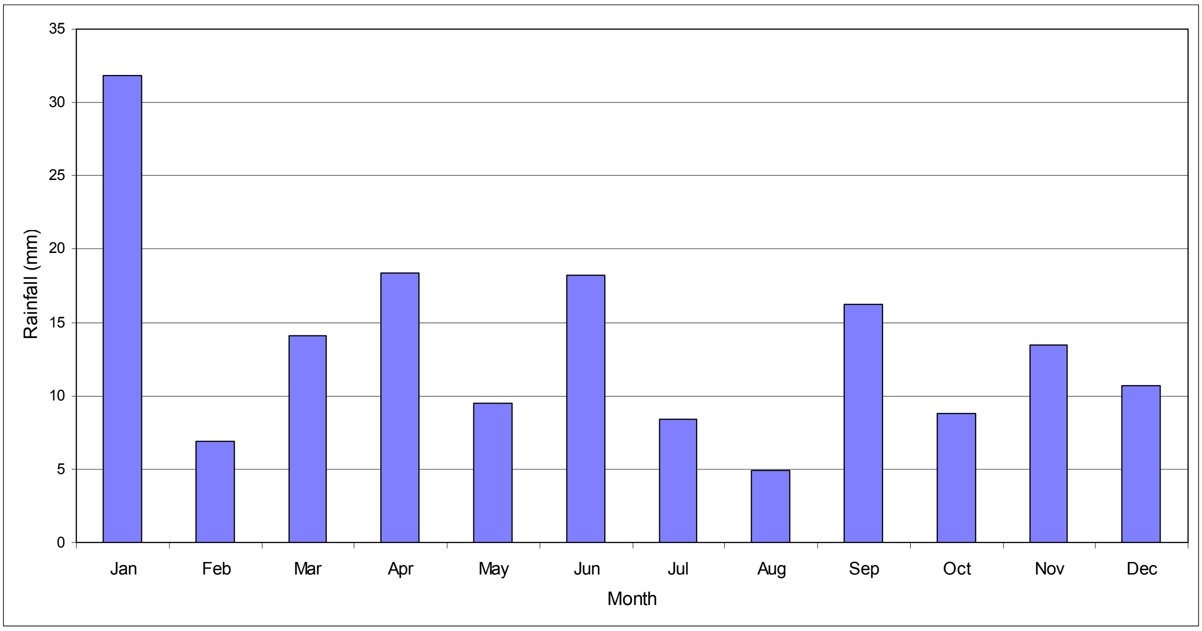
Note: Regional Historic Data sourced from Nowra RAN AWS (BoM, 2010).

3.2.3 Rainfall

Precipitation is important to air pollution studies since it reduces the potential for fugitive dust emissions and represents an effective removal mechanism of atmospheric pollutants. A graph displaying the recorded monthly mean rainfall measured at Culburra Treatment Works between 1962 and 2010 (BoM, 2010) is shown in **Figure 8**.

Rainfall experienced in the greater region surrounding the Project Site can be described as low to moderate, with the historic annual average rainfall recorded at Culburra Treatment Works totalling approximately 1196.5 mm. Rainfall in the region surrounding the Project Site is typically lower from July to December with maxima generally experienced from January through to June.

Figure 8 Historic Monthly Mean (5th Decile) Rainfall at Culburra Treatment Works between 1962 and 2010



Note: Regional Historic Data sourced from Culburra Treatment Works (BoM, 2010).

3.2.4 Atmospheric Stability and Mixing Depth

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. These classes indicate the characteristics of the prevailing meteorological conditions and are used as input into various air dispersion models (**Table 6)**.

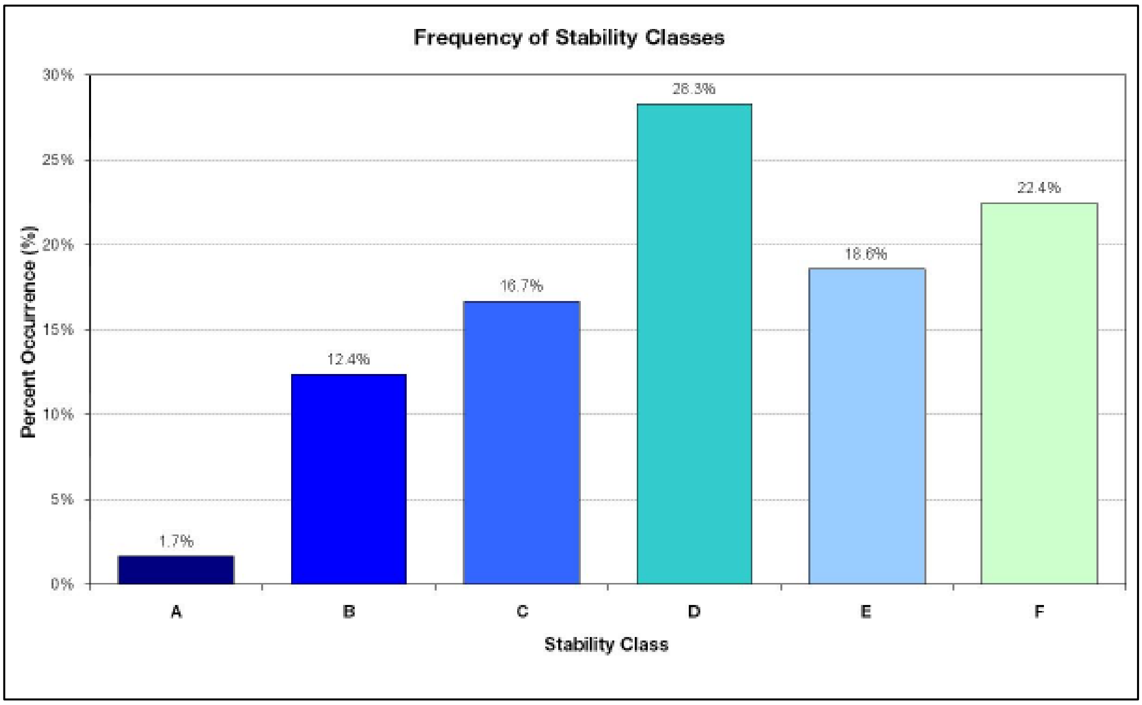
Table 6 Description of Atmospheric Stability Classes

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 calculated frequency of each stability class at the Project Site from during 2004 as predicted by CALMET is shown in **Figure 9**.

