APPENDIX 9

Sapphire Wind Farm Noise Impact Assessment

SLR Consulting Australia Pty Ltd

global environmental solutions

Sapphire Wind Farm

Noise Impact Assessment

Report Number 40-1822-R1

26 August 2011

Wind Prospect CWP Pty Ltd
45 Hunter Street
NEWCASTLE NSW 2300

Version: Revision 3

Sapphire Wind Farm

Noise Impact Assessment

PREPARED BY:

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Suite 6, 131 Bulleen Road Balwyn North VIC 3104 Australia

T: 61 3 9249 9400 F: 61 3 9249 9499
E: melbourne@slrconsulting.com www.slrconsulting.com

DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
40-1822-R1	Revision 3	26 August 2011	Philip Setton	JA	JA
40-1822-R1	Revision 2	24 May 2011	Gustaf Reutersward	JA	GR
40-1822-R1	Revision 1	18 May 2011	Gustaf Reutersward	JA	GR
40-1822-R1	Revision 0	19 April 2011	Gustaf Reutersward	JA	GR

EXECUTIVE SUMMARY

SLR Consulting Australia Pty Ltd (SLR Consulting) has completed a noise impact assessment of the Sapphire Wind Farm. The methodology and criteria used in the assessment are supported by the South Australian Environmental Protection Authority (SA EPA) *Environment Noise Guidelines for Wind Farms (February 2003)*, World Health Organization (WHO) limits, construction noise guidelines (DECCW Interim Construction Noise Guideline 2009) and blasting impact.

Noise monitoring was conducted in the period 7th July 2009 through to 23rd July 2009 at eleven nearby locations to determine baseline conditions and establish indicative criteria for surrounding residential receivers.

Noise predictions were made for receptors within a 6 km of a proposed WTG. WTG noise for four indicative WTG models and 2 layouts has been predicted and assessed against relevant criteria prescribed by the SA EPA Guideline and World Health Organisation (WHO) goals where appropriate. An evaluation of night-time baseline data was also included.

The 159 WTG layout equipped with Gamesa G87 WTGs at a hub height of 100 metres, was predicted to comply with all relevant noise criteria, SA EPA Guideline and WHO limits, at all respective receivers.

The 159 WTG layout equipped with Vestas V90 WTGs at a hub height of 100 metres, was predicted to generally comply with all relevant noise criteria, SA EPA Guideline and WHO limits, at all respective receivers except for 1 marginal (<0.5 dBA) exceedance.

The 125 WTG layout equipped with Vestas V112 WTGs at a hub height of 100 metres, was predicted to generally comply with all relevant noise criteria, SA EPA Guideline and WHO limits, at all respective receivers except for 1 marginal (<1 dBA) exceedance.

The 125 WTG layout equipped with Siemens SWT 101 WTGs at a hub height of 101 metres, was predicted to generally comply with all relevant noise criteria, SA EPA Guideline and WHO limits, at all respective receivers except for 1 marginal (<1 dBA) exceedance and one medium (<3 dBA) exceedance.

All project involved receivers were below the WHO criteria.

The project is yet to select and finalise the WTG make and model. Upon finalising the WTG model a revised noise prediction and assessment will be completed in which the noise impact mitigation techniques listed in **Section 7.9** will be investigated thoroughly to produce a fully compliant layout.

WTG vibration levels have been evaluated and based upon overseas research available were found to be acceptable.

Construction noise and vibration impacts have been assessed and the 'worst case' scenarios modelled were found to be generally acceptable.

Blasting impact has been assessed and found to be acceptable. With a maximum instantaneous charge (MIC) of up to 90 kg, the airblast overpressure is anticipated to be below the acceptable level of 115 dB Linear for all existing residences. Similarly, vibration levels are anticipated to be well below the acceptable criteria.

Construction traffic noise impact has been assessed and the 'worst case' maximum construction traffic generated scenario would increase existing traffic noise levels along local roads by up to 4-7 dBA but due to the typically large setback of dwellings from the road network would result in noise level that would be considered acceptable under the ECRTN.

TABLE OF CONTENTS

1 INTRODUCTION 9

1.1 Objectives 9

1.2 Wind Farm Assessment Methodology 9
1.2.1 Acceptability Limit Criteria 9
1.2.2 Wind Farm Noise Level Prediction 9
1.2.3 Ambient Noise Monitoring 10
1.2.4 Assessment Procedure 10

2 ENVIRONMENTAL NOISE CRITERIA 11

2.1 Introduction 11

2.2 Applicable Noise Policies and Guidelines 11

2.3 SA EPA Wind Farm Noise Guidelines 12

2.4 NSW Industrial Noise Policy (INP) 13

2.5 World Health Organisation 13

2.6 Construction Noise Guidelines 14

2.7 Vibration Guidelines 16
2.7.1 Building Damage 17

2.8 Blasting Criteria 17

2.9 Traffic Noise 17

3 GENERAL SITE DESCRIPTION 19

3.1 Characteristics of the site 20

3.2 Dwelling Locations 21

4 PROPOSED WIND FARM LAYOUT 25

4.1 WTG Type and Details 27

5 OPERATIONAL NOISE LEVELS 28

5.1 Introduction 28

5.2 Wind Turbine Noise 28

5.3 Substation Transformer Noise Levels 36

6 BACKGROUND LEVELS AND NOISE LIMITS 39

TABLE OF CONTENTS

6.1 Measurement Locations 39
6.2 Measurement Details 42
6.3 Night Period Analysis 43
6.4 Rating Background Levels 43
6.5 Falkland 45
6.6 Springfield 46
6.7 Ardleigh 47
6.8 Down Field 48
6.9 Kingshill 49
6.10 Carinya 50
6.11 Tralee 51
6.12 Yarrawah Park 52
6.13 Mindora 53
6.14 Mt Buckley 54
6.15 Warrandah 55
7 ACOUSTIC ASSESSMENT OF PROPOSED WIND FARM BASE LAYOUT 56
7.1 Predicted Noise Levels – 159 WTG Layout, Gamesa G87 56
7.2 Predicted Noise Levels – 159 WTG Layout, Vestas V90 56
7.3 Predicted Noise Levels – 125 WTG Layout, Vestas V112 56
7.4 Predicted Noise Levels – 125 WTG Layout, Siemens SWT 101 57
7.5 Assessment of Tonality and Infrasound 57
7.6 Project involved residences 58
7.7 Temperature Inversions 58
7.8 Atmospheric stability and wind profile 59
7.9 Adaptive Management 59
7.10 Wind Turbine Vibration 60
7.10.1 Ground borne 60
7.10.2 Air borne 60

TABLE OF CONTENTS

8 ASSESSMENT OF CONSTRUCTION NOISE & VIBRATION LEVELS 62

8.1 Construction Noise 62
8.1.1 Concrete Batching Plants 66

8.2 Construction Vibration Assessment 67

8.3 Blasting 67
8.3.1 Blasting Assessment 67

8.4 Traffic Noise 68
8.4.1 Night-time deliveries 69

9 CONCLUSION 70

10 CLOSURE 71

TABLES

Table 1 WHO Guideline values for environmental noise in specific environments 14
Table 2 Noise at Residences Using Quantitative Assessment 15
Table 3 Preferred and maximum values for continuous and impulsive vibration 16
Table 4 Blast Emission Building Damage Assessment Criteria (AS 2187) 17
Table 5 Road Traffic Noise Criteria 18
Table 6 Surrounding Receivers 22
Table 7 Sapphire Proposed 159 WTG Layout (Vestas V90 or Gamesa G87) 25
Table 8 Sapphire Proposed 125 WTG Layout (Siemens SWT 2.3-101 or Vestas V112) 26
Table 9 WTG Manufacturers Data 27
Table 10 WTG LAeq noise level (dBA) at $V_{ref,10m}$ = 8 m/s, V_{100m} = 11.5m/s 29
Table 11 Substation site options 36
Table 12 Predicted 'worst case' 330 kV switching substation noise 37
Table 13 Measurement Locations 40
Table 14 Measurement Details for each Location 42
Table 15 RBL for each Period at each Location (dBA) 43
Table 16 Audible tonality assessment to IEC 61400-11 57
Table 17 Predicted Construction Noise Levels (dBA) 63
Table 18 Typical Vibration Emission Levels from Construction Plant 67
Table 19 Construction Traffic Noise 68

TABLE OF CONTENTS

FIGURES

Figure 1	Location of proposed Sapphire Wind Farm	19
Figure 2	Dwelling Locations and WTG layouts	21
Figure 3	159 WTG Layout Gamesa G87 2.0 MW , LAeq Noise Contour Map	32
Figure 4	159 WTGs Vestas V90 2.0 MW, LAeq Noise Contour Map	33
Figure 5	125 WTGs Vestas V112 3.0 MW, LAeq Noise Contour Map	34
Figure 6	125 WTGs Siemens SWT 101 2.3 MW, LAeq Noise Contour Map	35
Figure 7	Alternative locations for 330 kV substations	36
Figure 8	Alternative locations for 132 kV substations	37
Figure 9	Falkland Measurement Location	45
Figure 10	Background Noise Measurements and Noise Criteria Curve - Falkland	45
Figure 11	Springfield Measurement Location	46
Figure 12	Background Noise Measurements and Noise Criteria Curve – Springfield	46
Figure 13	Ardleigh Measurement Location	47
Figure 14	Background Noise Measurements and Noise Criteria Curve – Ardleigh	47
Figure 15	Measurement location Down Field	48
Figure 16	Background Noise Measurements and Noise Criteria Curve – Down Field	48
Figure 17	Kingshill Measurement Location	49
Figure 18	Background Noise Measurements and Noise Criteria Curve – Kingshill	49
Figure 19	Carinya Measurement Location	50
Figure 20	Background Noise Measurements and Noise Criteria Curve – Carinya	50
Figure 21	Tralee Measurement Location	51
Figure 22	Background Noise Measurements and Noise Criteria Curve - Tralee	51
Figure 23	Yarrawah Park Measurement Location	52
Figure 24	Background Noise Measurements and Noise Criteria Curve – Yarrawah Park	52
Figure 25	Mindora Measurement Location	53
Figure 26	Background Noise Measurements and Noise Criteria Curve – Mindora	53
Figure 27	Mt Buckley Measurement Location	54
Figure 28	Background Noise Measurements and Noise Criteria Curve – Mt Buckley	54
Figure 29	Warrandah Measurement Location	55
Figure 30	Background Noise Measurements and Noise Criteria Curve – Warrandah	55

TABLE OF CONTENTS

APPENDICES

Appendix A WTG Noise Assessment Curves
A1 -– 125 WTG Base Layout, Gamesa G87 (2.0 MW)
A2 -– 125 WTG Base Layout, Vestas V90 (2.0 MW)
A3 -– 159 WTG Base Layout, Vestas V112 (3.0 MW)
A4 -– 159 WTG Base Layout, Siemens SWT-2.3-101 (2.0 MW)

Appendix B Manufacturer provided Sound Power Level Documentation – IEC 61400-11
B1 - Gamesa G87 (2.0 MW)
B2 - Vestas V90 (2.0 MW)
B3 - Vestas V112 (3.0 MW)
B4 - Siemens SWT-2.3-101 (2.0 MW)

Appendix C Noise monitoring data
175-Falkland *
199-Springfield
43- Ardleigh *
194 Down Field *
11-Kingshill *
54-Carinya *
71-Tralee *
227 Yarrawah Park *
23-Mindora
153-Mt Buckley
32-Warrandah *

Appendix D Acoustic terminology

Appendix E Horizontal distance from receptor to WTG

1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR Consulting), formerly Heggies Pty Ltd, have been engaged by Wind Prospect CWP Pty Ltd as the acoustical consultants for the proposed Sapphire Wind Farm located approximately 28 km east of Inverell approximately 18km west of Glen Innes in NSW.

1.1 Objectives

This report describes the methodology and findings of the Noise Impact Study (NIS) for the Sapphire Wind Farm forming part of the Environmental Impact Assessment for the proposed project.

This report details the main aspects of the proposed wind farm project, the acoustic criteria, the background noise measurements and the predicted noise levels at all potentially impacted receivers from the operation of the proposed wind farm.

It also addresses the acoustic impact of the wind farm during the construction phase, including blasting and transportation noise.

1.2 Wind Farm Assessment Methodology

1.2.1 Acceptability Limit Criteria

The methodology and acceptability limit criteria that have been applied to this study are based upon the *South Australia Environment Protection Authority (SA EPA) Noise Guidelines for Wind Farms (February 2003)* (SA EPA Guidelines). The principal acceptability limit criteria is that the wind farm $L_{A90(10\ min)}$ noise should not exceed the greater of an amenity limit of 35 dBA or the pre-existing background noise by more than 5 dBA (for any given wind speed).

The project requirements and wind farm acceptability limit criteria are discussed in more detail in **Section 6**.

1.2.2 Wind Farm Noise Level Prediction

The noise emission model used in this study to predict wind farm noise levels at sensitive receptors is based on ISO 9613 as implemented in the SoundPLAN computer noise model. The model predicts noise levels through spherical spreading and includes the effect of air absorption (as per ISO 9613), ground attenuation and shielding.

Predicted L_{Aeq} noise levels were calculated based upon sound power levels determined in accordance to the recognised standard IEC-61400-11 *(Wind Turbine Generator Systems - Part 11: Acoustic Noise Measurement Techniques)*, where available, for the wind range 6 to 10 m/s.

The noise character of Wind Turbine Generator (WTG) noise emissions is also assessed for any special audible characteristics, such as tonality or low frequency content, which would be deemed more annoying or offensive. If characteristics such as tonality are identified then the predicted noise level would be penalised by the addition of 5 dBA. It should be noted that the characteristic noise level modulation of WTGs, commonly referred to as ‘swish’, is considered to be a fundamental part of wind farm noise and is taken into account by the SA EPA Guideline assessment procedure.

1.2.3 Ambient Noise Monitoring

In order to establish the intrusive noise limit, background noise monitoring is required to establish the pre-existing ambient noise environment as a function of wind speed. As wind speed increases the ambient noise level at most receivers generally also increases as natural sources such as wind in trees etc begin to dominate. The variation of background noise with wind speed is usually quite site specific and related to various physical characteristics such as topographic shielding and the extent and height of exposed vegetation.

Noise monitoring is completed for a period of approximately 2 weeks and correlated to synchronous wind speed and direction data at the wind farm monitoring mast. The captured data is screened for validity, with data monitored during periods of rain or where the average wind speed at the microphone position likely exceeded 5 m/s being discarded from the data set. Other data that was obviously affected by external noise sources (eg. pond pumps, grass mowing, birds at dawn, frogs etc) was also removed from the data set. A regression analysis of all valid data is used to determine a line of 'best fit' from which the noise limit is established.

1.2.4 Assessment Procedure

In general, the assessment procedure contains the following steps:

- Predict and plot the L_{Aeq} 35 dBA noise level contour from the wind farm under reference conditions. Receivers outside the contour are considered to be within acceptable wind farm noise levels.
- Establish the pre-existing background noise level at each of the relevant assessment receivers within the L_{Aeq} 35 dBA noise level contour through background noise monitoring.
- Predict wind farm noise levels at all relevant assessment receivers for the wind range from cut-in of the WTG to approximately 10 m/s.
- Assess the acceptability of wind farm noise at each relevant assessment receiver to the established limits.

In addition, where the assessment of a receiver has predicted unacceptable resulting wind farm noise levels, a process of noise mitigation and alternative wind farm layouts is considered and Steps 3 and 4 are repeated until an acceptable arrangement is developed.

A brief explanation and description of the acoustic terminology used in this report is included in **Appendix D**

2 ENVIRONMENTAL NOISE CRITERIA

2.1 Introduction

The New South Wales (NSW) Government Department of Planning (DOP) has issued information on the required inputs into the Environmental Assessment (EA). The environmental assessment requirements (**DGRs**) issued by the Director-General in relation to noise impacts:

- → *include a comprehensive noise assessment of all phases and components of the project including, but not limited to, turbine operation, the operation of the electrical substation, construction, and traffic noise. The assessment must identify noise sensitive locations (including approved but not yet developed dwellings), baseline conditions based on monitoring results, the levels and character of noise (e.g. tonality, impulsiveness etc) generated by noise sources, noise criteria, modelling assumptions and worst case and representative noise impacts;*
- → *in relation to wind turbine operation, determine the noise impacts under operating meteorological conditions (i.e. wind speeds from cut in to rated power), including impacts under meteorological conditions that exacerbate impacts (including varying atmospheric stability classes. The probability of such occurrences must be quantified;*
- → *include monitoring to ensure that there is adequate wind speed/profile data and ambient background noise data that is representative for all sensitive receptors;*
- → *provide justification for the nominated average background noise level used in the assessment process, considering any significant difference between daytime and night time background noise levels;*
- → *include an assessment of vibration impacts associated with the project;*
- → *in relation to overhead transmission lines, assess the risk of corona noise at nearest receivers;*
- → *if any noise agreements with residents are proposed for areas where noise criteria cannot be met, provide sufficient information to enable a clear understanding of what has been agreed and what criteria have been used to frame any such agreements;*
- → *clearly outline the noise mitigation, monitoring and management measures that would be applied to the project. This must include an assessment of the feasibility, effectiveness and reliability of proposed measures and any residual impacts after these measures have been incorporated; and*
- → *include a contingency strategy that provides for additional noise attenuation should higher noise levels than those predicted result following commissioning and/or noise agreements with landowners not eventuate.*

2.2 Applicable Noise Policies and Guidelines

The assessment must be undertaken consistent with the following guidelines for each aspect of the project.

- → *Wind Turbines - the South Australian Environment Protection Authority's Wind Farms - Environmental Noise Guidelines (2003);*
- → *Electrical Substation – NSW Industrial Noise Policy (EPA 2000)*
- → *Site Establishment and Construction – Interim Construction Noise Guidelines (DECC, 2009);*
- → *Traffic Noise – Environmental Criteria for Road Traffic Noise (NSW EPA, 1999); and*
- → *Vibration – Assessing Vibration: A Technical Guideline (DECC, 2006).*

2.3 SA EPA Wind Farm Noise Guidelines

The South Australia EPA Noise Guidelines for Wind Farms (SA EPA Guidelines) recommends the following noise criteria for new wind farms,

> "*The predicted equivalent noise level ($L_{Aeq,\ 10min}$), adjusted for tonality in accordance with these guidelines, should not exceed:*
>
> - 35 dBA, or
> - the background noise level by more than 5 dBA,
>
> *whichever is the greater, at all relevant receivers for each integer wind speed from cut-in to rated power of the WTG.*"

These guidelines also provide information on measuring the background noise levels, locations and requirements on the number of valid data points to be obtained and the methodology for excluding invalid data points. It also outlines the process for determining lines of best fit for the background data, and determination of the noise limit.

The Guideline explicitly states that the "swish" or modulation noise from wind turbines is a fundamental characteristic of such turbines; however, it specifies that tonal or annoying characteristics of turbine noise should be penalised.

A 5 dBA penalty should be applied to the measured noise level if an "authorised" officer determines that tonality is an issue and that tonality should be assessed in a way acceptable to the EPA.

The Guideline does not provide an assessment for the potential of low frequency noise or infrasound, but it does state that recent turbine designs do not appear to generate significant levels of infrasound, as the earlier turbine models did.

The guideline accepts that wind farm developers commonly enter into agreements with private landowners in which they are provided compensation. The guideline is intended to be applied to premises that do not have an agreement with the wind farm developers. This does not absolve the obligations of the wind farm developer entirely as appropriate action can be taken under the *Environmental Protection Act* if a development 'unreasonably interferes' with the amenity of an area. The guideline lists that there is unlikely to be unreasonable interference if;

- a formal agreement is documented between the parties
- the agreement clearly outlines to the landowner the expected impact of the noise from the wind farm and its effect on the landowner's amenity
- the likely impact of exposure will not result in adverse health impacts (e.g. the level does not result in sleep disturbance)

The proponent Wind Prospect CWP has discussed the possible noise implications of the various proposed turbine layouts with the involved residents whose property the turbines would be located on. These property owners have been provided copies of the Noise Assessment for their information, and have been advised that SA EPA Guidelines may be exceeded under certain turbine configurations.

These agreements would specify:

(a) That Wind Prospect CWP would ensure that the properties met the World Health Organisation noise guidelines (see **Section 2.5**); and,

(b) Wind Prospect CWP would implement an adaptive management approach which could include the use of building treatments and turbine operation / management strategies if operational noise causes significant impact to the amenity of involved residents.

This noise agreement would only be required under those turbine configurations where the SA EPA Guidelines would be exceeded for that particular property.

2.4 NSW Industrial Noise Policy (INP)

The NSW Industrial Noise Policy (INP) requirements include site selection for background measurements, description of the site, the equipment used, graphing of results and amenity noise criteria during each of the three periods (Day, Evening and Night) as per the Industrial Noise Policy.

The proposed site for the Sapphire Wind Farm is in a rural area and therefore the Amenity Criteria for rural residential receivers, as detailed in Table 2.1 in the NSW INP, is applicable.

The criteria vary as a function of time of day. The Day, Evening and Night Periods are defined as,

Day Period	7:00 am - 6:00 pm 8:00 am - 6:00 pm (Sundays and Public Holidays)
Evening Period	6:00 pm - 10:00 pm
Night Period	10:00 pm - 7:00 am 10:00 pm - 8:00 am (Sundays and Public Holidays)

The Amenity Criteria (L_{Aeq} level) for the residential noise sensitive locations for the Sapphire wind farm project are,

Day Period	50 dBA
Evening Period	45 dBA
Night Period	40 dBA

The Intrusiveness Criterion in the INP is based on the rating background level (RBL), where the Criterion is,

$$L_{Aeq,\ 15\ min} \leq \text{RBL} + 5\ \text{dBA}$$

This is almost identical to the SA EPA Guidelines (**Section 2.3**), the difference being the measurement interval (15 and 10 minute) and the determination of the background noise level (rating level, based on the 10^{th} percentile of measured background levels, or using a line of best fit through the data points).

The INP states where the measured RBL is less than 30 dBA, then the RBL is considered to be 30 dBA.

In summary it is evident that the non project related residential receivers assessed under the *SA EPA Wind Farm Guideline* will generally comply to INP amenity criteria. Furthermore, intrusiveness is covered by the *SA EPA Wind Farm Guideline.*

2.5 World Health Organisation

As discussed in **Section 2.3**, the proponent intends to enter into noise agreements with the owners of project-involved residences in accordance with World Health Organisation (WHO) guidelines, as it is necessary to ensure that the project does not result in an 'unreasonable interference' with the amenity of these areas or cause any adverse health affects.

The WHO publication '*Guidelines for Community Noise'* identifies the main health risks associated with noise and derives acceptable environmental noise limits for various activities and environments.

The appropriate guideline limits are listed in **Table 1.**

Table 1 WHO Guideline values for environmental noise in specific environments

Specific Environment	Critical Health Effect(s)	L_{Aeq} (dBA)	Time base (hours)	L_{AMax} (dBA, Fast)
Outdoor living area	Serious Annoyance, daytime & evening	55	16	-
	Moderate annoyance, daytime & evening	50	16	-
Dwelling indoors	Speech Intelligibility & moderate annoyance, daytime & evening	35	16	
Inside bedrooms	Sleep disturbance, night-time	30	8	45
Outside bedrooms	Sleep disturbance – window open, night-time	45	8	60

For the assessment of project involved residences the adopted external criteria of 45 dBA or the level given by the SA EPA Guideline criteria, where higher, will be adopted. Effectively this becomes 45 dBA or background + 5 dBA, whichever is the higher.

2.6 Construction Noise Guidelines

The DECCW issued the "*Interim Construction Noise Guideline"* in July 2009. The main objectives of the guideline are stated in Section 1.3, a portion of which is presented below:

- promote a clear understanding of ways to identify and minimise noise from construction works.
- focus on applying all 'feasible' and 'reasonable' work practices to minimise construction noise impacts.
- encourage construction to be undertaken only during the recommended standard hours unless approval is given for works that cannot be undertaken during these hours.

The guideline sets out Noise Management Levels (NMLs) at residences, and how they are to be applied, as presented in **Table 2**. This approach intends to provide respite for residents exposed to excessive construction noise outside the recommended standard hours whilst allowing construction during the recommended standard hours without undue constraints.

Table 2 Noise at Residences Using Quantitative Assessment

Time of Day	Management Level $L_{Aeq(15minute)}$ [1]	How to Apply
Recommended standard hours: Monday to Friday 7.00 am to 6.00 pm Saturday 8.00 am to 1.00 pm No work on Sundays or public holidays	Noise affected RBL + 10 dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details
	Highly noise affected 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
Outside recommended standard hours	Noise affected RBL + 5 dBA	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.

Note 1: Noise levels apply at the property boundary that is most exposed to construction noise. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence.

2.7 Vibration Guidelines

Impacts from vibration can be considered both in terms of effects on building occupants (human comfort) and the effects on the building structure (building damage). Of these considerations, the human comfort limits are the most stringent. Therefore, for occupied buildings, if compliance with human comfort limits is achieved, it will follow that compliance will be achieved with the building damage objectives.

The DECCW's *Assessing Vibration: A Technical Guideline* provides acceptable values for continuous and impulsive vibration based upon guidelines contained in BS 6472–1992, *Evaluation of human exposure to vibration in buildings (1–80 Hz)*.

Both preferred and maximum vibration limits are defined for various locations and are shown in **Table 3**, with the preferred night-time PPV criteria of 0.2 mm/s being the most relevant to the project.

Table 3 Preferred and maximum values for continuous and impulsive vibration

Location	**Assessment period**[1]	**Preferred values** RMS acceleration m/s^2		**Maximum values** RMS acceleration m/s^2		**Peak Velocity PPV** mm/s	
		z-axis	x- and y-axes	z-axis	x- and y-axes	Preferred	Maximum
Continuous vibration							
Critical areas[2]	Day- or night-time	0.0050	0.0036	0.010	0.0072	0.14	0.28
Residences	Daytime	0.010	0.0071	0.020	0.014	0.28	0.56
	night-time	0.007	0.005	0.014	0.010	0.20	0.40
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028	0.56	1.1
Workshops	Day- or night-time	0.04	0.029	0.080	0.058	1.1	2.2
Impulsive vibration							
Critical areas[2]	Day- or night-time	0.0050	0.0036	0.010	0.0072	0.14	0.28
Residences	Daytime	0.30	0.21	0.60	0.42	8.6	17.0
	night-time	0.010	0.0071	0.020	0.014	2.8	5.6
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92	18.0	36.0
Workshops	Day- or night-time	0.64	0.46	1.28	0.92	18.0	36.0

1 Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am

2 Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specified above. Stipulation of such criteria is outside the scope of this policy, and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472–1992

These limits relate to a long-term (16 hours for daytime), continuous exposure to vibration sources. Where vibration is intermittent, a higher level of vibration is typically acceptable.

2.7.1 Building Damage

In regard to potential building damage, the German Standard DIN4150 recommends a limit of 10 mm/s PPV within any building and the British Standard BS7385: Part 2 - 1993 sets a limit within buildings which depends upon the vibration frequency, but is as low as 7.5 mm/s PPV (at 4.5Hz). For the purposes of ensuring a reasonable factor of safety a conservative limit of approximately 5 mm/s PPV has been applied for this project.

2.8 Blasting Criteria

The ground vibration and airblast levels which cause concern or discomfort to residents are generally lower than the relevant building damage limits.

The DECCW advocates the use of the Australian and New Zealand Environment Conservation Council (ANZECC) guideline *"Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration"* for assessing potential residential disturbance arising from blast emissions. The ANZECC guidelines for control of blasting impact at residences are as follows:

> The recommended maximum level for airblast is 115 dB Linear. The level of 115 dB Linear may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level should not exceed 120 dB Linear at any time.
>
> The recommended maximum for ground vibration is 5 mm/s, Peak Vector Sum (PVS) vibration velocity. It is recommended however, that 2 mm/s (PVS) be considered as the long term regulatory goal for the control of ground vibration. The PVS level of 5 mm/s may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level should not exceed 10 mm/s at any time.
>
> Blasting should generally only be permitted during the hours of 9:00 am to 5:00 pm Monday to Saturday. Blasting should not take place on Sundays and public holidays.

