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HEGGIES

REPORT 20-2014-R7

Revision 1

Santos LNG Facility
Noise Assessment

PREPARED FOR

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Santos LNG Facility

Noise Assessment

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PROJECT DECRIPTION

Heggies Pty Ltd (Heggies) has been engaged by URS Australia Pty Ltd (URS) on behalf of Santos Ltd (Santos) to undertake a comprehensive noise assessment utilising the latest noise model input data provided by Bechtel for the LNG facility in Gladstone.

The latest available noise model input data provided by Bechtel which differs from that data used in the EIS study includes:

- LNG facility source noise levels;
- LNG facility source locations;
- On-site topography; and
- On-site ground cover (sound absorption).

The noise assessment methodology and noise criteria used for this assessment are as per Heggies GLNG EIS Noise and Vibration Report – 20-2014-R1R4 dated 22 May 2009.

The following report summarises the results of re-modelling (including all noise modelling inputs and assumptions) in order to allow an informed decision to be made regarding noise management options for the project.

CRITERIA

The limiting noise criteria for the operational phase of the LNG facility is summarised in the table below.

Summary of the Limiting Operational Criteria

Assessment Location	Background Noise Creep Criteria	Design Criteria[1]	Sleep disturbance[2]
	$L_{A90(1hour)}$ (dBA)	$L_{Aeq(1hour)}$ (dBA)	L_{Amax} (dBA)
Plant 1	31	44	40
Plant 2	25	34	40
Plant 3	27	40	40
Plant 4	27	40	40
Plant 5	25	34	40
Plant 6	28	41	40
Plant 7 [3]	30	43	40

Note: Limiting operational criteria is defined as the most stringent of the day, evening and night-time project operational criteria

1: Design criterion is the most stringent of the Planning Noise Level (PNL) and Specific Noise Level (SNL) (as defined in EcoAccess Guideline: Planning for Noise Control).

2: An appropriate sleep disturbance criterion for continuous noise is 30 dBA LAeq internal. Based on 10 dBA noise reduction between external and internal noise levels for partially open windows in accordance with the Ecoaccess Guideline, the external sleep disturbance is 40 dBA LAeq.

3: Noise criteria are based on typical background noise levels for an "Industrial Area' as shown in the Queensland Department of Environment and Resource Management's (DERM) *Ecoaccess Guideline: Planning for Noise Control* 'Recommended Outdoor Planning Noise Levels'.

MODELLING METHODOLOGY

The noise predictions for this assessment have been performed utilising the CONCAWE prediction method within SoundPLAN.

New information for noise source locations, heights and source noise levels were supplied by Bechtel (2009[1,2,3]) and incorporated in the existing 3D noise prediction model developed during the EIS study.

Meteorological Conditions

Analysis of annual meteorological data from two weather stations in the Gladstone Region resulted in the updating of the modelled meteorological conditions. These revised meteorological conditions are presented below.

Summary of Modelled Meteorological Conditions

Parameter	Neutral Weather	Worst Case Weather [1]	Prevailing Weather
Temperature	10°C	10°C	10°C
Humidity	70%	90%	70%
Pasquill Stability Category	D	F (simulates temperature inversion conditions)	D
Wind Speed	0 m/s	2 m/s	3 m/s (Southerly wind direction)

Note 1: Worst case weather is presented here only as a reference case as it occurs less than 30% of the total night time winter period (as per the Ecoaccess Guideline).

Analysis of the available meteorological data for the greater Gladstone area indicates that the prevailing southerly wind direction (SSE through SW) occurs for approximately 50% of the night time period.

OPERATIONAL NOISE ASSESSMENT

Bechtel has indicated that the proposed ground surface on the LNG facility site will be gravel. A sound absorption coefficient of 0.6 was used for the gravel on site in this study (the EIS assumed soft ground with a sound absorption coefficient of 1.0). The reduced ground sound absorption on site increases the predicted noise levels at the nearest noise sensitive receivers by approximately 1 dBA.

Incorporating the latest unmitigated noise model input data supplied by Bechtel (ie new SWL's, source locations and topography), the predicted noise level at P1a (Tide Island) was 13 dBA above the relevant noise criterion for neutral weather conditions. Bechtel also provided a proposed feasible mitigation option with reduced SWL's for all mitigated plant items, the predicted noise level at P1a (Tide Island) was 6 dBA above the relevant noise criterion for neutral weather conditions.

Noise predictions were also carried out for worst case and prevailing weather conditions. It was noted that for the prevailing weather condition (ie prevailing southerly wind direction), all receivers had lower predicted noise levels in comparison to both neutral and worst case weather conditions. During prevailing weather conditions, Tide Island will have winds blowing from receiver to source, significantly reducing the predicted noise level at this receiver in comparison to neutral weather (5 dBA difference) and worst case weather conditions (10 dBA difference). Based on the meteorological data analysis, prevailing weather conditions were expected to occur approximately 50 % of the night time period.

The SWL's and associated noise reductions required for each item of plant and equipment associated with the LNG facility were investigated for two (2) noise reduction scenarios. The level of noise reduction nominated for noise reduction scenario 1 was based on achieving the noise criteria during neutral weather conditions. Noise reduction scenario 2 was based on mitigated noise source levels supplied by Bechtel. The two (2) noise reduction scenarios investigated were as follows:

- **Noise Reduction Scenario 1** – the level of noise reduction required to achieve the criteria at all receptors (including Tide Island and Witt Island) during neutral weather conditions.
- **Noise Reduction Scenario 2 (Bechtel Mitigated)** – proposed mitigation measures by Bechtel (2009[3]) include pipe lagging and low noise air coolers.

It should be noted that for the prevailing weather condition, 4-5 dBA lower noise levels are predicted for the noise sensitive receivers south of the LNG facility in comparison to the neutral weather condition. Under the prevailing weather condition, the required noise reduction to achieve the noise criteria at the relevant noise sensitive receivers would be 4-9 dBA (instead of the 8-13 dBA for neutral weather condition). In addition, it is also noted that the prevailing weather conditions are expected to occur for a significant portion of the total night time period (approximately 50%).

It should be noted that this report presents predicted noise levels due to a 3-train plant. A 2-train plant would result in a noise level reduction at the sensitive receptors compared to the 3-train predicted noise levels.

NOISE MITIGATION

In order to achieve the best outcome with respect to noise emissions from the LNG facility (with consideration to technical constraints), it is recommended that the following levels of noise reductions should be considered (in order of priority):

1. 18 dBA of noise reduction – in order to achieve all applicable noise criteria at all noise sensitive receptors during all types of meteorological conditions.
2. 13 dBA of noise reduction (Noise Reduction Scenario 1) - in order to achieve all applicable noise criteria at all noise sensitive receptors during both neutral and prevailing meteorological conditions. All noise criteria would be achieved during worst case weather conditions at all noise sensitive receptors, with the exception of those at P1a (Tide Island) and P1b (Witt Island), where the intrusive and sleep disturbance noise criteria would be achieved but not the background creep noise criteria.

It should be noted that residences on Tide Island and Witt Island are not permanent (ie occupied intermittently).

The proposed noise mitigation by Bechtel (2009[3]) (Noise Reduction Scenario 2) achieves all noise criteria at all noise sensitive receivers, except Tide Island, for prevailing weather. For neutral weather there is an exceedence of the criteria of 1 dBA to 6 dBA.

Heggies considers that an appropriate level of noise control (discussed above) is able to be achieved by implementing appropriate noise mitigation measures consistent with the type specified in the GLNG EIS study.

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1 INTRODUCTION

Heggies Pty Ltd (Heggies) was engaged by URS Australia Pty Ltd (URS) on behalf of Santos Ltd (Santos) to undertake a noise assessment for the Santos LNG facility in Gladstone, Queensland.

The purpose of the assessment is to model the noise emissions from the Santos LNG facility with the latest available noise model input data provided by the Bechtel plant design team. The following noise model inputs have been updated since the EIS based on information provided by Bechtel:

- LNG facility source noise levels;
- LNG facility source locations;
- On-site topography; and
- On-site ground cover (sound absorption).

In addition to the above mentioned noise model input data, a detailed analysis of the worst case and prevailing meteorological conditions within the general Gladstone region was also carried out. These meteorological conditions have been incorporated into the noise modelling scenarios (where applicable).

With the exceptions of the revisions above, the noise assessment methodology and noise criteria are as per Heggies EIS Noise and Vibration Report (20-2014-R1R4 dated 22 May 2009).

The level of noise reduction required from the LNG facility is documented for the following scenarios:

- **Noise Reduction Scenario 1** – the level of noise reduction required to achieve the noise criteria at all receptors (including Tide Island and Witt Island).
- **Noise Reduction Scenario 2 (Bechtel Mitigated)** – proposed mitigation measures by Bechtel (2009[3]) include pipe lagging and low noise air coolers.

The following section summarises the results of re-modelling (including all noise modelling inputs and assumptions) in order to allow an informed decision to be made regarding noise management options for the project.

2 NOISE CRITERIA

Operational noise levels emitted by the LNG facility are assessable in accordance with the Queensland Department of Environment and Resource Management's[1] (DERM) *Ecoaccess Guideline: Planning for Noise Control* (Ecoaccess Guideline). The relevant operational noise criteria for the LNG facility is summarised in **Table 1**. The background noise creep and intrusive noise (SNL) criteria are based on measured existing ambient background noise in the Gladstone Region (refer to the Heggies EIS Noise and Vibration Report (2009) for further details).

Table 1 Summary of the Operational Noise Criteria – LNG Facility

Assessment Location	Background Noise Creep Criteria	Intrusive Noise Criteria	Sleep Disturbance Criteria[1]
	LA90(1hour) (dBA)	LAeq(1hour) (dBA)	LAmax (dBA)
Plant 1 (Tide Island)	31	44	40
Plant 2	25	34	40
Plant 3	27	40	40
Plant 4	27	40	40
Plant 5	25	34	40
Plant 6	28	41	40
Plant 7	30	43	40

Note: Operational noise criteria are defined as the most stringent of the day, evening and night-time project operational noise criteria.

Note1: An appropriate sleep disturbance criterion for continuous noise is 30 dBA LAeq internal. Based on 10 dBA noise reduction between external and internal noise levels for partially open windows in accordance with the Ecoaccess Guideline, the external sleep disturbance is 40 dBA LAeq.

3 MODELLING METHODOLOGY

The noise predictions for this project have been performed utilising the CONCAWE prediction method within SoundPLAN. The CONCAWE prediction method is specially designed for large industrial facilities and incorporates the influence of distance attenuation, ground absorption, air absorption and topographic shielding attenuation, as well as meteorological conditions, including wind effects.

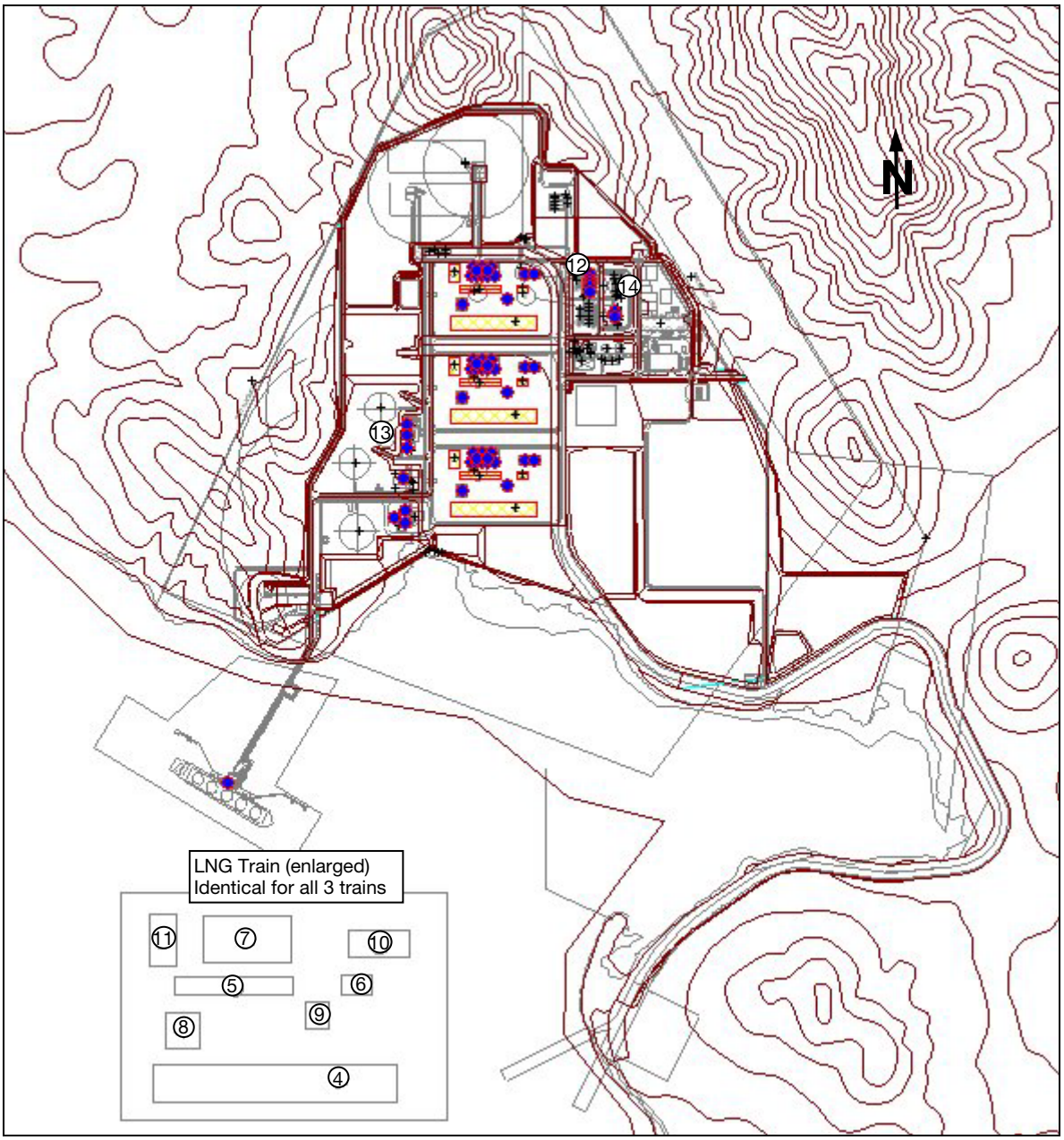
The statistical accuracy of environmental noise predictions using CONCAWE was investigated by Marsh (Applied Acoustics 15 - 1982). Marsh concluded that CONCAWE was accurate to ±2 dBA in any one octave band between 63 Hz and 4 kHz and ± 1 dBA overall.

3.1 LNG Facility Site Layout

New information for noise source locations, heights and source noise levels were supplied by Bechtel (2009[1]) and incorporated in the existing 3D noise prediction model developed during the EIS study. The topography as supplied by Bechtel (2009[2]) around the LNG facility site and noise source locations are shown in **Figure 1**.

[1] Formerly Environmental Protection Agency (EPA)

Figure 1 Noise Source Locations and Topography within LNG Facility Site



Note: Numbers shown on **Figure 1** (and defined in **Table 2**) correspond to areas where noise sources are located within the noise model.

Gladstone harbour, Port Curtis and surrounding rivers/estuaries have been modelled as a reflective (hard) surface. All other areas (outside the LNG facility site boundary) of the model have been modelled as absorptive (soft) surfaces.

A ground absorption coefficient of zero has been modelled for a reflective surface (ie water), whilst absorptive (soft) surfaces have been modelled using a ground absorption coefficient of 1.0.

Based on information provided by Bechtel, the ground surface on the LNG facility site will be gravel. A literature review on sound absorption associated with gravel (two references with sound absorption data for gravel are presented – Egan (2007), and Kaye and Evans (1940)) showed that the relevant sound absorption coefficient for gravel is in the range of 0.6 to 0.8, depending on thickness and type of gravel. To be conservative Heggies has used 0.6 as a ground sound absorption coefficient on the LNG facility site.

3.2 Bechtel LNG Facility Source Noise Levels

The sound power levels (SWL) for the LNG facility plant equipment as supplied by Bechtel (2009[1]) are presented in **Table 2**. The column "area number" refers to the area numbers in **Figure 1** for noise source locations.