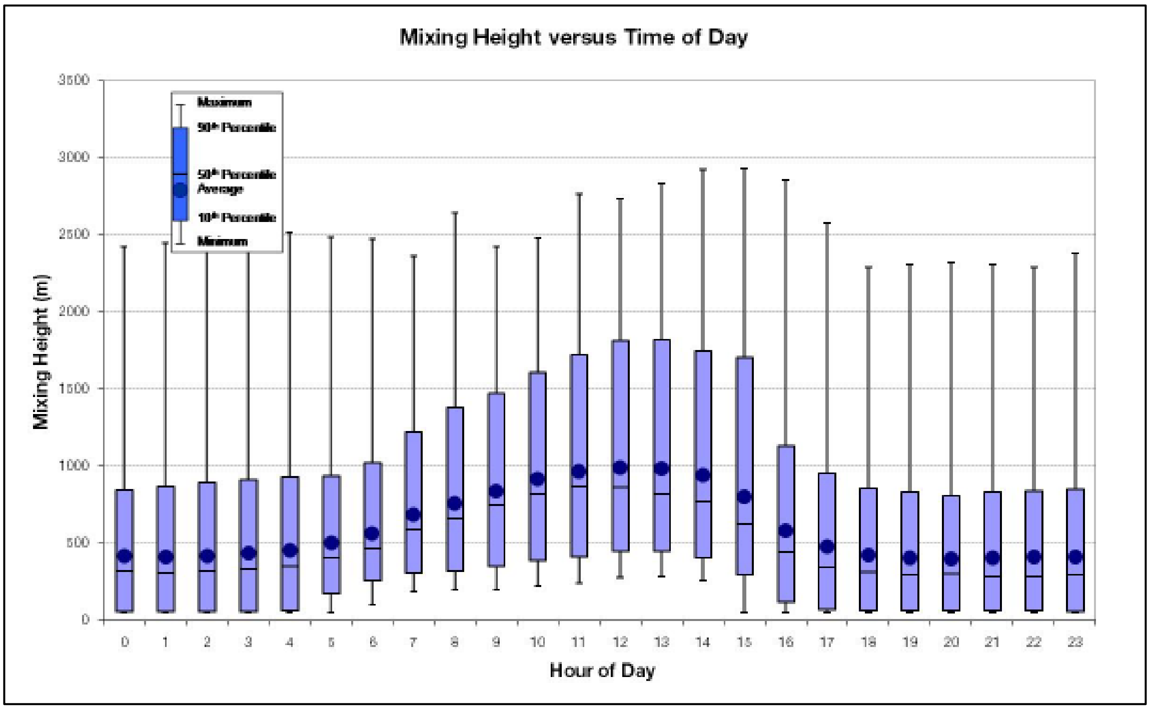
The results indicate a high frequency of conditions typical to Stability Class “D”. Stability Class “D” is indicative of neutral atmospheric conditions with a moderate level of atmospheric dispersion due to mechanical mixing. A high occurrence of Stability Class “F” is also predicted, indicative of highly stable atmospheric conditions typically associated with night-time clear skies, light winds and the presence of a temperature inversion.

Figure 9 CALMET Predicted Stability Class Distribution for the Project Site during 2004



Diurnal variations in maximum and average mixing depths predicted by CALMET at the Project Site during 2004 are illustrated in **Figure 10**. It can be seen that an increase in the mixing depth during the morning, arising due to the onset of vertical mixing following sunrise, is apparent with maximum mixing heights occurring in the mid to late afternoon, due to the dissipation of ground-based temperature inversions and the growth of the convective mixing layer.

Figure 10 CALMET Predicted Diurnal Variation in Mixing Depth for the Project Site during 2004



4 ATMOSPHERIC DISPERSION MODELLING

The dispersion modelling carried out for the Project utilises the United States Environmental Protection Agency (US EPA) approved CALPUFF Dispersion Model software. CALPUFF is a transport and dispersion model that advects “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 CALMET, discussed in **Section 3.1** Temporal and spatial variations in the meteorological fields selected are explicitly incorporated in the resulting distribution of puffs throughout a simulation period. The primary output files from CALPUFF contain either hourly concentration or hourly deposition fluxes evaluated at selected receptor locations. CALPOST is then used to process these files, producing tabulations that summarise results of the simulation (Scire et al, 2006).

Odour concentrations were simulated for a regular Cartesian receptor grid covering a nested 5 km by 5 km computational domain, set within the CALMET modelling domain and centred on the Project Site, with a grid resolution of 200 m. Concentrations were also predicted at the sensitive receptors identified in **Section 1.4**.

4.1 Emission Estimation

4.1.1 Odour Sampling Results for STPs

As noted in **Section 2**, odour concentration is measured in terms of odour units (OU), where 1 OU is the concentration of odour-containing air that can just be detected by 50% of members of an odour panel (persons chosen as representative of the average population sensitivity to odour). This process is defined within Australian Standard AS4323.3 (2001) *Stationary Source Emissions – Part 3: Determination of Odour Concentration by Dynamic Olfactometry.*

An Odour Emission Rate (OER) is the product of the odour concentration and the volumetric flow rate, and is often annotated as OU.m^3/s, or OU.m^3/min. 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.