Blasting should generally take place no more than once per day.

The Australian Standard 2187.2-1993 "*Explosives - Storage, Transport and Use. Part 2: Use of Explosives*" does not present human comfort criteria for ground vibration from blasting. It does however make mention of human comfort level for airblast in saying "a limit of 120 dB for human comfort is commonly used". This is consistent with the ANZECC guidelines.

AS 2187.2-1993 nominates building damage assessment criteria as presented in **Table 4**.

Table 4 Blast Emission Building Damage Assessment Criteria (AS 2187)

Building Type	Vibration Level	Airblast Level (dB re 20 µPa)
Sensitive (and Heritage)	PVS 5 mm/s	133 dB(Linear) Peak
Residential	PVS 10 mm/s	133 dB(Linear) Peak
Commercial/Industrial	PVS 25 mm/s	133 dB(Linear) Peak

2.9 Traffic Noise

The NSW *Environmental Criteria for Road Traffic Noise* (ECRTN May 1999) presents guidelines for the assessment of road traffic noise arising from new or redeveloped roads. The document provides road traffic noise guidelines for a range of road or residential developments, as well as guidelines that apply for other nominated sensitive land uses.

> The road traffic guidelines recommended are based on the functional categories of the subject roads, as applied by the Roads Traffic Authority (RTA).

The functional categories are as follows:

- Arterial roads (including freeways) carrying predominantly through-traffic from one region to another, forming principal avenues of communication for urban traffic movements.
- Sub-arterial roads connecting the arterial roads to areas of development and carrying traffic from one part of a region to another. They may also relieve traffic on arterial roads in some circumstances.
- Collector roads connecting the sub-arterial roads to the local road system in developed areas.
- Local roads, which are the subdivisional roads within a particular developed area. These are used solely as local access roads

For this project, traffic associated with the construction stage has the potential to increase noise levels on existing arterial and local roads during the day (no night period construction proposed). As such, the relevant traffic noise criteria, as provided in Table 1 of ECRTN, are provided in **Table 5** below.

Table 5 Road Traffic Noise Criteria

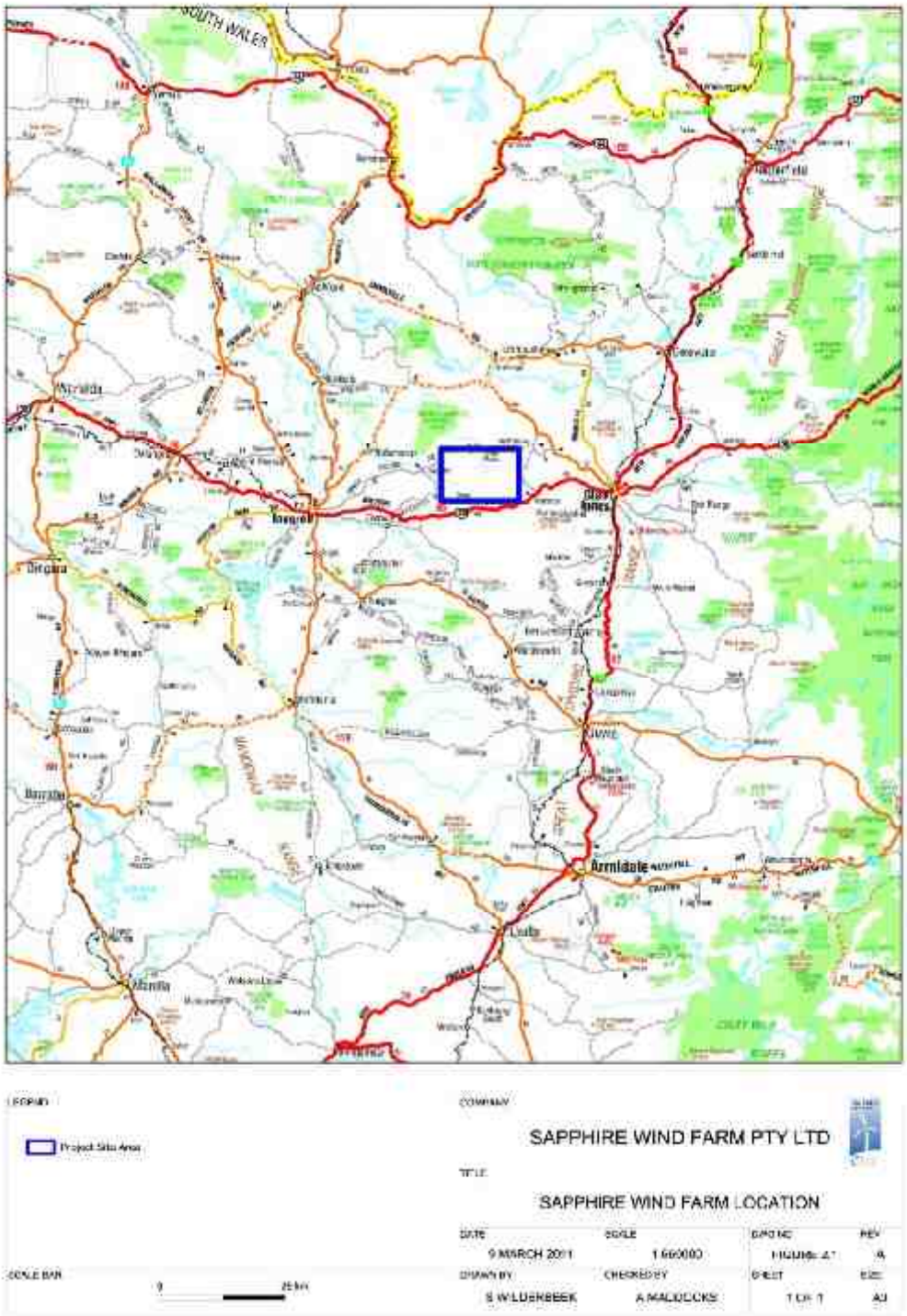
Type of Development	**Criteria**	
	Day 7am - 10pm (dBA)	**Where Criteria are Already Exceeded**
Redevelopment of existing freeway/arterial road	$L_{Aeq(15hour)}$ 60 dBA	In all cases, the redevelopment should be designed so as not to increase existing noise levels by more than 2 dBA.
Redevelopment of existing local roads	$L_{Aeq(1hour)}$ 55 dBA	In all cases, the redevelopment should be designed so as not to increase existing noise levels by more than 2 dBA.

3 GENERAL SITE DESCRIPTION

The Sapphire Wind Farm is located approximately 28 km east of Inverell and approximately 18km west of Glen Innes in the New England Tablelands district of NSW. The proposed wind farm covers approximately 297 hectares, and is in the region called Kings Plains, Wellingrove and Sapphire. It is located to the north of the Gwydir Highway.

The location of the Sapphire Wind Farm is shown in **Figure 1** below.

Figure 1 Location of proposed Sapphire Wind Farm



3.1 Characteristics of the site

The proposed site incorporates up to 22 landowners. Some of these properties include residential dwellings, however, as they form part of the project consortium with agreements, they have not been subject to the formal assessment process. However, an indicative assessment has been carried out to ensure no unreasonable impact and to provide the basis of the agreements between Wind Prospect CWP and the site landowners.

Topographically, the proposed site broadly includes a U-shaped escarpment and ridge which borders an elevated plateau, with turbines being located on land typically 750 m – 1100 m above sea level. A 330 kV transmission line passes immediately to the west of the project site. There is a 132 kV transmission line which passes to the south of site.

The surrounding district is primarily used for agricultural (grazing) purposes with areas of the project site covered in native vegetation.

The Gwydir Highway is sufficiently far away to the south of the project site that background noise levels at most receptor locations will not be affected by road traffic noise. All properties surrounding the proposed site have an ambient background noise environment that is determined by pre-dominantly natural sources which are largely wind influenced.

The prevailing wind is from easterlies and westerlies. The district receives approximately 800 mm – 900 mm of rainfall annually.

3.2 Dwelling Locations

Properties to the south are generally located along or accessed from the Gwydir Highway and properties to the east located along or accessed from Polhill Road and to the north from Kings Plains Road. Properties to the west or centre of the project are located along or accessed from Waterloo Road or the Eastern Feeder Road or the Western Feeder Road.

The assessment locations include all dwellings located within 6 km of a proposed WTG. **Figure 2** shows the current proposed 159 WTG layout and 125 WTG layout and all nearby dwellings and locations where baseline noise monitoring was completed**.**

Figure 2 Dwelling Locations and WTG layouts

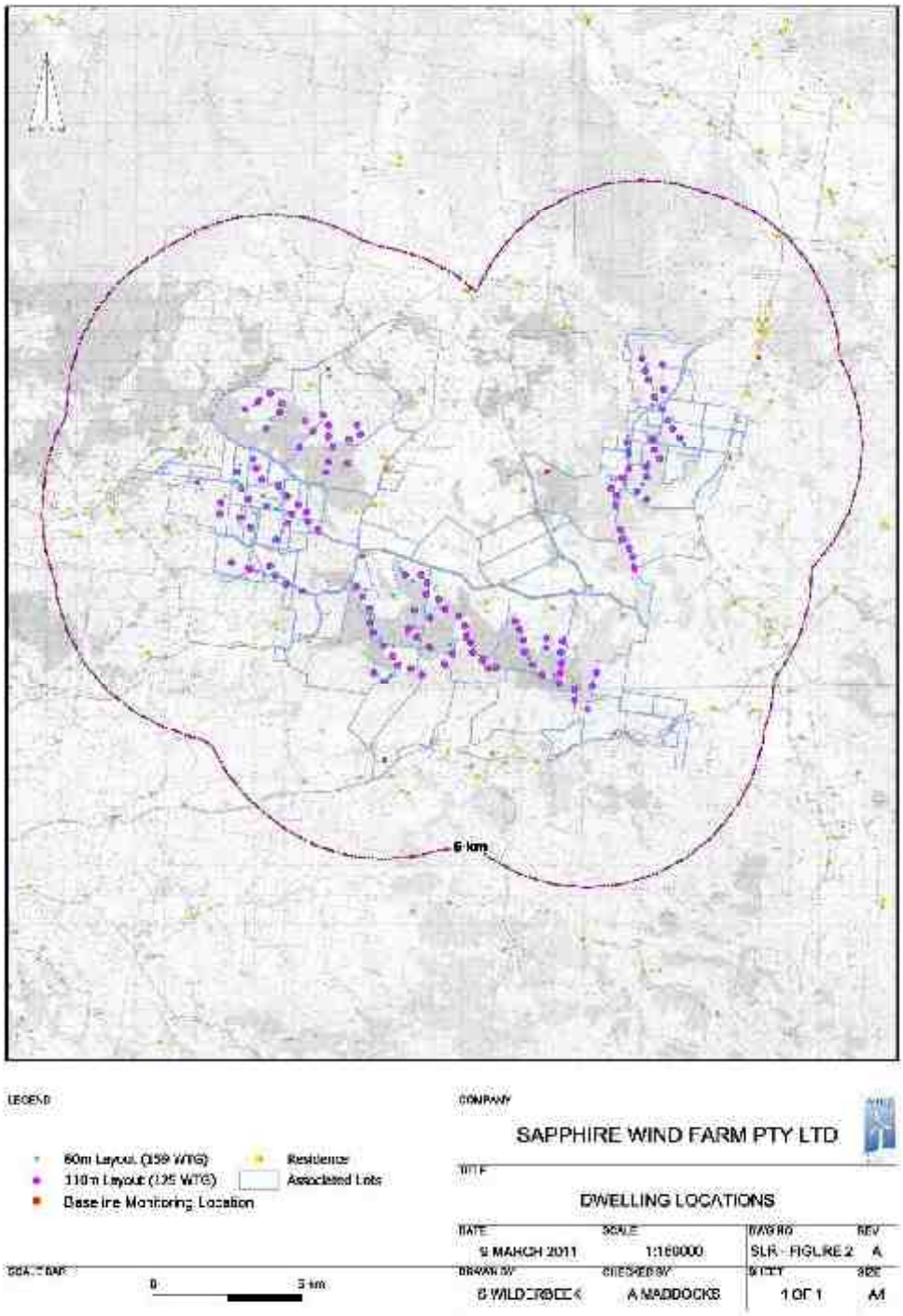


Table 6 lists the on-site and off-site receiver locations and their position. Other dwellings located beyond 6 km of a proposed WTG are not considered within this assessment, primarily as WTG noise is unlikely to be audible at these distances and compliance to noise criteria more critical at closer receivers.

Table 6 Surrounding Receivers

Location	East (m)	North (m)
0 Woodlands	345656	6722033
1 Rock Leigh	339587	6713397
2 Royal Oaks	351407	6705486
8 Woodstock*	344734	6710344
11 Kingshill*	347698	6712560
16 Narren Vale*	347964	6712709
19 Wongajong	337282	6714250
21 Inverness	349208	6704597
23 Mindora	352080	6705927
24 Millie	346895	6720935
26 Coleraine	342391	6719183
27 Bellview	345747	6705021
28 Leeweena*	354052	6710888
29 Swamp Oak	338449	6714147
30 Highlands*	344366	6709456
32 Warrandah*	348545	6715514
34 Croye	345670	6720193
37 Lochlea*	348517	6715896
38 Yarrandoo*	347511	6714046
39 Canjurra	354243	6723623
40 Nolimba	354512	6720316
43 Ardleigh*	353919	6715414
45 Golden Grove	347645	6705095
53 Lochbore	338107	6713277
54 Carinya*	346594	6718876
55 Tara	343517	6704861
59 Mubbarra*	351847	6711045
60 Woodburn*	353527	6714064
63 Spring Creek	341747	6715890
65 Roseana	339086	6715690
66 Kaludabah	352906	6721766
70 Warrawee	352554	6704583
71 Tralee*	342175	6715048
74 Hillview	350617	6705977
84 Argyle	340955	6711465
85 Yarrabin*	352462	6711770

Location	East (m)	North (m)
87 The Knoll	339310	6714061
89 Glenidle	350098	6719960
90 Kings Plains Castle*	351311	6721485
91 Derra Downs*	345942	6718360
93 Weean	349717	6718265
96 Bon Vista	350062	6706296
97 Manaroo*	354732	6711418
104 Meadow Vale	352871	6715339
105 Cubba*	352203	6715808
106 Glen Valley	340512	6709341
109 Strathdarr	348116	6714302
110 Pine Grove	353148	6714764
111 Kia-Tami*	345866	6709763
112 Windemere*	348773	6720327
115 Evergreen	359702	6709490
118 Fassifern	361141	6710925
134 Wangalee	360204	6721206
137 Tarana	360055	6711821
139 Fruin Glen*	359066	6713012
145 Karoola	359074	6713906
153 Mt Buckley	356193	6706606
157 Greenfield	360646	6718054
163 Fairy Meadow*	360326	6717140
170 Tauraurga*	356480	6710616
175 Falkland*	360082	6715875
179 Waterloo	361396	6709936
185 Farley	360869	6717145
194 Down Field*	356401	6711098
195 Pitiochry	361875	6713620
199 Springfield	361040	6719272
208 Adavale	359507	6707479
215 Rutherglen	361491	6717821
219 Maids Valley	360213	6711026
220 Quabadee	360918	6707397
224 Osterley*	356270	6718169
226 Coorimbla Park*	348746	6705191
227 Yarrawa Park*	348460	6705713
229 Cottages*	351196	6721501
230 Ashgrove	351629	6705174
231 Swan Peak	341074	6709238
233 Weean Cottage	349774	6718156

Location	East (m)	North (m)
234 House #2	355285	6711563
235 Waterloo Cottage	361416	6710180
237 Blumkaitis	361047	6719709
238 Tomali Park	341323	6716902
239 Frasers Creek	341582	6716131
240 Krystal Blue	341127	6713513
241 Pieta	353603	6705629
242 Glen Idle	352517	6705629
244 Arranmore	361431	6721013
245 Willow View	361298	6720212
246 937	361161	6720351
247 962	361334	6720544
249 Yardwell	361243	6720055
250 Junee	362218	6718863
251 Blue Grove	363149	6719066
252 DA Approved	361049	6720593
253 Highview	359206	6721447
254 Tantangra	357787	6721754
257 311*	348408	6715889
258 Lambert	339201	6714752
259 Alkoomie	352981	6706029
260 Linden Lea	361334	6718673
261 Wirra Willa	340656	6716039

Note: * Denotes the location is involved with the project

4 PROPOSED WIND FARM LAYOUT

The proponent has developed two base turbine layouts for the proposed Sapphire Wind Farm. The 80 metre 159 WTG layout which have been evaluated as either Vestas V90 or Gamesa G87 turbines is listed in **Table 7**. The 100m 125 WTG layout which have been evaluated as either Siemens SWT 2.3-101 turbines or Vestas V112 turbines is listed in **Table 8**.

Table 7 Sapphire Proposed 159 WTG Layout (Vestas V90 or Gamesa G87)

WTG #	Easting	Northing	WTG #	Easting	Northing	WTG #	Easting	Northing	WTG #	Easting	Northing
1	347266	6716525	41	344373	6714597	81	350946	6710557	121	356773	6712597
2	344448	6716872	42	345898	6713747	82	349451	6710805	122	356840	6712309
3	344926	6717491	43	345848	6713997	83	350035	6710600	123	356248	6714297
4	344998	6717747	44	346223	6713497	84	349573	6709797	124	356273	6714572
5	345798	6717147	45	345673	6711472	85	349448	6710222	125	356084	6714857
6	346048	6716872	46	345148	6711647	86	349198	6709972	126	356123	6715147
7	345625	6716269	47	344798	6711922	87	349954	6709563	127	357284	6715264
8	344648	6717197	48	344673	6712197	88	350351	6710840	128	357148	6714997
9	346578	6716639	49	344172	6712089	89	350285	6711138	129	357024	6714704
10	347523	6717047	50	343788	6712221	90	349873	6711322	130	357264	6714450
11	347648	6716697	51	343328	6712359	91	349898	6711697	131	357698	6715872
12	346598	6716922	52	347723	6711197	92	350142	6711527	132	357348	6715747
13	346324	6717322	53	347973	6710822	93	349726	6711927	133	357273	6715497
14	347223	6715697	54	347998	6710572	94	349003	6712128	134	356542	6715009
15	346548	6715672	55	347998	6710297	95	349149	6711937	135	356598	6715372
16	346473	6715397	56	348073	6710022	96	349420	6711771	136	356698	6715647
17	344023	6715872	57	347848	6711447	97	353073	6710047	137	356650	6716206
18	344223	6715572	58	348794	6711276	98	353098	6709772	138	356644	6716645
19	344323	6715147	59	347498	6711572	99	353198	6709422	139	356663	6716438
20	343623	6714847	60	348340	6709831	100	353433	6708881	140	356721	6715925
21	343498	6715397	61	348429	6709584	101	353923	6709522	141	357548	6716147
22	343623	6715647	62	348750	6709223	102	353923	6709797	142	357473	6716622
23	343473	6715097	63	349698	6708647	103	354398	6709372	143	358148	6716872
24	343823	6714547	64	349373	6708822	104	354423	6709647	144	358398	6716647
25	342923	6713997	65	348923	6708922	105	354523	6709872	145	358548	6716347
26	343598	6713872	66	348673	6708572	106	354423	6709122	146	358023	6717172
27	343948	6713547	67	348448	6708372	107	354398	6708872	147	357798	6717547
28	345198	6713672	68	348198	6708597	108	352898	6710349	148	357798	6719040
29	345323	6713997	69	348073	6708797	109	353300	6709174	149	357223	6718797
30	345173	6714497	70	350498	6708972	110	354198	6708622	150	357348	6718522
31	342969	6714263	71	351173	6709797	111	354323	6708297	151	357864	6718209
32	343093	6714576	72	350664	6709622	112	353774	6708606	152	357548	6717947
33	344774	6713167	73	350748	6709322	113	355441	6708221	153	357483	6717682
34	345018	6713397	74	351458	6709627	114	355598	6708672	154	357124	6719242
35	344043	6714008	75	352223	6708847	115	354843	6707728	155	344633	6718073

WTG #	Easting	Northing	WTG #	Easting	Northing	WTG #	Easting	Northing	WTG #	Easting	Northing
36	345542	6714321	76	351898	6708822	116	354848	6708097	156	343761	6717550
37	345023	6714722	77	351748	6709097	117	355298	6707422	157	344316	6717905
38	344873	6714947	78	351455	6709353	118	356398	6713447	158	344086	6717689
39	344798	6714172	79	351323	6710022	119	356473	6713097	159	346797	6716252
40	344448	6714297	80	351097	6710241	120	356698	6712847			

Table 8 Sapphire Proposed 125 WTG Layout (Siemens SWT 2.3-101 or Vestas V112)

WTG #	Easting	Northing	WTG #	Easting	Northing	WTG #	Easting	Northing	WTG #	Easting	Northing
1	347506	6711563	33	343948	6713547	65	346223	6713472	97	356683	6715522
2	347723	6711222	34	343598	6713872	66	350948	6710572	98	356473	6715197
3	347973	6710822	35	342923	6713997	67	351148	6710247	99	356084	6714857
4	347973	6710347	36	342948	6714372	68	351208	6709922	100	356298	6714597
5	348073	6710022	37	345198	6713672	69	351361	6709678	101	356248	6714297
6	349473	6710772	38	345323	6713997	70	351748	6709097	102	357273	6714472
7	349986	6710517	39	345898	6713747	71	351948	6708822	103	356948	6714747
8	349148	6711947	40	345548	6714322	72	352223	6708847	104	357285	6715264
9	349698	6711947	41	345848	6714047	73	351451	6709367	105	357273	6715597
10	349898	6711697	42	343498	6715397	74	352848	6710397	106	356673	6716022
11	349848	6711322	43	344323	6715147	75	353022	6710132	107	356623	6716422
12	350287	6711127	44	343892	6714497	76	353122	6709772	108	357723	6715847
13	350498	6710797	45	344479	6714267	77	353194	6709386	109	357548	6716147
14	348429	6709583	46	343623	6714847	78	353923	6709822	110	357473	6716522
15	348750	6709223	47	345172	6714586	79	353923	6709522	111	358148	6716872
16	348923	6708922	48	344900	6714925	80	354398	6709372	112	358023	6717172
17	348448	6708372	49	344040	6715843	81	353432	6708933	113	357798	6717547
18	348098	6708672	50	344137	6715520	82	353775	6708606	114	358409	6716589
19	349348	6708822	51	347648	6716697	83	354414	6709018	115	357548	6717947
20	349723	6708622	52	347523	6717022	84	354449	6709729	116	357348	6718522
21	350498	6708972	53	347223	6715697	85	354373	6708672	117	357223	6718822
22	350748	6709299	54	346573	6715722	86	355298	6707422	118	357124	6719242
23	349973	6709547	55	346473	6715397	87	354843	6707728	119	357798	6719040
24	349560	6709857	56	346579	6716643	88	354848	6708097	120	344633	6718072
25	349276	6710156	57	345798	6717147	89	354323	6708297	121	344204	6717796
26	345698	6711422	58	346598	6716997	90	355441	6708221	122	343761	6717550
27	345148	6711647	59	346398	6717347	91	355598	6708672	123	346737	6716252
28	344798	6711922	60	346048	6716797	92	356866	6712158	124	347266	6716525
29	344623	6712247	61	345619	6716244	93	356698	6712847	125	357863	6718209
30	343323	6712372	62	344923	6717447	94	356398	6713447			
31	343923	6712147	63	344998	6717747	95	356456	6713149			
32	344823	6713147	64	344479	6716886	96	356804	6712576			

4.1 WTG Type and Details

The WTG manufacturer and model has not yet been finalised, and accordingly it is necessary to nominate each of the models currently being considered for the noise impact investigation.

The 159 WTG wind farm layout has been assessed using the two different WTG models under consideration being:

- Gamesa G87 2.0 MW turbines
- Vestas V90 2.0 MW turbines;

The 125 WTG wind farm layout has been assessed using the two different WTG models under consideration being:

- Vestas V112 3.0 MW turbines; and
- Siemens SWT 101 2.3 MW turbines

All turbines are three bladed, upwind, pitch-regulated and active yaw.

Table 9 summarises the relevant turbine input data used for noise level prediction.

Table 9 WTG Manufacturers Data

Make, model, power	**Gamesa G87 2.0 MW**	**Vestas V90 2.0 MW**	**Vestas V112 3.0 MW**	**Siemens SWT-2.3-101, 2.3 MW**
Rotor diameter	87 m	90 m	112 m	101 m
Hub height	100 m	100 m	94m	101.5 m
Cut-in wind speed	4 m/s	4 m/s	3 m/s	3.5 m/s
Rated wind speed	15 m/s	25 m/s	12 m/s	12 - 13 m/s
Rotor speed	9 – 19 rpm	8.6 - 18.4 rpm	4.4 – 17.7 rpm	6 – 16 rpm
'Standard Mode' Sound Power Level, $L_{WA,ref}$	106.4 dBA	103.7 dBA	106.5 dBA	107 dBA

Noise emissions for the proposed WTG's have been provided by the WTG manufacturers and have either been independently tested according to International Standard IEC 61400-11 or are warranted noise levels calculated in accordance with the International Standard. Copies of the certification test or manufacturers documentation that give the sound power level variation with wind speed, frequency spectra and tonality assessment are contained in **Appendix B.**

5 OPERATIONAL NOISE LEVELS

5.1 Introduction

As discussed in **Section 1.2.2**, a three-dimensional computer noise model was used to predict L_{Aeq} noise levels from all WTG's at all surrounding residential dwellings.

The ISO 9613 noise model incorporates a 'hard ground' assumption and includes one-third octave band calculated effects for air absorption, ground attenuation and topographic shielding. It is noted that ISO 9613 equations predict for average downwind propagation conditions and also hold for average propagation under a well-developed moderate ground-based temperature inversion.

The estimated accuracy of the prediction model is approximately ±3 dBA.

5.2 Wind Turbine Noise

For indicative purposes the WTG noise levels from the proposed 159 WTG and 125 WTG base layouts were calculated for the reference wind condition of 8 m/s at 10m AGL. The resulting WTG noise levels are listed in **Table 10** for the four different turbines.

The predicted noise contour plots resulting from the 159 WTG layout equipped with Gamesa G87 2.0 MW turbines is depicted in **Figure 3** and Vestas V90 2.0 MW turbines in **Figure 4**.

The predicted noise contour plots resulting from the 125 WTG layout equipped with Vestas V112 3.0 MW turbines is depicted in **Figure 5** and Siemens SWT-101 2.3 MW turbines in **Figure 6**.

Furthermore, noise levels from the proposed wind farm were calculated for all integer wind speeds in the range of 5 to 10 m/s (at 10m AGL) at all surrounding assessment receivers within 6 km of a turbine. Whilst the rated wind speed of the WTG's is typically 13 to 14 m/s, published manufacturers sound power level test data (IEC 61400-11) has only been generated as high as 10 m/s. It should be noted that noise produced by WTG's begins to 'plateau off' at higher wind speeds and because of the higher masking background noise level at higher wind speeds, noise impacts and compliance are not critical at these speeds. The assessed wind range sufficiently covers the most noise critical operational conditions.

To compare predicted noise levels with the assessment criteria, the wind speed data, normally measured at 10m AGL, was extrapolated to 100m using the logarithmic profile law (Section 8 Data reduction procedures, page 20, International Standard IEC61400-11 ©IEC:2002+A1:2006 (E) *'Wind Turbine Generator Systems – Part 11: Acoustic noise measurement techniques'*).

The assessment graphs of WTG operational noise levels were prepared for each turbine model currently being considered for the Sapphire Wind Farm:

- Gamesa G87 2.0 MW turbines is depicted in **Appendix A1**;
- Vestas V90 2.0 MW turbines is depicted in **Appendix A2**;
- Vestas V112 3.0 MW is depicted in **Appendix A3**; and
- Siemens SWT 101 2.3 MW is depicted in **Appendix A4**.