Table 2 Sound Power Level (SWL) for Bechtel LNG Facility

Description	Total Qty of Noise Sources	Area Number[1]	Source Height (m)	SWL for a Single Noise Source (dBA)	SWL for Total Qty of Noise Sources (dBA)
PER TRAIN (ISBL)					
Coolers					**121**
Air Coolers	102	4	20	96	116
Air Coolers	4	5	20	97	103
Air Coolers	8	5	20	98	107
Air Coolers	8	5	20	98	107
Air Coolers	8	5	20	98	107
Air Coolers	12	5	20	99	110
Air Coolers	4	6	20	99	105
Air Coolers	8	6	20	97	106
Air Coolers	2	5	20	99	102
Air Coolers	6	5	20	99	107
Air Coolers	6	5	20	99	107
Air Coolers	6	5	20	99	107
Air Coolers	36	11	20	99	115
Combustion Turbines					**117**
Gas Turbine and Stack	2	7	28.5	109	112
Gas Turbine and Stack	2	7	28.5	109	112
Gas Turbine and Stack	2	7	28.5	109	112
Compressors					**113**
Compressors	2	7	10	104	107
Compressors	2	7	10	99	102
Compressors	2	7	10	95	98
Compressors	2	7	10	105	108
Gearboxes	2	7	10	79	82
Compressors	2	7	10	104	107
Gearboxes	2	7	10	80	83

Description	Total Qty of Noise Sources	Area Number[1]	Source Height (m)	SWL for a Single Noise Source (dBA)	SWL for Total Qty of Noise Sources (dBA)
Compressor Piping	**n/a**	**5**	**9**		**134**
Misc. Equipment					**117**
Compressor	1	9	2	107	107
Compressor	1	14	2	105	105
Pump	1	10	1	105	105
Pump	2	10	1	113	116
Pump	1	8	1	103	103
Total SWL for 1 Train (ISBL)					**135**
Total SWL for 3 Train (ISBL)					**139**
OSBL AREA					
Gas Turbine Generators	5	12	2	112	119
BOG Compressor	(3) 4 during loading	13	2	116.5	122.5
Demin Water Pump	1	13	2	99	99
Service Water Pump	1	13	2	101	101
Portable Water Pump	1	13	2	101	101
Total SWL (OSBL)					**124**
Total SWL for LNG Facility with 3 Trains					**139**

Note 1: Area number is referring to noise source locations as shown in **Figure 1**.

3.3 Meteorological Conditions

In accordance with the Ecoaccess Guideline, considerations must be given to the effects of prevailing and worst case meteorological conditions (wind, temperature, humidity and temperature inversions) on noise propagation from the LNG facility.

Wind Effects

The Ecoaccess Guideline describes two (2) alternative methods for assessing the effects of wind on noise emissions:

1. By using a wind rose to determine whether wind is a feature based on the frequency of occurrence and wind speed and assessing the source-to-receiver components of winds that are relevant.
2. By assuming that wind is a feature of the area (foregoing the need to use a wind rose) and applying a 'maximum impact' scenario.

It should be noted that sufficient meteorological data was not previously available during the EIS assessment of the LNG facility and therefore wind was assumed to be a feature of the area (as per method 2 above). Therefore, a wind component was added to the worst case weather conditions and all sensitive receptors within the LNG facility study area were assessed accordingly.

Annual meteorological data from weather stations located at Gladstone Radar (near Round Hill) and Gladstone Airport have been sourced and analysed for this detailed assessment in order to determine wind roses for the area. The summarised meteorological data for 2007 and 2008 are presented in **Appendix A**.

In accordance with the Ecoaccess Guideline, annual meteorological data was analysed for the following wind parameters:

- 30% occurrence in any assessment period (day, evening or night) in any season.
- 3 m/s or less source to receiver component.
- 10m height for wind speed.

Analysis of the Gladstone Radar meteorological data showed that no wind directions were noted to occur 30% of the time or more for wind speeds of 3 m/s or less.

Analysis of the Gladstone Airport meteorological data showed that only wind from the SSE through SW occurred at least 30% of the time in any one season at speeds of up to 3 m/s. Therefore, a southerly wind component has been included in noise predictions carried out for prevailing weather conditions (refer **Section 4**). It is noted that there are no identified sensitive receivers to the NNW to NE of the LNG facility (toward which the prevailing wind would adversely impact).

Temperature Inversion

The other meteorological effect to be considered in accordance with the Ecoaccess Guideline is that of temperature inversions. The Ecoaccess Guideline recommends that the effects of temperature inversions should be assessed when they occur for greater than 30 percent of the total night-time period during winter (June, July and August).

Where the frequency of temperature inversions is unknown, the Ecoaccess Guideline recommends the use of default parameters for temperature inversions and drainage-flow wind speed such as those specified below. This approach was adopted during the EIS study.

The EIS study applied the following default temperature inversion parameters (non-arid):

- 30% occurrence for night time (6pm-7am) period during winter (June, July, August).
- Moderate inversions (F-class stability category).
- 3°C/100m inversion strength with a 2m/s source to receiver component (where applicable).

It should be noted that sufficient meteorological data was not previously available during the EIS assessment of the LNG facility and therefore temperature inversion was assumed to be a feature of the area and the default inversion parameters applied for the worst case weather conditions and all sensitive receptors within the LNG facility study area were assessed accordingly.

The results of a temperature inversion analysis performed as part of the air quality assessment (URS (2009)) for the Santos GLNG Project have been considered as part of this report. The temperature inversion assessment indicates that temperature inversions of more than 3 °C per 100m occur less than 30% of the time during the winter months. Therefore temperature inversions are not considered to be a characteristic of the Gladstone area (in accordance with the Ecoaccess Guideline). However, whilst the Ecoaccess Guideline indicates that temperature inversions do not warrant further assessment, the worst case weather conditions have been included in this assessment in order to show the full range of predicted noise emission levels at the nearest noise sensitive receivers (similar to previous EIS studies carried out for the Gladstone area).

Modelled Meteorological Parameters

Based on the above analysis of available meteorological data, the weather conditions used to assess the effect of neutral, worst case and prevailing meteorological conditions are shown in **Table 3** below.

Table 3 Meteorological Conditions – Neutral, Worst Case and Prevailing

Parameter	Neutral Weather	Worst Case Weather[1]	Prevailing Weather
Temperature	10°C	10°C	10°C
Humidity	70%	90%	70%
Pasquill Stability Category	D	F (simulates temperature inversion conditions)	D
Wind Speed	0 m/s	2 m/s	3 m/s (Southerly wind direction)

Note 1: Worst case weather is presented here only as a reference case as it occurs less than 30% of the total night time winter period (as per the Ecoaccess Guideline).

The Ecoaccess Guideline recommends that an assessment of noise impacts is carried out for both worst case weather conditions and prevailing weather conditions. However, based on the available meteorological data the worst case weather conditions (specified in **Table 3**) occur for less than 30% of the total night time period and therefore do not warrant assessment (in accordance with the Ecoaccess Guideline). Heggies has included noise predictions for the worst case weather conditions in this report in order to show the full range of predicted noise emission levels expected at the nearest noise sensitive receivers.

Analysis of the available meteorological data for the greater Gladstone area indicates that the prevailing southerly wind direction (SSE through SW) occurs for approximately 50% of the night time period.

The assessment of noise impacts during the prevailing night time weather conditions is considered to be of significance for the following reasons:

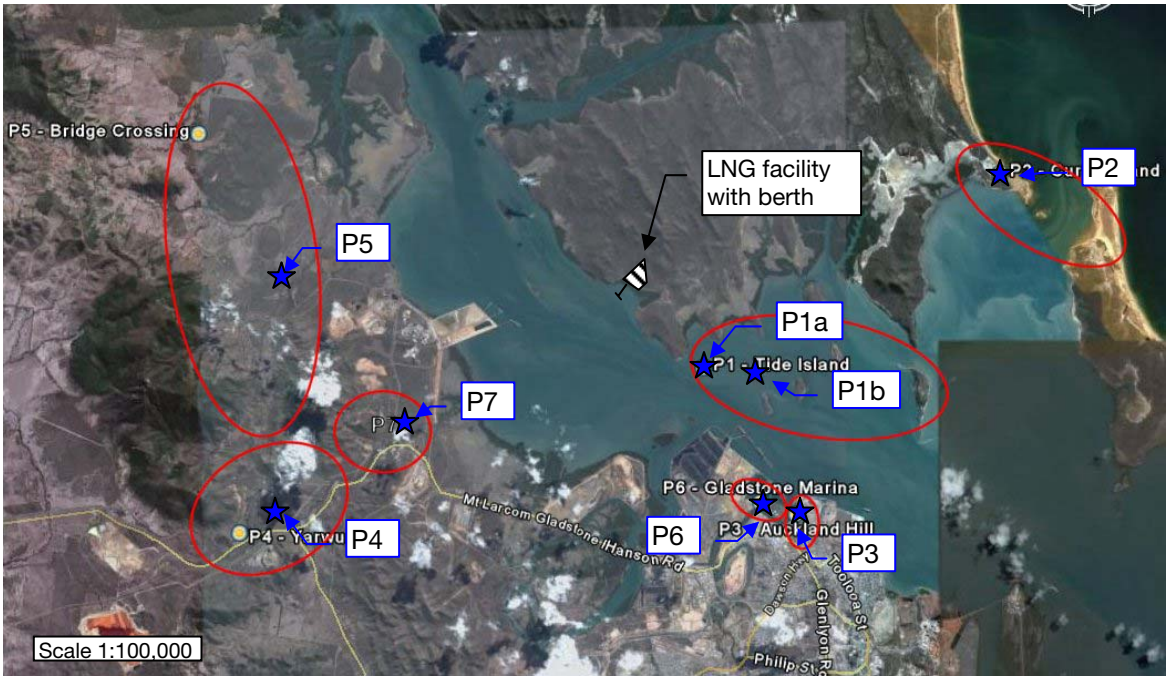
- The prevailing weather conditions occur for a significant proportion of the total night time period (approximately 50% annually);
- The prevailing weather conditions occur for a significant proportion of the total night time period during winter when background noise levels would generally be lowest (approximately 60 to 70 % of winter night time period); and
- The prevailing weather conditions in the greater Gladstone area occur during the night time period when the limiting (most stringent) noise criteria is applicable.

4 NOISE PREDICTION RESULTS AND ASSESSMENT

Noise level predictions have been undertaken at numerous sensitive receivers (approximately 50) in the surrounding community of Gladstone. These have been grouped based on their location with respect to the nearest representative ambient noise monitoring location (each group is referred to as an assessment location). Each of these prediction locations within each group are assessed against the same operational criteria based on the results of the noise monitoring (refer to the Heggies EIS Noise and Vibration Report (2009) for further details). Only the prediction location within each group with the highest predicted noise level (ie most noise affected receiver) is reported. All receivers have been positioned 1.5 m above ground and a minimum of 4 m from the nearest building facade (ie free field).

An aerial overview of the Gladstone region highlighting the location of the LNG facility and the assessment locations is shown in **Figure 2**. The assessment locations where the operational noise levels from the LNG facility have been assessed are marked P1 to P7. These locations (P1 to P7) are representative of the nearest noise sensitive receptors surrounding the proposed LNG facility. The distance from the boundary of the LNG Facility to the nearest noise receptor (P1a - Tide Island) is approximately 3.4 km.

Figure 2 LNG Facility and Assessment Locations (P1-P7)



4.1 Bechtel LNG Facility Source Noise Levels

Noise emission levels have been predicted at noise sensitive receivers in the vicinity of the LNG facility using the sound power levels supplied by Bechtel (see **Table 2**). The noise prediction results are summarised in **Table 4**.

A noise contour map showing the predicted noise levels for the neutral weather condition is presented in **Appendix B**.

Table 4 Predicted Noise Levels

Assessment Locations (Distance from LNG Facility)	Background Noise Creep Criteria (dBA)	Predicted Sound Pressure Levels (dBA)		
		Neutral Weather	Worst Case Weather	Prevailing Weather
P1a (3.4 km) Tide Island	31	44 (+13)	49 (+18)	39 (+8)
P1b (4.4 km) Witt Island	31	41 (+10)	48 (+17)	37 (+6)
P2 (10 km)	25	26 (+1)	33 (+8)	26 (+1)
P3 (7.9 km)	27	36(+9)	43 (+16)	32 (+5)
P4 (12.4 km)	27	25 (-2)	32 (+5)	22 (-5)
P5 (10.5 km)	25	29 (+4)	36 (+11)	28 (+3)
P6 (7.2 km)	28	32 (+4)	40 (+12)	27 (-1)
P7 (7.0 km)	30	38 (+8)	45 (+15)	34 (+4)

Assessment Locations (Distance from LNG Facility)	Background Noise Creep Criteria (dBA)	Predicted Sound Pressure Levels (dBA)		
		Neutral Weather	Worst Case Weather	Prevailing Weather
Boundary A[1]	-	72	73	72
Boundary B[1]	-	55	56	55
Boundary C[1]	-	47	49	49
Boundary D[1]	-	47	49	48

Note: Numbers in brackets show the difference relative to the noise criteria.

1: Boundary locations are as defined in the Heggies EIS Noise and Vibration Report (2009).

It can be seen that the predicted noise level at P1a (Tide Island) is 13 dBA above the noise criterion for the neutral weather conditions. The required noise reductions to achieve the noise criteria are discussed in **Section 4.2** below.

It can also be noted from the results in **Table 4** that for the prevailing weather condition (ie prevailing southerly wind direction), all receivers have lower predicted noise levels in comparison to both neutral and worst case weather conditions. During prevailing weather conditions P1a (Tide Island) will have winds blowing from receiver to source, significantly reducing the predicted noise level at this receiver in comparison to neutral weather (5 dBA difference) and worst case weather conditions (10 dBA difference). Based on the meteorological data analysis (see **Section 3.3**), prevailing weather conditions are expected to occur approximately 50 % of the night time period.

4.2 Noise Reduction Scenarios

Based on the predicted noise levels in **Table 4** (neutral weather), the following two (2) noise reduction scenarios were investigated:

- **Noise Reduction Scenario 1** – the level of noise reduction required to achieve the noise criteria at all receptors (including Tide Island and Witt Island) for neutral weather conditions.
- **Noise Reduction Scenario 2 (Bechtel Mitigated)** – proposed mitigation measures by Bechtel (2009[3]) include pipe lagging and low noise air coolers amongst other mitigated noise sources.

The required noise reductions for scenario 1 above have been calculated based on the noise source contributions at the relevant sensitive receivers. The noise sources with the highest noise contribution at the receivers have been reduced to a level which will allow the noise criteria to be achieved for each relevant scenario. There can be other combinations of noise reductions that also achieve the criteria (ie reduce the SWL for the combustion turbines more and air coolers less etc). The SWL's for the two (2) noise reduction scenarios above are presented in **Table 5**. The SWL's and noise reductions nominated for each item of plant for the noise reduction scenario 1 in **Table 5** are indicative only.

It is noted that the noise reductions nominated for the noise reduction scenario 1 in **Table 5** do not give consideration to the feasibility of achieving these reductions via noise mitigation measures. The nominated noise reductions are only intended to show the level of noise reduction required to achieve the relevant noise criteria for each scenario.

The noise reduction scenario 2 represents the proposed noise reduction by the Bechtel design team.

The level of noise reduction documented for the noise reduction scenario 1 in **Table 5** is based on achieving the noise criteria under neutral weather conditions. Significantly less noise reduction would be required for the LNG facility to achieve the relevant noise criteria during prevailing weather conditions, whilst further noise reduction would be required during worst case weather conditions.