Table 7 presents the results of odour sampling programs conducted at a number of other wastewater treatment facilities by SLR Consulting and other consultants. It is noted that where a range of values for a single source type were provided within a study, the maximum SOER was adopted.

The following studies were drawn upon in compiling odour emission rates for this assessment:

- Murrumba Downs Wastewater Treatment Plant (SLR Consulting (formerly Heggies), 2006) – Capacity: 17 ML/day;
- Sydney Water Replacement Flows Project (SLR Consulting (formerly Heggies), 2008) – Capacity: Various;
- Boneo STP (SLR Consulting (formerly Heggies), 2009) – Capacity: 12 ML/day;
- South West Rocks STP (SKM, 2008) – Capacity: 6 ML/day; and
- Lake Cathie / Bonny Hills STP (ERM, 2005) – Capacity: 10 ML/day.

Table 7 Results of Odour Sampling Performed at other STPs

Odour Source	Heggies, 2006	Heggies, 2008	Heggies, 2009	SKM, 2008	ERM, 2005
	Specific Odour Emission Rate (OU.m^3/m^2/min)				
Inlet Works	ND	ND	ND	369.4	272.4
Aerobic Zone	22.0	12.5	77.0	13.8	6.0
Settling	ND	6.3	ND	0.9	ND
Clarification/Decanting	4.2	4.0	8.0	ND	3.6
Chlorine Contact Tank	ND	ND	8.0	ND	ND
Sludge Lagoon	ND	34.3	28.0	52.7	3.0
Filter	ND	10.9	ND	ND	ND
Equalisation Basin	ND	2.1	ND	ND	3.6
Sludge Storage	ND	ND	9.0	ND	ND
	Odour Emission Rate (OU.m^3/min)				
Inlet Works	62,000[1]	ND	ND	ND	ND
Sludge Storage	ND	960	ND	ND	ND

Note 1: Measured OER doubled to account for both inlet works screens
ND = No Data

4.1.2 Estimation of Emission Rates

Odour emission rates were calculated for the existing STP operations using the published emission rate data discussed above and are summarised in **Table 8**. Assumptions used in deriving the emission rates were as follows:

- The emission rates provided in **Table 7** correspond to STP operations larger in capacity than the Project and an average of the listed SOER for each source has been taken as the SOER to be used in this modelling assessment.
- The specific odour emission rate (SOER) for the inlet work is relatively high but the small surface area of the inlet works at Culburra means it is not the major source for the site, representing only 12% of the total site emissions.
- The emissions from the EATs during aeration were calculated based on the average SOER reported for the aerobic zone at other STPs, while the emissions from the EATs during decanting were calculated based on the average SOER reported for clarification tanks at other STPs.
- The emissions from the EATs were assumed as worst case emissions, i.e. the EATs were assumed to be aerating at all times.
- The sludge lagoons were assumed to be at full capacity.
- The odour emission rate measured at the chlorine contact tank at another STP (only one result is available) was assumed for Culburra. Again this is a minor source for the site.
- The centrifuge dewatering system is assumed to produce negligible odour emissions.
- Source dimensions were taken from site drawings provided by Shoalhaven Water.

The estimated emissions shown in **Table 8** indicate that the inlet works, the EATs (during aeration), the sludge lagoons and the sludge dewatering and storage area are the main sources of odour at the site. Emissions from the flow equalisation basin and the EATs during the settling and decanting phases are minor, and emissions from the wet weather storage pond, chlorine contact tank and filters are negligible.

Table 8 Estimated Emissions for Existing Operations

Odour Source	Source ID	Surface Odour Emission Rate	Source Dimensions	Surface Area	Odour Emission Rate
		(OU.m^3/m^2/min)	(m)	(m^2)	(OU.m^3/min)
Inlet Works	IW	321	16 x 4	64	20,538
Modified Aeration Tank 1	EAT1		12.5 x 37	463	
- Aeration		26			12,158
- Settling		7			3,241
- Decanting		5			2,315
Modified Aeration Tank 2	EAT2		12.5 x 37	463	
- Aeration		26			12,158
- Settling		7			3,241
- Decanting		5			2,315
Flow Equalisation Basin	FEB	3	83 x 18	1,494	4,258
Wet Weather Storage Pond[1]	WWS	0.1		5,209	521
Chlorine Contact Tank	CCT	8	10 x 7.5	75	600
Filters	FIL	11	3.5 x 7	25	275
Sludge Lagoon No.1	SL1	30	33 x 33	1,089	32,126
Sludge Lagoon No.2	SL2	30	33 x 33	1,089	32,126
Sludge Lagoon No.3	SL3	30	33 x 33	1,089	32,126
Sludge Storage Area	SSA	9		1,295	11,655
Total					**158,541**

Note 1: The SOER has been adopted from SLR Consulting odour monitoring of Woodlawn Bioreactor (Report 30-2464-R2) and the emission rate relates to stormwater storage

4.2 Odour Peak-to-Mean Ratios

The NSW DECCW document "*Technical Notes - Assessment and Management of Odour from Stationary Sources in New South Wales*", (DECCW, 2006b – the Odour Notes) 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 10.1 of the Odour Notes. 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 are E or F.

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

5 ODOUR IMPACT ASSESSMENT RESULTS

5.1 Odour Impact Assessment

Table 9 presents the 99th percentile 1 second average odour concentrations at the surrounding sensitive receptor locations, as predicted by CALPUFF, for current operations at the Project Site. It can be seen that concentrations are predicted to range between 0.4 OU and 5.6 OU at all receptors. The corresponding isopleth plots of these dispersion modelling results are presented in **Figure 11**.