Table 10 WTG L_{Aeq} noise level (dBA) at $V_{ref,10m}$ = 8 m/s, V_{100m} = 11.5m/s

Receiver / Property	159 WTGs Gamesa G87 2.0 MW	159 WTGs Vestas V90 2.0 MW	125 WTGs Vestas V112 3.0 MW	125 WTGs Siemens SWT 101 2.3 MW
0 Woodlands	16.5	18.8	20.7	22
1 Rock Leigh	27.4	29.5	31.1	32.6
2 Royal Oaks	27.9	29.9	32	33.7
8 Woodstock*	30.3	32.8	34.5	36.6
11 Kingshill*	36.8	39.1	40	41.7
16 Narren Vale*	36.4	38.6	39.2	41
19 Wongajong	23	25.4	27	28
21 Inverness	26.2	28.4	30.1	31.7
23 Mindora	26.1	28.1	30.3	32.2
24 Millie	24.4	26.5	28.9	30.6
26 Coleraine	29.6	31.7	33.2	35
27 Bellview	24.4	26.7	28.2	29.6
28 Leeweena*	37.5	39.8	41.7	43.6
29 Swamp Oak	25	27.2	28.8	30.1
30 Highlands*	29.7	31.8	33.2	35.1
32 Warrandah*	32.9	35.1	37.3	39.2
34 Croye	25.3	27.3	29.7	31.6
37 Lochlea*	33.9	36.2	38.6	40.6
38 Yarrandoo*	32	34.3	36.2	38.5
40 Nolimba	27	29.1	31	32.6
43 Ardleigh*	29.8	31.9	33.3	35.2
45 Golden Grove	26.7	28.8	30.4	31.9
53 Lochbore	24.3	26.6	28.2	29.4
54 Carinya*	31.5	33.6	36	38.2
55 Tara	22.2	24.5	26	27.3
59 Mubbarra*	37.9	40.2	42.4	44.3
60 Woodburn*	30.3	32.4	34.5	36.2
63 Spring Creek	33.7	35.8	37	38.7
65 Roseana	25.4	27.5	28.7	30.5
70 Warrawee	26.9	29	31.1	32.7
71 Tralee*	36.6	38.8	39.7	41.6
74 Hillview	29.5	31.5	33.6	35.3
84 Argyle	29	31.1	32.8	34.3
85 Yarrabin*	33.5	35.6	37.7	39.8
87 The Knoll	26.8	28.9	30.4	31.9
89 Glenidle	22.5	24.9	26.6	28
90 Kings Plains Castle*	20.9	23.2	24.9	26.5
91 Derra Downs*	35.9	38.2	40.7	42.7
93 Weean	23.5	25.7	27.8	29.2

Receiver / Property	159 WTGs Gamesa G87 2.0 MW	159 WTGs Vestas V90 2.0 MW	125 WTGs Vestas V112 3.0 MW	125 WTGs Siemens SWT 101 2.3 MW
96 Bon Vista	30.3	32.3	34.3	36.1
97 Manaroo*	33.1	35.2	37.1	39.2
104 Meadow Vale	29.1	31.1	32.8	34.5
105 Cubba*	27.5	29.6	31.5	33.1
106 Glen Valley	16.4	18.7	20.4	21.6
109 Strathdarr	32.8	34.8	36.6	38.5
110 Pine Grove	28.7	30.8	32.6	34.4
111 Kia-Tami*	31	33	34.4	36.4
112 Windemere*	22.1	24.4	26	28.1
115 Evergreen	25	27.1	29.3	30.8
118 Fassifern	23.5	25.7	27.7	29
134 Wangalee	20.3	22.2	24.2	26.5
137 Tarana	26.9	29	31	32.5
139 Fruin Glen*	30.6	32.7	34.4	36.3
145 Karoola	32.4	34.5	36.1	38
153 Mt Buckley	30.7	33	35.7	37.5
157 Greenfield	26.7	28.7	30.3	32.4
163 Fairy Meadow*	28.3	30.4	31.5	33.9
170 Tauraurga*	32.3	34.3	36.6	38.6
175 Falkland*	31.5	33.6	34.9	36.8
179 Waterloo	14.6	17	19	20.1
185 Farley	28.6	30.6	32.2	34
194 Down Field*	32.7	34.9	37.6	39.5
195 Pitiochry	25.1	27.2	28.9	30.3
199 Springfield	24.8	26.8	28.8	30.9
208 Adavale	23.2	25.4	27.7	29.2
215 Rutherglen	26.5	28.5	30.2	31.9
219 Maids Valley	25.3	27.4	29.4	30.9
220 Quabadee	16.9	19.2	21.7	23
224 Osterley*	36	38.3	40.1	42
226 Coorimbla Park*	27.1	29.2	31	32.6
227 Yarrawa Park*	28.1	30.2	31.9	33.6
229 Cottages*	21.2	23.5	25.3	26.9
230 Ashgrove	27.8	29.8	31.8	33.5
231 Swan Peak	25.6	27.8	29.5	30.8
233 Weean Cottage	23.6	25.9	27.9	29.3
234 House #2	32.7	34.9	37	39
235 Waterloo Cottage	14.8	17.1	19.1	20.3
237 Blumkaitis	24.6	26.5	28.6	30.6
238 Tomali Park	27.3	29.3	30.7	32.8

Receiver / Property	159 WTGs Gamesa G87 2.0 MW	159 WTGs Vestas V90 2.0 MW	125 WTGs Vestas V112 3.0 MW	125 WTGs Siemens SWT 101 2.3 MW
239 Frasers Creek	30.6	32.7	33.8	35.9
240 Krystal Blue	31.7	33.7	35.2	37
241 Pieta	26.3	28.3	30.9	32.8
242 Glen Idle	28.2	30.2	32.4	34.2
245 Willow View	23.7	25.7	28	29.7
246 937	23.2	25.2	27.4	29.2
247 962	23.1	25.1	27.2	28.9
249 Yardwell	24	26	28.3	30
251 Blue Grove	22.6	24.9	26.7	27.9
252 DA Approved	22.8	24.8	26.9	28.7
253 Highview	23.9	25.8	28.1	30.4
254 Tantangra	23.6	25.5	27.8	30.1
257 311*	34.3	36.6	39.1	41
258 Lambert	18.3	20.5	21.9	23.4
259 Alkoomie	29.6	31.6	33.8	35.8
260 Linden Lea	25.3	27.3	29.3	31
261 Wirra Willa	29.7	31.7	33.2	34.8

Note: * Denotes the location is involved with the project

Figure 3 **159 WTG Layout Gamesa G87 2.0 MW , L_{Aeq} Noise Contour Map**

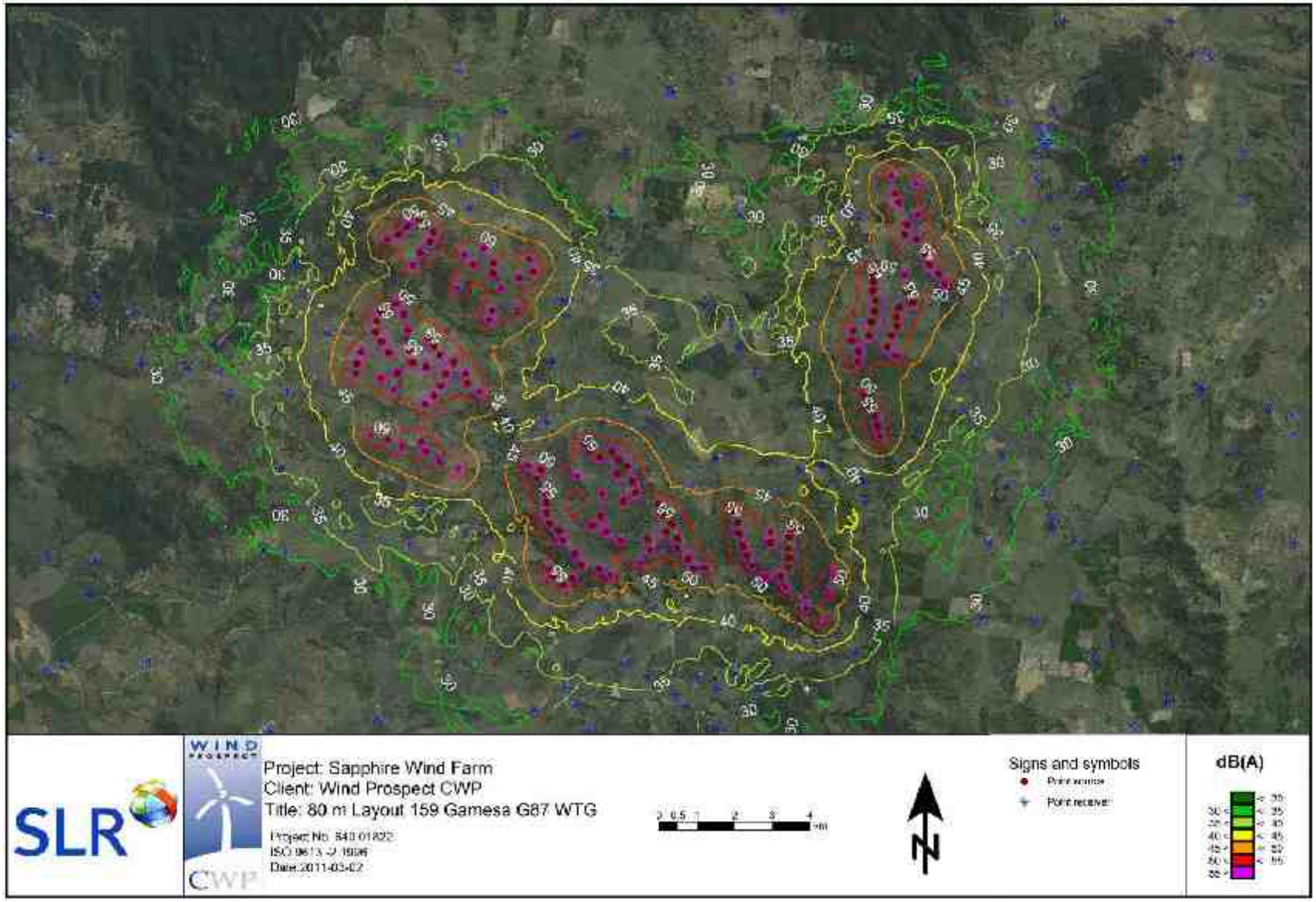


Figure 4 **159 WTGs Vestas V90 2.0 MW, L_{Aeq} Noise Contour Map**

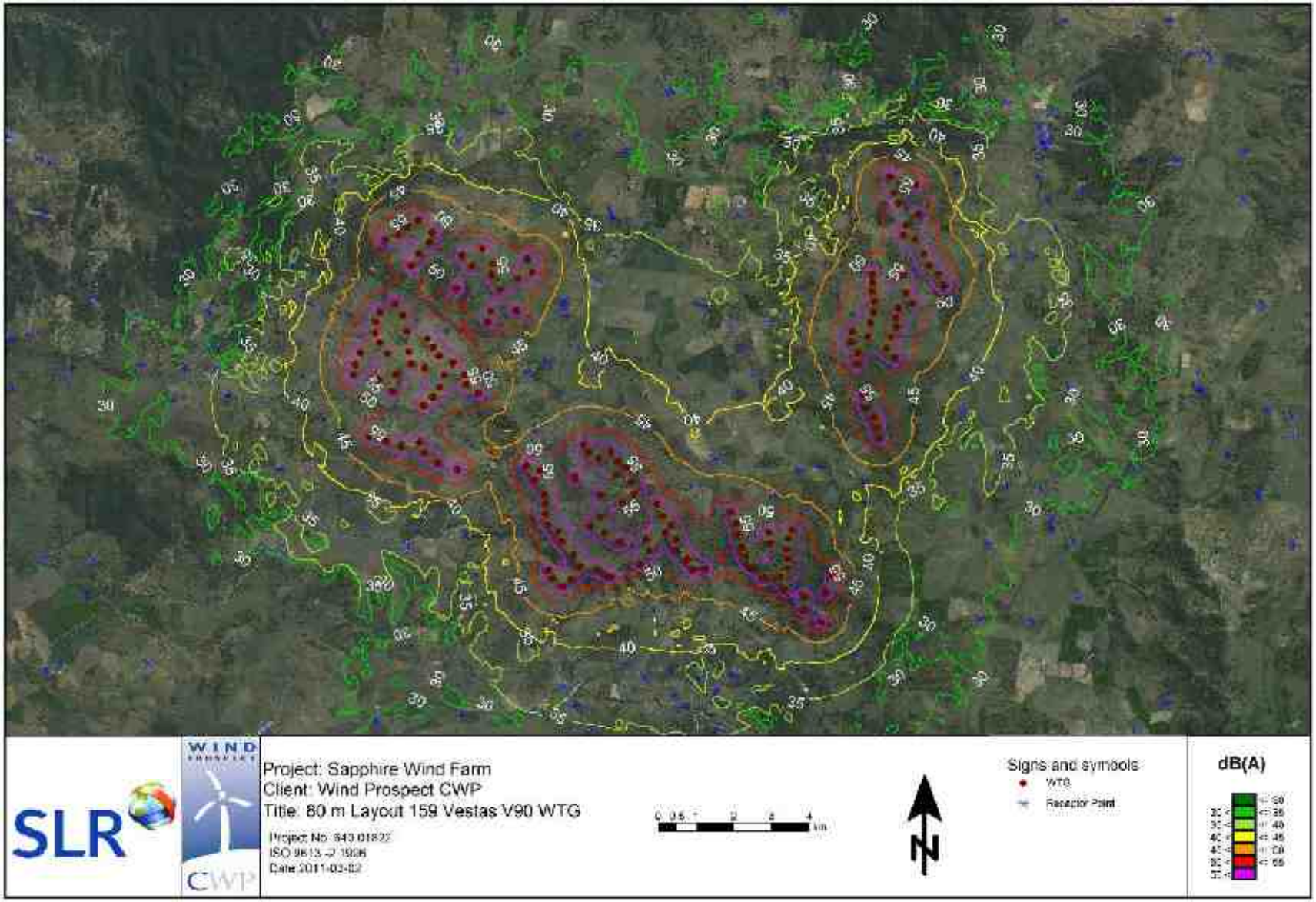


Figure 5 **125 WTGs Vestas V112 3.0 MW, L_{Aeq} Noise Contour Map**

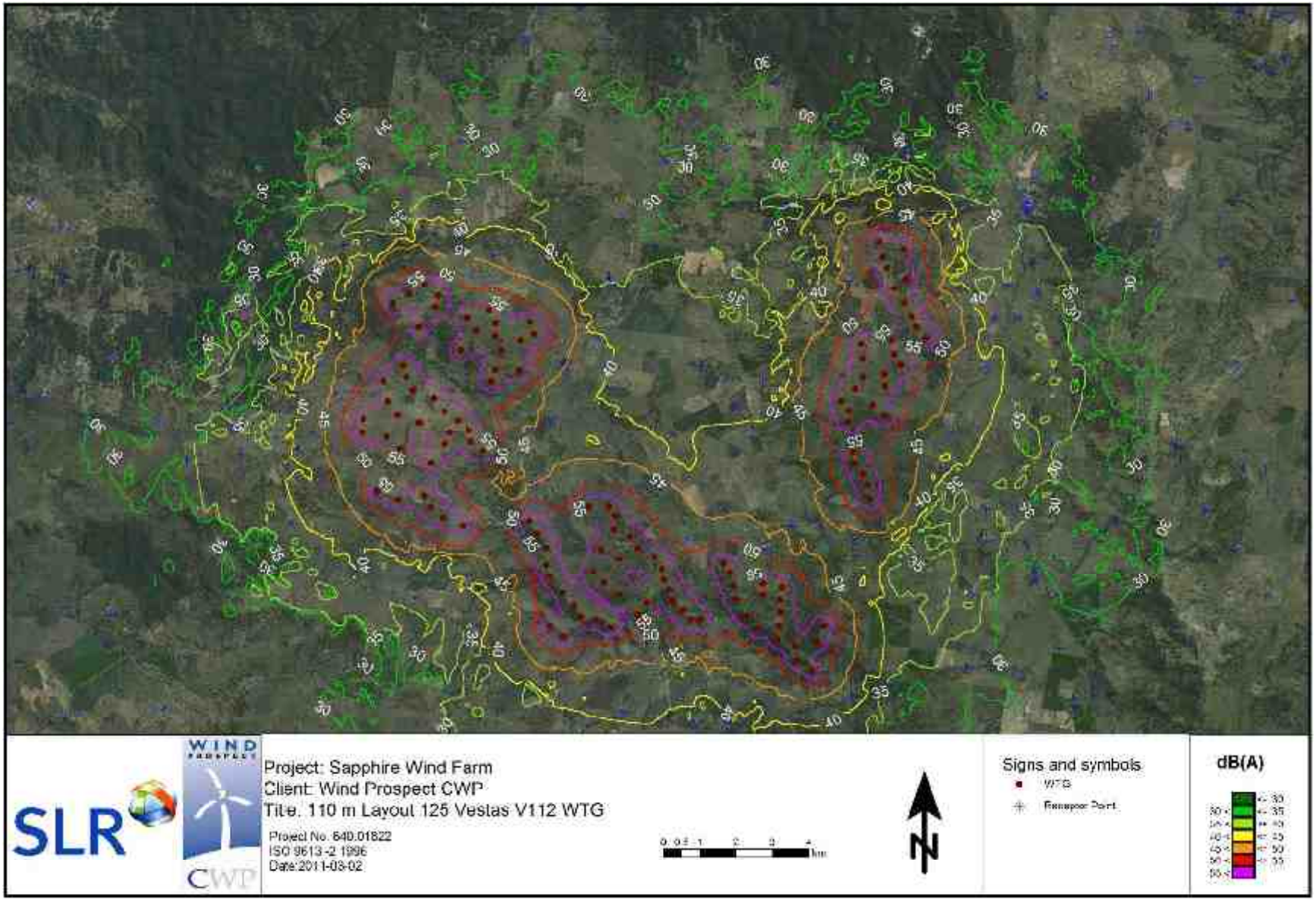
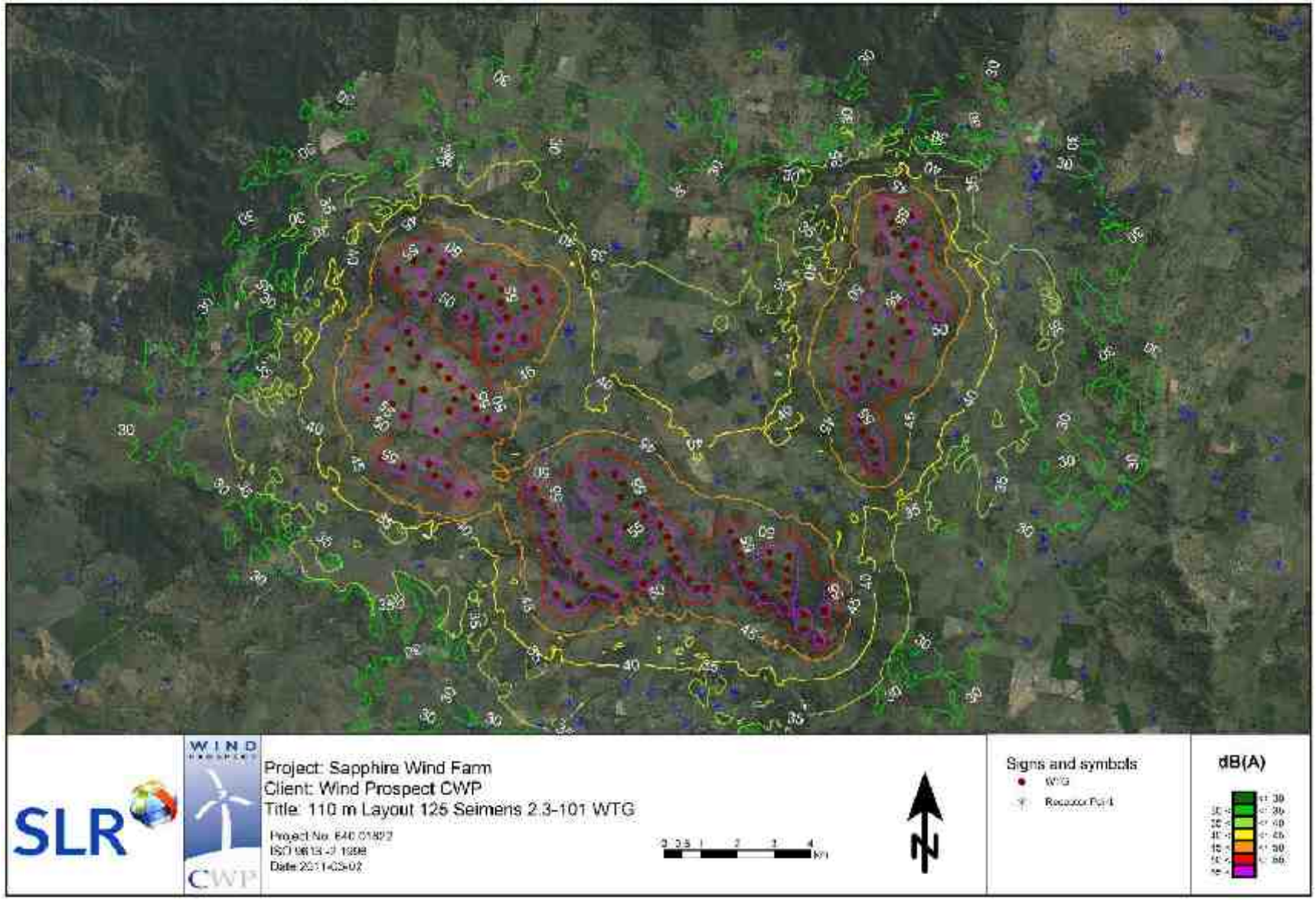


Figure 6 **125 WTGs Siemens SWT 101 2.3 MW, L_{Aeq} Noise Contour Map**



5.3 Substation Transformer Noise Levels

The appropriate noise criteria for Substation Noise are provided in *NSW INP* (See **Section 2.2** and **2.4**). A combined collector and switching substation is required at the point of connection to the TransGrid owned transmission infrastructure to export power from the project. There are two possible points of connection; a 330kV transmission line runs through the western section of the wind farm and a 132 kV transmission line runs to the south of the wind farm along the Gwydir Highway. Only one substation is required for the project.

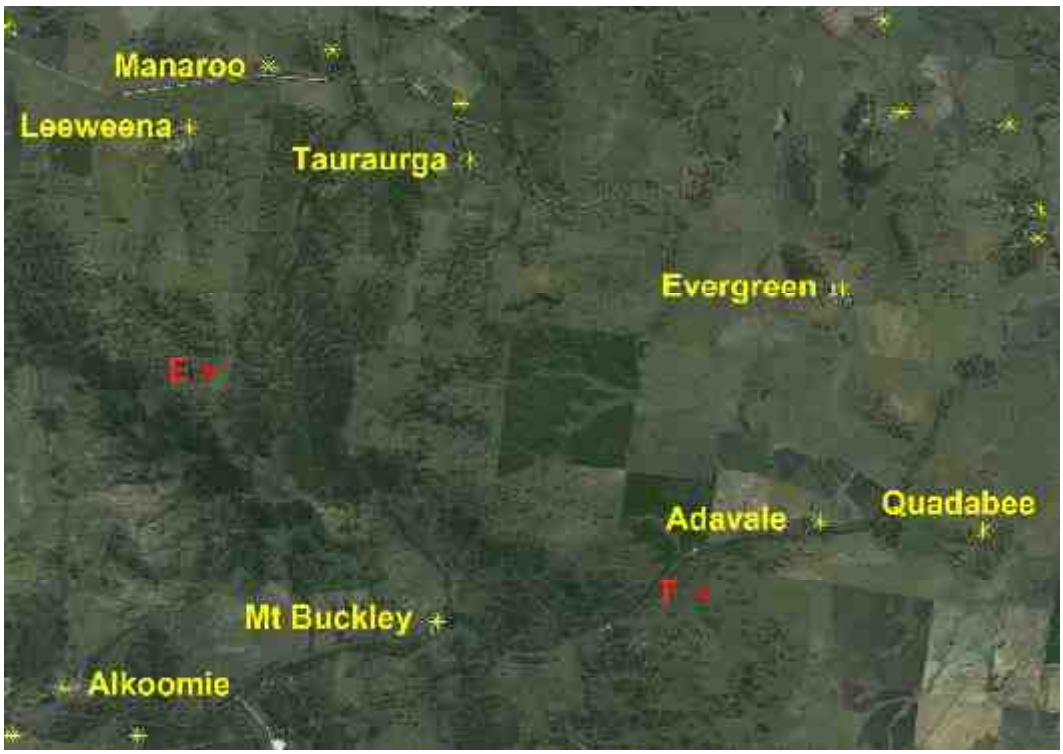
A number of substation sites are being considered as listed in the options presented in **Table 11**. The alternative locations for the substation sites are depicted in **Figure 7** and **Figure 8**.

Table 11 Substation site options

Substation Option	Substation Type	East (m)	North (m)	Nearest receptor (proximity)
A	330 kV	347164	6713081	11 Kingshill (630m), 16 Narren Vale (775m), 38 Yarrandoo (950m)
B	330 kV	347683	6711612	11 Kingshill (900m), 38 Yarrandoo (2440m), 16 Narren Vale (2630m)
C	330 kV	348253	6709952	111 Kia-Tami (2320m), 11 Kingshill (2630m),16 Narren Vale (2750m),
D	330 kV	347083	6712964	11 Kingshill (700m), 16 Narren Vale (875m), 38 Yarrandoo (1160m),
E	132 kV	354213	6708773	28 Leeweena (2120m), 97 Manaroo (2695m), 170 Tauraurga (2920m),
F	132 kV	358507	6706840	208 Adavale (1187m), 153 Mt Buckley (2326m), 220 Quabadee (2475m)

Figure 7 Alternative locations for 330 kV substations

Figure 8 Alternative locations for 132 kV substations



Assessment of noise from the substation will be assessed separately from the wind farm and will be subject to a separate approval also included in this report.

A 330kV substation would 'step up' the voltage from the wind farm internal interconnection power lines to 330kV for connection to the existing 330kV to the west of the site transmission line using two 150 or 200 MVA transformers. A 132kV substation would 'step up' the voltage from the wind farm internal interconnection power lines to 132kV for connection to the existing 132kV transmission line to the south of the site using a single 160 MVA transformer.

Australian Standard AS 60076 Part 10 2009: *"Power Transformers – Determination of sound levels"* indicates that the 330 kV transformer facility may produce sound power levels up to 102 dBA and the 132 kV up to 97 dBA. The dominant frequency of such a transformer is 100 Hz.

Noise predictions for transformer substations have been made using CONCAWE algorithms assuming an absolute 'worst case' meteorology enhancement condition of downwind 3 m/s and Pasquill Stability Class F temperature inversion. The results are presented in **Table 12** for the nearest receptor locations.

Table 12 Predicted 'worst case' 330 kV switching substation noise

Substation Option			
A	37 dBA @ 11 Kingshill	36 dBA @ 16 Narren Vale	36 dBA @ 38 Yarrandoo
B	37 dBA @ 11 Kingshill	34 dBA @ 16 Narren Vale	26 dBA@ 38 Yarrandoo
C	20 dBA @ 111 Kia-Tami	28 dBA @ 11 Kingshill	27 dBA @ 16 Narren Vale
D	39 dBA @ 11 Kingshill	35 dBA @ 16 Narren Vale	35 dBA @ 38 Yarrandoo
E	21 dBA @ 28 Leeweena	10 dBA @ 97 Manaroo	23 dBA @ 170 Tauraurga
F	24 dBA @ 208 Adavale	16 dBA @ 153 Mt Buckley	13 dBA @ 220 Quabadee

It is evident from the predicted 330 kV substation noise that all substation locations other than Option C may result in a 'worst case' propagated noise level higher than the NSW Industrial Noise Policy minimum noise limit of 35 dBA. It may be possible to locate the substation at the alternative options should the final selection of transformers facility result in a lower sound power level than that assumed or some noise mitigation be incorporated into the design.