Table 5 Sound Power Level (SWL) for Bechtel LNG Facility – Neutral Weather

Description	SWL for Total Qty of Noise Sources (dBA)		
	Bechtel SWL	Noise Reduction Scenario 1	Noise Reduction Scenario 2 (Bechtel Mitigated)
PER TRAIN (ISBL)			
Coolers	**121**	**116 (5)**	**118 (3)**
Air Coolers	116	111	115
Air Coolers	103	98	101
Air Coolers	107	102	104
Air Coolers	107	102	104
Air Coolers	107	102	104
Air Coolers	110	105	106
Air Coolers	105	100	101
Air Coolers	106	101	104
Air Coolers	102	97	98
Air Coolers	107	102	103
Air Coolers	107	102	103
Air Coolers	107	102	103
Air Coolers	115	110	111
Air Coolers			98
Combustion Turbines	**117**	**111 (6)**	**121(-4)**
Gas Turbine and Stack	112	106	116
Gas Turbine and Stack	112	106	116
Gas Turbine and Stack	112	106	116
Compressors	**113**	**113**	**111(2)**
Compressors	107	107	102
Compressors	102	102	104
Compressors	98	98	101
Compressors	108	108	107
Gearboxes	82	82	95
Compressors	107	107	104
Gearboxes	83	83	95
Compressor Piping	**134**	**112 (22)**	**115 (19)**
Misc. Equipment	**117**	**114 (3)**	**117**

Description	SWL for Total Qty of Noise Sources (dBA)		
	Bechtel SWL	**Noise Reduction Scenario 1**	**Noise Reduction Scenario 2 (Bechtel Mitigated)**
Compressor	107	107	107
Compressor	105	105	105
Pump	105	105	105
Pump	116	110	116
Pump	103	103	103
Total SWL for 1 Train (ISBL)	**135**	**120 (15)**	**125 (10)**
Total SWL for 3 Train (ISBL)	**139**	**125 (14)**	**129 (10)**
OSBL AREA			
Gas Turbine Generators	119	113	121
BOG Compressor	122.5	116.5	118
Demin Water Pump	99	99	99
Service Water Pump	101	101	101
Portable Water Pump	101	101	101
Total SWL (OSBL)	**124**	**118 (6)**	**123(1)**
Total SWL for LNG Facility with 3 Trains	**139**	**126 (13)**	**130 (9)**

Note: The noise reduction scenarios are based on achieving the noise criteria at the relevant noise sensitive receivers under neutral weather conditions.
The numbers in brackets show noise reduction relative to noise source levels supplied by Bechtel (2009[1])

The predicted noise levels at the relevant noise sensitive receivers for the two (2) noise reduction scenarios described above (see **Table 5**) are presented in **Table 6**. For each noise reduction scenario, the predicted noise levels in **Table 6** are based on the SWL for each item of plant (as documented in **Table 5**). The predicted noise contour maps for the two (2) noise reduction scenarios (during neutral weather conditions) are presented in **Appendix C**.

The predicted noise levels in **Table 6** for noise reduction scenario 1 and noise reduction scenario 2 show that the applicable intrusive noise criteria are predicted to be achieved during all meteorological conditions and at all noise sensitive receivers.

Table 6 Predicted Noise Levels – LNG Facility Noise Reduction Scenarios

Assessment Locations	Intrusive Noise (SNL) Criteria	Sleep Disturbance Criteria	Back-ground Creep Criteria (dBA)	Predicted Sound Pressure Levels (dBA)					
				Noise Reduction Scenario 1			Noise Reduction Scenario 2 (Bechtel Mitigated)		
				Prevailing Weather	Neutral Weather	Worst Case Weather	Prevailing Weather	Neutral Weather	Worst Case Weather
P1a (3.4 km)	44	40	31	27 (-4)	**31 (0)**	36 (+5)	33 (2)	37 (+6)	42 (+11)
P1b (4.4 km)	44	40	31	24 (-7)	29 (-2)	34 (+3)	31 (0)	34 (+3)	39 (+8)
P2 (10 km)	34	40	25	13 (-12)	13 (-12)	17 (-8)	20 (-5)	20 (-5)	24 (-1)
P3 (7.9 km)	40	40	27	19 (-8)	23 (-4)	27 (0)	26 (-1)	29 (+2)	33 (+6)
P4 (12.4 km)	40	40	27	9 (-18)	12 (-15)	16 (-11)	16 (-11)	18 (-9)	22 (-5)
P5 (10.5 km)	34	40	25	15 (-10)	16 (-9)	20 (-5)	22 (-3)	22 (-3)	26 (+1)
P6 (7.2 km)	41	40	28	15 (-13)	19 (-9)	24 (-4)	21 (-7)	25 (-3)	30 (+2)
P7 (7.0 km)	43	40	30	21 (-9)	25 (-5)	29 (-1)	28 (-2)	31 (+1)	35 (+5)
Boundary A[1]	-	-	-	59	60	60	64	64	65
Boundary B[1]	-	-	-	42	42	43	47	47	47
Boundary C[1]	-	-	-	37	35	37	42	41	42
Boundary D[1]	-	-	-	36	36	37	43	43	44

Note: Numbers in brackets show the difference relative to the noise criteria.
Bold value indicates the noise sensitive receiver limiting the relevant noise reduction scenario.

Note 1: Boundary locations are as defined in the Heggies EIS Noise and Vibration Report (2009).

4.3 Noise Source Ranking

The noise contributions at the assessment location P1 (Tide Island) is presented in **Table 7** for the unmitigated and mitigated SWL's provided by Bechtel.

Table 7 Ranking of the Noise Contribution from Different Plant Items at Tide Island

Source Description	**Predicted Sound Pressure Levels (dBA) P1 (Tide Island)**	
	Bechtel Unmitigated (2009[1])	Bechtel Mitigated (2009[3])
Compressor piping	43	24
Air Coolers	32	30
Combustion Turbines	31	35
BOG Compressors	25	20
Pumps	23	23
Gas Turbine Generators	22	24

The ranking of the noise contributions at the assessment location P1 (Tide Island) in **Table 7** reveal that for the unmitigated Bechtel (2009[1]) the compressor piping is dominant.

To further reduce the predicted noise level at the noise sensitive receivers for the noise reduction scenario 2 (Bechtel Mitigated) the dominant noise sources, combustion turbines and air coolers, will require further noise reduction.

4.4 Noise Prediction Summary

Table 8 presents the sound power levels supplied by Bechtel for the EIS study and for this study. It shows that for the current Bechtel noise source levels a noise reduction of 8 to 13 dBA is required to achieve the relevant noise criteria for the nominated noise reduction scenarios during neutral weather conditions.

Table 8 Summary of Sound Power Levels for the Santos LNG Facility

	A-weighted Sound Power Levels, SWL dBA		
	ISBL 1 Train	**ISBL 3 Trains**	**Total LNG Facility 3 Trains**
EIS Study Bechtel[1]	131	136	136
Bechtel[2]	135	139	139
Bechtel[3]	125	129	130
Required SWL to achieve the criteria at ALL sensitive receivers	120	125	126
Required SWL to achieve criteria at the Mainland sensitive receivers (ie excluding Tide Island and Witt Island)	125	130	131
Required Noise Reduction for Bechtel[2]			**8-13 dBA**

Note: The noise reductions are based on achieving the noise criteria at the relevant noise sensitive receivers under neutral weather conditions. The required reductions in SWL's are based on reducing the noise sources with highest noise contribution at the relevant noise sensitive receptors. The noise contribution is not only dependent on the SWL, but also on sources location and source height.

Note 1: Pre-FEED Studies (2008).

Note 2: Bechtel (2009[1]).

Note 3: Bechtel mitigated (2009[3]).

The SWL's presented in **Table 8** (for the relevant noise reduction scenarios) and throughout this report are those required to achieve the applicable noise criteria at the relevant noise sensitive receivers under neutral weather conditions.

It should be noted that for the prevailing weather condition, 4-5 dBA lower noise levels are predicted for the noise sensitive receivers south of the LNG facility in comparison to the neutral weather condition. Under the prevailing weather condition the required noise reduction to achieve the noise criteria at the relevant noise sensitive receivers would be 4-9 dBA (instead of the 8-13 dBA for neutral weather condition). In addition, it is also noted that the prevailing weather conditions are expected to occur for a significant portion of the total night time period (approximately 50%) (refer **Section 3.3**).

It can be noted that the Bechtel (2009[3]) mitigated noise source levels have reduced the predicted noise level at Tide Island by 7 dBA.

4.5 Noise Mitigation

In order to achieve the best outcome with respect to noise emissions from the LNG facility (with consideration to technical constraints), it is recommended that the following levels of noise reductions should be considered (in order of priority):

1. 18 dBA of noise reduction – in order to achieve all applicable noise criteria at all noise sensitive receptors during all types of meteorological conditions.
2. 13 dBA of noise reduction (Noise Reduction Scenario 1) - in order to achieve all applicable noise criteria at all noise sensitive receptors during both neutral and prevailing meteorological conditions. All noise criteria would be achieved during worst case weather conditions at all noise sensitive receptors, with the exception of those at P1a (Tide Island) and P1b (Witt Island), where the intrusive and sleep disturbance noise criteria would be achieved but not the background creep noise criteria.

It should be noted that residences on Tide Island and Witt Island are not permanent (ie occupied intermittently).

The proposed noise mitigation by Bechtel (2009[3]) (Noise Reduction Scenario 2) achieves all noise criteria at all noise sensitive receivers, except Tide Island, for prevailing weather. For neutral weather there is an exceedence of the criteria of 1 dBA to 6 dBA.

Heggies considers that an appropriate level of noise control (discussed above) is able to be achieved by implementing appropriate noise mitigation measures consistent with the type specified in the GLNG EIS study.

5 CONCLUSION

A comprehensive noise assessment has been undertaken utilising the latest noise model input data provided by Bechtel for the GLNG LNG facility in Gladstone.

The latest available noise model input data provided by Bechtel which differs from that data used in the GLNG EIS study includes:

- LNG facility source noise levels;
- LNG facility source locations;
- On-site topography; and
- On-site ground cover (sound absorption).

Bechtel has indicated that the proposed ground surface on the LNG facility site will be gravel. A sound absorption coefficient of 0.6 has been used for the gravel on site in this study (the EIS assumed soft ground with a sound absorption coefficient of 1.0). The reduced ground sound absorption on site increases the predicted noise levels at the nearest noise sensitive receivers by approximately 1 dBA.

Incorporating the latest noise model input data supplied by Bechtel (ie new SWL's, source locations and topography) results in the predicted noise levels as presented in **Table 4**. The predicted noise level at P1a (Tide Island) is 13 dBA above the relevant noise criterion for neutral weather conditions. With the mitigated noise source levels supplied by Bechtel the predicted noise level at P1a (Tide Island) is 6 dBA above the relevant noise criterion for neutral weather conditions.

It should be noted that this report presents predicted noise levels due to a 3-train plant. A 2-train plant would result in a noise level reduction at the sensitive receptors compared to the 3-train predicted noise levels.

Noise predictions have also been carried out for worst case and prevailing weather conditions. It is noted that for the prevailing weather condition (ie prevailing southerly wind direction), all receivers have lower predicted noise levels in comparison to both neutral and worst case weather conditions. During prevailing weather conditions Tide Island will have winds blowing from receiver to source, significantly reducing the predicted noise level at this receiver in comparison to neutral weather (5 dBA difference) and worst case weather conditions (10 dBA difference). Based on the meteorological data analysis (see **Section 3.3**), prevailing weather conditions are expected to occur approximately 50 % of the night time period.

The SWL's and associated noise reductions (see **Table 5**) required for each item of plant and equipment associated with the LNG facility were investigated for the noise reduction scenarios discussed in **Section 4.2**. The level of noise reduction nominated in **Table 5** for each of the noise reduction scenarios is based on reducing the plant items with the highest noise contribution at the receivers and achieving the noise criteria during neutral weather conditions (refer **Section 4.2**).

- **Noise Reduction Scenario 1** – the level of noise reduction required to achieve the criteria at all receptors (including Tide Island and Witt Island) during neutral weather conditions.
- **Noise Reduction Scenario 2 (Bechtel Mitigated)** - mitigation measures by Bechtel (2009[3]) include pipe lagging and low noise air coolers amongst other mitigated noise sources.

It is noted that the noise reductions nominated for noise reduction scenario 1 in **Table 5** do not give consideration to the feasibility of achieving these reductions via noise mitigation measures. The nominated noise reductions are only intended to show the level of noise reduction required to achieve the relevant noise criteria for each scenario. The noise reduction scenario 2 in **Table 5** is what has been proposed by Bechtel.

Heggies considers that with the implementation of noise mitigation measures consistent with the type specified in the GLNG EIS study, the levels of noise reduction specified in **Section** 4.5 would be able to be achieved.

6 REFERENCES

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Bechtel (2009[2]). *ModelRG_PlanEL_16Rev6_6_30_09.dwg*, email dated 4 September 2009

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Appendix A

Report 20-2014-R7

METEROLOGICAL DATA FOR GLADSTONE REGION

Meteorological Data – Gladstone Radar 2007

Time	Period	Wind Direction	Calm - ≤ 0.5 m/s	0.5 m/s - ≤ 2.0 m/s	2 m/s - ≤ 3.0 m/s	Calm - ≤ 3.0 m/s	3 m/s - ≤ 5.0 m/s	> 5.0 m/s
Day	Annual	NE	0.0%	0.8%	3.0%	3.9%	16.6%	27.6%
		ENE	0.0%	0.8%	2.7%	3.5%	17.1%	41.7%
		E	0.0%	0.7%	2.1%	2.8%	14.6%	45.5%
		ESE	0.0%	0.7%	1.6%	2.2%	10.0%	40.1%
		SE	0.0%	0.6%	1.4%	2.0%	7.5%	25.4%
	Summer	NE	0.0%	0.6%	2.0%	2.5%	16.1%	38.6%
		ENE	0.0%	0.3%	1.5%	1.8%	16.6%	56.7%
		E	0.0%	0.1%	1.0%	1.1%	13.4%	61.2%
		ESE	0.0%	0.1%	0.6%	0.7%	7.8%	52.3%
		SE	0.0%	0.1%	0.6%	0.7%	5.7%	33.0%
	Autumn	NE	0.0%	0.7%	1.7%	2.4%	16.1%	32.8%
		ENE	0.0%	0.8%	1.8%	2.6%	17.0%	51.2%
		E	0.0%	0.9%	2.0%	2.8%	15.8%	58.2%
		ESE	0.0%	0.8%	1.8%	2.5%	11.7%	52.4%
		SE	0.0%	0.9%	1.6%	2.4%	8.4%	31.8%
	Winter	SW	0.0%	4.6%	11.5%	16.1%	20.9%	2.8%
	Spring	NE	0.0%	0.7%	3.2%	3.9%	21.7%	32.8%
		ENE	0.0%	0.6%	2.6%	3.2%	20.6%	45.3%
		E	0.0%	0.5%	1.8%	2.3%	15.5%	45.1%
		ESE	0.0%	0.4%	1.2%	1.7%	8.6%	37.0%
		SE	0.0%	0.3%	1.1%	1.4%	5.4%	23.1%
Evening	Annual	ENE	0.0%	0.7%	4.5%	5.2%	16.8%	29.1%
		E	0.0%	0.4%	2.5%	2.9%	14.9%	38.6%
		ESE	0.0%	0.3%	1.5%	1.7%	11.9%	40.7%
		SE	0.0%	0.2%	1.2%	1.4%	9.0%	30.8%
	Summer	NNE	0.0%	1.1%	5.2%	6.3%	21.3%	5.5%
		NE	0.0%	0.9%	5.0%	5.9%	23.9%	22.3%
		ENE	0.0%	0.5%	3.2%	3.7%	22.4%	44.4%
		E	0.0%	0.2%	0.9%	1.1%	14.8%	55.5%
		ESE	0.0%	0.1%	0.1%	0.2%	7.0%	55.9%
		SE	0.0%	0.0%	0.1%	0.1%	4.8%	40.3%
	Autumn	ENE	0.0%	0.2%	4.1%	4.3%	21.7%	35.0%
		E	0.0%	0.2%	2.2%	2.4%	21.7%	50.8%
		ESE	0.0%	0.2%	1.4%	1.5%	17.6%	54.1%
		SE	0.0%	0.1%	0.9%	1.0%	10.7%	43.3%
		SSE	0.0%	0.1%	0.6%	0.7%	6.8%	21.0%
	Winter	WSW	0.0%	4.8%	16.4%	21.2%	15.5%	1.1%
		W	0.0%	5.5%	18.5%	24.0%	11.0%	0.4%
		WNW	0.0%	5.3%	16.7%	22.0%	5.8%	0.0%
	Spring	NNE	0.0%	2.8%	13.3%	16.0%	21.6%	2.7%