It is predicted that under worst case operating conditions, odour concentrations will satisfy the Project odour criterion of 2 OU at nearly all sensitive receptors. However, the Project criterion will be exceeded at the western boundary of Area 1.

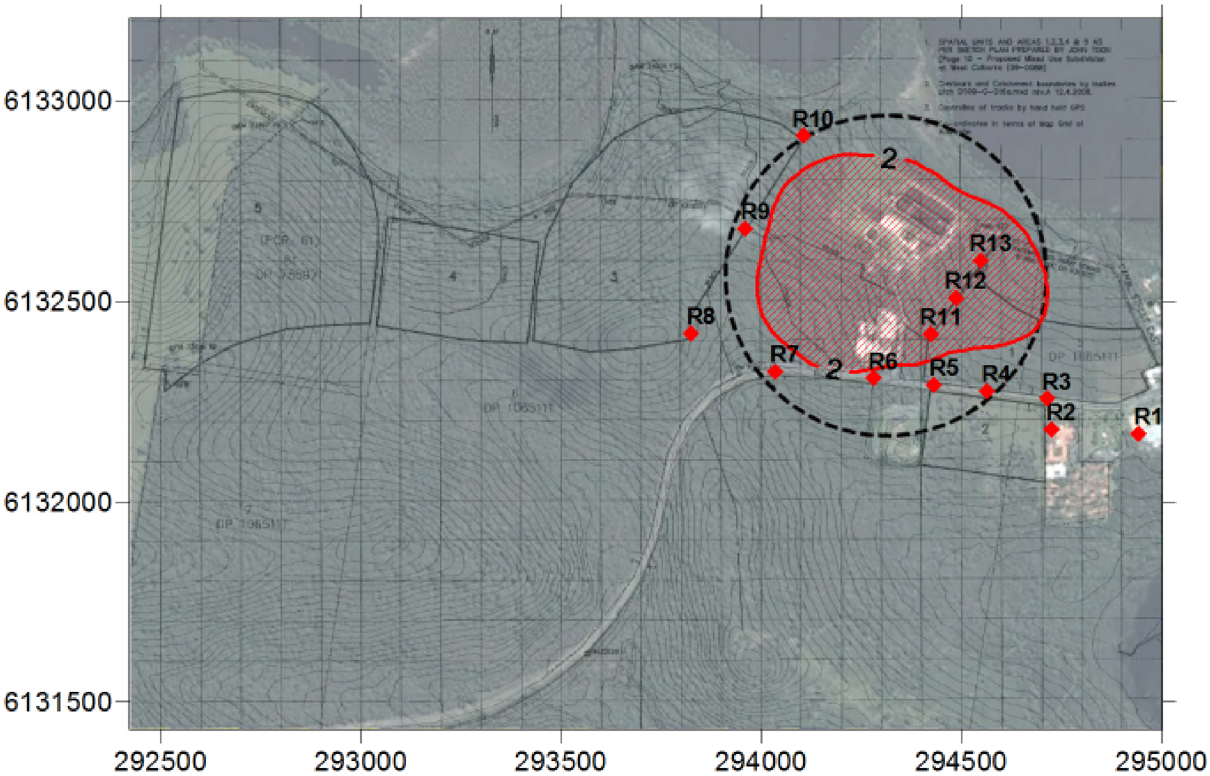
The Councils Development Control Plan (DCP 67) 400 m buffer distance is shown to be conservative, with no exceedances detected outside the buffer zone. Incompatible land use is nevertheless predicted for the northwest corner of Area 1.

Table 9 Predicted 99th Percentile 1 Second Average Odour Concentration

Receptor ID	Location	Predicted Odour Concentration (OU) – Existing Operations
R1	Bowling club	0.4
R2	Existing Retirement Village	0.8
R3	Area2 Boundary N1	0.9
R4	Area 2 Boundary N2	1.1
R5	Area 2 Boundary N3	1.5
R6	Proposed Sports Complex	1.8
R7	Proposed High School	1.5
R8	Area 3 Boundary E1	1.1
R9	Area 3 Boundary E2	1.1
R10	Area 3 Boundary E3	1.0
R11	Area 1 Boundary W1	**3.0**
R12	Area 1 Boundary W2	**5.6**
R13	Area 1 Boundary W3	**3.5**

Note: Results greater than 2OU are highlighted in **bold red text**

Figure 11 99th Percentile 1 Second Average Odour Concentration – Culburra STP



*2004 Meteorology, Emission Rates adopted from **Section 4.1**; Adopted Criterion – 2 OU*

5.2 Conclusions

SLR Consulting Australia Pty Ltd (SLR Consulting) has been commissioned by Allen, Price & Associates on behalf of Realty Realizations Pty Ltd (the proponent) to prepare an Odour Impact Assessment for a concept plan for a proposed mixed used subdivision in West Culburra, New South Wales.

It is SLR Consulting's understanding that the proposed subdivision may encroach on the established buffer zone around the neighbouring Culburra Sewage Treatment Plant (the Project Site) and that an odour assessment is required to determine whether the proposed subdivision will introduce incompatible land uses and investigate the application of the 400 m buffer distance as specified in Councils Development Control Plan (DCP 67).

The advanced atmospheric dispersion model CALPUFF was selected to carry out the dispersion modelling calculations. The odour assessment criterion applicable to high density urban areas was applied, based on the proposed number of dwellings in the surrounding area, to assess the performance of the STP. This was based on the proposed number of dwellings in the surrounding area and the resultant population density of greater than 2,000 persons. The results of the dispersion modelling for the Culburra STP suggested that no exceedance of the odour criterion of 2 odour units (2 OU) would occur beyond the 400 m buffer zone. The potential for exceedance of the odour criterion was predicted for an area to the southeast of the proposed site, to a distance of approximately 400 m, with the potential for introduction of incompatible land uses in the northwest corner of Area 1.