Both alternative locations for the 132 kV substation would satisfy the NSW Industrial Noise Policy minimum noise limit of 35 dBA.

6 BACKGROUND LEVELS AND NOISE LIMITS

6.1 Measurement Locations

The locations for the background noise measurements were selected based on the potential for acoustic impact to the nearest receivers, as recommended by Table 3.1 of the NSW INP. The SA EPA Guidelines recommend that the measurement locations should be located at least 5 metres from a reflecting surface (other than the ground) and locations within 20 metres of a residence are generally appropriate.

Monitoring equipment was generally placed in the vicinity of the residence at a suitable location that would be protected from the prevailing wind direction in order to protect the microphone from wind induced noise effects. Care was taken not to place the equipment in locations that would be affected by extraneous noise sources.

Background noise monitoring locations were selected based on the predicted wind farm noise level from the preliminary layout at reference conditions.

The relative proximity of some receiver locations to one another and their similar wind exposure and surrounding environment meant that background noise monitoring could be conducted at one representative location and be considered indicative of other similar locations.

Monitoring was commenced at 13 locations, however, due to unforeseen equipment failures a number of locations did not collect sufficient data. Where this occurred the nearest monitored location was selected as being representative which was considered generally conservative as the inferred baseline curve was low.

The noise data collected from 11 locations around the proposed wind farm site are presented in the report. These are listed in **Table 13**.

Table 13 Measurement Locations

Location	Indicative of		Notes / Similar Characteristic for wind induced noise
175-Falkland *	224 Osterley *	157 Greenfield	Geographic proximity, similar region, exposure to wind
	175 Falkland*	215 Rutherglen	
	185 Farley	195 Pitiochry	
	163 Fairy Meadow *		
199-Springfield	247 962	245 Willow View	Geographic proximity, similar region, exposure to wind
	199 Springfield	254 Tantangra	
	237 Blumkaitis	246 937	
	250 Junee	247 962	
	249 Yardwell	252 DA Approved	
	253 Highview	134 Wangalee	
43- Ardleigh *	28 Leeweena *	105 Cubba *	Geographic proximity, similar region, exposure to wind
	85 Yarrabin *	40 Nolimba	
	97 Manaroo *	229 Cottages *	
	60 Woodburn *	90 Kings Plains Castle *	
	43 Ardleigh *	66 Kaludabah	
	104 Meadow Vale *	39 Canjurra	
	110 Pine Grove		
194 Down Field *	234 House #2	220 Quabadee	Geographic proximity, similar region, exposure to wind
	194 Down Field *	115 Evergreen	
	145 Karoola	118 Fassifern	
	139 Fruin Glen *	170 Tauraurga *	
	137 Tarana	235 Waterloo Cottage	
	219 Maids Valley	179 Waterloo	
11-Kingshill *	11 Kingshill *	111 Kia-Tami *	Geographic proximity, similar region, exposure to wind
	16 Narren Vale *	8 Woodstock *	
	109 Strathdarr	30 Highlands *	
	38 Yarrandoo *		
54-Carinya *	91 Derra Downs *	34 Croye	Geographic proximity, similar region, exposure to wind
	54 Carinya *	24 Millie	
	26 Coleraine	0 Woodlands	
71-Tralee *	71 Tralee *	87 The Knoll	Geographic proximity, similar region, exposure to wind
	63 Spring Creek	65 Roseana	
	240 Krystal Blue	29 Swamp Oak	
	239 Frasers Creek	53 Lochbore	
	261 Wirra Willa	19 Wongajong	
	84 Argyle	258 Lambert	
	1 Rock Leigh	106 Glen Valley *	
	238 Tomali Park		
227 Yarrawah Park *	96 Bon Vista	21 Inverness	Geographic proximity, similar region, exposure to wind
	227 Yarrawa Park *	231 Swan Peak	
	226 Coorimbla Park *	27 Bellview	

Location	Indicative of		Notes / Similar Characteristic for wind induced noise
	45 Golden Grove	55 Tara	
23-Mindora	59 Mubbarra * 259 Alkoomie 74 Hillview 242 Glen Idle 2 Royal Oaks	230 Ashgrove 241 Pieta 70 Warrawee 23 Mindora	Geographic proximity, similar region, exposure to wind
153-Mt Buckley	153 Mt Buckley	208 Adavale	Geographic proximity, similar region, exposure to wind
32-Warrandah *	257 311 * 37 Lochlea * 32 Warrandah * 96 Bon Vista 227 Yarrawa Park * 226 Coorimbla Park * 45 Golden Grove	21 Inverness 231 Swan Peak 27 Bellview 233 Weean Cottage 93 Weean 89 Glenidle 55 Tara 112 Windemere *	Geographic proximity, similar region, exposure to wind

Note: * Denotes the location is involved with the project

It is anticipated that further baseline background noise monitoring will be conducted before project commissioning in order to obtain more comprehensive and representative data.

At each location noise monitoring equipment was placed in the vicinity of the residence and the position of the monitoring equipment was documented with photographs.

The weather data from the Bureau of Meteorology monitoring station at Glenn Innes was obtained for the period of the survey. This data was used to identify and exclude any data during rain periods, which may have affected the background noise levels. The measured data for rain confirmed that the monitoring period was generally dry and as a result only a small number of data points were rejected due to rain.

The SA EPA Guidelines require measurements to be conducted in 10 minute intervals, while the NSW INP request 15 minute interval data. Given that almost all wind data, including the wind farm site monitored data, is in 10 minute intervals, this period was used for all measurements.

Simultaneous noise monitoring and wind monitoring from Sapphire was conducted during the period 7th July 2009 through to 23rd July 2009. Wind speed was monitored at the 60 metre mast located at Tralee on the western side of the project site, at heights of 45 metres and 60 metres above ground level (AGL). These values were used to extrapolate the wind speed at a height of 100 metres AGL using the wind profile power law. Local noise data was then correlated to the 100 metre AGL extrapolated wind speed.

6.2 Measurement Details

The measurement location, monitoring period, equipment type and serial number of the noise logger used for all testing are summarised in **Table 14**.

The SA EPA Guidelines require a set of approximately 2,000 valid data points. All data points below the cut-in wind speed of the proposed turbines and any adversely affected data (rain, external extraneous noise sources etc) should be excluded. The cut-in wind speed for the proposed turbines is 3 m/s. The number of valid data points for each location is also shown in **Table 14.**

The measured background noise levels (L_{A90}) are then plotted against the extrapolated 100 metre wind speed to obtain a background versus wind speed characteristic for each location.

The line of best fit for the data set is then determined, as required by the SA EPA Guideline using a linear, second order (quadratic) or third order (cubic) polynomial. The Guideline requires that the correlation coefficient for each line type be reported and the one with the highest correlation coefficient used. As required, the R^2 value, which is a measure of the correlation coefficient for each of the three type of line of best fit are also shown. At each location the cubic polynomial gave the highest correlation and was therefore used for the line of best fit. The SA EPA Guideline does not specify a minimum acceptable correlation coefficient, although we note that some of the sites have low correlation coefficient.

Table 14 Measurement Details for each Location

Measurement Location	Measurement Period	Noise Logger Model # Serial number	Total No. of monitoring intervals	No. of valid data points		Correlation Coefficient (R^2)		
				All	Night	Linear	Quad.	Cubic
175-Falkland *	07-07-2009 - 14:10 23-07-2009 - 18:40	ARL EL-316 #16-004-033	2332	1906	754	0.017	0.0372	0.0432
199-Springfield	07-07-2009 - 14:50 23-07-2009 - 21:00	ARL EL-31 6 #16-203-530	2342	1959	756	0.0342	0.0594	0.0595
43- Ardleigh *	07-07-2009 - 15:40 23-07-2009 - 12:30	ARL EL-316 #16-306-040	2286	2156	812	0.3651	0.3879	0.3895
194 Down Field *	07-07-2009 - 18:20 16-07-2009 - 23:50	ARL EL-316 #16-299-426	1330 **	1015	292	0.2764	0.2771	0.3017
11-Kingshill *	07-07-2009 - 17:30 23-07-2009 – 20:50	ARL EL-316 #16-306-044	2325	1602	405	0.4878	0.5101	0.5143
54-Carinya *	08-07-2009 - 12:50 23-07-2009 – 17:40	ARL EL-316 #16-208-527	2190	2057	755	0.1677	0.1761	0.1788
71-Tralee *	08-07-2009 - 12:10 23-07-2009 – 20:40	ARL EL-316 #16-203-524	2212	2088	761	0.0414	0.0424	0.0471
227 Yarrawah Park *	08-07-2009 - 10:30 23-07-2009 – 21:30	ARL EL-316 #16-301-471	2227	1963	756	0.0733	0.0847	0.0854
23-Mindora	08-07-2009 - 9:00 23-07-2009 – 18:30	ARL EL-316 #16-203-528	2218	2050	754	0.1017	0.1115	0.1222
153-Mt Buckley	08-07-2009 - 9:40 15-07-2009 – 16:30	ARL EL-316 #16-306-045	1050**	975	342	0.4631	0.4748	0.4784
32-Warrandah *	08-07-2009 – 13:40 17-07-2009 – 0:20	ARL EL-316 #16-203-529	1217**	1140	411	0.3748	0.3875	0.4003

* Denotes the location is involved with the project

**Logger stopped prematurely due to flat battery

Measurement data at three of the monitoring locations fell short of the preferred 2000 intervals due to premature battery failure, however, as between 53% and 66% of the data had been collected and the correlation coefficient was relatively good (between 0.3 to 0.47) the result is still deemed statistically relevant.

6.3 Night Period Analysis

Measurement data was also reduced and analysed for only the night period (10:00 pm to 7:00 am). The resulting reduced data sets, which include typically 300 to 800 data points, were fitted with a cubic polynomial regression line of best fit.

The regression line for night only data is generally lower than that for all data by between 1 dB to 5 dB and varies considerably from location to location. Lower night data is attributed to two main factors, that extraneous noise sources (animals, traffic etc.) are lower during the night period and that the wind shear profile for the night period is usually greater for that compared to the day which results in lower ground level wind speeds for a given hub height reference wind speed, when compared to that during the day period.

It should be noted that the minimum criteria noise level for project involved receptors (45 dBA from WHO) and project uninvolved receptors (35 dBA from SA EPA Guideline) are not changed.

The resulting effect on project involved receptors criteria with consideration to only the lower night period background data is generally minimal with the criteria being exactly the same (criteria is a constant 45 dBA as background noise regression lines are always less than 35 dBA) or marginally higher at high wind speeds where compliance is more easily achieved.

The criteria for project uninvolved receptors with consideration to only the night period background data is generally marginally lower at higher wind speeds, however, as this is generally not the most critical wind range for compliance the net effect of night data based criteria is negligible with regards to compliance.

6.4 Rating Background Levels

The Rating Background Level (RBL) for each location during each time period is shown in **Table 15**. Note, that the results are based on 10 minute logging intervals, rather than the 15 minute intervals required in the NSW INP.

Table 15 RBL for each Period at each Location (dBA)

Location	Day	Evening	Night
175-Falkland *	26.5	29.2	24.2
199-Springfield	27.3	28.7	24.9
43- Ardleigh *	28.7	22.8	22.6
194 Down Field *	36.2	36.6	39.6
11-Kingshill *	38.2	39.3	40.1
54-Carinya *	27.0	21.5	21.4
71-Tralee *	28.7	22.9	22.0
227 Yarrawah Park *	30.6	25.1	24.7
23-Mindora	30.8	23.0	22.9
153-Mt Buckley	27.3	24.2	23.4
32-Warrandah *	26.2	23.5	23.1

* Denotes the location is involved with the project

The entire set of noise logger results, showing the measured L_{A90}, L_{Aeq} and L_{A10} noise levels, together with wind speed, are shown in **Appendix C.**

The horizontal distance between each of the assessment locations and WTG's for the proposed layouts are shown in **Appendix E.**

6.5 Falkland

The property of Falkland is located directly to the east of the proposed wind farm, near Polhill Road, approximately 1.8 km from the nearest proposed WTG. The residence is situated in low lying marsh land near Wellingrove Creek. This residence is occupied by one of the landowners that make up part of the proposed Sapphire Wind Farm site.

The dwelling is bordered by a mixture of mature deciduous and native trees. The measurement location was just to the south of the house. The monitoring location is shown in **Figure 9.**

Elevated noise levels occurred at approximately 6 pm each evening which might be attributed to natural sources such as bird song or frogs. Such periods were generally removed from the analysed data set. The correlation coefficient is particularly low at this location which may be due to its low lying (more protected from wind) position.

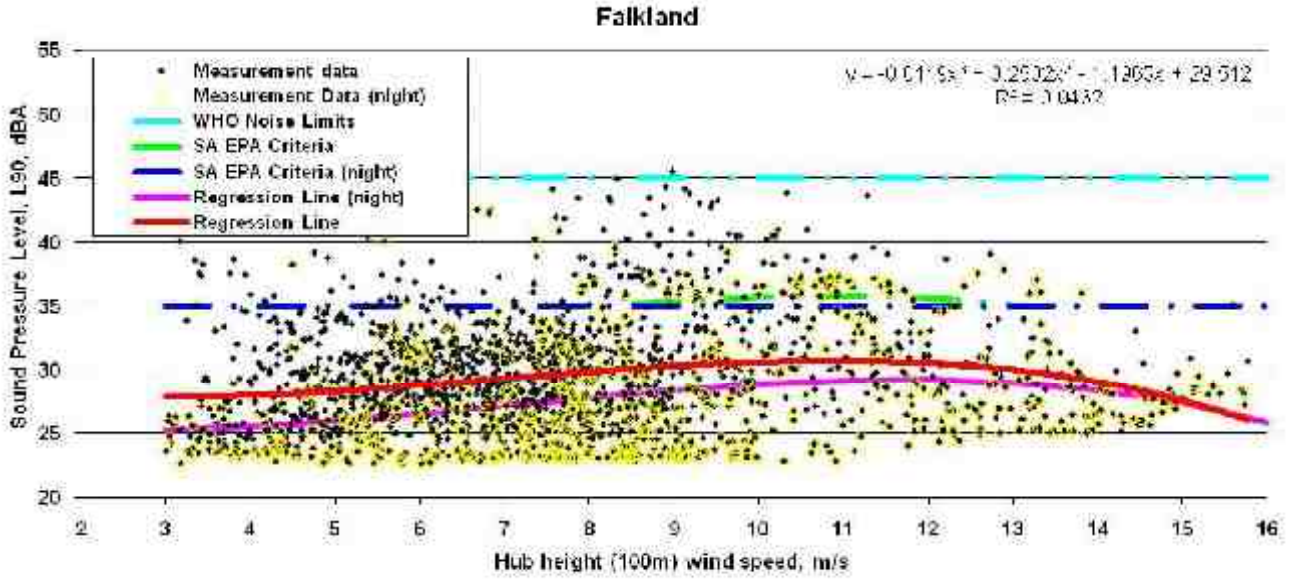
Figure 9 Falkland Measurement Location

The results of the background noise monitoring taken in July 2009, showing the data points, line of best fit and the Noise Criteria Curve are shown in **Figure 10.**

Graphically represented noise statistical indices, together with wind speed are presented in **Appendix C1**.

The daytime Rating Background Level (RBL) was approximately 27 dBA.

Figure 10 Background Noise Measurements and Noise Criteria Curve - Falkland



6.6 Springfield

The Springfield property is located to the north east of the proposed wind farm, near Polhill Road (Victoria Street) at the southern end of Wellingrove township, on the eastern side and slightly elevated above in low lying marsh land near Wellingrove Creek. The residence is approximately 3.3 km from the nearest proposed WTG. The residence is relatively protected by some surrounding trees and out buildings.

Elevated noise levels occurred at approximately 6 pm most evenings which might be attributed to natural sources such as bird song or frogs. Such periods were generally removed from the analysed data set. The correlation coefficient is particularly low at this location which may be due to its low lying position.

Figure 11 Springfield Measurement Location

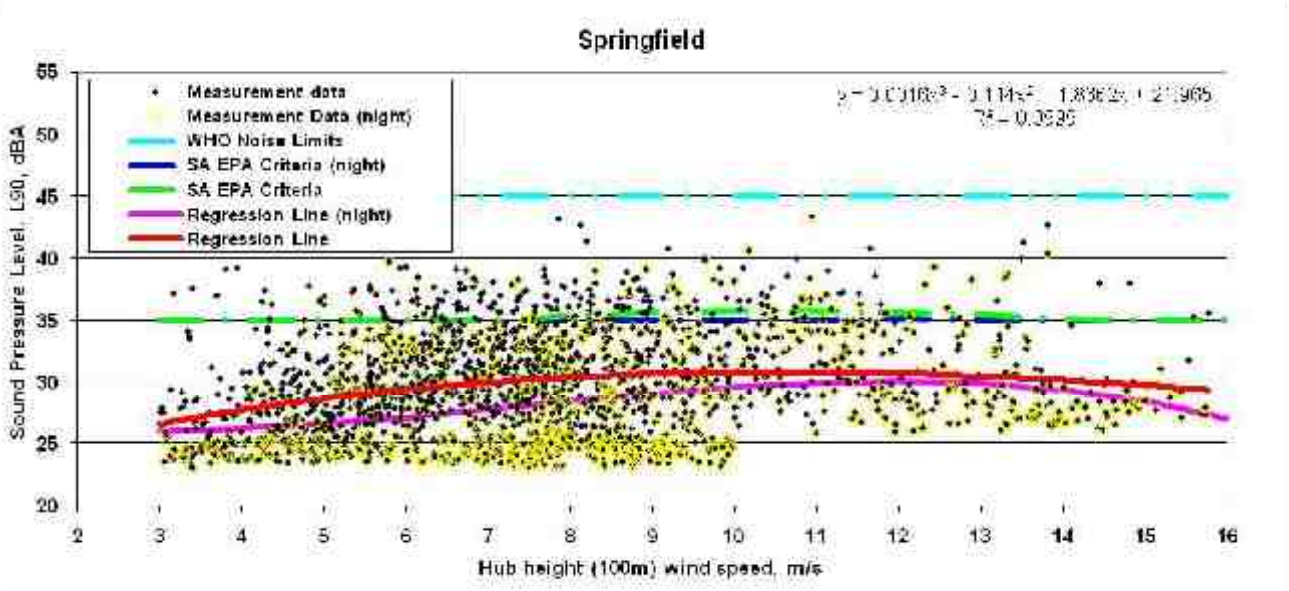
The measurement location, shown in **Figure 11,** was to the west of the house in the rear garden.

The results of the background noise monitoring taken in July 2009, showing the data points, line of best fit and the Noise Criteria Curve are shown in **Figure 12.**

Graphically represented noise statistical indices, together with wind speed are presented in **Appendix C2.**

The daytime Rating Background Level (RBL) was approximately 27 dBA.

Figure 12 Background Noise Measurements and Noise Criteria Curve – Springfield



6.7 Ardleigh

The Ardleigh property is located to the central eastern part of the proposed wind farm off the Eastern Feeder Road, approximately 2.2 km from the nearest WTG. This residence is occupied by one of the landowners that make up part of the proposed Sapphire Wind Farm site.

The residence is relatively protected by topography and is surrounded by large native trees, and a well established garden. The noise monitoring equipment was positioned to the south of the house. The measurement location is shown in **Figure 13**

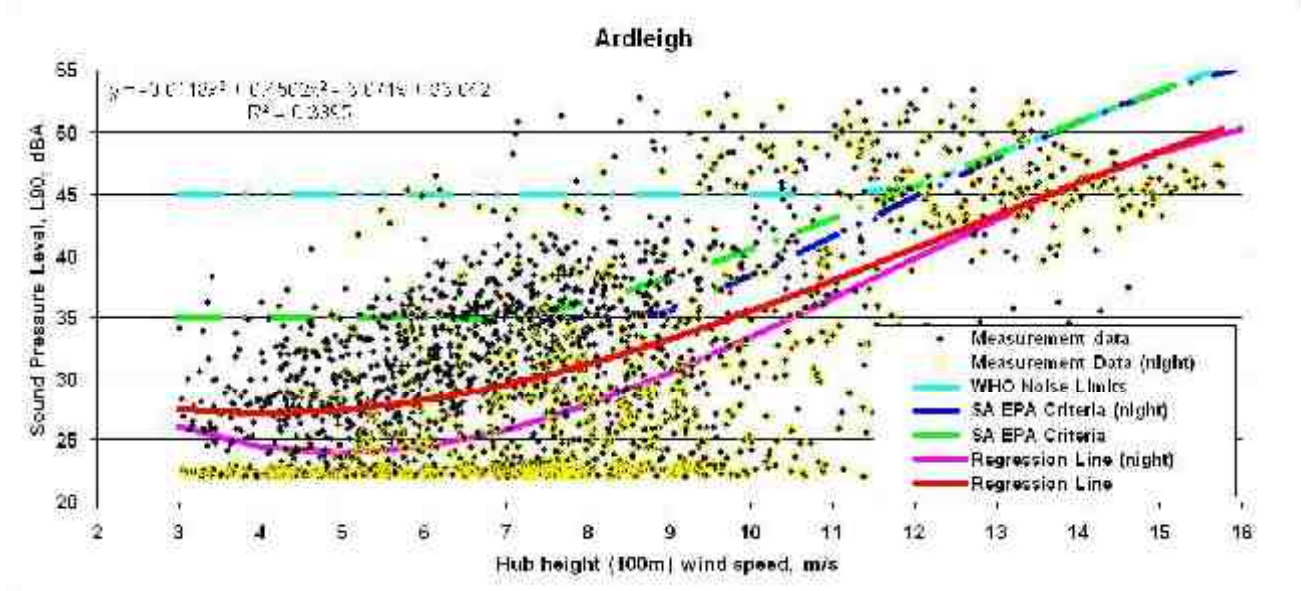
Figure 13 Ardleigh Measurement Location

The results of the background noise monitoring taken in July 2009, showing the data points, line of best fit and the Noise Criteria Curve are shown in **Figure 14.**

Graphically represented noise statistical indices, together with wind speed are presented in **Appendix C3.**

The daytime Rating Background Level (RBL) was approximately 29 dBA.

Figure 14 Background Noise Measurements and Noise Criteria Curve – Ardleigh



6.8 Down Field

The property of Down Field is located to the central eastern of the proposed wind farm off Waterloo Road, approximately 1.2 km from the nearest proposed WTG. This residence is occupied by one of the landowners that make up part of the proposed Sapphire Wind Farm site.

The residence is relatively protected from winds by topography to the west, but is exposed from other directions. Well established trees and garden offer some further protection. The noise monitoring equipment was positioned to the west of the house. The measurement location is shown in **Figure 15** below.

Background noise levels at this location are relatively elevated and correlate well with wind speed. Monitoring at this location was cut short due to battery failure.

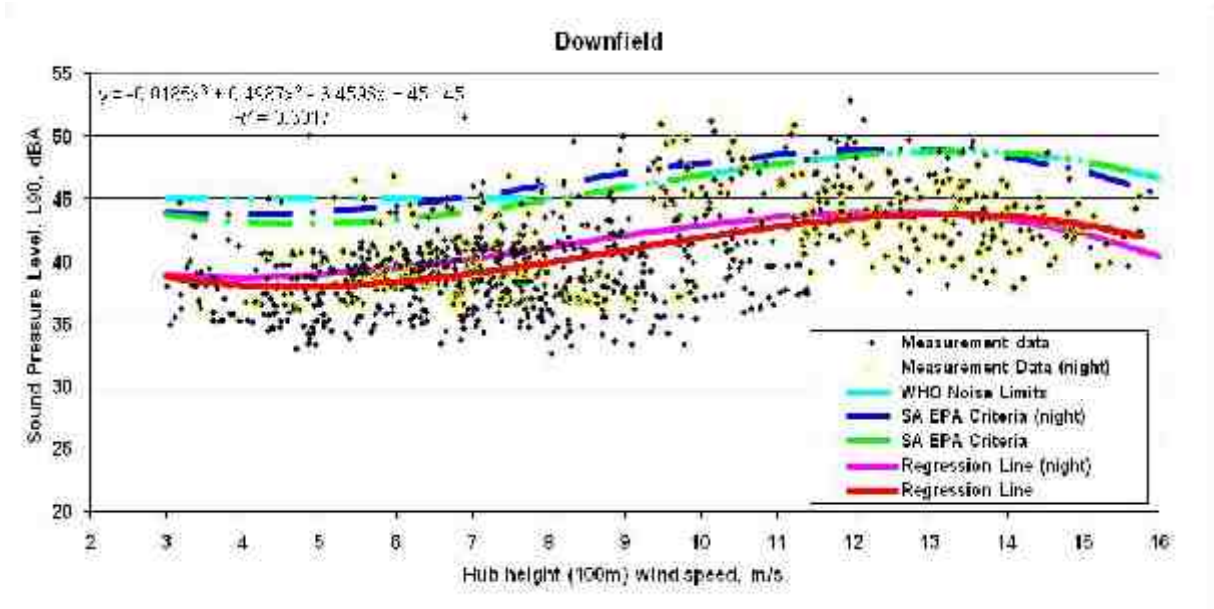
Figure 15 Measurement location Down Field

The results of the background noise monitoring taken in July 2009, showing the data points, line of best fit and the Noise Criteria Curve are shown in **Figure 16**.

Graphically represented noise statistical indices, together with wind speed are presented in **Appendix C4.**

The Rating Background Level (RBL) was approximately 36 dBA for the day period.

Figure 16 Background Noise Measurements and Noise Criteria Curve – Down Field



6.9 Kingshill

The property of Kingshill is located to the central-western side of the proposed wind farm, approximately 1.0 km from the nearest proposed WTG. This residence is occupied by one of the landowners that make up part of the proposed Sapphire Wind Farm site.

The residence is positioned on elevated land close to the top of the ridge which forms the western arm of the wind farm. The residence is relatively exposed with respect to the wind, with a pine windbreak to the south and smaller trees and shrubs in the garden and out buildings offering some protection from other directions. The measurement location is shown in **Figure 17.**

Figure 17 Kingshill Measurement Location

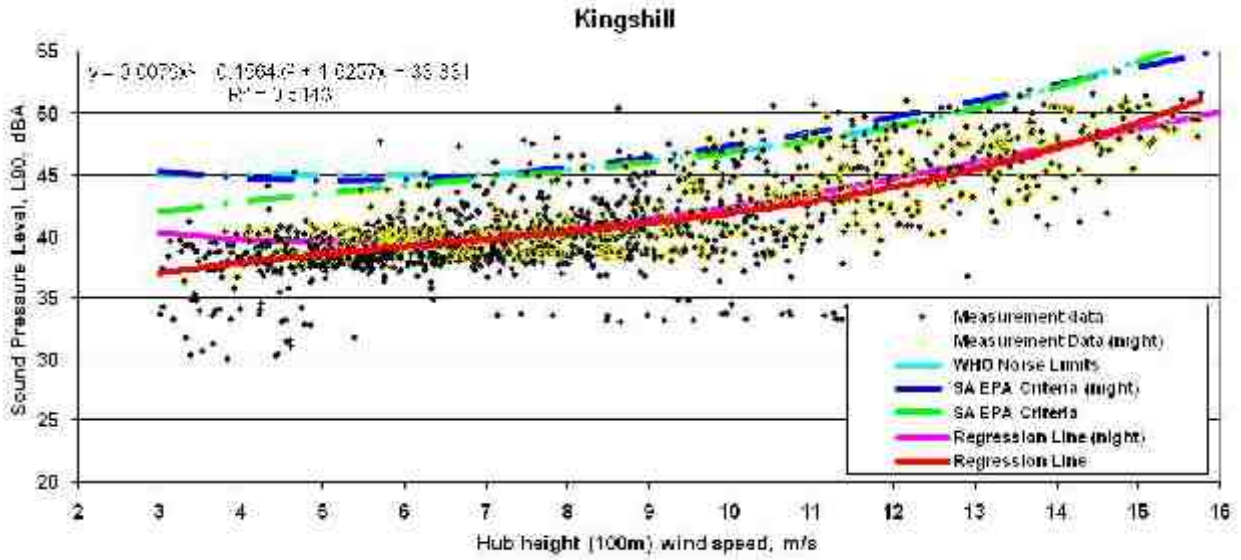
Background noise level data at this location are characterised by long periods of constant elevated noise level of 38-41 dBA generally during the night. It is not clear what the cause of this phenomenon is, possibly a continuously running piece of equipment at near proximity to the noise logger. The affected data has generally been removed from the analysis set, which is a conservative approach.