Meteorological Data - Gladstone and Gladstone Airport

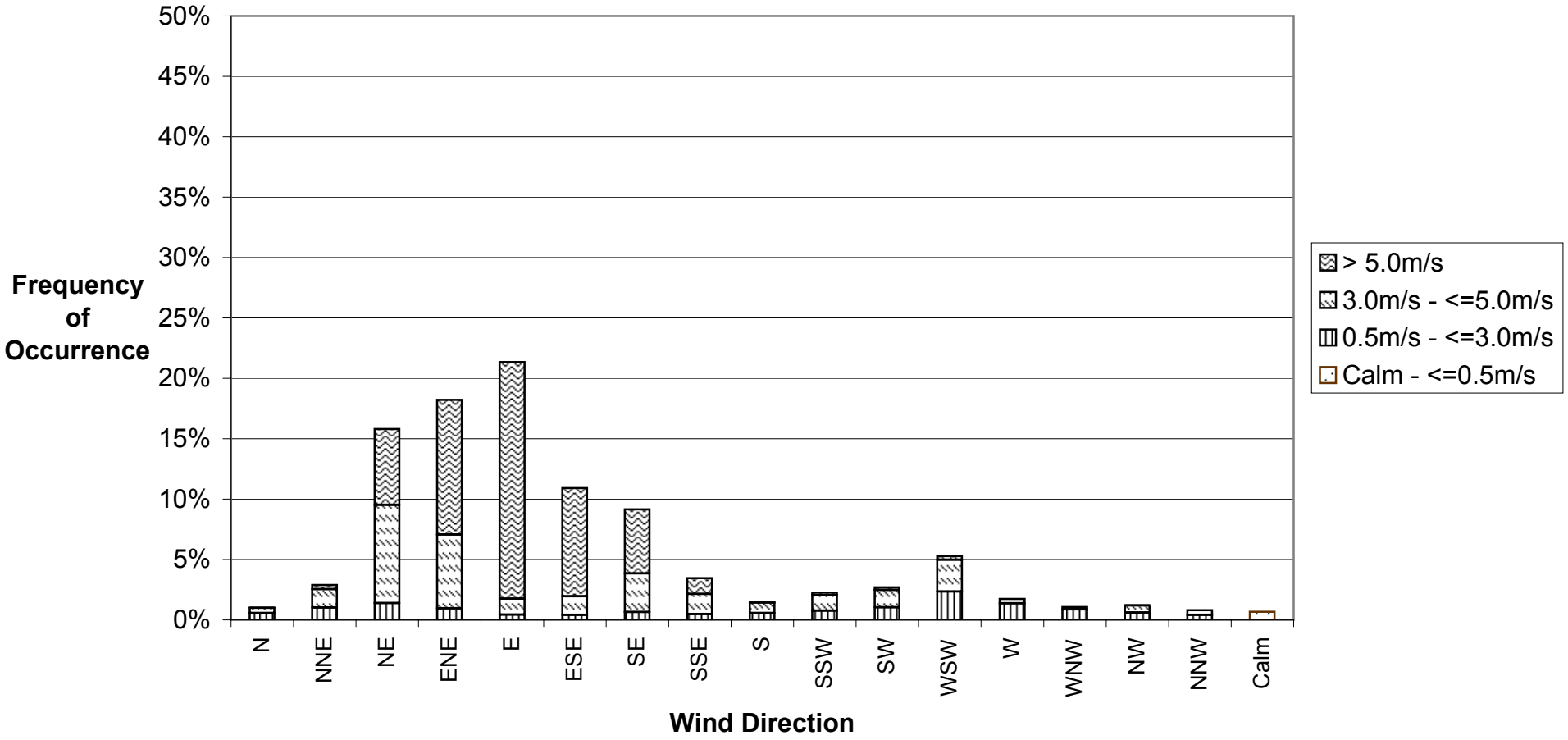
Time	Period	Wind Direction	Calm - ≤ 0.5 m/s	0.5 m/s - ≤ 2.0 m/s	2 m/s - ≤ 3.0 m/s	Calm - ≤ 3.0 m/s	3 m/s - ≤ 5.0 m/s	> 5.0 m/s
		NE	0.0%	2.1%	10.0%	12.0%	23.3%	15.2%
		ENE	0.0%	1.0%	5.8%	6.8%	19.4%	30.0%
		E	0.0%	0.3%	2.4%	2.7%	15.0%	36.3%
		ESE	0.0%	0.1%	0.7%	0.8%	9.2%	38.1%
		SE	0.0%	0.1%	0.3%	0.4%	4.3%	26.6%
Night	Annual	SE	0.0%	0.8%	3.0%	3.8%	26.9%	21.6%
		SSE	0.0%	0.9%	3.5%	4.4%	30.0%	19.6%
		S	0.0%	1.0%	4.0%	5.0%	30.4%	14.4%
		SSW	0.0%	1.4%	5.7%	7.1%	22.1%	5.9%
	Summer	E	0.0%	0.6%	3.2%	3.8%	17.4%	20.1%
		ESE	0.0%	0.5%	1.9%	2.4%	21.9%	28.6%
		SE	0.0%	0.5%	2.1%	2.5%	25.7%	28.0%
		SSE	0.0%	0.4%	2.2%	2.6%	25.4%	22.9%
		S	0.0%	0.3%	2.0%	2.3%	22.0%	14.3%
	Autumn	ESE	0.0%	0.8%	3.3%	4.1%	21.7%	26.7%
		SE	0.0%	1.1%	4.8%	5.9%	37.1%	32.1%
		SSE	0.0%	1.3%	5.4%	6.7%	40.4%	30.1%
		S	0.0%	1.2%	5.5%	6.7%	37.2%	21.1%
		SSW	0.0%	1.4%	5.6%	7.0%	21.9%	6.8%
	Winter	SE	0.0%	1.2%	1.2%	2.4%	20.5%	8.3%
		SSE	0.0%	1.5%	2.5%	4.0%	27.9%	9.5%
		S	0.0%	1.8%	4.6%	6.4%	37.0%	10.2%
		SSW	0.0%	2.4%	11.1%	13.5%	39.8%	7.7%
		SW	0.0%	3.2%	17.6%	20.9%	35.3%	5.0%
		WSW	0.0%	3.7%	18.9%	22.6%	28.0%	3.7%
		W	0.0%	3.3%	17.4%	20.7%	17.1%	1.6%
	Spring	SE	0.0%	0.4%	3.8%	4.2%	24.2%	17.9%
		SSE	0.0%	0.5%	4.0%	4.6%	26.1%	16.1%
		S	0.0%	0.7%	3.7%	4.4%	25.0%	12.0%

Note: Table only shows those wind directions which have an occurrence of 20% or more for at least one (1) wind speed category. Percentages shown take into consideration the occurrences of adjacent wind directions to account for variations in wind directions for a given speed.

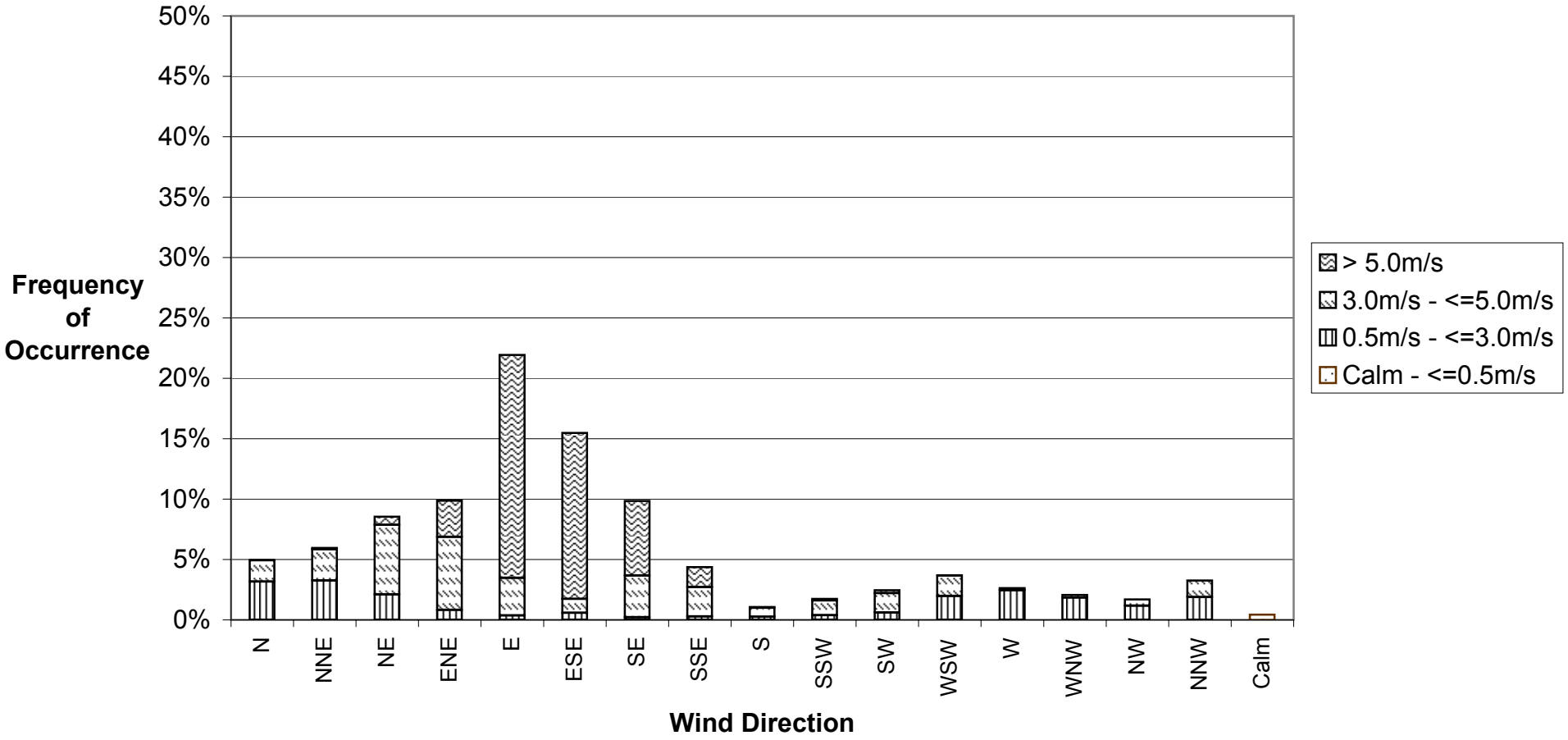
Percentages in pink refer to occurrences of between 20% and 30%.

Percentages in red refer to occurrences of great than 30%.

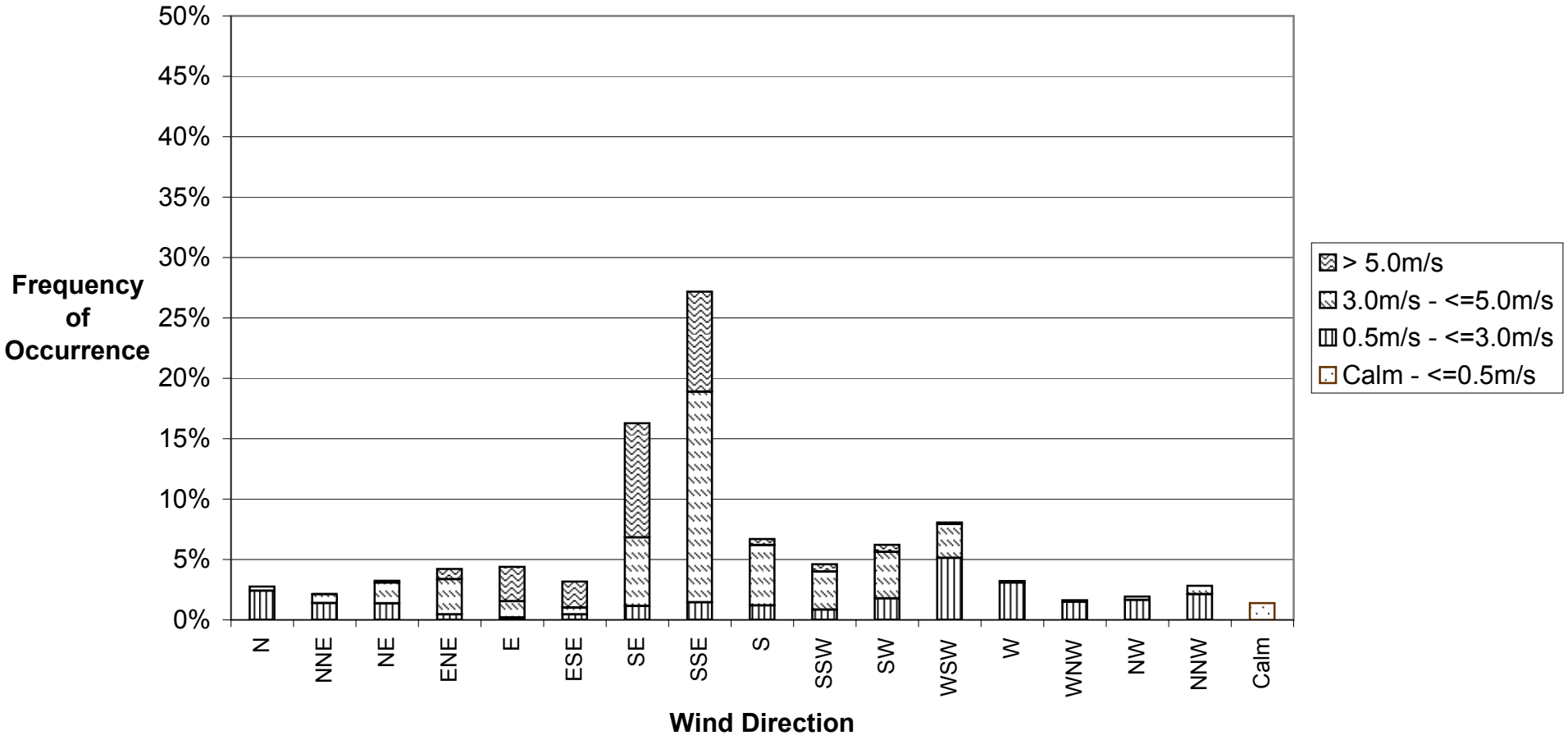
Annual Day Wind Data
Gladstone Radar
2007



Annual Evening Wind Data
Gladstone Radar
2007



Annual Night Wind Data
Gladstone Radar
2007



Meteorological Data – Gladstone Radar 2008

Time	Period	Wind Direction	Calm - ≤ 0.5 m/s	0.5 m/s - ≤ 2.0 m/s	2 m/s - ≤ 3.0 m/s	Calm - ≤ 3.0 m/s	3 m/s - ≤ 5.0 m/s	> 5.0 m/s
Day	Annual	NE	0.0%	1.0%	4.2%	5.2%	20.9%	19.8%
		ENE	0.0%	1.0%	3.9%	4.9%	22.2%	31.8%
		E	0.0%	1.0%	3.0%	4.0%	19.0%	36.7%
		ESE	0.0%	0.9%	2.0%	2.9%	12.4%	35.3%
		SE	0.0%	0.8%	1.8%	2.6%	8.2%	24.6%
	Summer	NE	0.0%	0.8%	3.0%	3.9%	20.0%	25.5%
		ENE	0.0%	0.8%	2.3%	3.1%	20.3%	39.5%
		E	0.0%	0.8%	1.5%	2.2%	16.0%	44.9%
		ESE	0.0%	0.7%	0.9%	1.6%	9.3%	42.8%
		SE	0.0%	0.6%	0.8%	1.4%	6.3%	30.3%
	Autumn	ENE	0.0%	0.3%	2.2%	2.6%	15.9%	34.7%
		E	0.0%	0.4%	2.0%	2.4%	15.7%	45.8%
		ESE	0.0%	0.6%	1.8%	2.4%	12.7%	50.7%
		SE	0.0%	0.9%	2.0%	2.8%	10.3%	37.9%
		SSE	0.0%	1.2%	2.5%	3.6%	10.0%	20.8%
	Winter	NE	0.0%	1.9%	8.1%	10.0%	20.3%	5.6%
		ENE	0.0%	1.9%	7.9%	9.8%	23.5%	12.5%
		E	0.0%	1.8%	6.1%	7.9%	22.6%	17.1%
	Spring	NNE	0.0%	1.0%	2.9%	3.9%	23.4%	16.5%
		NE	0.0%	1.1%	3.2%	4.3%	28.7%	31.0%
		ENE	0.0%	1.1%	3.2%	4.3%	29.1%	40.5%
		E	0.0%	1.0%	2.6%	3.6%	21.9%	39.1%
		ESE	0.0%	0.8%	1.7%	2.5%	11.0%	28.8%
Evening	Annual	E	0.0%	0.9%	5.6%	6.6%	17.3%	29.9%
		ESE	0.0%	0.6%	4.0%	4.6%	16.0%	34.6%
		SE	0.0%	0.3%	2.4%	2.7%	12.3%	29.2%
	Summer	NE	0.0%	1.4%	7.7%	9.1%	21.5%	11.7%
		ENE	0.0%	0.9%	5.2%	6.1%	20.1%	25.8%
		E	0.0%	0.5%	2.7%	3.2%	15.4%	37.4%
		ESE	0.0%	0.3%	1.4%	1.7%	10.6%	42.0%
		SE	0.0%	0.2%	0.9%	1.1%	8.4%	33.7%
	Autumn	ENE	0.0%	0.7%	5.4%	6.1%	14.0%	20.9%
		E	0.0%	0.5%	4.2%	4.7%	17.4%	39.7%
		ESE	0.0%	0.2%	3.0%	3.2%	20.4%	49.1%
		SE	0.0%	0.0%	1.8%	1.8%	16.5%	46.5%
		SSE	0.0%	0.1%	1.1%	1.2%	11.9%	30.9%
	Winter	ESE	0.0%	1.4%	9.0%	10.4%	22.9%	14.2%
		SE	0.0%	0.8%	5.7%	6.5%	21.1%	13.3%
	Spring	NNE	0.0%	2.0%	14.9%	16.9%	20.2%	2.8%
		NE	0.0%	1.6%	12.8%	14.4%	24.9%	12.7%