No exceedances of the odour criterion were detected for any of the remaining areas.

Commercial development of the area south of the STP, between Area 1 and 3 has been suggested in the draft concept drawings, with detailed plans yet to be finalised. Current NSW DECCW guidance does not differentiate between commercial and residential properties in terms of the potential for odour impacts. It is however expected that the tolerance for offensive odour is higher in commercial areas than in residential areas where people may be subjected to the odour for a longer period of time.

The following points should be considered in relation to the odour assessment:

- Dispersion modelling was conducted using a range of odour emission rates obtained from STP sites which possessed a larger annual capacity than the Culburra STP. There is a high likelihood that the adopted odour emission rates may have over accounted for the potential odorous emissions from sources at the Culburra STP. The quantification of site-specific odour emission rates from the operational STP would provide further clarity and certainty on this matter. Circumstantial evidence suggests that the odour emission rates for the STP may be over-estimated, with no odour being perceived during several site visits in the area surrounding the STP, and anecdotal evidence from existing commercial operators reporting no offensive odour.
- No odour mitigation technologies were applied to the odorous sources at the proposed STP. Such solutions may include those applied at source, including source covers and foul air extraction systems, or further afield, including tree barriers within the buffer zone to increase the turbulent mixing of emissions leaving the STP site.

6 REFERENCES

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7 GLOSSARY

ADWF	Average Dry Weather Flow
AECOM	AECOM Australia Pty Ltd
AHD	Australian Height Datum
AWS	Automatic Weather Station
BoM	Bureau of Meteorology
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DECCW	Department of Environment, Climate Change and Water
ERM	Environmental Resources Management
Heggies	Heggies Pty Ltd (SLR Consulting Pty Ltd)
MGA	Map Grid of Australia
NASA	National Aeronautics and Space Administration
OU	Odour Units; concentration of odorous mixtures in odour units
OER	Odour Emission Rate (OU.m^3/s)
OUV	Odour Unit Volumes
P/M60	Peak to Mean Ratio
REMS	Northern Shoalhaven Reclaimed water management scheme
SKM	Sinclair Knight Merz
SOER	Specific Odour Emission Rate
STP	Sewerage Treatment Plant
TAPM	The Air Pollution Model
The Approved Methods	The Approved Methods for the Modelling and Assessment of Air Pollutants in NSW
The Odour Framework	Technical Framework: Assessment and Management of Odour from Stationary Sources in New South Wales
The Odour Notes	Technical Notes - Assessment and Management of Odour from Stationary Sources in New South Wales
The Project Site	The site of the proposed STP at Culburra

8 CLOSURE

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 and has been accepted in good faith as being accurate and valid.