The results of the background noise monitoring taken in July 2009, showing the data points, line of best fit and the Noise Criteria Curve are shown in **Figure 18.**

Graphically represented noise statistical indices, together with wind speed are presented in **Appendix C5.**

The daytime Rating Background Level (RBL) was approximately 38 dBA.

Figure 18 Background Noise Measurements and Noise Criteria Curve – Kingshill



6.10 Carinya

The property of Carinya is located to the northwest of the proposed wind farm approximately 1.5 km from the nearest proposed WTG and is accessed from Kings Plains Road. This residence is occupied by one of the landowners that make up part of the proposed Sapphire Wind Farm site.

The residence is protected from all directions by tall native trees and smaller trees and shrubs located around the garden. Noise monitoring equipment was placed to the west of the house, shown in **Figure 19** below.

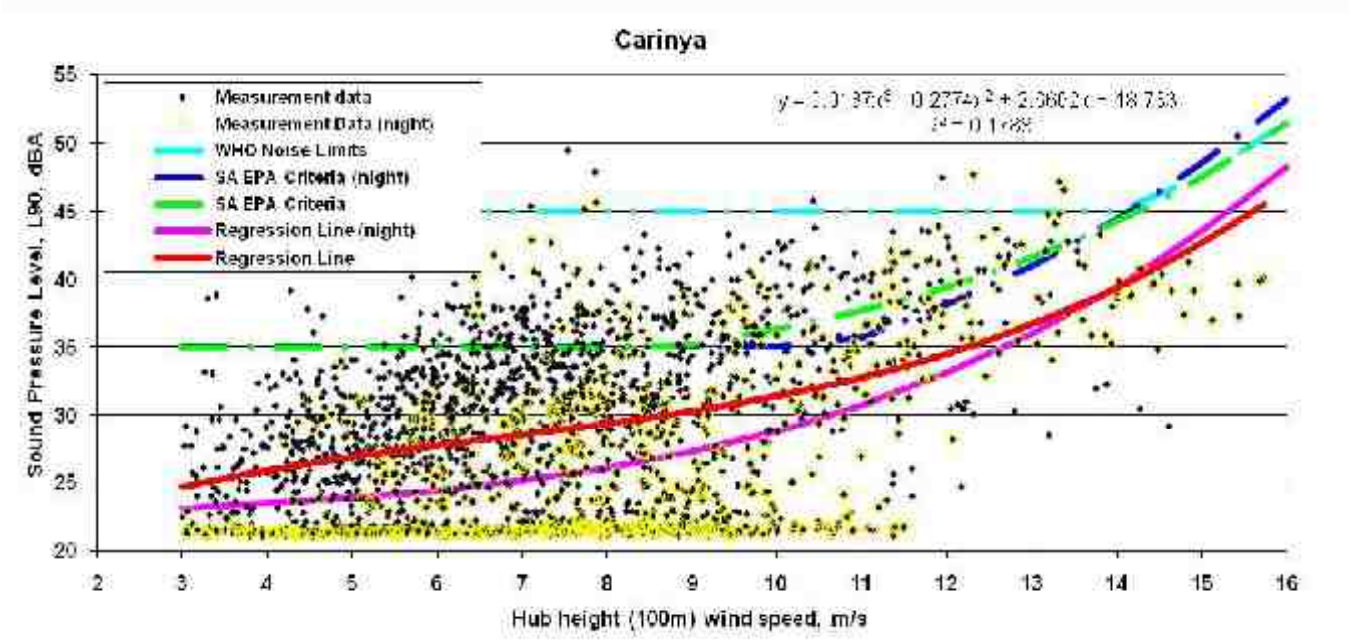
Figure 19 Carinya Measurement Location

The results of the background noise monitoring taken in July 2009, showing the data points, line of best fit and the Noise Criteria Curve are shown in **Figure 20**.

Graphically represented noise statistical indices, together with wind speed are presented in **Appendix C6.**

The Rating Background Level (RBL) was approximately 27 dBA for the day period.

Figure 20 Background Noise Measurements and Noise Criteria Curve – Carinya



6.11 Tralee

The property of Tralee is located to the west of the proposed wind farm site approximately 1.0 km from the nearest proposed WTG and is accessed from Kings Plains Road. This residence is occupied by one of the landowners that make up part of the proposed Sapphire Wind Farm site.

The residence is partly protected by topography to the north and east and has a number of large trees and a garden around the house yard area.

The measurement location was to the south of the house and is shown in **Figure 21.**

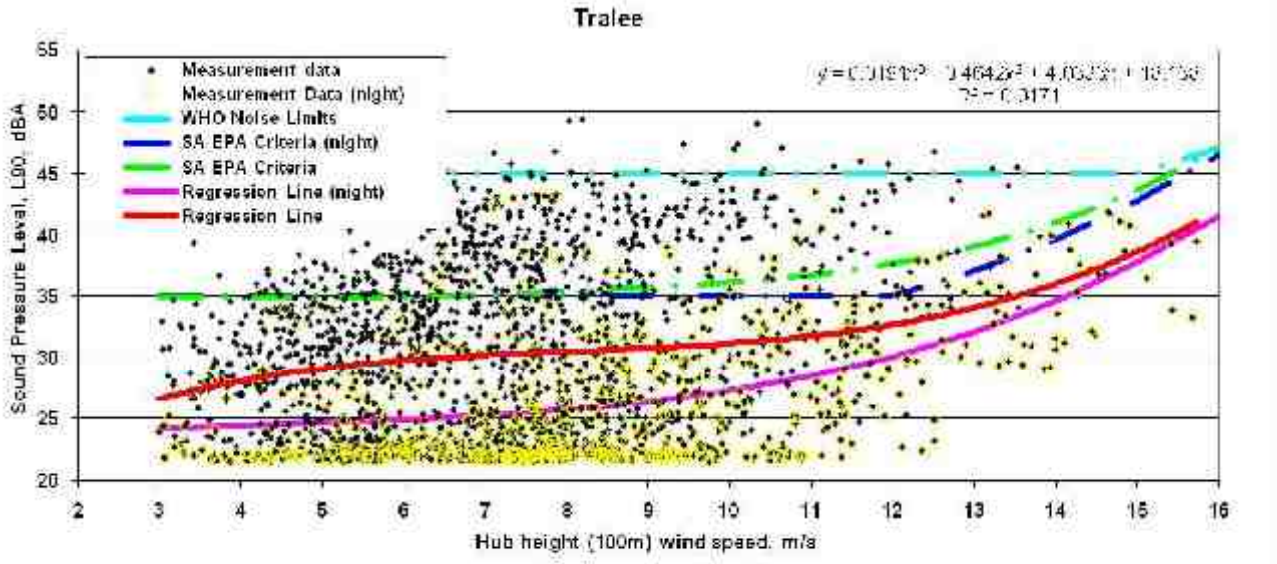
Figure 21 Tralee Measurement Location

The results of the background noise monitoring taken in July 2009, showing the data points, line of best fit and the Noise Criteria Curve are shown in **Figure 22.**

Graphically represented noise statistical indices, are presented in **Appendix C7.**

The daytime Rating Background Level (RBL) was approximately 29 dBA.

Figure 22 Background Noise Measurements and Noise Criteria Curve - Tralee



6.12 Yarrawah Park

The residence of Yarrawah Park is located to the south of the proposed wind farm approximately 2.7 km from the nearest proposed WTG and is approximately 270 metres to the north of the Gwydir Highway. The residence is positioned on low lying land beside Swan Brook. This residence is occupied by one of the landowners that make up part of the proposed Sapphire Wind Farm site.

A small number of large native trees and smaller garden shrubs grow around the house yard area. The measurement location, as shown in **Figure 23**, was to the south of the house and was chosen as some activity in the cattle yards to the north of the house was anticipated. On some days there were periods of elevated noise levels which may be attributed to cattle yard and farming activity, in general these have been removed from the analysis set.

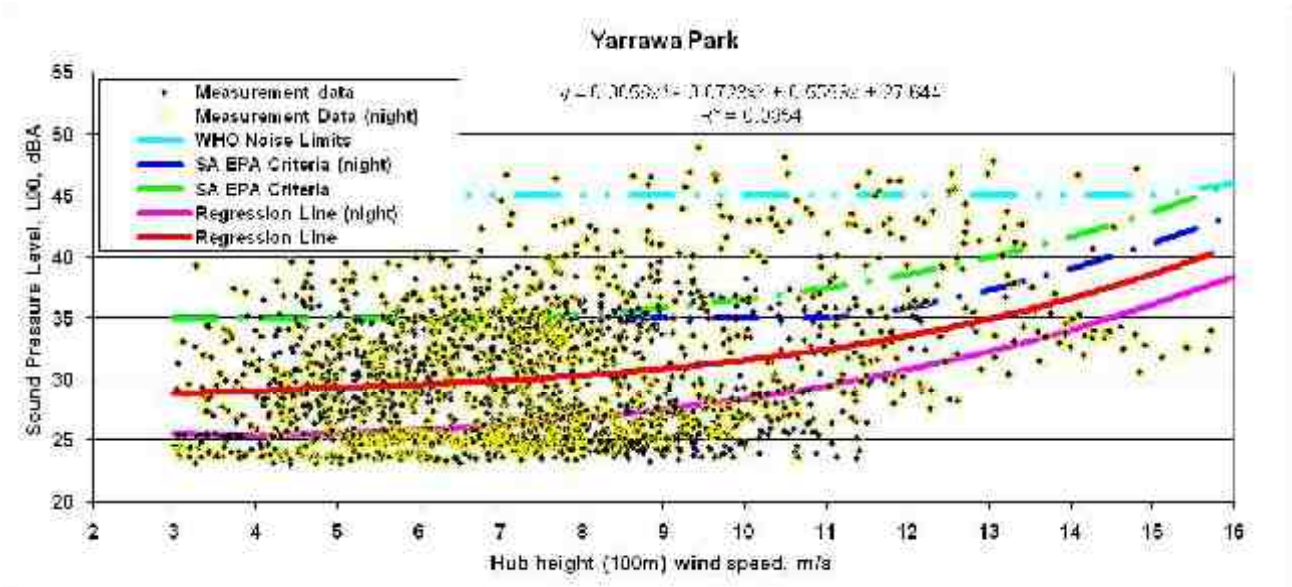
Figure 23 Yarrawah Park Measurement Location

The results of the background noise monitoring taken in July 2009, showing the data points, line of best fit and the Noise Criteria Curve are shown in **Figure 24**.

Graphically represented noise statistical indices, together with wind speed are presented in **Appendix C8**. Higher noise levels at dawn were a feature of this location and likely a result of birds**.**

The daytime RBL was approximately 31 dBA.

Figure 24 Background Noise Measurements and Noise Criteria Curve – Yarrawah Park



6.13 Mindora

The residence of Mindora is located to the south of the proposed wind farm approximately 2.9 km from the nearest proposed WTG and is approximately 200 metres to the north of the Gwydir Highway. The residence is protected by topography from the north and has a small number of native trees and out buildings.

Noise monitoring equipment was placed to the north of the house, shown in **Figure 25** below.

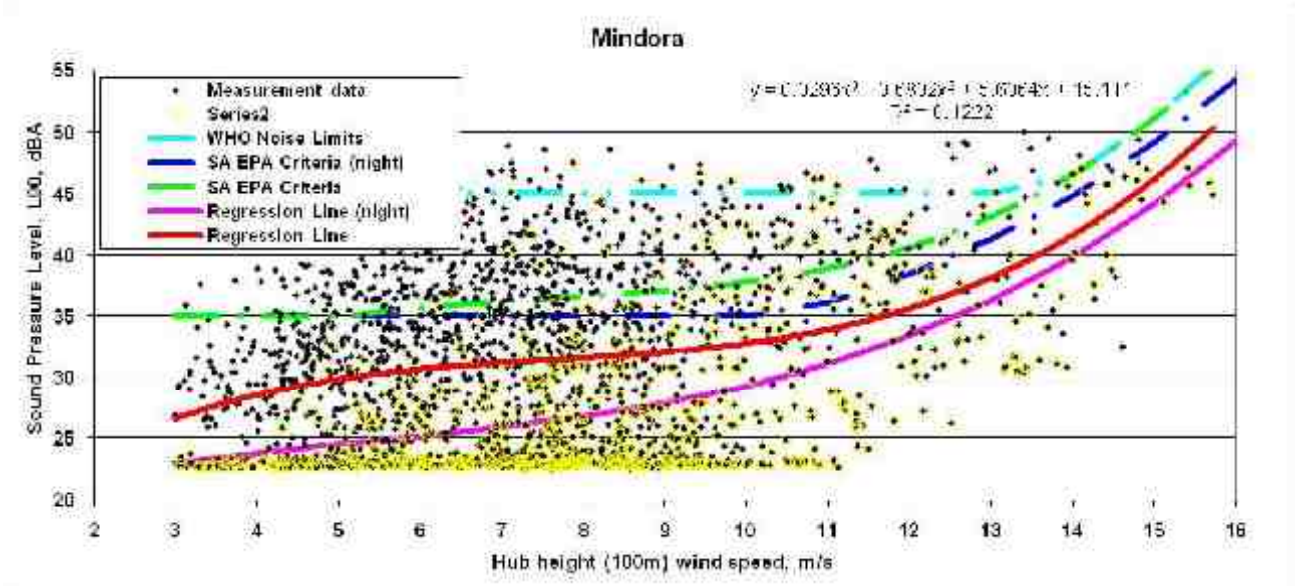
Figure 25 Mindora Measurement Location

The results of the background noise monitoring taken in July 2009, showing the data points, line of best fit and the Noise Criteria Curve are shown in **Figure 26**..

Graphically represented noise statistical indices, together with wind speed are presented in **Appendix C9.**

The Rating Background Level (RBL) was approximately 31 dBA for the day period.

Figure 26 Background Noise Measurements and Noise Criteria Curve – Mindora



6.14 Mt Buckley

The residence of Mt Buckley is located to the southeast of the proposed wind farm approximately 1.2 km from the nearest proposed WTG and is approximately 140 metres to the north of the Gwydir Highway. The residence is protected by topography from the north and north west and has a small number of trees and shrubs around the house yard.

Noise monitoring equipment was placed to the south west of the house, shown in **Figure 27** below.

Background noise levels at this location are relatively high and correlate quite well with wind speed. Monitoring at this location was cut short due to battery failure.

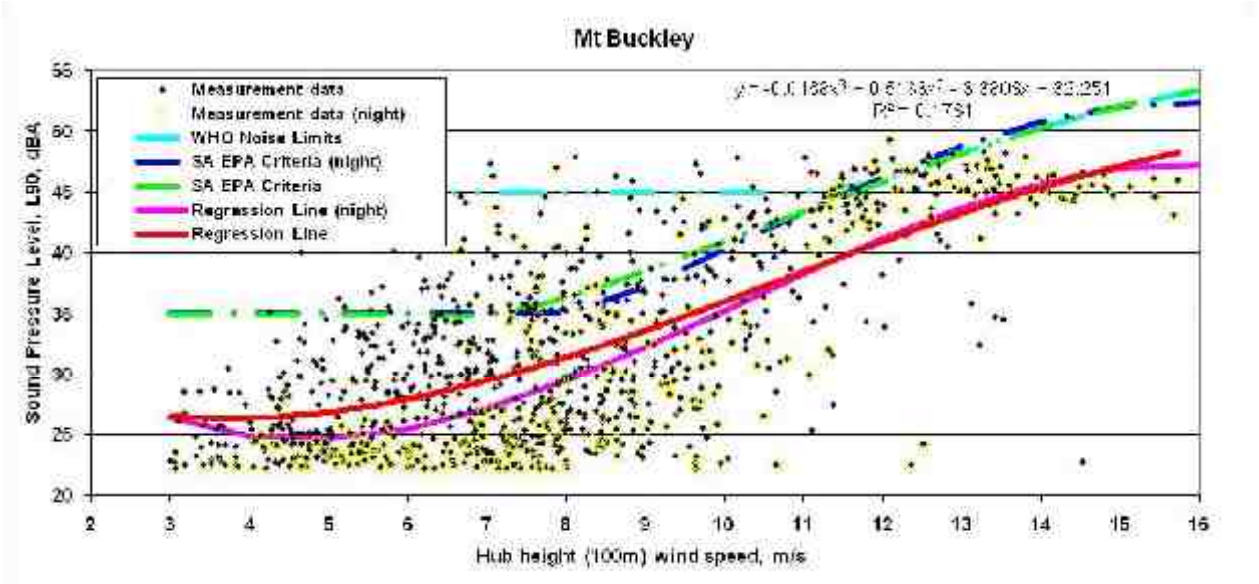
Figure 27 Mt Buckley Measurement Location

The results of the background noise monitoring taken in July 2009, showing the data points, line of best fit and the Noise Criteria Curve are shown in **Figure 28**.

Graphically represented noise statistical indices, together with wind speed are presented in **Appendix C10.**

The Rating Background Level (RBL) was approximately 27 dBA for the day period.

Figure 28 Background Noise Measurements and Noise Criteria Curve – Mt Buckley



6.15 Warrandah

The residence of Warrandah is located to the central west of the proposed wind farm approximately 1.3 km from the nearest proposed WTG and is accessed by the Western Feeder Road. The residence is protected by mature native and deciduous trees and a smaller shrubs and trees in the garden and around the house yard. This residence is occupied by one of the landowners that make up part of the proposed Sapphire Wind Farm site.

Noise monitoring equipment was placed to the west of the house, shown in **Figure 29** below.

Background noise levels at this location are relatively high and correlate quite well with wind speed. Monitoring at this location was cut short due to battery failure.

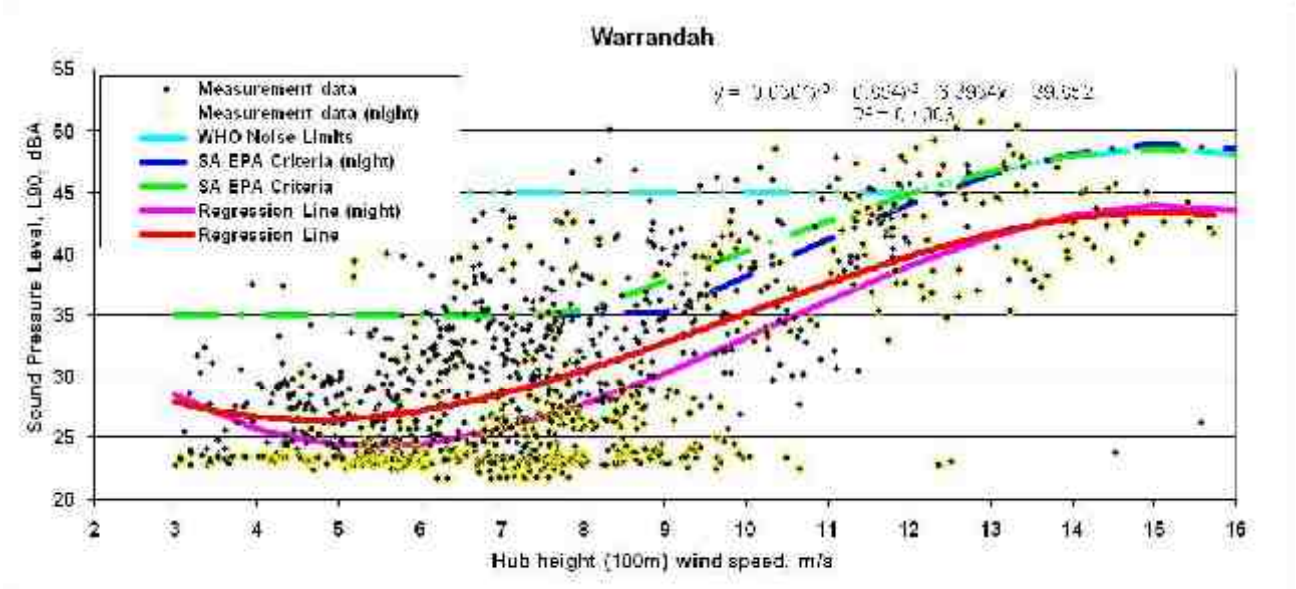
Figure 29 Warrandah Measurement Location

The results of the background noise monitoring taken in July 2009, showing the data points, line of best fit and the Noise Criteria Curve are shown in **Figure 30**.

Graphically represented noise statistical indices, together with wind speed are presented in **Appendix C10.**

The Rating Background Level (RBL) was approximately 27 dBA for the day period.

Figure 30 Background Noise Measurements and Noise Criteria Curve – Warrandah



7 ACOUSTIC ASSESSMENT OF PROPOSED WIND FARM BASE LAYOUT

An assessment of the acceptability of wind farm noise levels at all assessment receivers located within a distance of 6 km of the proposed wind farm was made in accordance with SA EPA Guideline criteria and the pre-existing background noise level regression analysis detailed in **Section 6**.

Results for all four investigated WTG models for the 159 WTG and 125 WTG layouts are shown in **Table 10** of **Section 5.2**, with the predicted noise levels for the 125 WTG layouts slightly higher than those of the 159 WTG layouts.

7.1 Predicted Noise Levels – 159 WTG Layout, Gamesa G87

The assessment figures contained in **Appendix A1** depict the predicted WTG noise level curves for the base 159 WTG layout equipped with Gamesa G87 WTGs at a hub height of 100 metres, superimposed over SA EPA Guideline Criteria and WHO based noise limits.

All non project involved receivers were below the SA EPA Guideline criteria. All receptors would achieve their respective criteria with consideration to the night-time only regression line based limits. Furthermore, most non project involved receivers are predicted to be below the background noise regression line.

All project involved receivers were well below the WHO criteria.

7.2 Predicted Noise Levels – 159 WTG Layout, Vestas V90

The assessment figures contained in **Appendix A2** depict the predicted WTG noise level curves for the base 159 WTG layout equipped with Vestas V90 WTGs at a hub height of 100 metres, superimposed over SA EPA Guideline Criteria and WHO based noise limits.

All non project involved receivers were generally below the *'Background + 5 dBA'* intrusive criteria, with the exception of a single marginal exceedance at 63 Spring Creek (0.2 dBA @ 8.6 m/s). All receptors would achieve their respective criteria with consideration to the night-time only regression line based limits with the exception of the above receiver.

Furthermore, most non project involved receivers are predicted to be below the background noise regression line.

All project involved receivers were well below the WHO criteria.

7.3 Predicted Noise Levels – 125 WTG Layout, Vestas V112

The assessment figures contained in **Appendix A3** depict the predicted WTG noise level curves for the base 159 WTG layout equipped with Vestas V112 WTGs at a hub height of 94 metres, superimposed over SA EPA Guideline Criteria and WHO based noise limits.

All non project involved receivers were generally below the *'Background + 5 dBA'* intrusive criteria, with the exception of a single marginal exceedance at 63 Spring Creek (0.8 dBA @ 8.6 m/s). All receptors would achieve their respective criteria with consideration to the night-time only regression line based limits with the exception of the above receiver.

Furthermore, most non project involved receivers are predicted to be below the background noise regression line.

All project involved receivers were well below the WHO criteria.

7.4 Predicted Noise Levels – 125 WTG Layout, Siemens SWT 101

The assessment figures contained in **Appendix A4** depict the predicted noise level Siemens SWT 101 WTGs 101 metres, superimposed over SA EPA Guideline Criteria and WHO based noise limits.

Non project involved receivers were generally below the *'Background + 5 dBA'* intrusive criteria, with the exception of a marginal exceedance at 240 Krystal Blue (0.8 dBA @ 10 m/s) and a medium exceedance at 63 Spring Creek (2.5 dBA @ 10 m/s). All receptors would achieve their respective criteria with consideration to the night-time only regression line based limits with the exception of the above two receivers.

Furthermore, most non project involved receivers are predicted to be below the background noise regression line.

All project involved receivers were well below the WHO criteria.

7.5 Assessment of Tonality and Infrasound

WTG manufacturers are obliged to conduct independent tests in accordance with IEC 61400-11. A part of this assessment is to conduct a tonal audibility test. The tonal audibility ∆Lta is typically assessed using the methodology outlined in *Joint Nordic Method Version 2 – Objective Method for Assessing the Audibility of Tones in Noise*.

The warranted tonal audibility data ∆La,k values have been supplied by the WTG manufacturers as follows.

Table 16 Audible tonality assessment to IEC 61400-11

Wind speed m/s	Manufacturer/WTG – ∆La,k value – audible tonality			
	Gamesa G87	**Vestas V90**	**Vestas V112**	**Siemens SWT-2.3-101**
3			N/A	No data
4			N/A	≤4
5			N/A	≤4
6	-16.08	-3.74	N/A	≤4
7	-15.55	-4.50	N/A	≤4
8	-13.88	-9.44	N/A	≤4
9	-13.89	-8.17	N/A	≤4
10	-11.26		N/A	≤4

No data is presently available for the Vestas V112 WTG.

For the purposes of the assessment tonality was not deemed to be audible (∆La,k <-3) and hence no penalty has been applied.

Infrasound is not tested as an obligatory part of IEC 61400-11. It is noted that, in general, modern WTGs do not exhibit significant infrasound emissions.

7.6 Project involved residences

The proponent Wind Prospect CWP intends to enter into noise agreements with some project involved residences prior to construction. Under the SA EPA Guidelines these residences are not required to comply to the 35 dBA or 'background + 5 dBA' limits. However, it is necessary to ensure that the project does not result in an 'unreasonable interference' with the amenity of these areas or cause any adverse health affects.

The World Health Organisation (WHO) publication '*Guidelines for Community Noise'* identifies the main health risks associated with noise and derives acceptable environmental noise limits for various activities and environments.

For the assessment of project involved residences the adopted external criteria of 45 dBA or the level given by the SA EPA Guideline criteria, where higher, will be adopted. Effectively this becomes 45 dBA or background + 5 dBA, whichever is the higher.

The predicted noise levels shown in **Table 10** and **Appendix A1, Appendix A2**, **Appendix A3 and Appendix A4** indicate that for all WTG scenarios and wind speeds, external noise levels from WTG's are below 45 dBA.

Predicted external noise levels will be further mitigated by shielding effects of the building, with the anticipated internal noise levels similarly reduced by the façade of the dwelling.

It should be further noted that all predicted noise levels are considered to be conservative with the model assuming 'hard ground', average downwind propagation from all WTG's to each receiver and a well developed moderate ground based temperature inversion, a scenario which is not able to be re-created in reality.

7.7 Temperature Inversions

The SA EPA Guidelines do not require or suggest temperature inversions be included during wind farm noise assessments. The NSW INP states that temperature inversions be included in an assessment if they are deemed to be a prevalent feature of the environment, which generally requires they occur for greater than 30% of the total night-time during winter (approximately two nights per week between 6:00 pm and 7:00 am). Currently there is insufficient data available to accurately determine the prevalence of temperature inversions.

Temperature inversion is an atmospheric condition in which temperature increases with height above ground. Such conditions may increase noise levels by focussing sound wave propagation paths at a single point. Temperature inversions occurring within the lowest 50m to 100m of atmosphere can affect noise levels measured on the ground. Temperature inversions are most commonly caused by radiative cooling of the ground at night leading to cooling of the air in contact with the ground. Such conditions are especially prevalent on cloudless nights with little wind.