Meteorological Data - Gladstone and Gladstone Airport

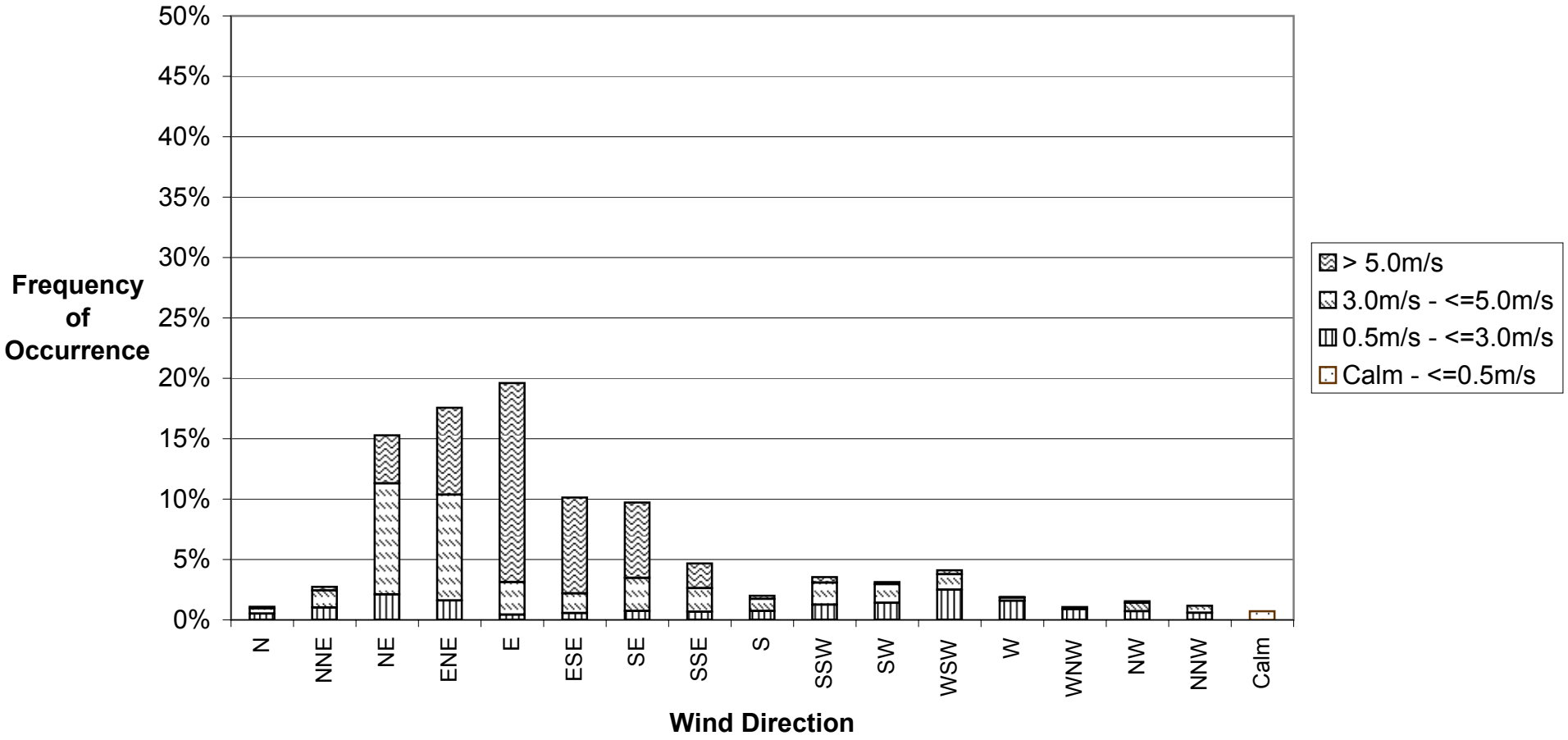
Time	Period	Wind Direction	Calm - ≤ 0.5 m/s	0.5 m/s - ≤ 2.0 m/s	2 m/s - ≤ 3.0 m/s	Calm - ≤ 3.0 m/s	3 m/s - ≤ 5.0 m/s	> 5.0 m/s
		ENE	0.0%	1.2%	8.9%	10.1%	22.8%	25.7%
		E	0.0%	0.6%	5.0%	5.6%	18.1%	32.6%
		ESE	0.0%	0.3%	2.8%	3.1%	10.1%	33.3%
		SE	0.0%	0.2%	1.3%	1.5%	3.1%	23.4%
Night	Annual	SE	0.0%	0.9%	3.4%	4.3%	26.9%	17.7%
		SSE	0.0%	1.0%	4.3%	5.3%	32.4%	16.3%
		S	0.0%	1.1%	5.2%	6.3%	34.5%	12.3%
		SSW	0.0%	1.9%	7.7%	9.6%	27.1%	5.1%
	Summer	ESE	0.0%	0.7%	2.3%	3.1%	15.0%	26.9%
		SE	0.0%	0.7%	2.5%	3.2%	21.8%	25.9%
		SSE	0.0%	0.7%	2.8%	3.4%	23.6%	20.7%
		S	0.0%	0.7%	3.1%	3.8%	21.5%	12.6%
	Autumn	SE	0.0%	0.5%	2.7%	3.2%	38.1%	26.5%
		SSE	0.0%	0.6%	3.9%	4.5%	48.2%	26.7%
		S	0.0%	0.8%	5.1%	5.9%	50.4%	22.1%
		SSW	0.0%	1.3%	7.6%	8.9%	37.7%	9.3%
	Winter	SE	0.0%	0.8%	3.4%	4.3%	23.9%	7.2%
		SSE	0.0%	1.0%	5.2%	6.2%	33.2%	7.8%
		S	0.0%	1.4%	7.4%	8.8%	43.0%	7.5%
		SSW	0.0%	2.5%	12.9%	15.3%	43.4%	4.8%
		SW	0.0%	3.6%	16.9%	20.5%	34.2%	2.6%
		WSW	0.0%	3.8%	15.9%	19.7%	24.7%	2.0%
	Spring	SE	0.0%	1.8%	5.0%	6.8%	23.9%	11.4%
		SSE	0.0%	1.8%	5.3%	7.1%	24.4%	9.9%
		S	0.0%	1.6%	5.3%	6.9%	22.6%	7.2%

Note: Table only shows those wind directions which have an occurrence of 20% or more for at least one (1) wind speed category. Percentages shown take into consideration the occurrences of adjacent wind directions to account for variations in wind directions for a given speed.

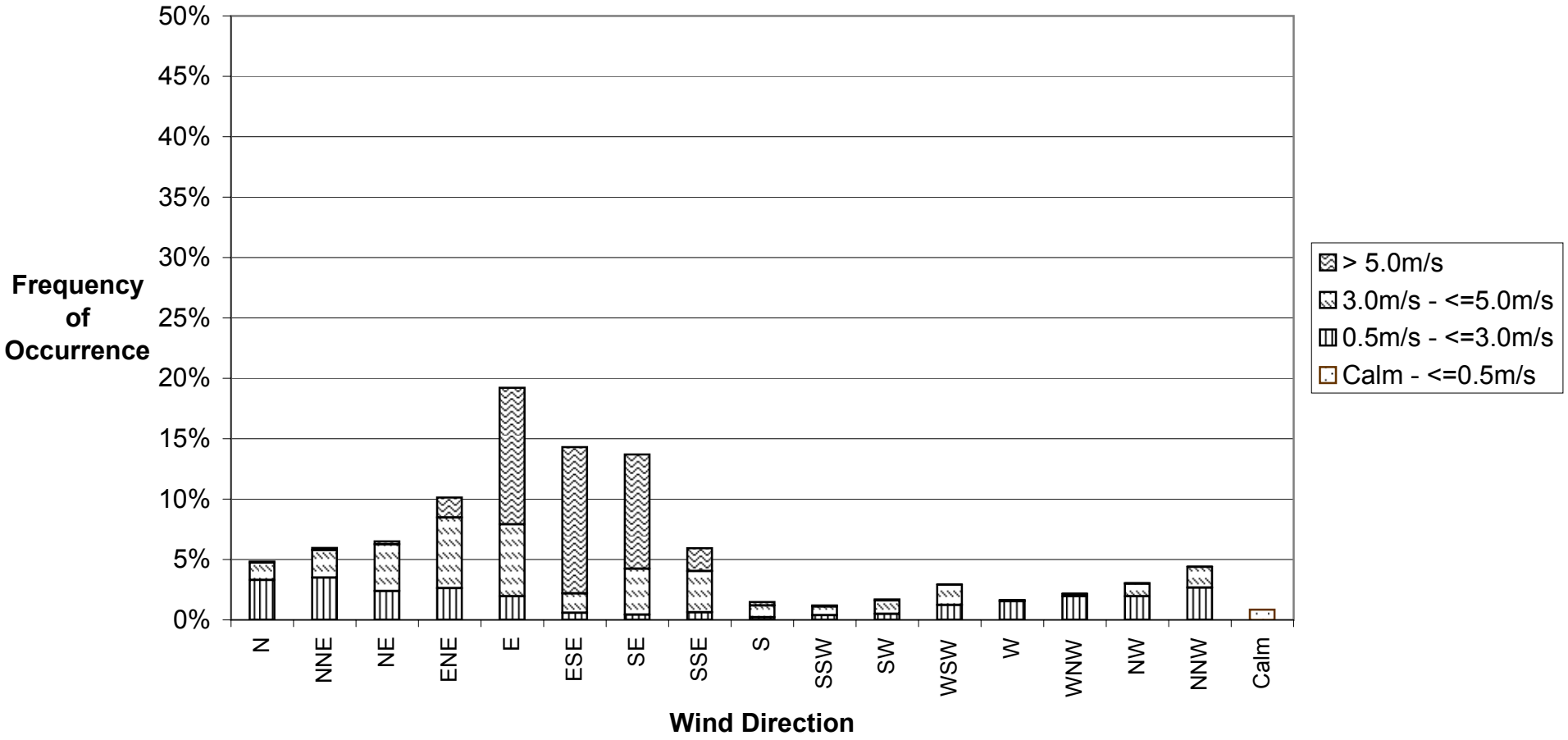
Percentages in pink refer to occurrences of between 20% and 30%.

Percentages in red refer to occurrences of 30% or more.

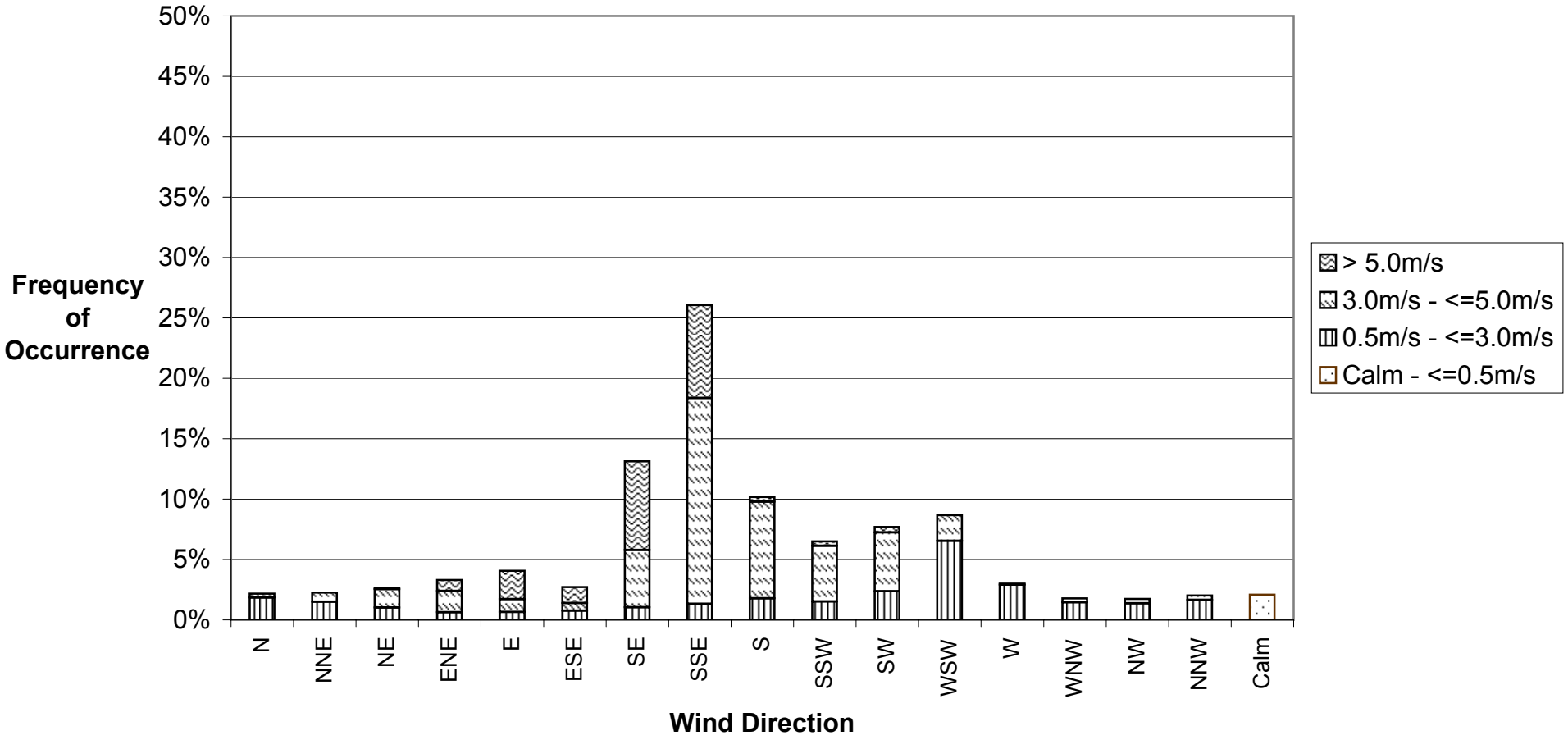
Annual Day Wind Data
Gladstone Radar
2008