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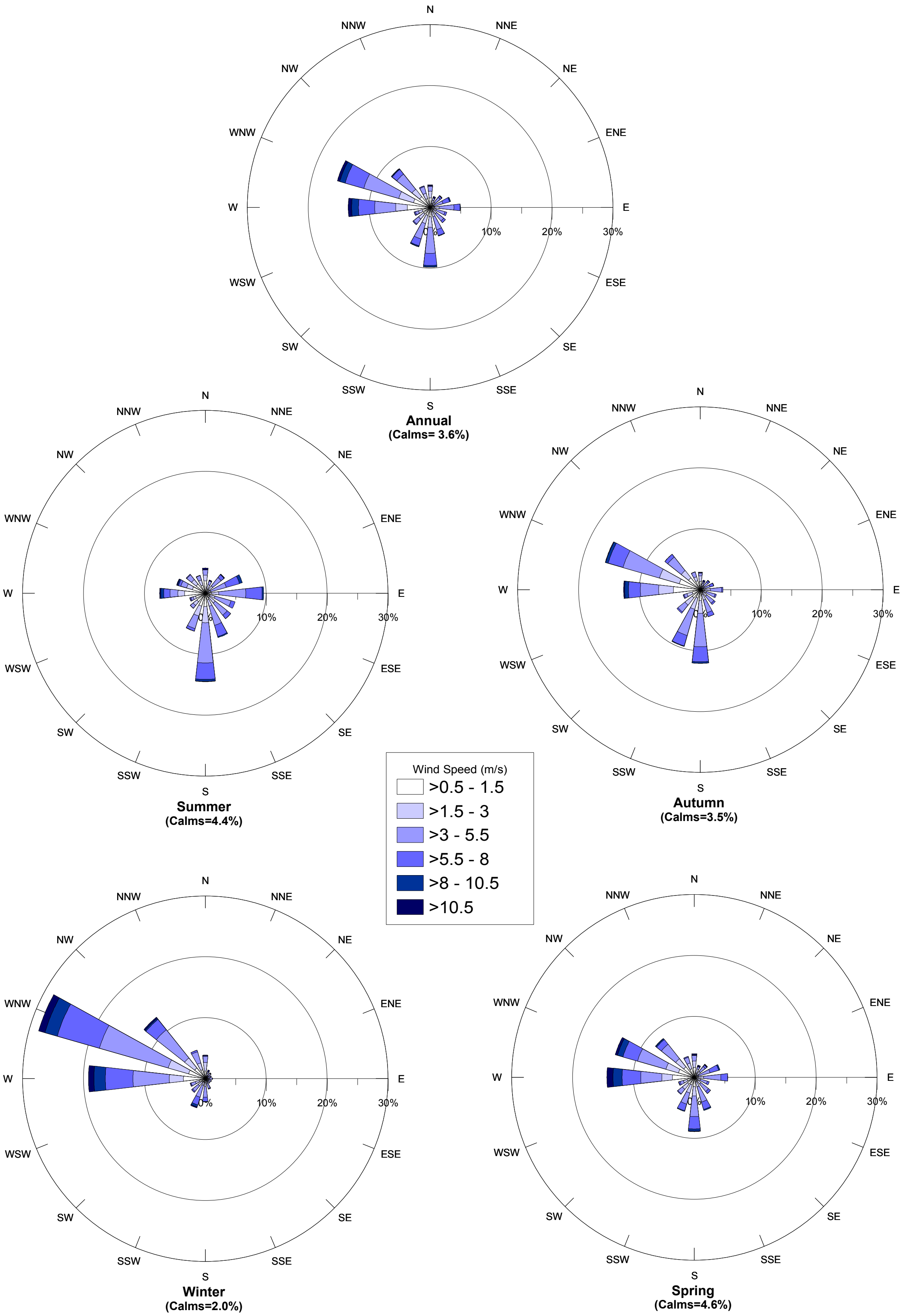
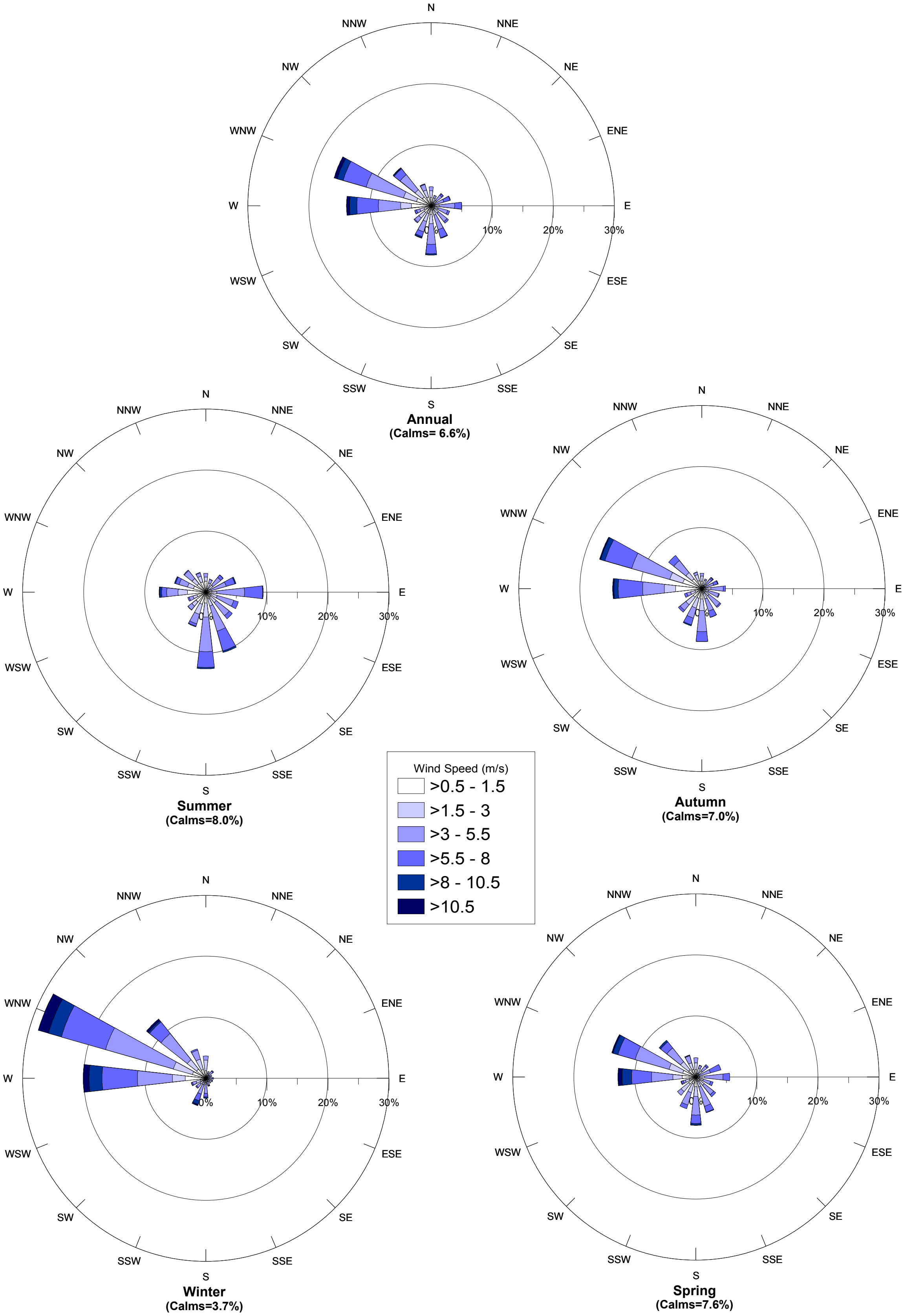
SLR Consulting disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.