Conventional approaches to assessing noise propagation under temperature inversion conditions require knowledge of the temperature gradient and assume that the noise source is located below the temperature inversion, typically near to the ground. The effect of temperature inversions on noise propagation from WTG's is therefore not typical of other sources.

WTG's for the Sapphire Wind Farm project are located on top of elevated ridges. The hub height (assumed acoustic centre of the WTG) is located typically on average 150m higher than receiver locations on the surrounding area. It is therefore unlikely that conventional temperature inversion conditions, in the lower 100m of the atmosphere, would affect noise propagation from such an elevated source.

A further consideration must be that temperature inversions require little to no wind in order to minimise atmospheric mixing and hence develop. During calm conditions the WTGs are unlikely to operate, as cut-in speed is 3m/s.

Notwithstanding the above, an adaptive management approach could be implemented if undue noise impacts are identified during WTG operation that are related to temperature inversion effects.

7.8 Atmospheric stability and wind profile

The wind velocity at a location can be represented by a vertical profile (gradient) that generally is at a minimum at ground level and increases with altitude. The wind velocity profile is primarily determined by physical factors such as surface roughness and topographic (relief) effects, which are reasonably constant over time, however can also be affected by more variable local atmospheric conditions including atmospheric stability and turbulence.

Atmospheric stability is determined by the total heat flux to the ground, primarily being the sum of incoming solar and outgoing thermal radiation and heat exchanged with the air. During clear summer days (incoming radiation dominates) air is heated from below and rises, causing significant thermal mixing, vertical air movements and turbulence. This process limits large variations in the vertical wind velocity profile.

During clear nights when outgoing radiation dominates, air is cooled from below, air density is greatest closer to the ground and minimal thermal mixing occurs. This leads to a stable atmosphere where horizontal layers of air are largely decoupled and allows for a higher wind velocity gradient.

The noise assessment methodology outlined in the SA EPA Guidelines, as do many other similar wind farm noise assessment methodologies, by necessity rely on the independently verified reference sound power data available for specific wind turbines measured at a manufacturer's test site. The measurement procedure has been standardised (IEC 61400-11) to require sound power data to be measured coincidentally with reference wind speed measurements at an altitude of 10 metres.

As discussed in **Section 5.2** the SA EPA Guideline methodology has been adapted to the alternative reference wind speed at a height of 100 metres AGL which is more representative of hub height wind speed. Accordingly the turbine sound power level data has been amended to the appropriate 100 metre AGL wind speed. This approach goes some way to alleviating the variability that changing wind profiles has with respect to a 10 metre reference height.

While the proposed layouts meet the requirements of the SA EPA Guidelines, some uncertainty remains as to the likely noise conditions that will result under specific atmospheric conditions over time. The SA EPA Guidelines noise limits are generally set within the requirements of the WHO Guidelines that relate to health impacts, and it is highly unlikely that the remaining uncertainty could lead to health impacts. However, it is possible that under certain conditions the amenity of existing dwellings could be reduced notwithstanding compliance with SA EPA Guidelines. These conditions are likely to be variable and intermittent, and not result in a long-term loss in amenity.

An adaptive management approach could be implemented if undue noise impacts are identified during WTG operation that are related to elevated WTG noise levels during stable atmosphere conditions.

7.9 Adaptive Management

If undue WTG noise impacts are identified during operations due to temperature inversion, atmospheric stability or other reasons, then an ‘adaptive management’ approach can be implemented to mitigate or remove the impact. This process could include;

- Receiving and documenting noise impact complaint through ‘hotline’ or other means.
- Investigating the nature of the reported impact.

- Identifying exactly what conditions or times lead to undue impacts.
- Operating WTG's in a reduced 'noise optimised' mode during identified times and conditions (sector management).
- Turning off WTG's that are identified as causing the undue impact.
- Providing acoustic upgrades (glazing, façade, masking noise etc) to affected dwellings.

7.10 Wind Turbine Vibration

Vibration or more specifically the oscillatory movement of receptor structures could potentially propagate from a source (in this case a wind farm) through either a ground path (ground borne vibration) or an airborne path as sound which could couple with lightweight structures and produce a movement in the structure.

7.10.1 Ground borne

Ground borne vibration levels attenuate with distance with varying amounts dependant upon such variables as frequency and geotechnical parameters. There are a few documented research reports with regards to wind farm generated ground vibration.

The Snow Report (*Low Frequency Noise & Vibration Measurements at a Modern Wind Farm*, ETSU W/13/01392/REP, D J Snow, 1997) describes measurements taken at a wind farm consisting of eleven 450 kW WTG's, where noise and vibration measurements were taken at increasingly distant points up to 1 kilometre. Low frequency vibration was determined down to 0.1 Hz with varying wind speeds and on/off operation. The research found that the absolute level of vibration signals measured at any frequency at 100 metres from the nearest WTG were significantly below the most stringent criteria given by BS 6472:1992 Evaluation of human exposure to vibration in buildings (1Hz to 80Hz). Furthermore vibration in the 0.5Hz to 1Hz range remained at similar levels when the wind farm was not operating, suggesting that the vibration measured may have been due to other (ambient) sources.

Detailed *Microseismic and infrasound monitoring of low frequency noise and vibrations from wind farms* were undertaken by the Applied and Environmental Geophysics Group of Keele University as part of a comprehensive report giving '*Recommendations on The Siting of Wind Farm in the Vicinity the Eskdalemuir, Scotland*'. The Eskadelmuir Seismic Array (EKA) is in the southern uplands of Scotland and is sited on a very quiet magnetic and seismic environment with twin 9 km long lines of seismometer instrumentation which are sensitive enough to pick up nuclear explosions from up to 15,000 km away. It should be noted that the objective of the study was to measure vibration levels many orders of magnitude lower than project criteria detailed in **Section 2.7**

The Eskdalemuir report details results taken from St Breock Downs wind farm (possibly the same measurements taken in the Snow Report). From the documented seismic vibration measurements taken at 25 metres from a single WTG a peak particle velocity (PPV) of approximately $8x10^{-5}$ mm/s has been calculated. This is approximately 2500 orders of magnitude lower than project criteria. Whilst we note that turbines proposed for Sapphire Wind Farm are larger than those measured above we are confident that ground vibration will be completely imperceptible at surrounding receptors. Furthermore, our own experience and observations at other operating wind farms has not indicated perceptible ground vibration at any distance from turbines.

7.10.2 Air borne

A good deal of misunderstanding and attention has been given in recent times to low frequency noise and infrasound generated by wind farms. Infrasound at sufficient levels has the potential to be perceived as vibration or alternatively cause the movement of lightweight structures which then in turn are perceived as vibration. It should be noted that the sometimes audible cyclical modulation of aerodynamic noise, the '*swish swish'* of blades, is often mistakenly identified as low frequency noise, where it actually is the low frequency modulation of audible noise.

The subject is most complex, dealing with frequencies that are sub audible, requiring alternative frequency weighting scales, specialist measurement equipment and techniques, and evaluating the variance of hearing sensitivity in a population at low frequency. Furthermore, it will depend on many variables including turbine type and size, wind conditions (including turbulence), propagation distance, building structure and materials, room sizing and positioning within room.

Comprehensive review, measurement testing and evaluation are offered in numerous technical reports investigating infrasound and low frequency noise from wind farms including;

A Review of Published Research on Low Frequency Noise and its Effects - Report for Defra by Dr Geoff Leventhall assisted by Dr Peter Pelmear and Dr Stephen Benton - 2002 (refer http://www.defra.gov.uk/environment/quality/noise/research/lowfrequency/documents/lowfreqnoise.pdf)

The Measurement of Low Frequency Noise at Three UK Wind Farms - report for DTI by Hayes McKenzie Partnership – 2006 (refer http://www.berr.gov.uk/files/file31270.pdf)

Wind turbines & Infrasound 2006 - Report for Canadian Wind Energy Association (CanWEA) by Howe Gastmeier Chapnik Limited (HGC Engineering) - 2006 (refer http://www.canwea.ca/images/uploads/File/CanWEA_Infrasound_Study_Final.pdf)

Wind Farms Technical Paper – Environmental Noise – report for Clean Energy Council Australia by Sonus Pty Ltd – 2010 (refer http://www.cleanenergycouncil.org.au/cec/mediaevents/media-releases/November2010/sonus-report.html)

The consensus drawn by all investigations is that infrasound noise emissions from modern WTG's are significantly below the recognised threshold of perception for acoustic energy within this range.

8 ASSESSMENT OF CONSTRUCTION NOISE & VIBRATION LEVELS

8.1 Construction Noise

The appropriate criteria for construction noise are provided in the Interim Construction Noise Guidelines (DECC, 2009) (See **Sections 2.2** and **2.6**).

Construction activities include;

- construction of access roads,
- establishment of turbine tower foundations and electrical substation,
- digging of trenches to accommodate underground power cables,
- erection of turbine towers and assembly of WTG's.

The equipment required to complete the above tasks will typically include;

- excavator/grader, bulldozer, dump trucks, vibratory roller
- bucket loader, rock breaker, drill rig, excavator/grader, bulldozer, dump truck, flat bed truck, concrete truck
- excavator, flat bed trucks
- cranes, fork lift, and various 4WD and service vehicles.

The anticipated construction period is anticipated to be less than 18 to 24 months, with civil works expected to span approximately 12 to 15 months, however, due to the large area of the wind farm site, intensive works will be located within a distance of potential impact for each surrounding residential receiver for only very short and intermittent periods of time.

It is anticipated that most construction will occur during standard construction hours and it is therefore considered appropriate that construction noise levels up to 10 dBA above the RBLs would be acceptable. Construction noise levels greater than 10 dBA above RBL could be considered as noise affected. At levels greater than 75 dBA receptors would be considered highly noise affected by construction noise.

Computer noise models of typical construction scenarios were developed which included all anticipated mobile equipment for the activity operating simultaneously at full load. A de-rating factor of 8 dBA was selected to convert modelled full load simultaneous operation to typical operations of multiple mobile construction vehicles.

To look at the possible worst case construction scenario for all nearby receivers, all four different construction activities were modelled at each turbine location and the highest noise levels for each receiver predicted.

The resulting predicted construction noise level for the relevant 'worst case' scenario is detailed in **Table 17** together with the Rating Background Level (RBL) obtained during the background noise monitoring campaign.

Table 17 Predicted Construction Noise Levels (dBA)

		1. Road Building	2. Trench Digging	3 Foundation establishment	3 Foundation establishment	4. WTG erection
Receptor	RBL + 10	Vibrating Roller	Excavator	Rock Breaker	Concrete Batch Plant	Crane
0 Woodlands	37	11	3	22	18	3
1 Rock Leigh	39	24	16	35	19	16
2 Royal Oaks	41	25	17	36	24	17
8 Woodstock*	48	27	19	38	27	19
11 Kingshill*	48	41	33	**52**	33	33
16 Narren Vale*	48	39	31	**50**	34	31
19 Wongajong	39	15	7	26	13	7
21 Inverness	41	21	13	32	24	13
23 Mindora	36	26	18	**37**	24	18
24 Millie	41	23	15	34	22	15
26 Coleraine	37	32	24	**43**	19	24
27 Bellview	37	20	12	31	21	12
28 Leeweena*	41	40	32	**51**	**42**	32
29 Swamp Oak	36	20	12	31	16	12
30 Highlands*	39	22	14	33	34	14
32 Warrandah*	39	27	19	38	28	19
34 Croye	48	22	14	33	24	14
37 Lochlea*	36	28	20	**39**	25	20
38 Yarrandoo*	37	30	22	**41**	35	22
40 Nolimba	48	27	19	38	19	19
43 Ardleigh*	39	20	12	31	23	12
45 Golden Grove	39	24	16	35	25	16
53 Lochbore	39	18	10	29	15	10
54 Carinya*	41	36	28	**47**	30	28
55 Tara	36	14	6	25	16	6
59 Mubbarra*	39	39	31	**50**	**45**	31
60 Woodburn*	37	27	19	**38**	29	19
63 Spring Creek	41	34	26	**45**	25	26
65 Roseana	36	21	13	32	17	13
70 Warrawee	39	22	14	33	19	14
71 Tralee*	39	37	29	**48**	28	29
74 Hillview	39	26	18	37	23	18
84 Argyle	39	27	19	38	24	19
85 Yarrabin*	41	33	25	**44**	**44**	25
87 The Knoll	39	23	15	34	18	15
89 Glenidle	41	11	3	22	14	3
90 Kings Plains Castle*	39	8	-	19	11	-

		1. Road Building	2. Trench Digging	3 Foundation establishment	3 Foundation establishment	4. WTG erection
Receptor	RBL + 10	Vibrating Roller	Excavator	Rock Breaker	Concrete Batch Plant	Crane
91 Derra Downs*	39	**40**	32	**51**	31	32
93 Weean	39	19	11	30	16	11
96 Bon Vista	36	26	18	**37**	20	18
97 Manaroo*	39	34	26	**45**	36	26
104 Meadow Vale	37	19	11	30	24	11
105 Cubba*	36	19	11	30	22	11
106 Glen Valley	41	20	12	31	21	12
109 Strathdarr	36	30	22	**41**	32	22
110 Pine Grove	39	20	12	31	26	12
111 Kia-Tami*	39	28	20	**39**	30	20
112 Windemere*	39	13	5	24	23	5
115 Evergreen	39	22	14	33	26	14
118 Fassifern	48	19	11	30	19	11
134 Wangalee	48	15	7	26	15	7
137 Tarana	36	24	16	35	24	16
139 Fruin Glen*	46	28	20	39	31	20
145 Karoola	37	29	21	**40**	33	21
153 Mt Buckley	37	28	20	**39**	23	20
157 Greenfield	46	22	14	33	22	14
163 Fairy Meadow*	37	22	14	33	25	14
170 Tauraurga*	46	34	26	45	36	26
175 Falkland*	46	34	26	45	28	26
179 Waterloo	37	11	3	22	17	3
185 Farley	37	30	22	**41**	23	22
194 Down Field*	37	**38**	30	**49**	33	30
195 Pitiochry	46	20	12	31	21	12
199 Springfield	37	15	7	26	18	7
208 Adavale	46	17	9	28	26	9
215 Rutherglen	37	25	17	36	20	17
219 Maids Valley	46	23	15	34	22	15
220 Quabadee	37	11	3	22	21	3
224 Osterley*	37	**38**	30	**49**	28	30
226 Coorimbla Park*	37	24	16	35	26	16
227 Yarrawa Park*	37	27	19	**38**	28	19
229 Cottages*	46	8	0	19	11	0
230 Ashgrove	46	23	15	34	23	15
231 Swan Peak	37	22	14	33	23	14
233 Weean Cottage	41	18	10	29	17	10
234 House #2	36	35	27	**46**	32	27

		1. Road Building	2. Trench Digging	3 Foundation establishment	3 Foundation establishment	4. WTG erection
Receptor	RBL + 10	Vibrating Roller	Excavator	Rock Breaker	Concrete Batch Plant	Crane
235 Waterloo Cottage	41	7	-	18	17	-
237 Blumkaitis	39	18	10	29	17	10
238 Tomali Park	41	25	17	36	22	17
239 Frasers Creek	41	29	21	40	24	21
240 Krystal Blue	36	34	26	**45**	24	26
241 Pieta	36	24	16	35	19	16
242 Glen Idle	46	16	8	27	22	8
245 Willow View	46	17	9	28	16	9
246 937	37	16	8	27	16	8
247 962	39	23	15	34	19	15
249 Yardwell	41	17	9	28	16	9
251 Blue Grove	37	16	8	27	14	8
252 DA Approved	37	16	8	27	15	8
253 Highview	37	17	9	28	16	9
254 Tantangra	37	18	10	29	16	10
257 311*	37	29	21	**40**	25	21
258 Lambert	37	12	4	23	18	4
259 Alkoomie	37	27	19	**38**	22	19
260 Linden Lea	37	20	12	31	22	12
261 Wirra Willa	37	27	19	**38**	21	19

* Denotes the property is involved with the project

The predicted 'worst case' construction noise impacts are for most receiver locations below the existing typical daytime rating background level.

Some nearby receivers may receive elevated construction noise levels (cells highlighted in red) and be would classified as 'noise affected' when turbine foundation civil works are located nearby and should the operation of a rock breaker be necessary, however, due to the anticipated short period of localised works would likely be considered satisfactory. Operation of the rock-breaker is dependent upon the geotechnical conditions of the foundation site and would be operated intermittently at most. Consideration for mitigative measures such as localised shrouding may be needed if adverse conditions are experienced if and when operating the rock-breaker at the most exposed positions.

No predicted levels exceed 75 dBA and therefore no receptors would be considered as being highly noise affected.

In consideration that the predicted levels represent 'worst case' construction scenarios and are within limits which would be considered acceptable, it is unlikely that construction noise will cause any unnecessary impact.

8.1.1 Concrete Batching Plants

Portable concrete batching plants (combined SWL 115 dBA) may be required to supply concrete onsite. Up to eight batch plant locations may be required to minimise the distance between the batching plant and the foundations being poured. Batching plant equipment may be relocated between the sites as the works progress to different areas of the site.

A noise model was developed to assess noise from the different concrete batching plant locations. The predicted noise levels for the proposed batch plant sites at the nearest affected properties are shown in the sixth column of **Table 17.**

In most cases concrete batch plant noise will be below ambient background noise levels and likely be inaudible. The three highlighted receptor locations are anticipated to be greater than 10 dBA above the daytime RBL and classified as 'noise affected'. No locations are anticipated to be 'highly noise affected'.

8.2 Construction Vibration Assessment

The activities and equipment with the potential to generate the highest levels of ground vibration are the operation of the vibratory roller during construction of access roads and the operation of the rock breaker during establishment of turbine tower foundations. Typical vibration levels from these sources are presented in **Table 18**.

Table 18 Typical Vibration Emission Levels from Construction Plant

Activity	PPV Vibration Level (mm/s) at Distance		
	10m	**20m**	**30m**
4-Tonne Vibratory Roller	2.0 - 2.4	0.4 - 1.2	0.2 - 0.8
Hydraulic Hammer (30t)	3	1.5	1.0

It is evident that given the large distances between receptors and structures where construction works are likely to be undertaken (refer **Appendix E**), the building damage and human comfort vibration criteria will easily be met during construction.

8.3 Blasting

8.3.1 Blasting Assessment

Blasting may be required in some areas to clear large rock outcrops to prepare turbine foundations.

The proposed wind farm site is a green field site where no previous blasting or blast monitoring has been conducted and therefore no specific site laws exist. We have therefore adopted a site law derived from measurement data at a different site to give an indicative result.

The 5% site laws for ground vibration and airblast are:

Ground Vibration $PVS\ (5\%) = 16202\ (SD_1)^{-2.03}$

Airblast $SPL(5\%) = 189.3 - 31.8 \log (SD_2)$

where PVS (5%) and SPL (5%) are the levels of ground vibration (Peak Vector Sum - mm/s) and airblast (dB Linear) respectively, above which 5% of the total population (of data points) will lie, assuming that the population has the same statistical distribution as the underlying measured sample.

SD_1 and SD_2 are the ground vibration and airblast scaled distances, where:

$$SD_1 = \frac{\text{Distance}}{\sqrt{\text{MIC}}} \quad (m.kg^{-0.5})$$

and,

$$SD_2 = \frac{\text{Distance}}{\sqrt[3]{\text{MIC}}} \quad (m.kg^{-0.33})$$

Based on the blast emissions site laws, calculations were also conducted to indicate the allowable MIC's for compliance with the general EPA Human Comfort criteria of 115 dB Linear (airblast) and 5 mm/s (ground vibration).

The closest anticipated distance between blasting and residences would be approximately 1000 metres (Kingshill). At this distance the predicted maximum MIC of up to 90 kg is likely to produce an airblast overpressure below the acceptable level of 115 dB Linear. An MIC of 90kg is expected to result in a vibration level (Peak Vector Sum) of 1.25 mm/s well within the recommended maximum level of 5 mm/s in the ANZECC Guidelines.

It is evident that the anticipated blasting is likely to meet all human comfort limits and building damage assessment criteria are easily met. All other sources of vibration would be less then above.

8.4 Traffic Noise

Traffic generated by the project during its construction phase has been evaluated in *Traffic and Transport Study: Proposed Sapphire Wind Farm* (February 2011) prepared by Bega Duo Designs. Traffic generated by the project during its operational phase will be insignificant.

Project construction traffic for the Sapphire wind farm will primarily utilise the Gwydir Highway and areas to the east accessed from Polhill Road and to the north from Kings Plains Road. Project areas to the west or centre of the project are located along or accessed from Waterloo Road or the Eastern Feeder Road or the Western Feeder Road.

The projected maximum construction traffic on proposed access roads represent in some cases a significant increase in traffic movements as shown in **Table 19.**

The projected increase in road traffic noise levels on all local roads is expected to be greater than 2 dBA during peak construction periods, however, road traffic noise levels are anticipated to meet the Roads and Traffic Authority of NSW (RTA) *Environmental Criteria for Road Traffic Noise (ECRTN) 1999* target for a local road of daytime $L_{Aeq(1\ hour)}$ = 55 dBA at modest setback distances. We note that being a rural farming community that most receptors are at much greater setback distances from their road frontage and therefore will easily meet the ECRTN requirement.

Table 19 Construction Traffic Noise

Proposed Access Road	VPD Current	VPD Projected Maximum Construction Traffic *	Projected increase in existing road traffic noise level	ECRTN classification	ECRTN requirement	Approximate distance at which ECRTN requirement is achieved
Gwydir Highway	1360	Up to 250	0.7 dBA	Freeway / Arterial	$L_{eq(15hr)}$ 60 dBA	60 m
Waterloo Road	60	Up to 250	7 dBA	Local	$L_{eq(1hr)}$ 55 dBA	40 m
Pollhil Road	< 50	Up to 250	7 dBA	Local	$L_{eq(1hr)}$ 55 dBA	<40 m
Western Feeder Road	< 50	Up to 250	7 dBA	Local	$L_{eq(1hr)}$ 55 dBA	<40 m
Kings Plain Road	< 200	Up to 250	4 dBA	Local	$L_{eq(1hr)}$ 55 dBA	60 m

Note * assumes that concrete is delivered from Glenn Innes or Inverell and is not produced by local batching plant.

8.4.1 Night-time deliveries

There could potentially be deliveries of equipment scheduled for out of hours, necessitated by traffic congestion considerations and safe passage of heavy vehicle convoys or especially long loads. Night-time traffic has the potential to cause sleep disturbance to residential receivers along the route. This potentially affects receivers situated closer to the road such as in Glenn Innes.

Preliminary calculations indicate that maximum noise levels at a residence approximately 10 metres from the road as a result of a heavy vehicle pass-by would be in the range 45-80 dBA. We would anticipate that night-time background noise levels along affected routes could be as low as 30 dBA and as such maximum noise levels from pass-bys may have the potential for sleep disturbance. However, the Gwydir Highway is already a significant route (~1400 vpd) and carries significant heavy vehicles and it is unlikely project related night-time traffic would be of any greater impact than vehicles already using the route.

To minimise potential noise impacts associated with night-time deliveries some potential measures to be considered are;

- Prior notification of affected public where night-time convoys are scheduled
- Restricted use of exhaust/engine brakes in built up areas

9 CONCLUSION

WTG noise for four indicative WTG models and 2 layouts has been predicted and assessed against relevant criteria prescribed by the SA EPA Guideline and World Health Organisation (WHO) goals where appropriate. An evaluation of night-time baseline data was also included.

The 159 WTG layout equipped with Gamesa G87 WTGs at a hub height of 100 metres, was predicted to comply with all relevant noise criteria, SA EPA Guideline and WHO limits, at all respective receivers.

The 159 WTG layout equipped with Vestas V90 WTGs at a hub height of 100 metres, was predicted to generally comply with all relevant noise criteria, SA EPA Guideline and WHO limits, at all respective receivers except for 1 marginal (<0.5 dBA) exceedance.

The 125 WTG layout equipped with Vestas V112 WTGs at a hub height of 100 metres, was predicted to generally comply with all relevant noise criteria, SA EPA Guideline and WHO limits, at all respective receivers except for 1 marginal (<1 dBA) exceedance.

The 125 WTG layout equipped with Siemens SWT 101 WTGs at a hub height of 101 metres, was predicted to generally comply with all relevant noise criteria, SA EPA Guideline and WHO limits, at all respective receivers except for 1 marginal (<1 dBA) exceedance and one medium (<3 dBA) exceedance.

All project involved receivers were below the WHO criteria.

The project is yet to select and finalise the WTG make and model. Upon finalising the WTG model a revised noise prediction and assessment will be completed in which the noise impact mitigation techniques listed in **Section 7.9** will be investigated thoroughly to produce a fully compliant layout.

WTG vibration levels have been evaluated and based upon overseas research available were found to be acceptable.

Construction noise and vibration impacts have been assessed and the ‘worst case’ scenarios modelled were found to be generally acceptable.

Blasting impact has been assessed and found to be acceptable. With a maximum instantaneous charge (MIC) of up to 90 kg, the airblast overpressure is anticipated to be below the acceptable level of 115 dB Linear for all existing residences. Similarly, vibration levels are anticipated to be well below the acceptable criteria.

Construction traffic noise impact has been assessed and the ‘worst case’ maximum construction traffic generated scenario would increase existing traffic noise levels along local roads by up to 4-7 dBA but due to the typically large setback of dwellings from the road network would result in noise level that would be considered acceptable under the ECRTN.

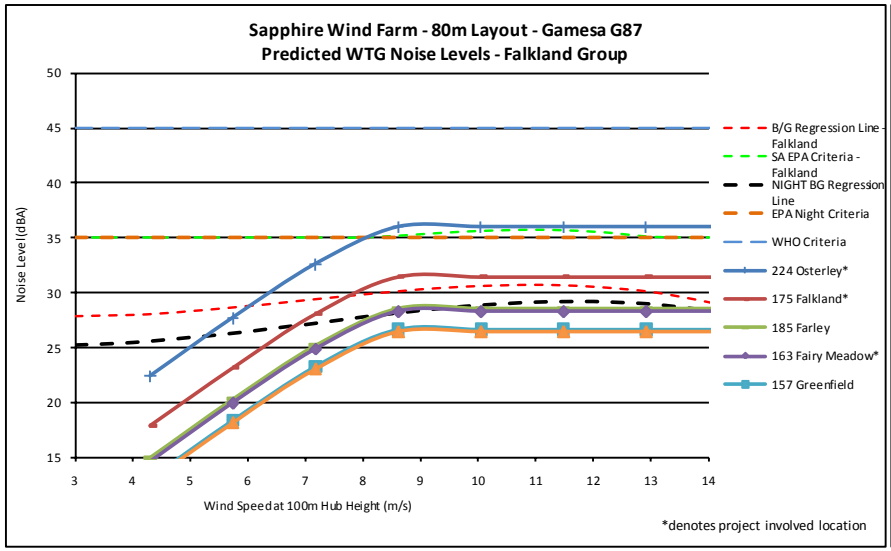
10 CLOSURE

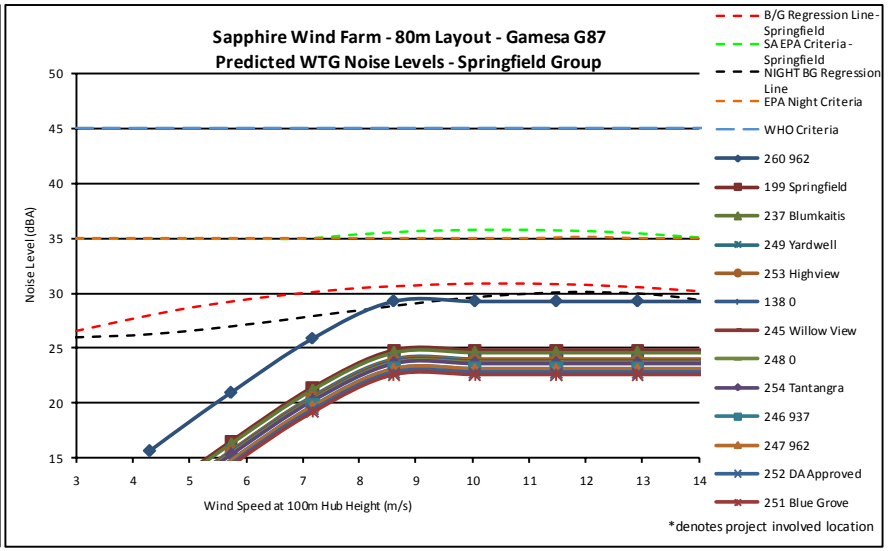
This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted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

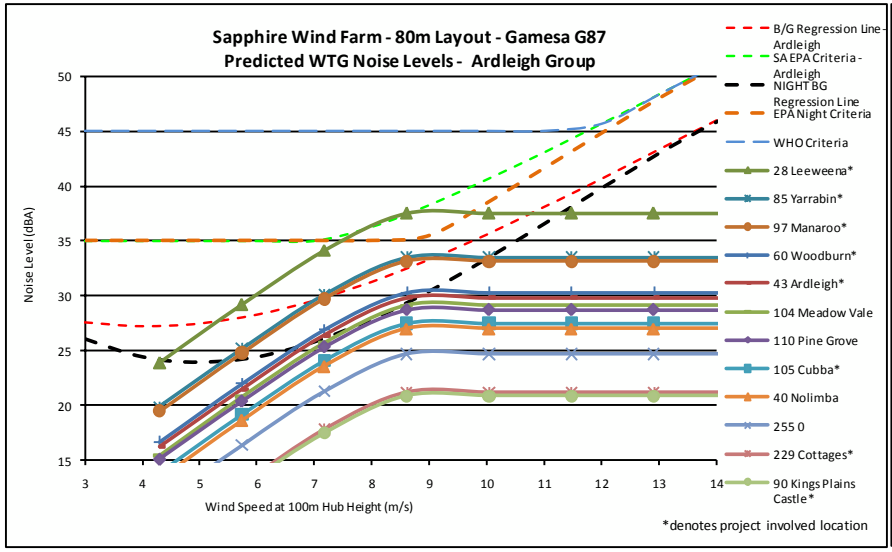
This report is for the exclusive use of Wind Prospect CWP Pty Ltd. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR Consulting.