Annual Evening Wind Data
Gladstone Radar
2008



Annual Night Wind Data
Gladstone Radar
2008



Meteorological Data – Gladstone Airport 2007

Time	Period	Wind Direction	Calm - ≤ 0.5 m/s	0.5 m/s - ≤ 2.0 m/s	2 m/s - ≤ 3.0 m/s	Calm - ≤ 3.0 m/s	3 m/s - ≤ 5.0 m/s	> 5.0 m/s
Day	Annual	NE	0.0%	0.6%	1.8%	2.3%	14.3%	25.2%
		ENE	0.0%	0.6%	1.7%	2.2%	14.3%	37.0%
		E	0.0%	0.6%	1.7%	2.3%	13.2%	38.4%
		ESE	0.0%	0.7%	1.9%	2.6%	11.7%	34.0%
		SE	0.0%	1.0%	2.4%	3.4%	11.1%	21.5%
	Summer	NE	0.0%	0.2%	1.3%	1.5%	12.9%	36.7%
		ENE	0.0%	0.2%	1.3%	1.5%	13.6%	51.9%
		E	0.0%	0.3%	1.4%	1.7%	13.8%	52.4%
		ESE	0.0%	0.4%	1.7%	2.1%	12.9%	44.7%
		SE	0.0%	0.4%	1.8%	2.3%	11.8%	28.3%
	Autumn	NE	0.0%	0.3%	1.4%	1.7%	16.2%	27.4%
		ENE	0.0%	0.4%	1.5%	2.0%	16.9%	45.1%
		E	0.0%	0.5%	1.6%	2.2%	15.7%	49.7%
		ESE	0.0%	0.6%	1.7%	2.3%	13.4%	46.4%
		SE	0.0%	0.8%	2.0%	2.8%	11.4%	28.8%
	Winter	SSW	0.0%	5.9%	14.7%	20.7%	21.3%	1.6%
		SW	0.0%	5.3%	15.1%	20.4%	21.3%	1.7%
	Spring	NNE	0.0%	0.4%	1.9%	2.3%	18.5%	21.8%
		NE	0.0%	0.4%	1.7%	2.1%	17.1%	31.3%
		ENE	0.0%	0.5%	1.5%	1.9%	15.1%	39.8%
		E	0.0%	0.5%	1.4%	1.9%	11.9%	38.2%
		ESE	0.0%	0.6%	1.5%	2.1%	9.2%	31.3%
		SE	0.0%	0.7%	1.9%	2.5%	8.3%	20.1%
Evening	Annual	E	0.0%	2.0%	6.1%	8.1%	19.0%	22.2%
		ESE	0.0%	2.4%	6.5%	8.9%	19.8%	22.7%
	Summer	NNE	0.0%	0.5%	6.0%	6.5%	24.5%	2.2%
		NE	0.0%	0.4%	5.6%	6.0%	28.2%	12.0%
		ENE	0.0%	0.3%	4.1%	4.4%	27.1%	27.4%
		E	0.0%	0.2%	3.0%	3.2%	25.0%	34.9%
		ESE	0.0%	0.3%	3.5%	3.8%	22.5%	35.5%
		SE	0.0%	0.7%	4.3%	4.9%	18.6%	25.8%
	Autumn	ENE	0.0%	3.2%	9.4%	12.6%	12.2%	21.5%
		E	0.0%	3.7%	11.1%	14.8%	20.5%	29.1%
		ESE	0.0%	4.1%	11.1%	15.2%	24.4%	29.3%
		SE	0.0%	4.4%	9.7%	14.2%	21.8%	22.1%
	Winter	SSE	0.0%	8.6%	12.5%	21.1%	9.5%	1.7%
		S	0.0%	10.8%	14.2%	25.0%	4.7%	0.5%
		SSW	0.0%	10.9%	13.8%	24.7%	3.3%	0.4%
		SW	0.0%	10.1%	12.7%	22.8%	2.8%	0.2%
	Spring	NNE	0.0%	4.2%	12.7%	16.9%	20.2%	1.8%

Meteorological Data - Gladstone and Gladstone Airport

Time	Period	Wind Direction	Calm - ≤ 0.5 m/s	0.5 m/s - ≤ 2.0 m/s	2 m/s - ≤ 3.0 m/s	Calm - ≤ 3.0 m/s	3 m/s - ≤ 5.0 m/s	> 5.0 m/s
		E	0.0%	1.4%	5.3%	6.6%	19.5%	21.3%
		ESE	0.0%	1.2%	3.3%	4.6%	19.0%	22.3%
Night	Annual	SE	0.0%	5.2%	15.5%	20.7%	20.7%	2.5%
		SSE	0.0%	9.0%	23.6%	32.6%	23.0%	1.8%
		S	0.0%	11.4%	27.6%	39.0%	20.0%	0.9%
		SSW	0.0%	10.7%	22.9%	33.6%	11.1%	0.2%
		SW	0.0%	8.1%	16.0%	24.1%	6.6%	0.1%
	Summer	ESE	0.0%	2.5%	12.5%	15.0%	28.6%	5.7%
		SE	0.0%	3.8%	16.6%	20.4%	30.6%	4.8%
		SSE	0.0%	5.3%	19.7%	25.0%	29.2%	2.9%
		S	0.0%	6.2%	19.0%	25.2%	20.3%	1.3%
	Autumn	ESE	0.0%	2.5%	10.5%	13.0%	21.8%	2.3%
		SE	0.0%	6.0%	19.8%	25.8%	26.8%	2.1%
		SSE	0.0%	9.9%	29.8%	39.7%	29.4%	1.6%
		S	0.0%	11.5%	33.6%	45.1%	24.4%	0.7%
		SSW	0.0%	10.3%	26.6%	36.9%	12.2%	0.0%
		SW	0.0%	6.8%	17.2%	24.0%	6.8%	0.0%
	Winter	**SSE**	0.0%	11.7%	24.7%	36.4%	14.1%	0.2%
		S	0.0%	16.4%	34.8%	51.2%	18.7%	0.3%
		SSW	0.0%	16.5%	33.2%	49.7%	16.8%	0.3%
		SW	0.0%	13.7%	28.2%	41.9%	14.8%	0.2%
		WSW	0.0%	8.0%	15.6%	23.6%	7.8%	0.1%
	Spring	SSE	0.0%	8.9%	20.0%	29.0%	19.4%	2.4%
		S	0.0%	11.2%	23.0%	34.2%	16.5%	1.4%
		SSW	0.0%	10.3%	18.5%	28.8%	8.3%	0.4%

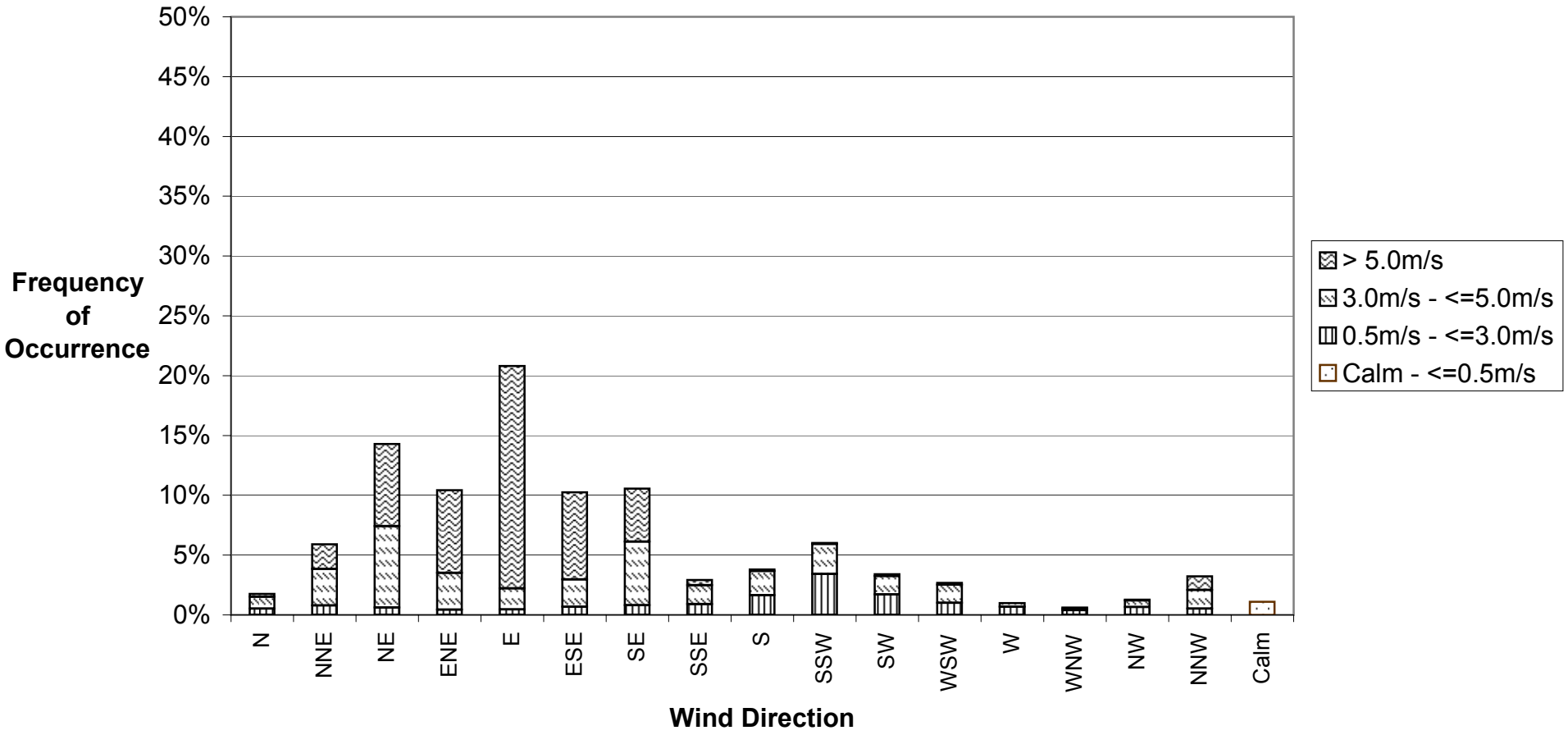
Note: Table only shows those wind directions which have an occurrence of 20% or more for at least one (1) wind speed category. Percentages shown take into consideration the occurrences of adjacent wind directions to account for variations in wind directions for a given speed.

Highlighted cells denote wind directions which occur for 30% of the time or more for wind speeds of 3 m/s or less.

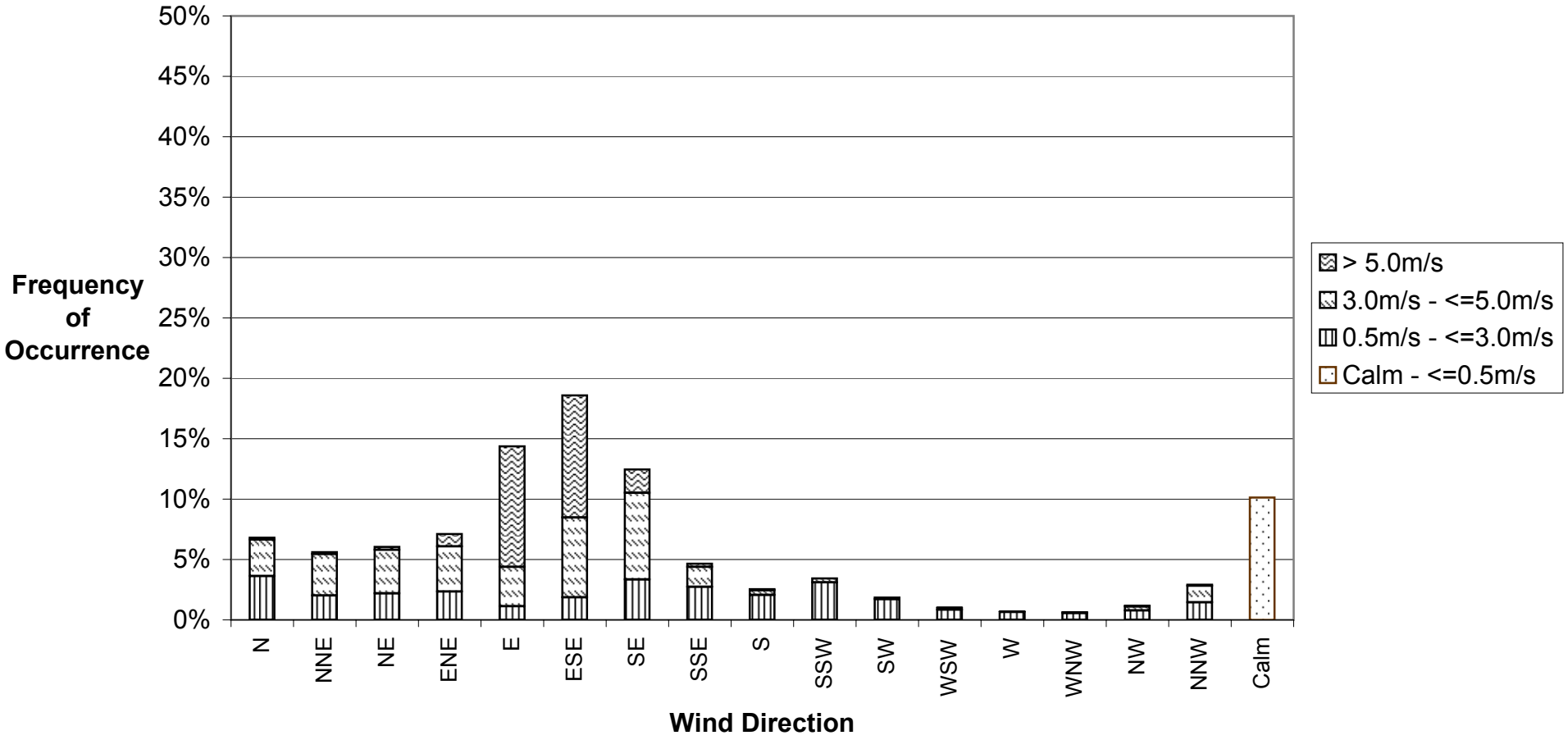
Percentages in pink refer to occurrences of between 20% and 30%.

Percentages in red refer to occurrences of 30% or more.

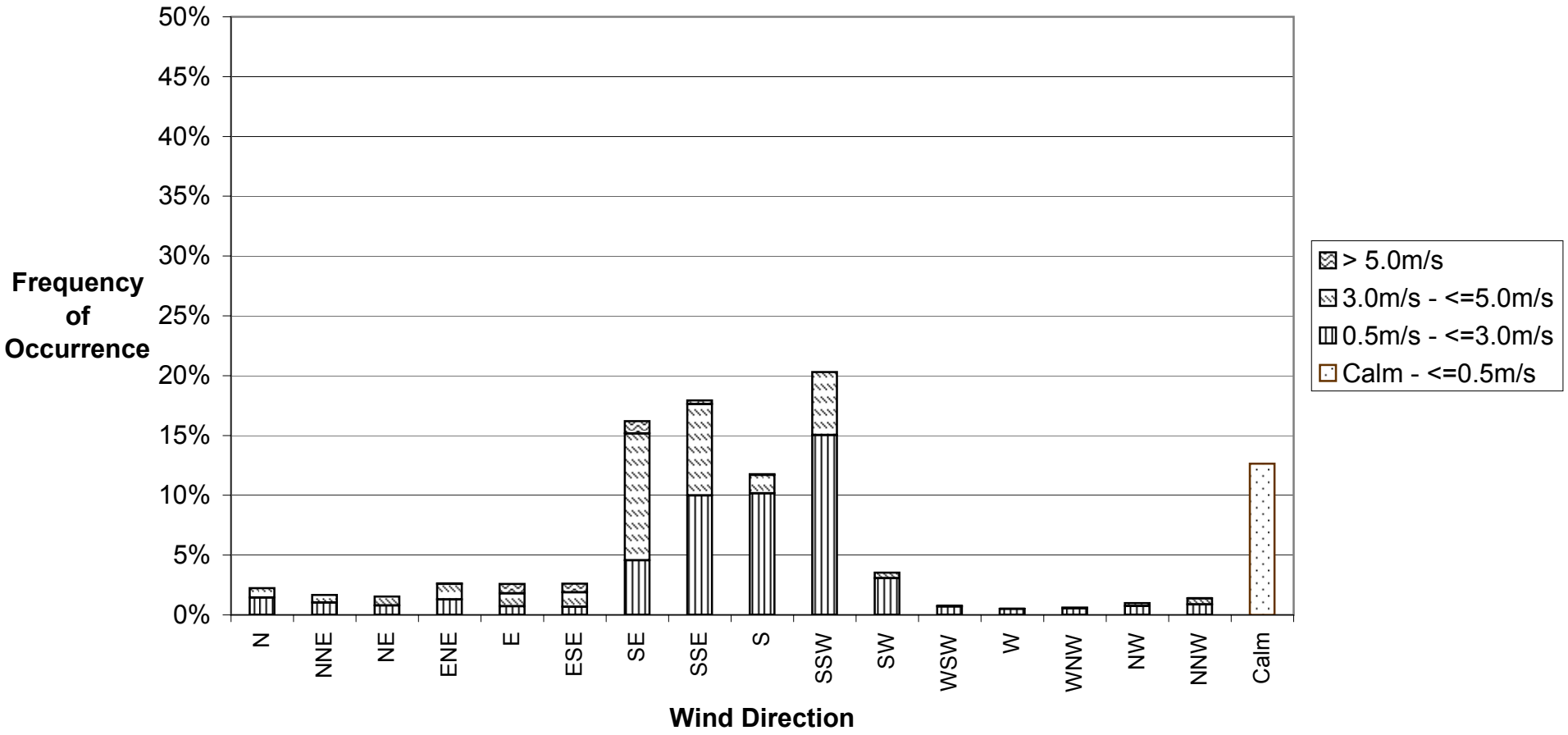
Annual Day Wind Data
Gladstone Airport
2007