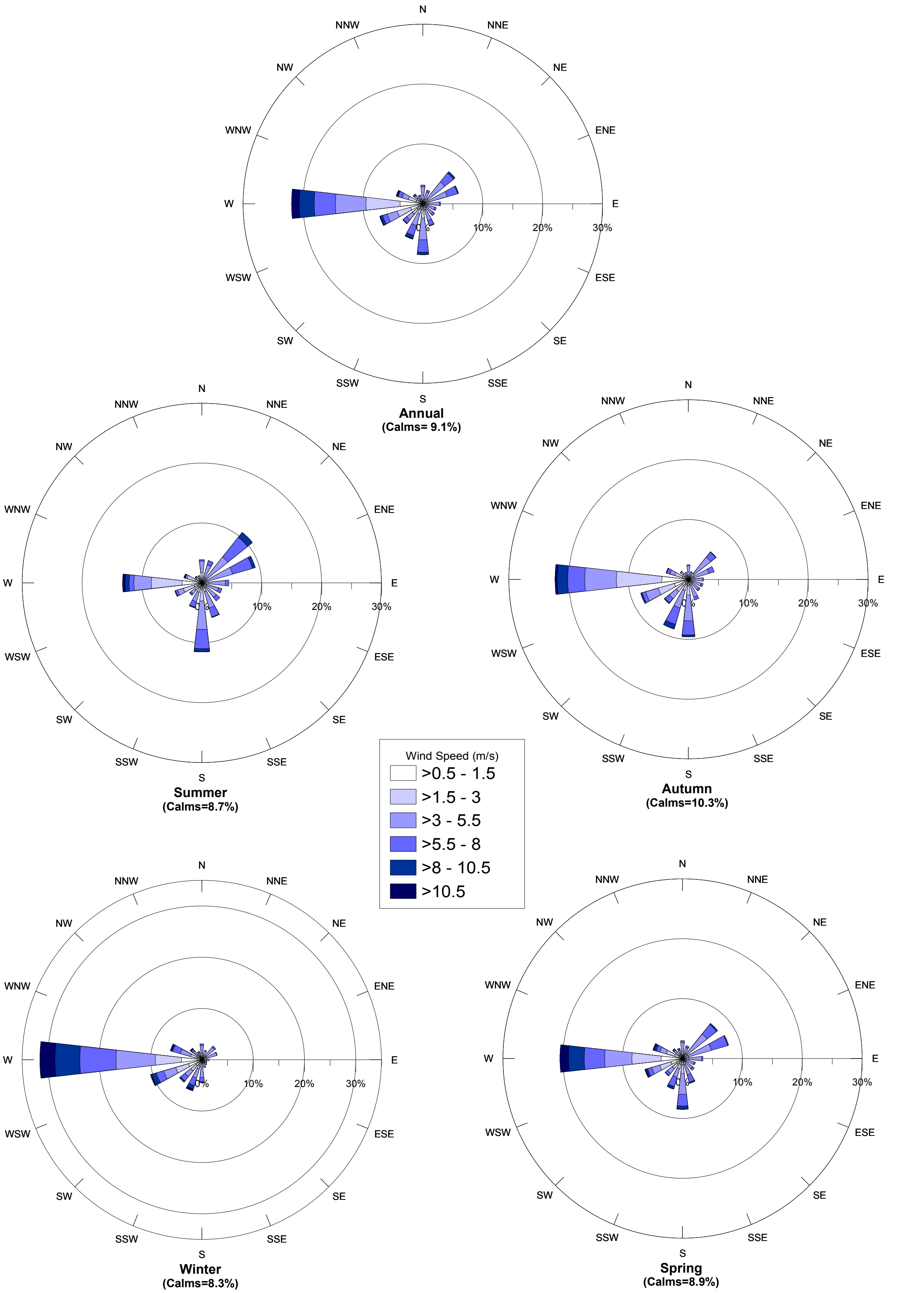
Annual and Seasonal Wind Roses for Nowra RAN AWS, 2001-2004



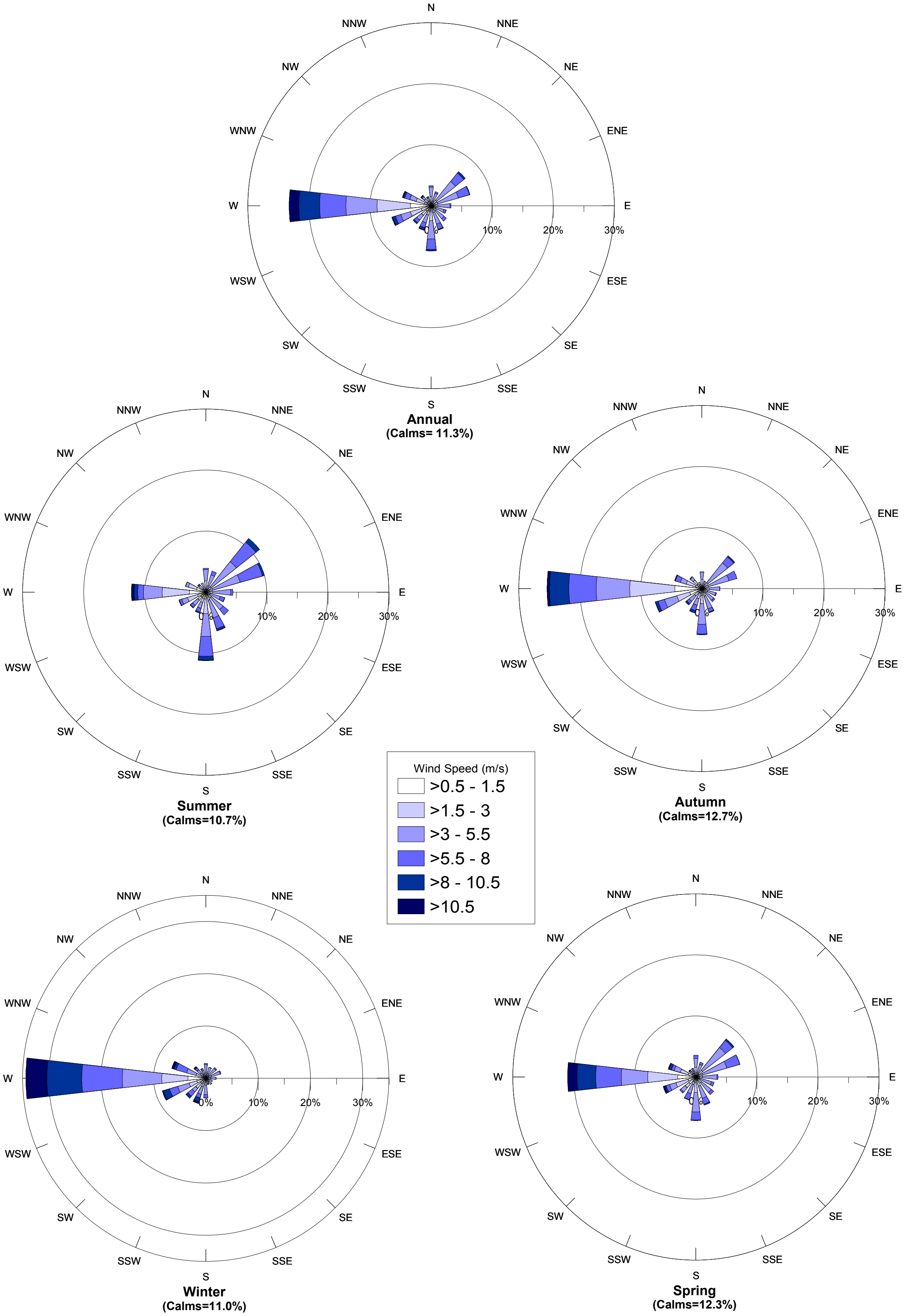
Annual and Seasonal Wind Roses for Nowra RAN AWS, 2004