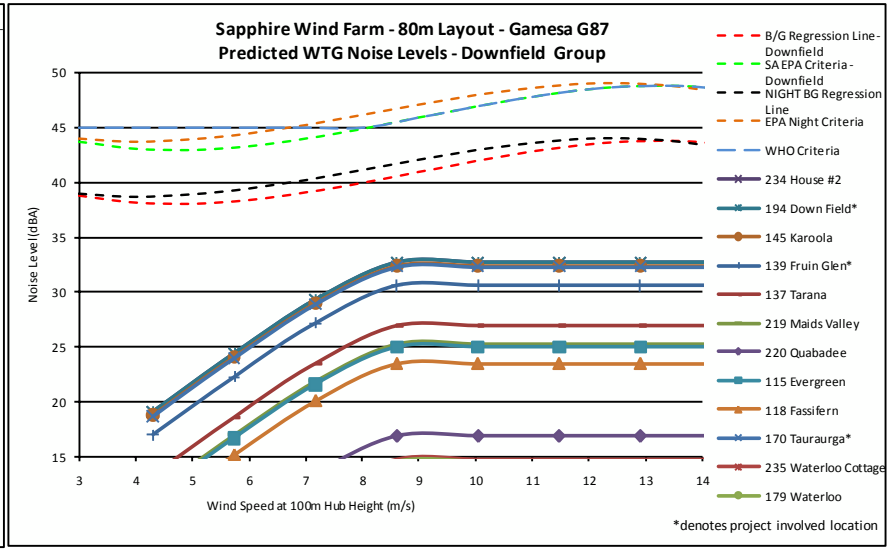
SLR Consulting disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.

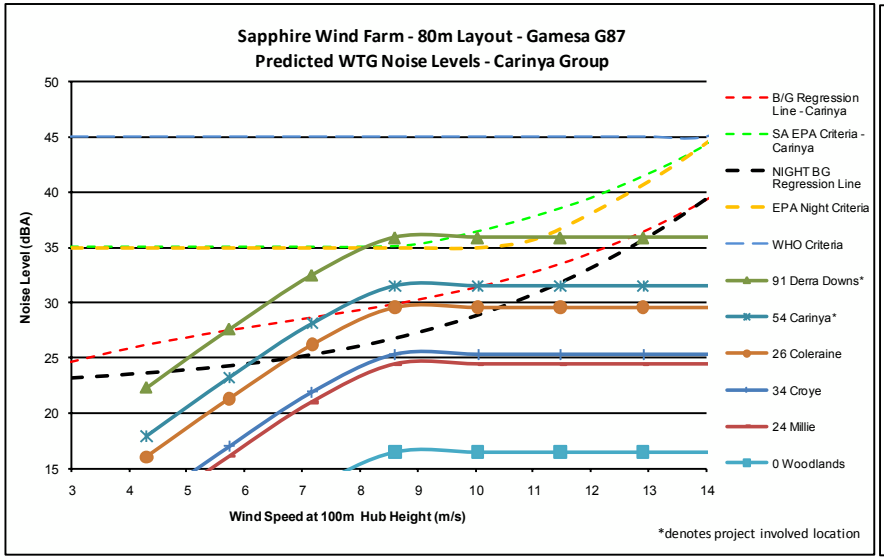
Appendix A-1
WTG Noise Assessment Curves
Gamesa G87

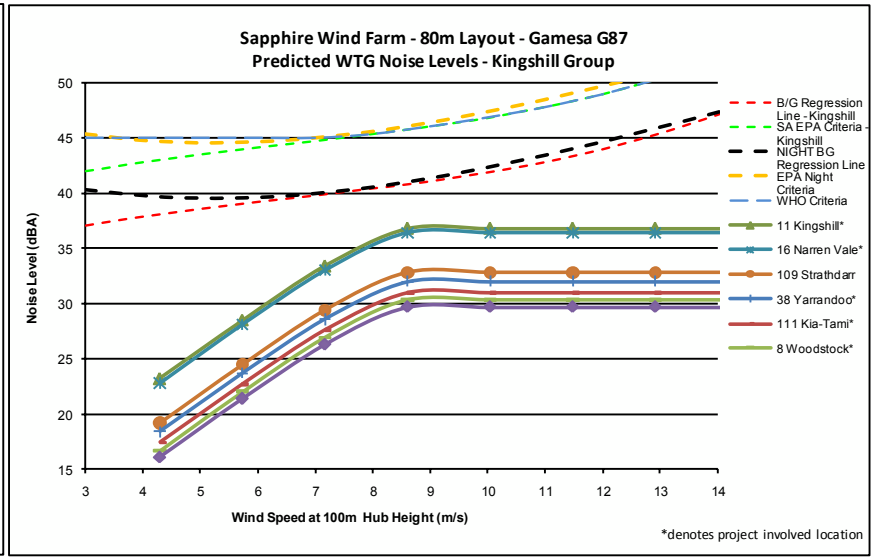

Sapphire Wind Farm - 80m Layout - Gamesa G87
Predicted WTG Noise Levels - Falkland Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Falkland
SA EPA Criteria - Falkland
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
224 Osterley*
175 Falkland*
185 Farley
163 Fairy Meadow*
157 Greenfield
*denotes project involved location

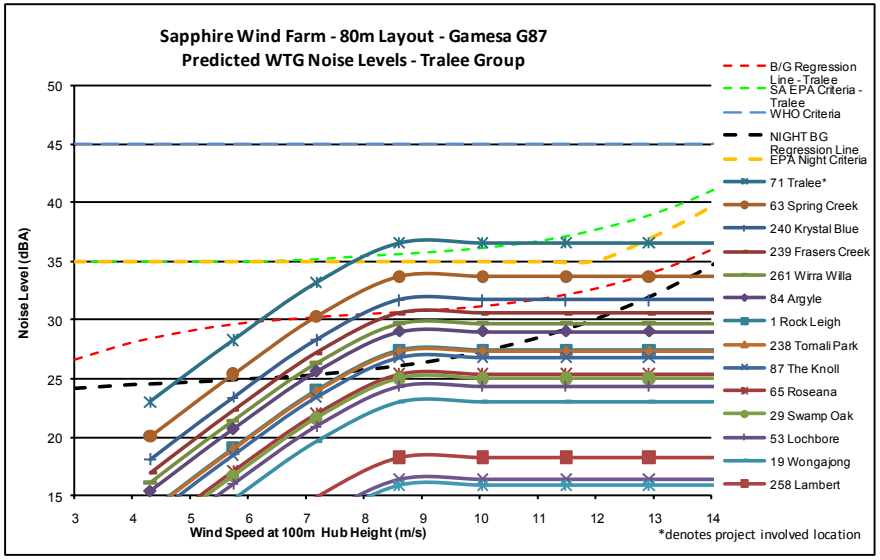

Sapphire Wind Farm - 80m Layout - Gamesa G87
Predicted WTG Noise Levels - Springfield Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Springfield
SA EPA Criteria - Springfield
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
260 962
199 Springfield
237 Blumkaitis
249 Yardwell
253 Highview
138 0
245 Willow View
248 0
254 Tantangra
246 937
247 962
252 DA Approved
251 Blue Grove
*denotes project involved location

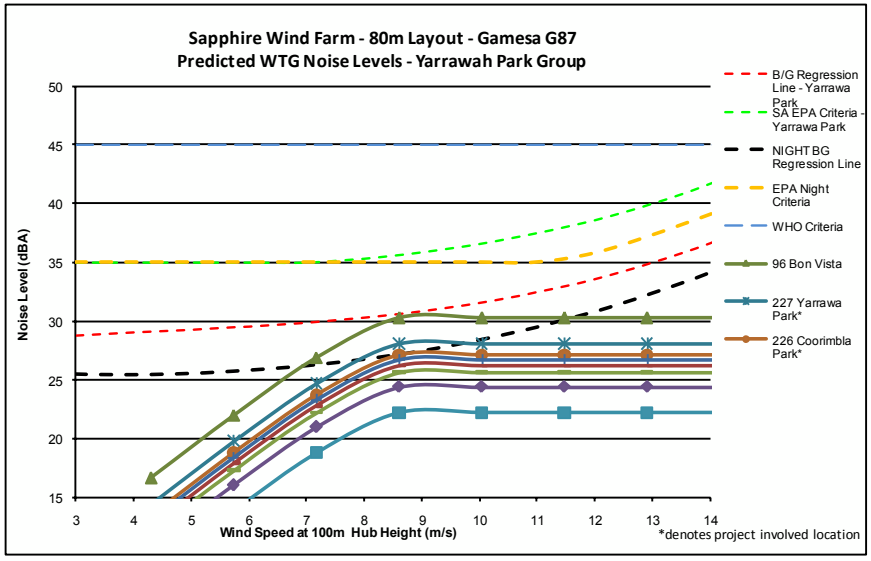

Sapphire Wind Farm - 80m Layout - Gamesa G87
Predicted WTG Noise Levels - Ardleigh Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Ardleigh
SA EPA Criteria - Ardleigh
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
28 Leeweena*
85 Yarrabin*
97 Manaroo*
60 Woodburn*
43 Ardleigh*
104 Meadow Vale
110 Pine Grove
105 Cubba*
40 Nolimba
255 0
229 Cottages*
90 Kings Plains Castle*
*denotes project involved location

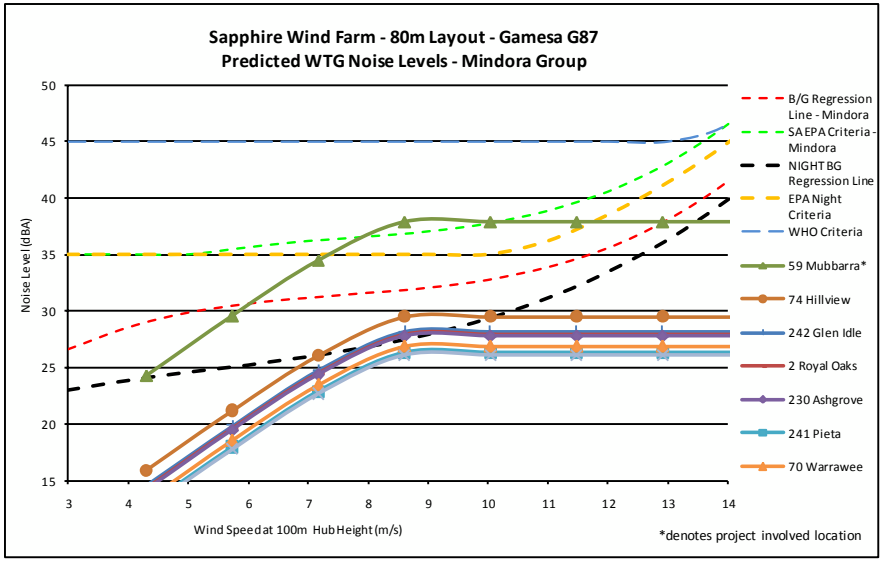

Sapphire Wind Farm - 80m Layout - Gamesa G87
Predicted WTG Noise Levels - Downfield Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Downfield
SA EPA Criteria - Downfield
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
234 House #2
194 Down Field*
145 Karoola
139 Fruin Glen*
137 Tarana
219 Maids Valley
220 Quabadee
115 Evergreen
118 Fassifern
170 Taurauga*
235 Waterloo Cottage
179 Waterloo
*denotes project involved location

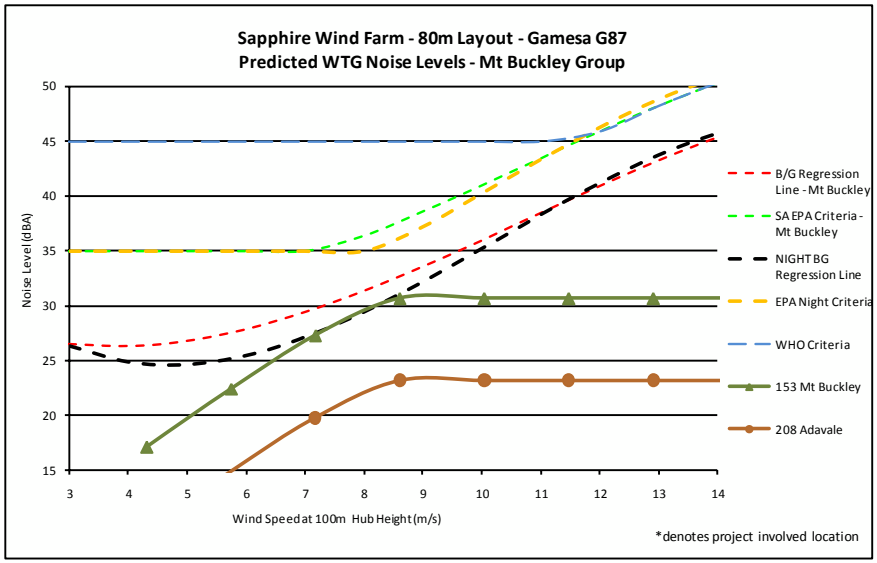

Sapphire Wind Farm - 80m Layout - Gamesa G87
Predicted WTG Noise Levels - Carinya Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Carinya
SA EPA Criteria - Carinya
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
91 Derra Downs*
54 Carinya*
26 Coleraine
34 Croye
24 Millie
0 Woodlands
*denotes project involved location

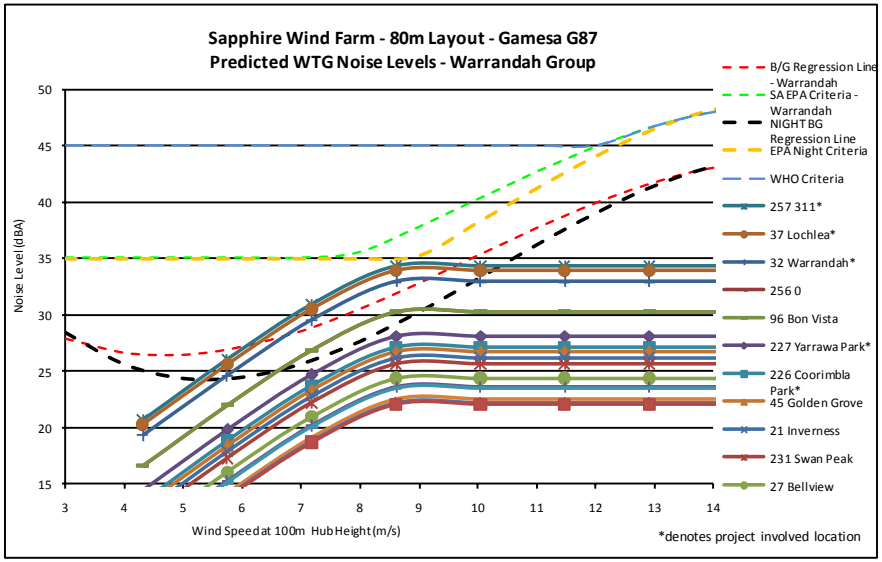

Sapphire Wind Farm - 80m Layout - Gamesa G87
Predicted WTG Noise Levels - Kingshill Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Kingshill
SA EPA Criteria - Kingshill
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
11 Kingshill*
16 Narren Vale*
109 Strathdarr
38 Yarrandoo*
111 Kia-Tami*
8 Woodstock*
*denotes project involved location


Sapphire Wind Farm - 80m Layout - Gamesa G87
Predicted WTG Noise Levels - Tralee Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Tralee
SA EPA Criteria - Tralee
WHO Criteria
NIGHT BG Regression Line
EPA Night Criteria
71 Tralee*
63 Spring Creek
240 Krystal Blue
239 Frasers Creek
261 Wirra Willa
84 Argyle
1 Rock Leigh
238 Tomali Park
87 The Knoll
65 Roseana
29 Swamp Oak
53 Lochbore
19 Wongajong
258 Lambert
*denotes project involved location

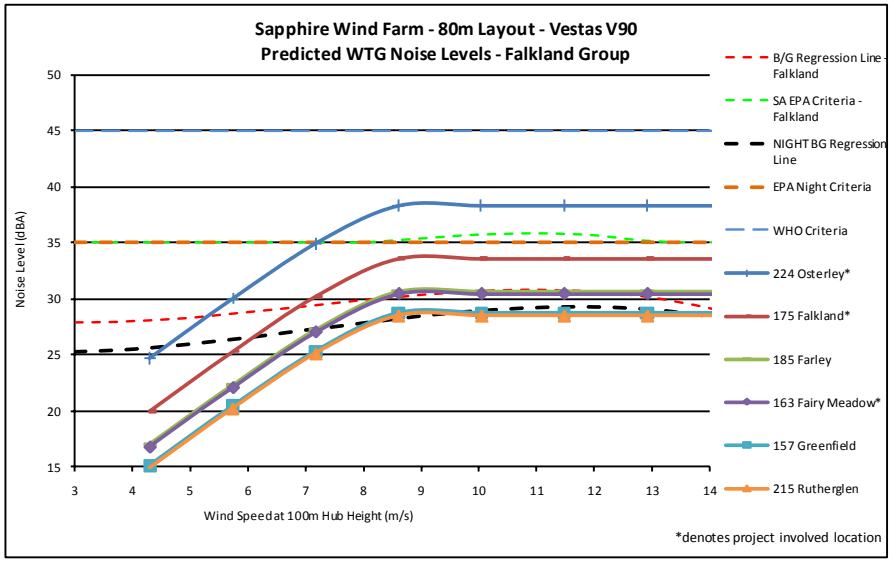

Sapphire Wind Farm - 80m Layout - Gamesa G87
Predicted WTG Noise Levels - Yarrawah Park Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Yarrawa Park
SA EPA Criteria - Yarrawa Park
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
96 Bon Vista
227 Yarrawa Park*
226 Coorimbla Park*
*denotes project involved location

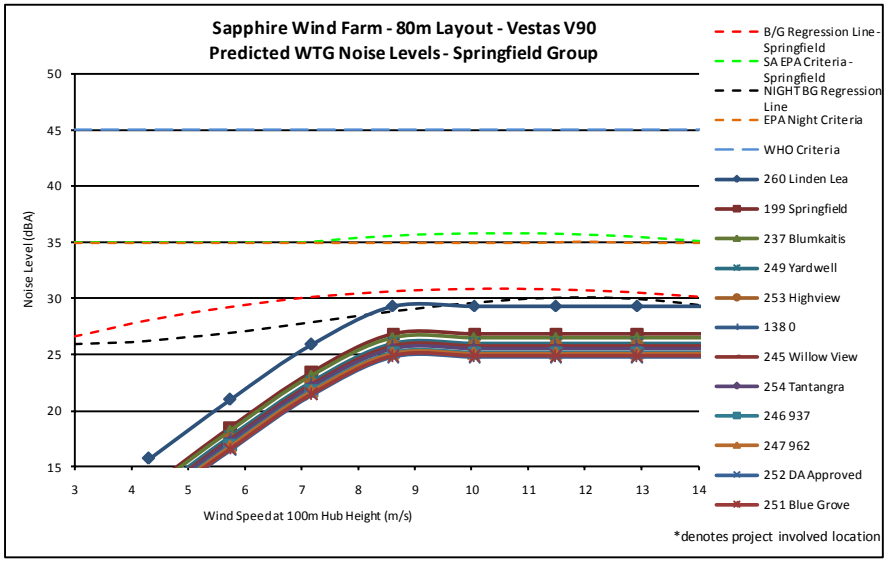

Sapphire Wind Farm - 80m Layout - Gamesa G87
Predicted WTG Noise Levels - Mindora Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Mindora
SA EPA Criteria - Mindora
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
59 Mubbarra*
74 Hillview
242 Glen Idle
2 Royal Oaks
230 Ashgrove
241 Pieta
70 Warrawee
*denotes project involved location

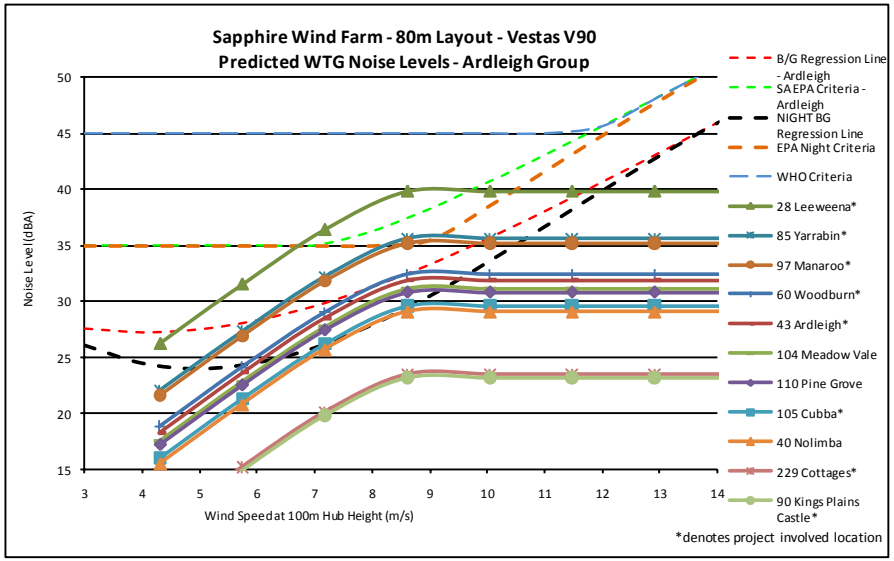

Sapphire Wind Farm - 80m Layout - Gamesa G87
Predicted WTG Noise Levels - Mt Buckley Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Mt Buckley
SA EPA Criteria - Mt Buckley
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
153 Mt Buckley
208 Adavale
*denotes project involved location

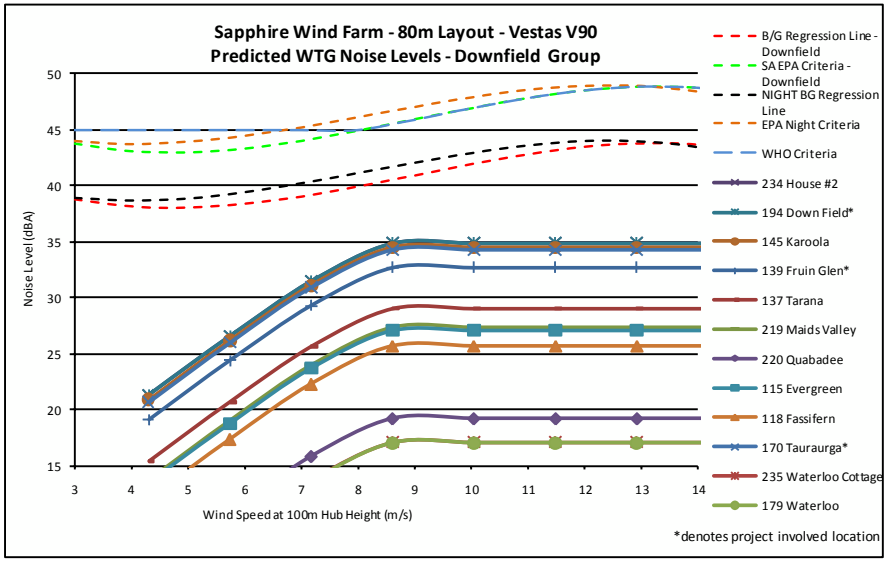

Sapphire Wind Farm - 80m Layout - Gamesa G87
Predicted WTG Noise Levels - Warrandah Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Warrandah
SA EPA Criteria - Warrandah
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
257 311*
37 Lochlea*
32 Warrandah*
256 0
96 Bon Vista
227 Yarrawa Park*
226 Coorimbla Park*
45 Golden Grove
21 Inverness
231 Swan Peak
27 Bellview
*denotes project involved location

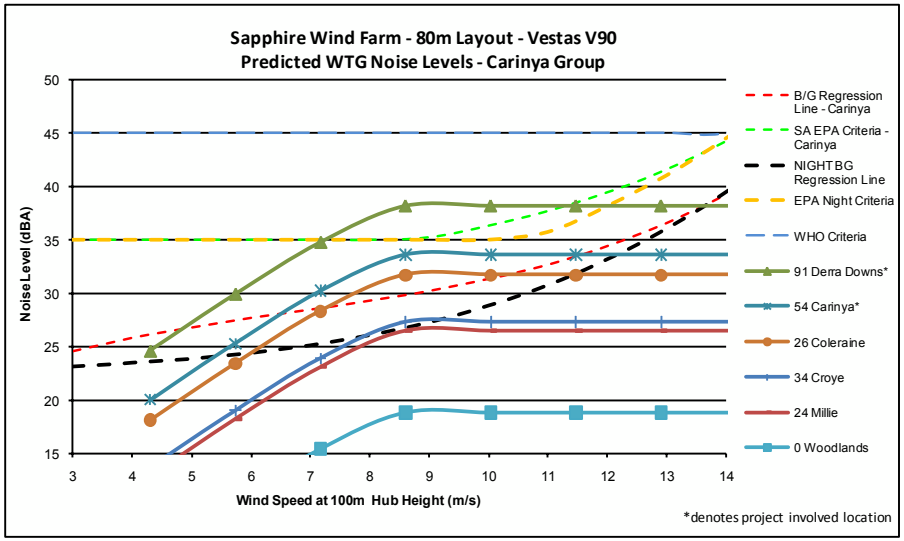
Appendix A-2
WTG Noise Assessment Curves
Vestas V90