Annual Evening Wind Data
Gladstone Airport
2007



Annual Night Wind Data
Gladstone Airport
2007



Meteorological Data – Gladstone Airport 2008

Time	Period	Wind Direction	Calm - ≤ 0.5 m/s	0.5 m/s - ≤ 2.0 m/s	2 m/s - ≤ 3.0 m/s	Calm - ≤ 3.0 m/s	3 m/s - ≤ 5.0 m/s	> 5.0 m/s
Day	Annual	ENE	0.0%	0.7%	2.4%	3.1%	17.6%	25.4%
		E	0.0%	0.7%	2.2%	2.8%	16.1%	30.2%
		ESE	0.0%	0.6%	2.1%	2.7%	13.4%	28.8%
		SE	0.0%	0.8%	2.6%	3.3%	12.0%	22.1%
	Summer	NE	0.0%	0.5%	1.9%	2.4%	14.5%	21.5%
		ENE	0.0%	0.4%	1.6%	2.0%	14.4%	31.0%
		E	0.0%	0.4%	1.7%	2.0%	14.2%	36.2%
		ESE	0.0%	0.4%	2.1%	2.5%	14.0%	34.3%
		SE	0.0%	0.5%	2.6%	3.2%	13.8%	26.9%
	Autumn	ENE	0.0%	0.2%	1.8%	2.0%	14.4%	24.3%
		E	0.0%	0.2%	1.5%	1.8%	15.0%	36.6%
		ESE	0.0%	0.3%	1.4%	1.7%	14.7%	41.9%
		SE	0.0%	0.4%	2.1%	2.5%	14.3%	35.0%
		SSE	0.0%	0.8%	4.6%	5.4%	14.5%	21.9%
	Winter	-	-	-	-	-	-	-
	Spring	NNE	0.0%	0.5%	1.8%	2.2%	20.3%	21.6%
		NE	0.0%	0.6%	1.6%	2.2%	22.4%	31.3%
		ENE	0.0%	0.7%	1.5%	2.3%	21.7%	38.3%
		E	0.0%	0.8%	1.6%	2.4%	17.2%	35.8%
		ESE	0.0%	0.8%	1.6%	2.4%	10.9%	26.0%
Evening	Annual	-	-	-	-	-	-	-
	Summer	NNE	0.0%	2.5%	9.3%	11.7%	20.6%	2.1%
		NE	0.0%	2.2%	8.2%	10.4%	21.5%	3.6%
		E	0.0%	1.7%	4.9%	6.6%	18.2%	21.7%
		ESE	0.0%	2.1%	4.8%	6.9%	19.6%	25.5%
		SE	0.0%	2.5%	5.0%	7.5%	18.8%	23.7%
	Autumn	ESE	0.0%	6.2%	9.1%	15.3%	26.2%	22.0%
		SE	0.0%	7.1%	10.0%	17.1%	28.1%	22.9%
		SSE	0.0%	8.2%	10.1%	18.3%	23.3%	17.2%
	Winter	ESE	0.0%	9.0%	11.6%	20.6%	13.0%	1.4%
		SE	0.0%	10.3%	13.3%	23.7%	13.6%	1.9%
		SSE	0.0%	12.6%	14.1%	26.7%	11.2%	1.6%
		S	0.0%	13.9%	13.7%	27.6%	6.3%	1.2%
		SSW	0.0%	12.4%	11.6%	24.0%	3.3%	0.6%
	Spring	NE	0.0%	4.9%	13.0%	17.9%	21.4%	3.7%
		ENE	0.0%	4.4%	11.2%	15.6%	20.3%	9.6%
		E	0.0%	4.5%	9.5%	14.0%	21.7%	15.2%
		ESE	0.0%	4.2%	6.9%	11.1%	20.3%	16.9%
Night	Annual	SSE	0.0%	10.1%	19.2%	29.2%	19.6%	3.1%
		S	0.0%	14.1%	28.4%	42.5%	21.9%	2.0%

Meteorological Data - Gladstone and Gladstone Airport

Time	Period	Wind Direction	Calm - ≤ 0.5 m/s	0.5 m/s - ≤ 2.0 m/s	2 m/s - ≤ 3.0 m/s	Calm - ≤ 3.0 m/s	3 m/s - ≤ 5.0 m/s	> 5.0 m/s
		SSW	0.0%	14.5%	28.5%	42.9%	16.1%	0.7%
		SW	0.0%	12.1%	23.3%	35.4%	10.2%	0.1%
		WSW	0.0%	7.2%	13.8%	21.0%	6.5%	0.1%
	Summer	SE	0.0%	4.4%	10.0%	14.5%	24.2%	8.6%
		SSE	0.0%	8.2%	15.8%	24.0%	24.0%	5.8%
		S	0.0%	11.5%	20.0%	31.5%	19.9%	2.5%
		SSW	0.0%	11.7%	18.2%	30.0%	9.3%	0.7%
		SW	0.0%	9.7%	13.2%	22.9%	2.0%	0.0%
	Autumn	SE	0.0%	3.2%	10.7%	13.9%	22.7%	3.7%
		SSE	0.0%	7.4%	25.6%	33.0%	28.8%	3.7%
		S	0.0%	10.9%	38.5%	49.4%	33.7%	3.3%
		SSW	0.0%	11.2%	38.7%	49.8%	24.2%	1.5%
		SW	0.0%	9.4%	31.1%	40.5%	13.7%	0.1%
		WSW	0.0%	5.3%	16.2%	21.4%	7.7%	0.0%
	Winter	**SSE**	0.0%	12.5%	17.7%	30.2%	11.5%	1.4%
		S	0.0%	18.3%	31.8%	50.1%	20.3%	1.2%
		SSW	0.0%	19.1%	35.1%	54.2%	22.2%	0.5%
		SW	0.0%	16.0%	31.9%	47.8%	20.3%	0.2%
		WSW	0.0%	9.3%	20.5%	29.7%	14.4%	0.1%
	Spring	SSE	0.0%	12.1%	17.5%	29.6%	14.1%	1.7%
		S	0.0%	15.8%	23.2%	39.0%	13.4%	0.9%
		SSW	0.0%	15.9%	21.7%	37.5%	8.3%	0.2%
		SW	0.0%	13.3%	17.0%	30.2%	4.6%	0.1%

Note: Table only shows those wind directions which have an occurrence of 20% or more for at least one (1) wind speed category. Percentages shown take into consideration the occurrences of adjacent wind directions to account for variations in wind directions for a given speed.

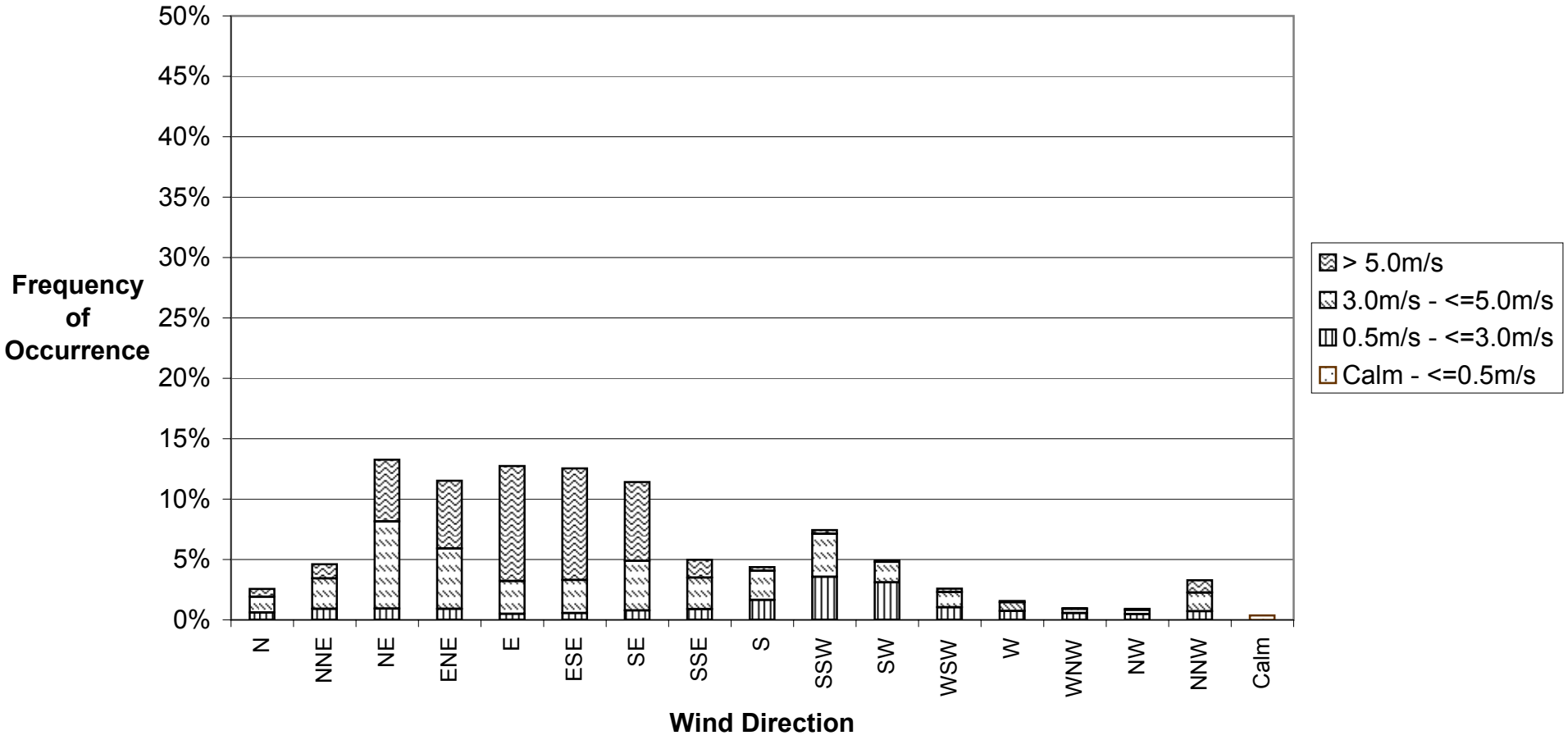
Highlighted cells denote wind directions which occur for 30% of the time or more for wind speeds of 3 m/s or less.

Percentages in pink refer to occurrences of between 20% and 30%.

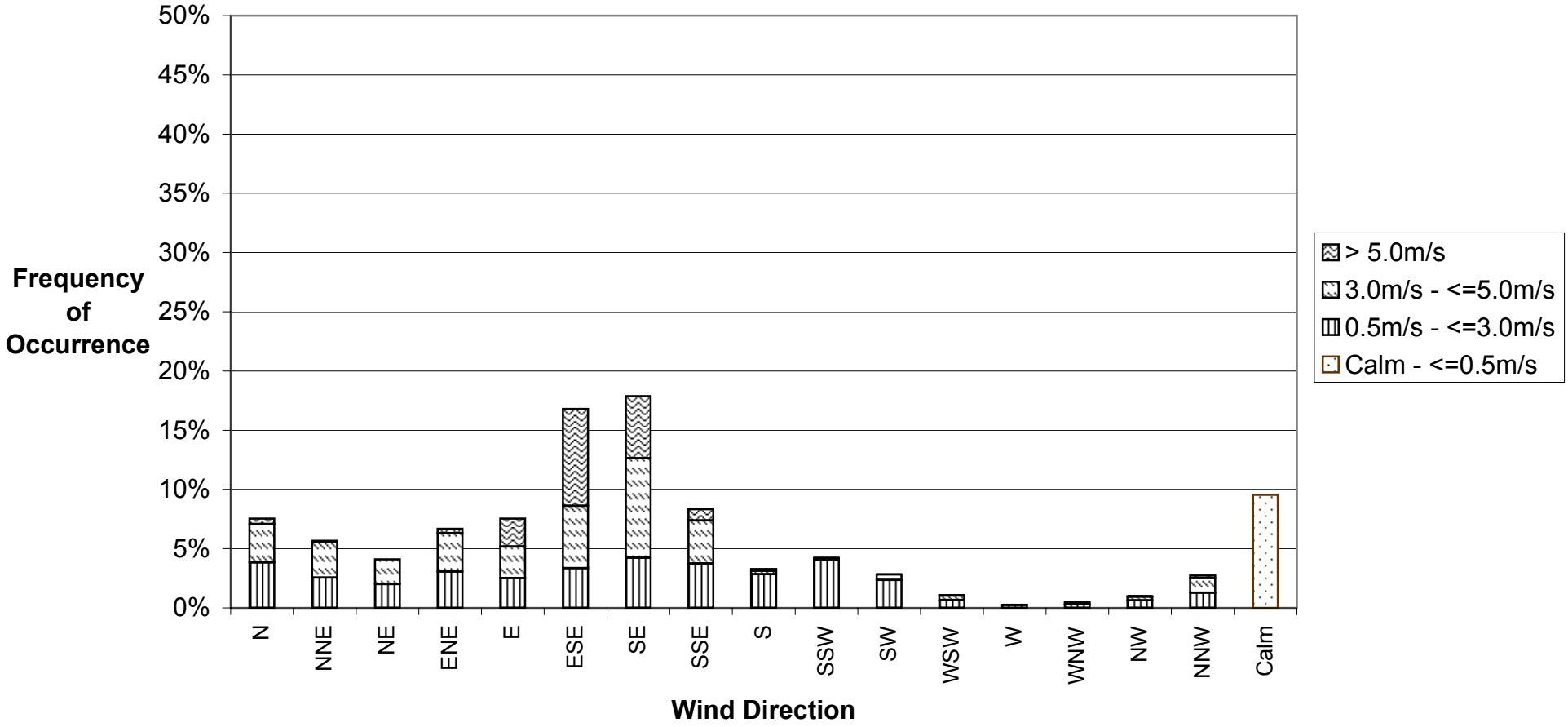
Percentages in red refer to occurrences of 30% or more.

'-' denotes that there is no wind direction with an occurrence of greater than 20% for any wind speed category.