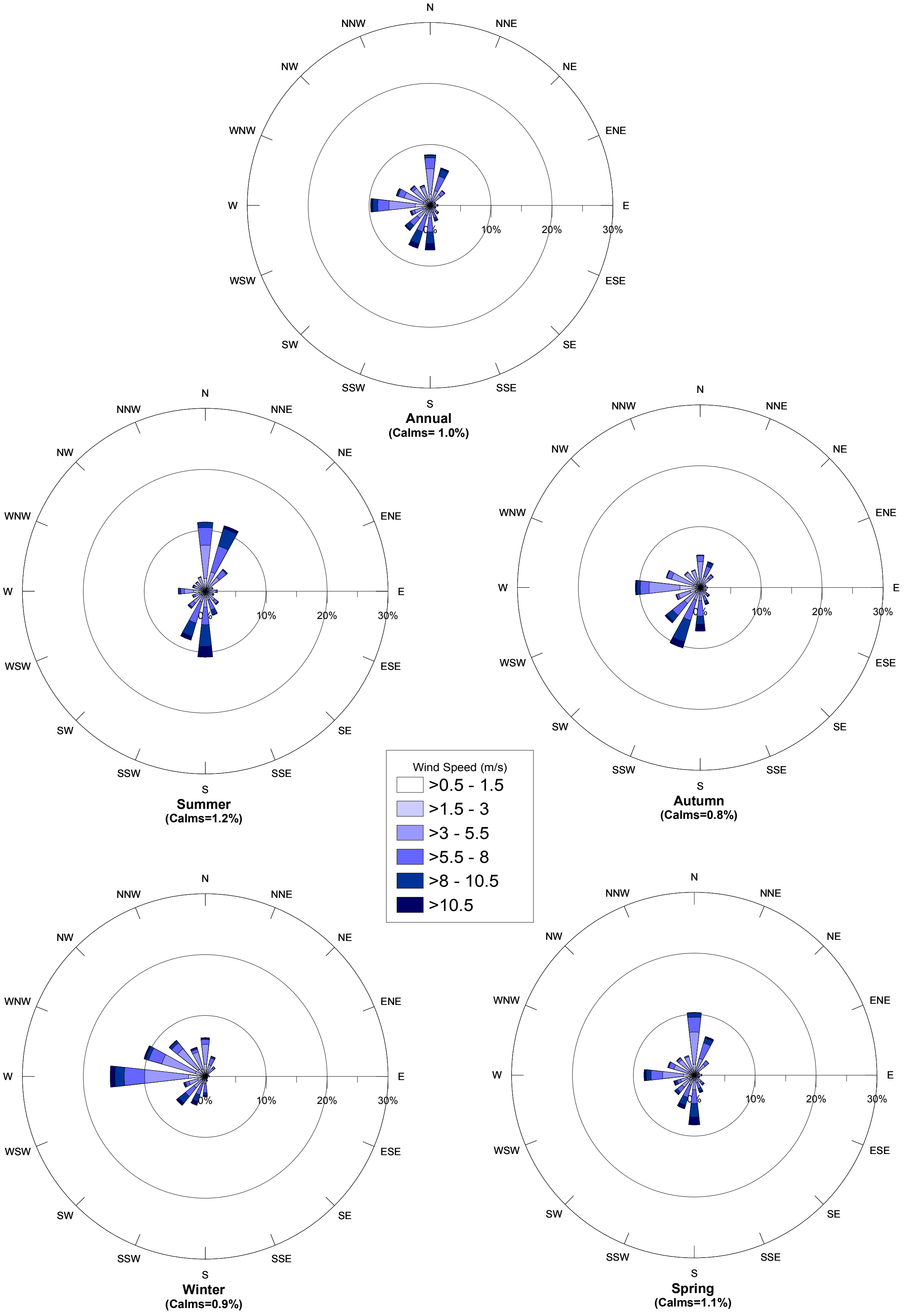
Annual and Seasonal Wind Roses for Albion Park AWS, 2001-2004



Annual and Seasonal Wind Roses for Albion Park AWS, 2004



Annual and Seasonal Wind Roses for Kiama AWS, 2001-2004



Annual and Seasonal Wind Roses for Kiama AWS, 2004