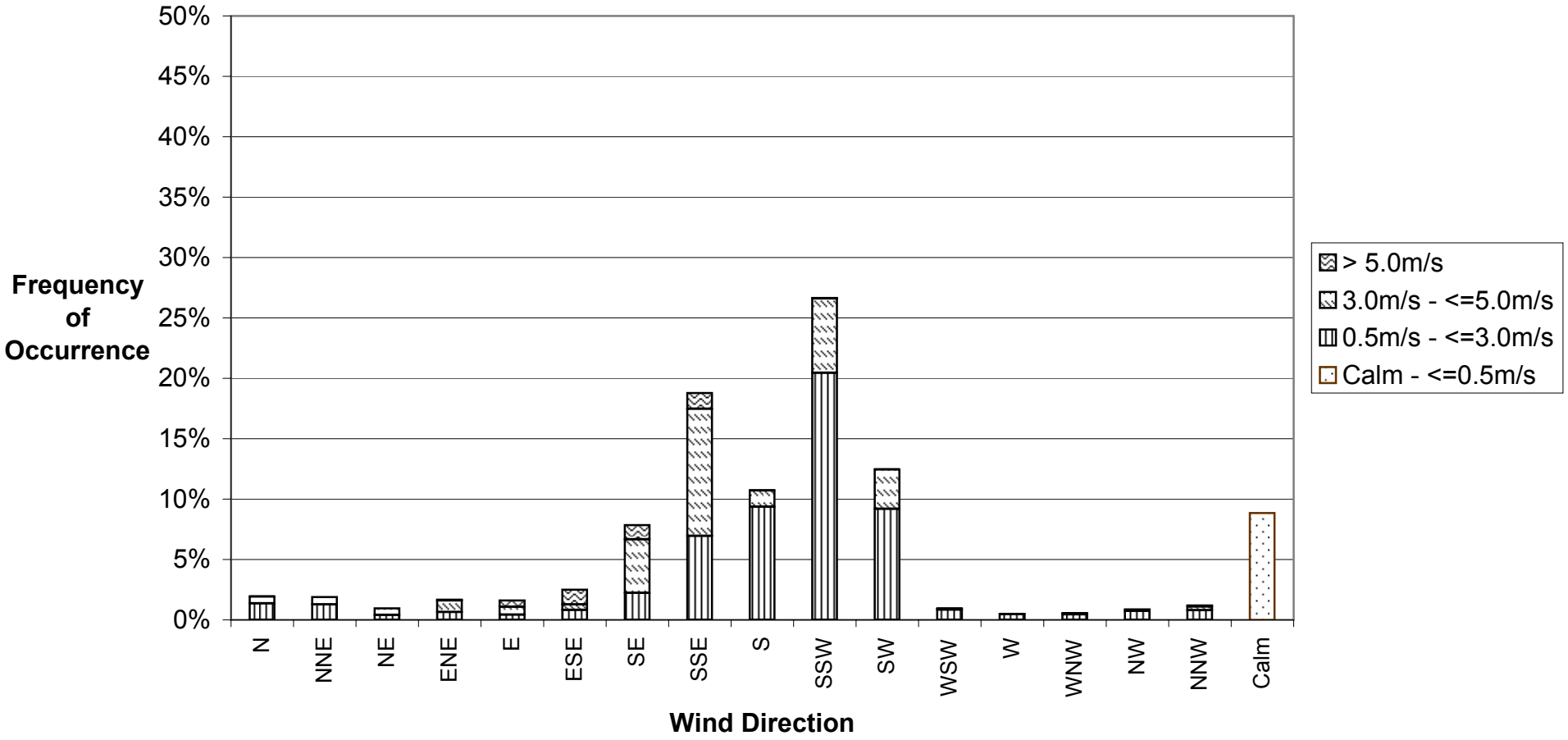
Annual Day Wind Data
Gladstone Airport
2008



Annual Evening Wind Data
Gladstone Airport
2008



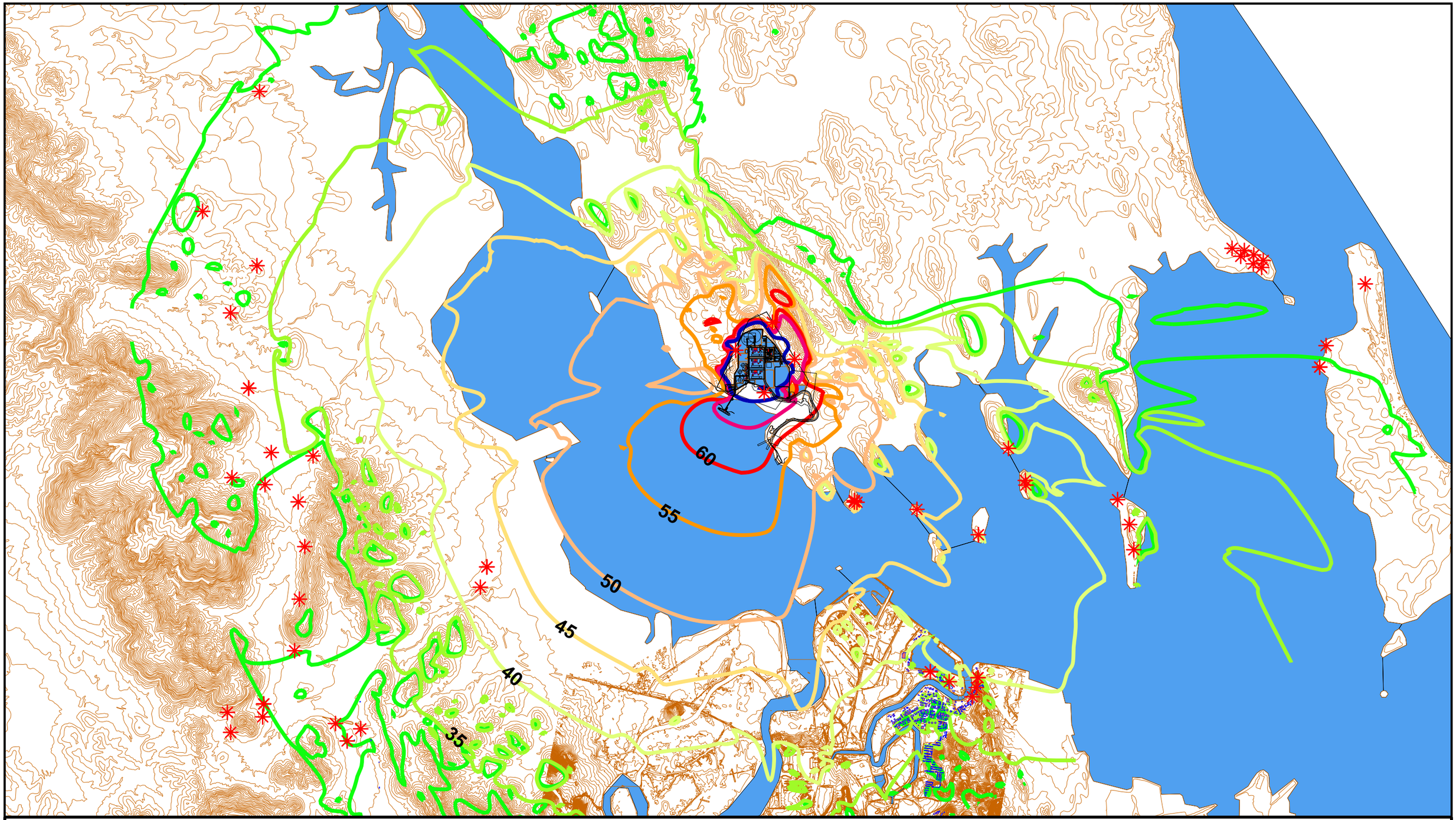
Annual Night Wind Data
Gladstone Airport
2008



Appendix B

Report 20-2014-R7

NOISE CONTOUR MAPS – UPDATED BECHTEL DATA – NEUTRAL WEATHER



LA90 (dBA)

	<= 25
25 <	<= 30
30 <	<= 35
35 <	<= 40
40 <	<= 45
45 <	<= 50
50 <	<= 55
55 <	<= 60
60 <	<= 65
65 <	

Legend

- Building
- Elevation line
- Water
- Point receiver

Note:

Predictions at 1.5m above ground and assumes neutral weather

N

Scale 1:75000

0 0.5 1 2 3 4 km

20-2014-R7
Gladstone GLNG
(LA90) Noise Contours

	Name	Date
Prepared	HM	19/10/09
Checked	MC	19/10/09
Authorised	MC	19/10/09

Appendix B
Map 1

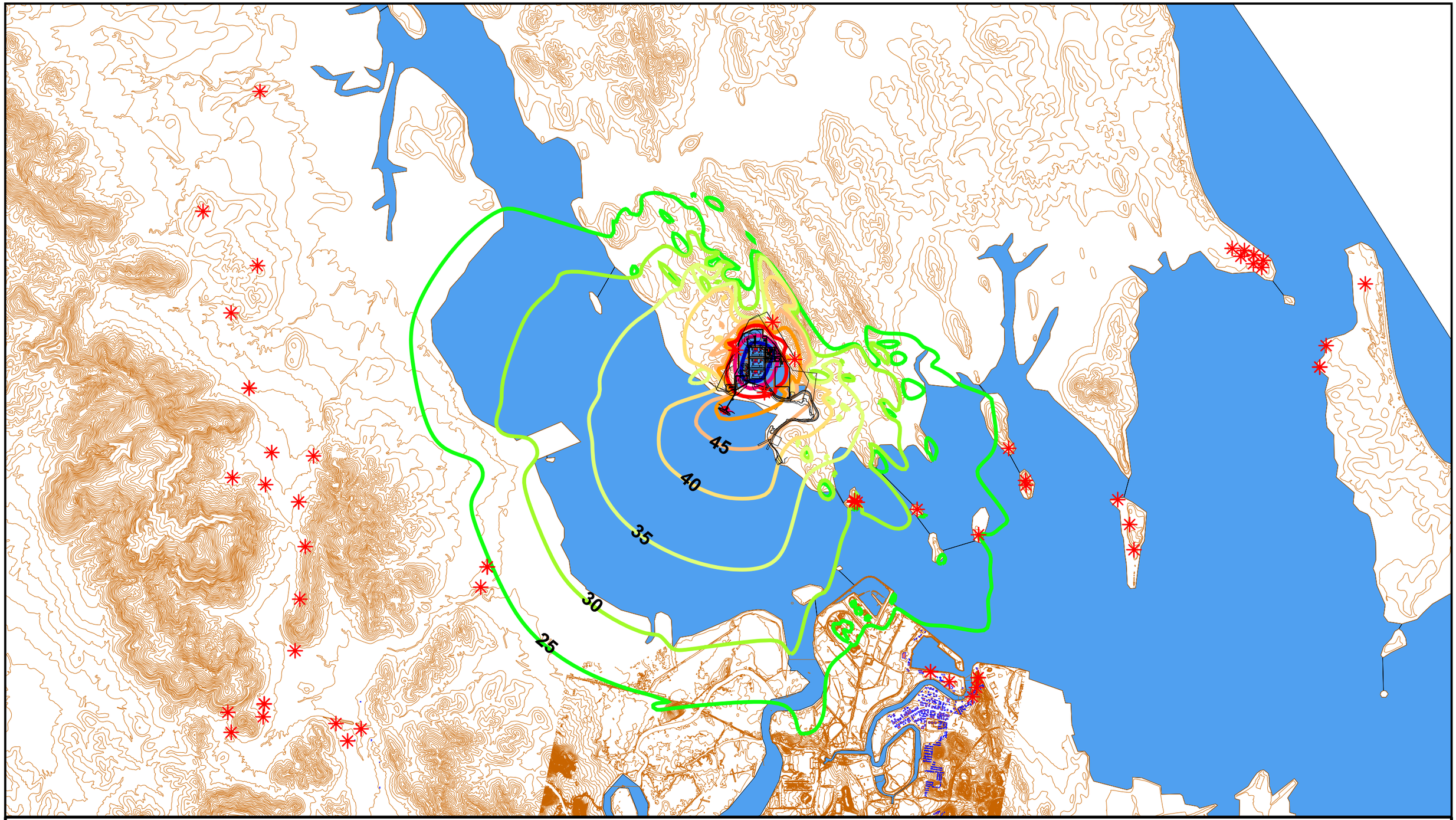
Predicted Noise Contours (LA90)
OCP LNG Facility 3 Trains

HEGGIES

Appendix C

Report 20-2014-R7

NOISE CONTOUR MAPS – NOISE REDUCTION SCENARIOS – NEUTRAL WEATHER



LA90 (dBA)

	<= 25
25 <	<= 30
30 <	<= 35
35 <	<= 40
40 <	<= 45
45 <	<= 50
50 <	<= 55
55 <	<= 60
60 <	<= 65
65 <	

Legend

- Building
- Elevation line
- Water
- Point receiver

Note:

Predictions at 1.5m above ground and assumes neutral weather

N

Scale 1:75000

0 0.5 1 2 3 4 km

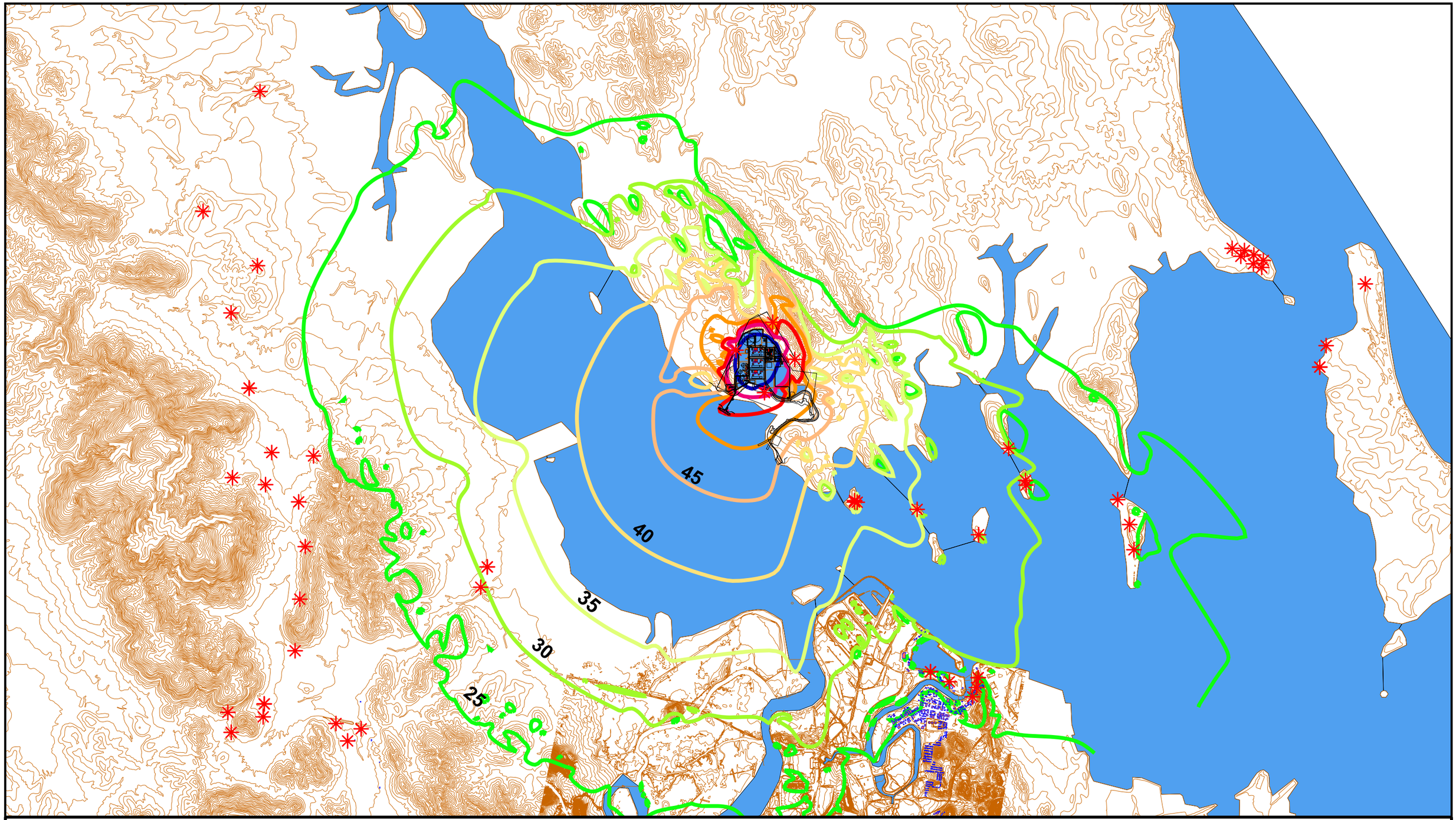
20-2014-R7
Gladstone GLNG
(LA90) Noise Contours

	Name	Date
Prepared	HM	19/10/09
Checked	MC	19/10/09
Authorised	MC	19/10/09

Appendix C
Map 1

Predicted Noise Contours (LA90)
OCP LNG Facility 3 Trains
Noise Reduction Scenario 1

HEGGIES



LA90 (dBA)

	<= 25
25 <	<= 30
30 <	<= 35
35 <	<= 40
40 <	<= 45
45 <	<= 50
50 <	<= 55
55 <	<= 60
60 <	<= 65
65 <	

Legend

- Building
- Elevation line
- Water
- Point receiver

Note:

Predictions at 1.5m above ground and assumes neutral weather

N

Scale 1:75000

0 0.5 1 2 3 4 km

20-2014-R7
Gladstone GLNG
(LA90) Noise Contours

	Name	Date
Prepared	HM	28/10/09
Checked	MC	28/10/09
Authorised	MC	28/10/09

Appendix C
Map 2
Predicted Noise Contours (LA90)
OCP LNG Facility 3 Trains
Noise Reduction Scenario 2
(Bechtel Mitigated)

HEGGIES