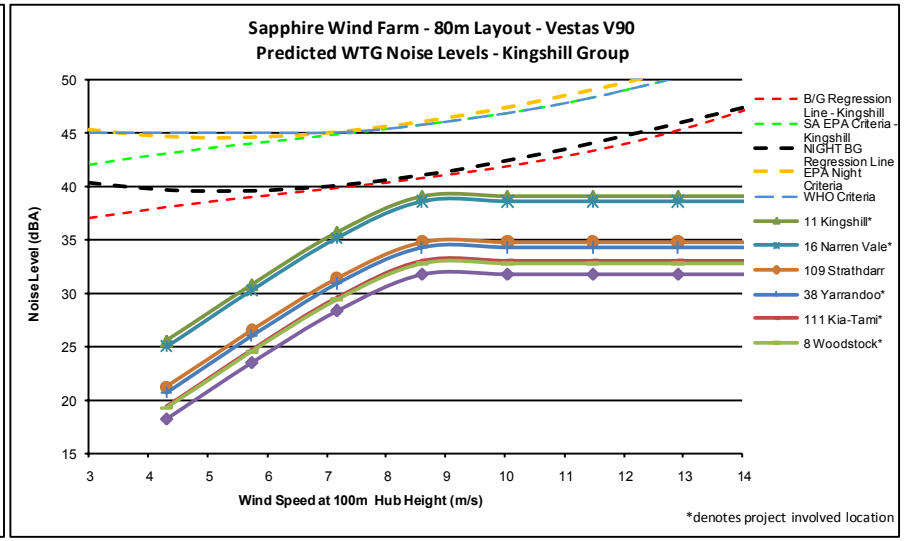

Sapphire Wind Farm - 80m Layout - Vestas V90
Predicted WTG Noise Levels - Falkland Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Falkland
SA EPA Criteria - Falkland
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
224 Osterley*
175 Falkland*
185 Farley
163 Fairy Meadow*
157 Greenfield
215 Rutherglen
*denotes project involved location

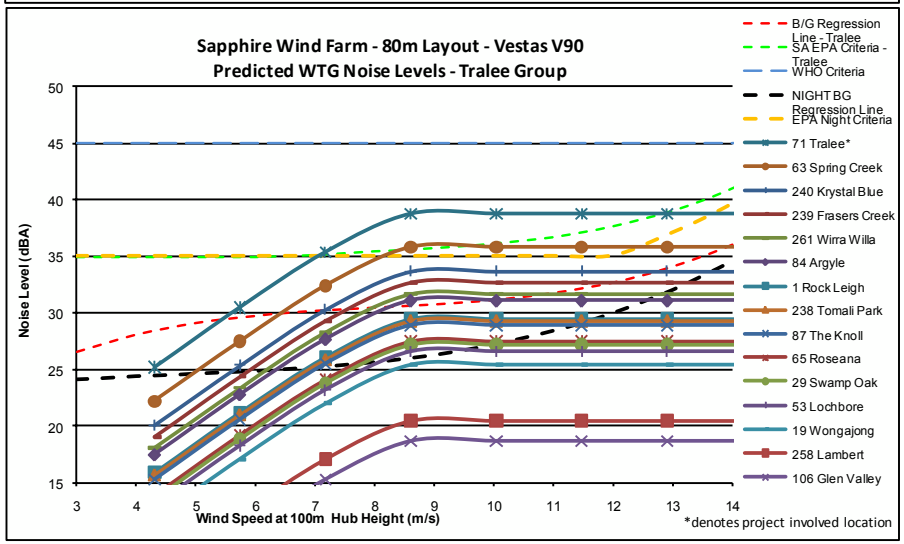

Sapphire Wind Farm - 80m Layout - Vestas V90
Predicted WTG Noise Levels - Springfield Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Springfield
SA EPA Criteria - Springfield
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
260 Linden Lea
199 Springfield
237 Blumkaitis
249 Yardwell
253 Highview
138 0
245 Willow View
254 Tantangra
246 937
247 962
252 DA Approved
251 Blue Grove
*denotes project involved location

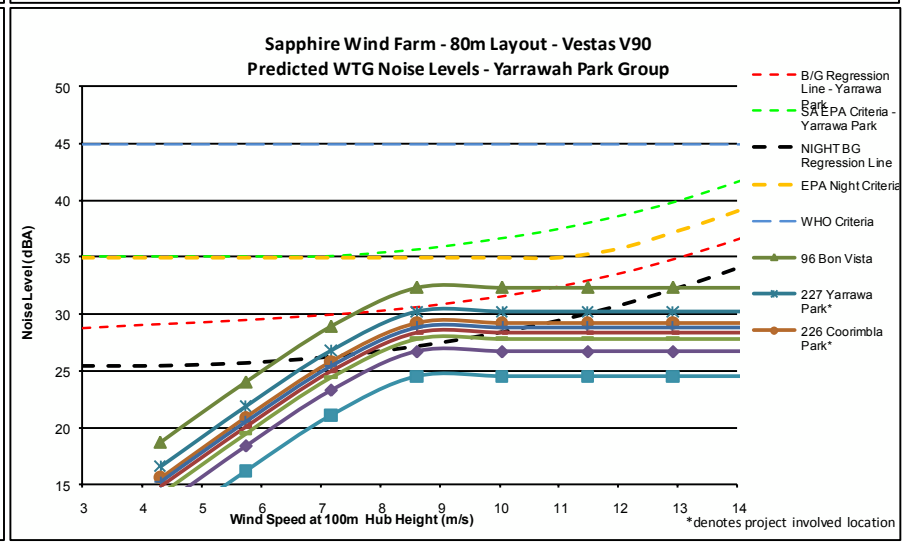

Sapphire Wind Farm - 80m Layout - Vestas V90
Predicted WTG Noise Levels - Ardleigh Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Ardleigh
SA EPA Criteria - Ardleigh
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
28 Leeweena*
85 Yarrabin*
97 Manaroo*
60 Woodburn*
43 Ardleigh*
104 Meadow Vale
110 Pine Grove
105 Cubba*
40 Nolimba
229 Cottages*
90 Kings Plains Castle*
*denotes project involved location

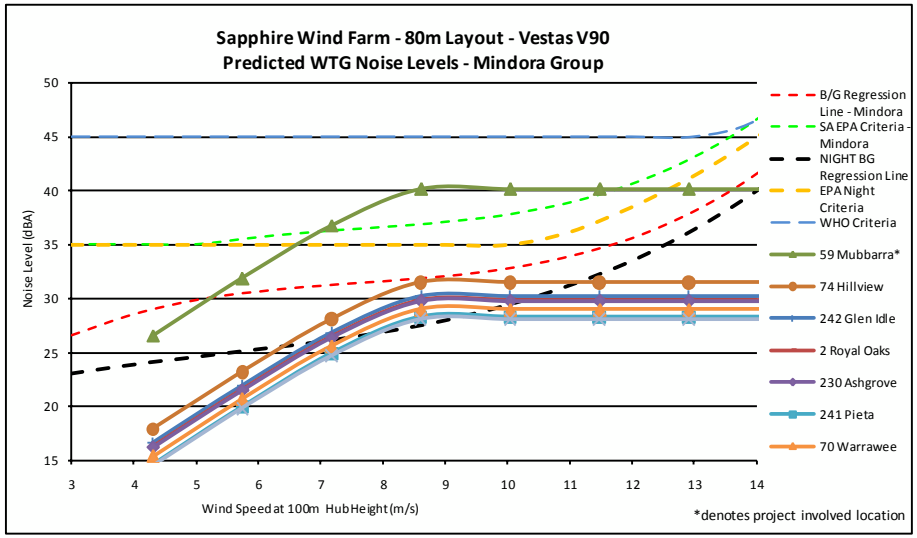

Sapphire Wind Farm - 80m Layout - Vestas V90
Predicted WTG Noise Levels - Downfield Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Downfield
SA EPA Criteria - Downfield
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
234 House #2
194 Down Field*
145 Karoola
139 Fruin Glen*
137 Tarana
219 Maids Valley
220 Quabadee
115 Evergreen
118 Fassifern
170 Taurauga*
235 Waterloo Cottage
179 Waterloo
*denotes project involved location

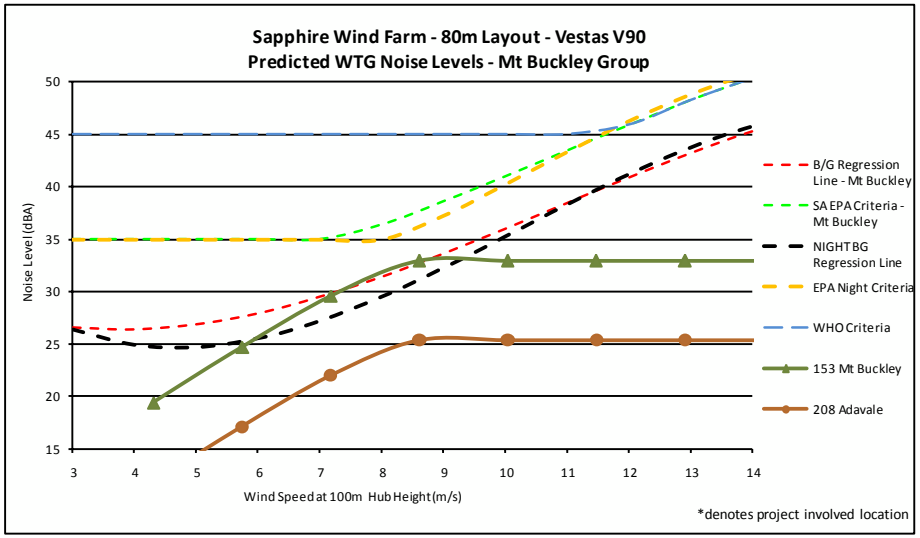

Sapphire Wind Farm - 80m Layout - Vestas V90
Predicted WTG Noise Levels - Carinya Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Carinya
SA EPA Criteria - Carinya
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
91 Derra Downs*
54 Carinya*
26 Coleraine
34 Croye
24 Millie
0 Woodlands
*denotes project involved location

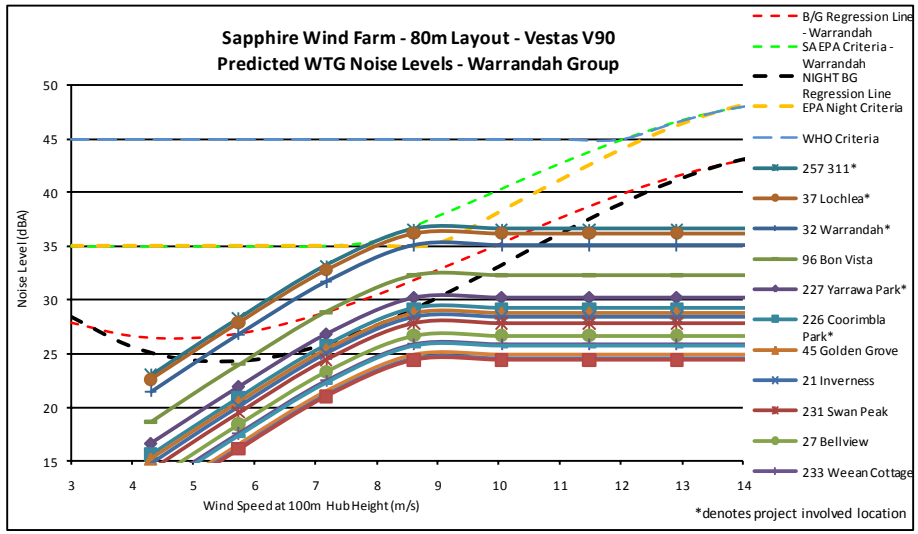

Sapphire Wind Farm - 80m Layout - Vestas V90
Predicted WTG Noise Levels - Kingshill Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Kingshill
SA EPA Criteria - Kingshill
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
11 Kingshill*
16 Narren Vale*
109 Strathdarr
38 Yarrandoo*
111 Kia-Tami*
8 Woodstock*
*denotes project involved location


Sapphire Wind Farm - 80m Layout - Vestas V90
Predicted WTG Noise Levels - Tralee Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Tralee
SA EPA Criteria - Tralee
WHO Criteria
NIGHT BG Regression Line
EPA Night Criteria
71 Tralee*
63 Spring Creek
240 Krystal Blue
239 Frasers Creek
261 Wirra Willa
84 Argyle
1 Rock Leigh
238 Tomali Park
87 The Knoll
65 Roseana
29 Swamp Oak
53 Lochbore
19 Wongajong
258 Lambert
106 Glen Valley
*denotes project involved location

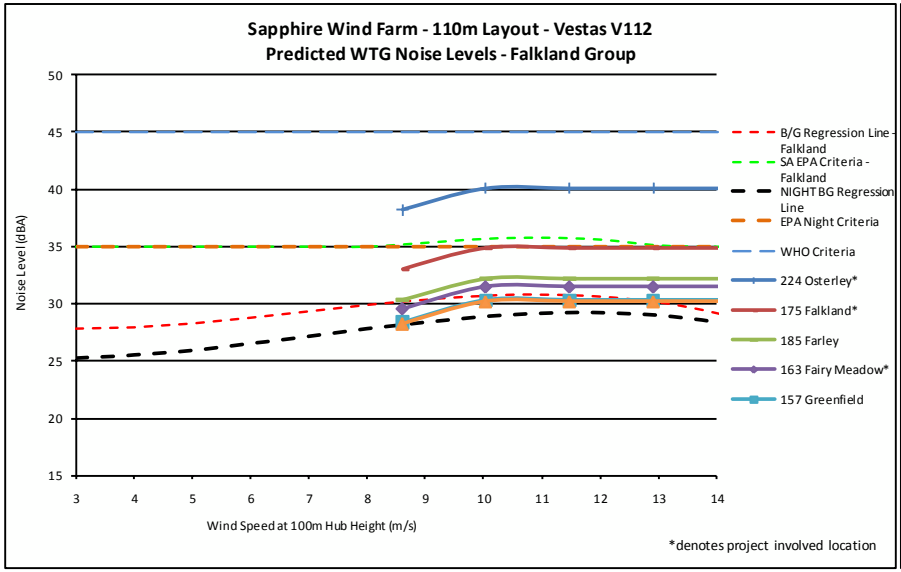

Sapphire Wind Farm - 80m Layout - Vestas V90
Predicted WTG Noise Levels - Yarrawah Park Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Yarrawa Park
SA EPA Criteria - Yarrawa Park
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
96 Bon Vista
227 Yarrawa Park*
226 Coorimbla Park*
*denotes project involved location

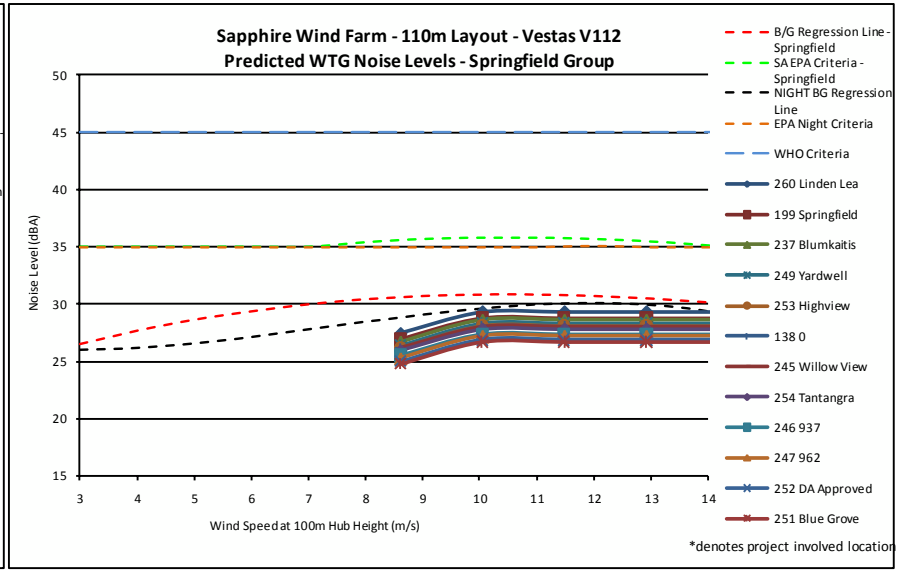

Sapphire Wind Farm - 80m Layout - Vestas V90
Predicted WTG Noise Levels - Mindora Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Mindora
SA EPA Criteria - Mindora
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
59 Mubbarra*
74 Hillview
242 Glen Idle
2 Royal Oaks
230 Ashgrove
241 Pieta
70 Warrawee
*denotes project involved location

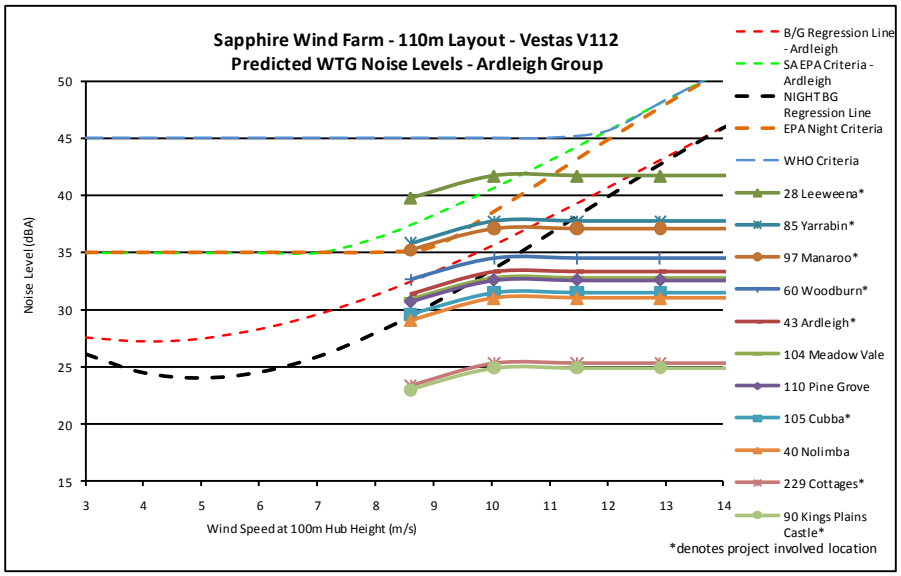

Sapphire Wind Farm - 80m Layout - Vestas V90
Predicted WTG Noise Levels - Mt Buckley Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Mt Buckley
SA EPA Criteria - Mt Buckley
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
153 Mt Buckley
208 Adavale
*denotes project involved location

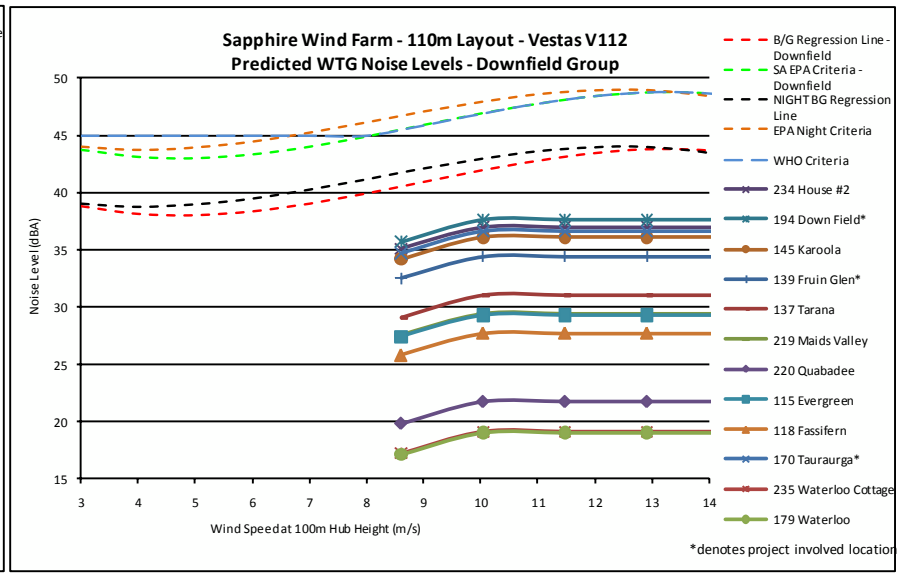

Sapphire Wind Farm - 80m Layout - Vestas V90
Predicted WTG Noise Levels - Warrandah Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Warrandah
SA EPA Criteria - Warrandah
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
257 311*
37 Lochlea*
32 Warrandah*
96 Bon Vista
227 Yarrawa Park*
226 Coorimbla Park*
45 Golden Grove
21 Inverness
231 Swan Peak
27 Bellview
233 Weean Cottage
*denotes project involved location

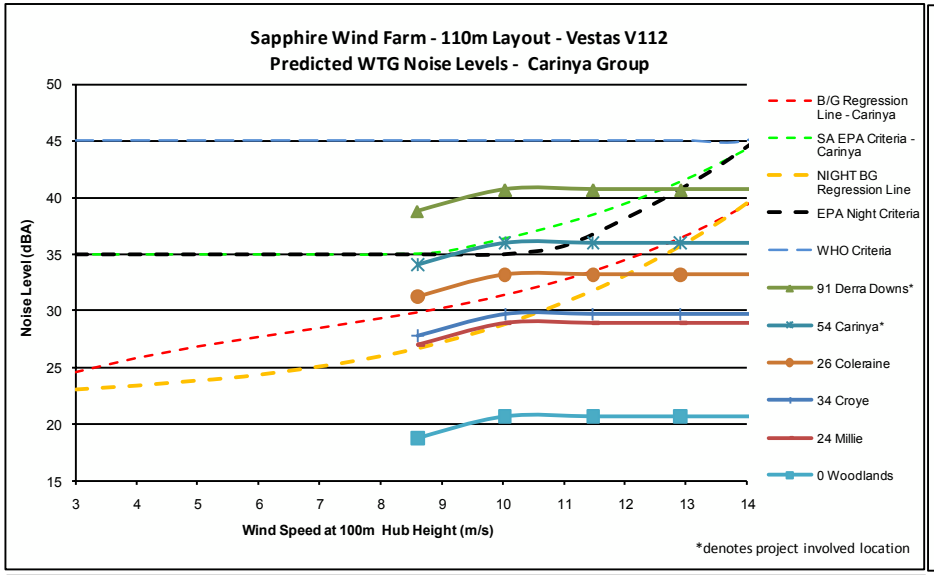
Appendix A-3
WTG Noise Assessment Curves
Vestas V112

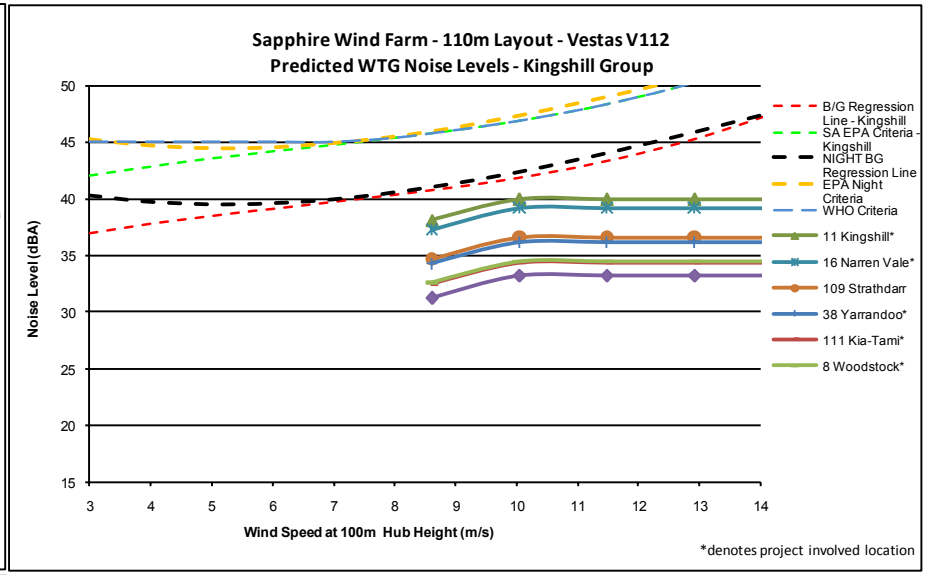

Sapphire Wind Farm - 110m Layout - Vestas V112
Predicted WTG Noise Levels - Falkland Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Falkland
SA EPA Criteria - Falkland
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
224 Osterley*
175 Falkland*
185 Farley
163 Fairy Meadow*
157 Greenfield
*denotes project involved location

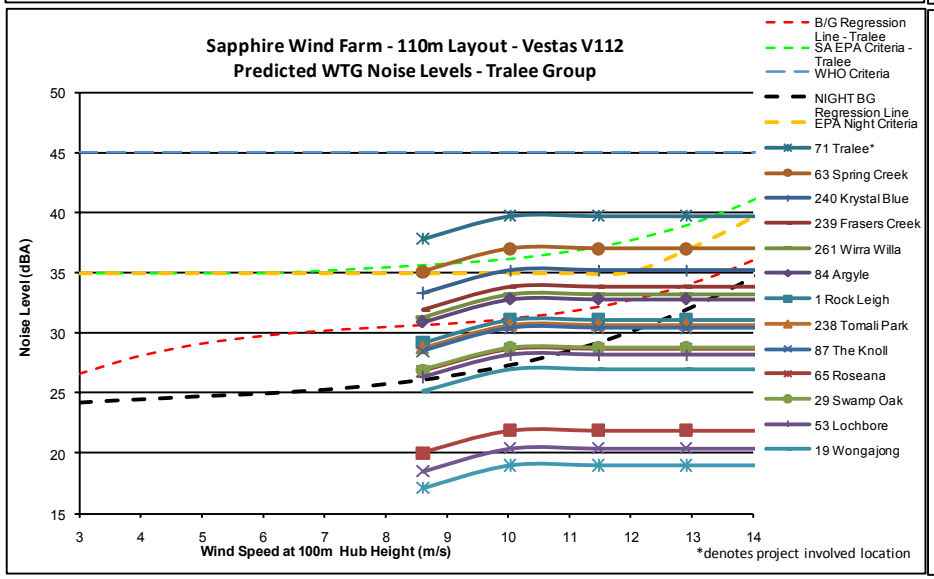

Sapphire Wind Farm - 110m Layout - Vestas V112
Predicted WTG Noise Levels - Springfield Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Springfield
SA EPA Criteria - Springfield
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
260 Linden Lea
199 Springfield
237 Blumkaitis
249 Yardwell
253 Highview
138 0
245 Willow View
254 Tantangra
246 937
247 962
252 DA Approved
251 Blue Grove
*denotes project involved location

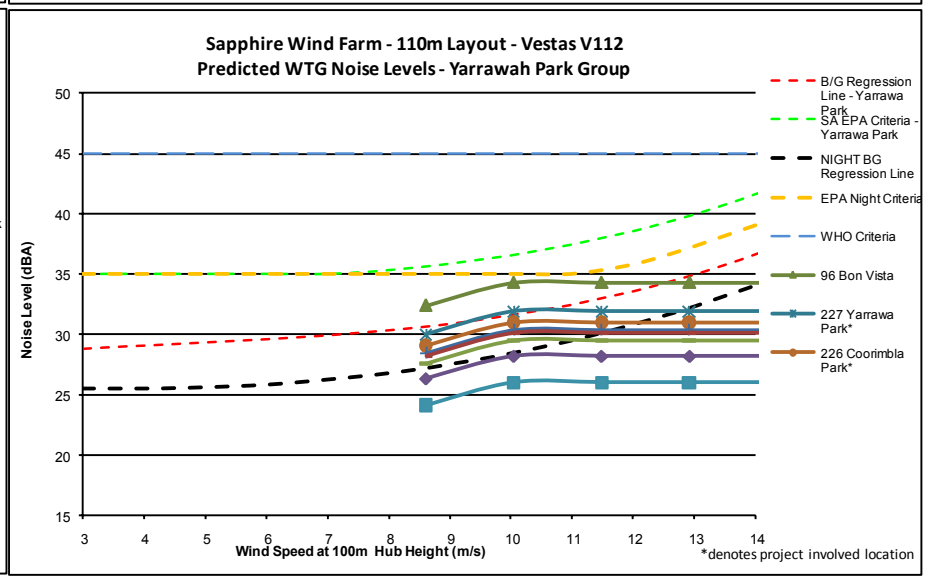

Sapphire Wind Farm - 110m Layout - Vestas V112
Predicted WTG Noise Levels - Ardleigh Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Ardleigh
SA EPA Criteria - Ardleigh
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
28 Leeweena*
85 Yarrabin*
97 Manaroo*
60 Woodburn*
43 Ardleigh*
104 Meadow Vale
110 Pine Grove
105 Cubba*
40 Nolimba
229 Cottages*
90 Kings Plains Castle*
*denotes project involved location

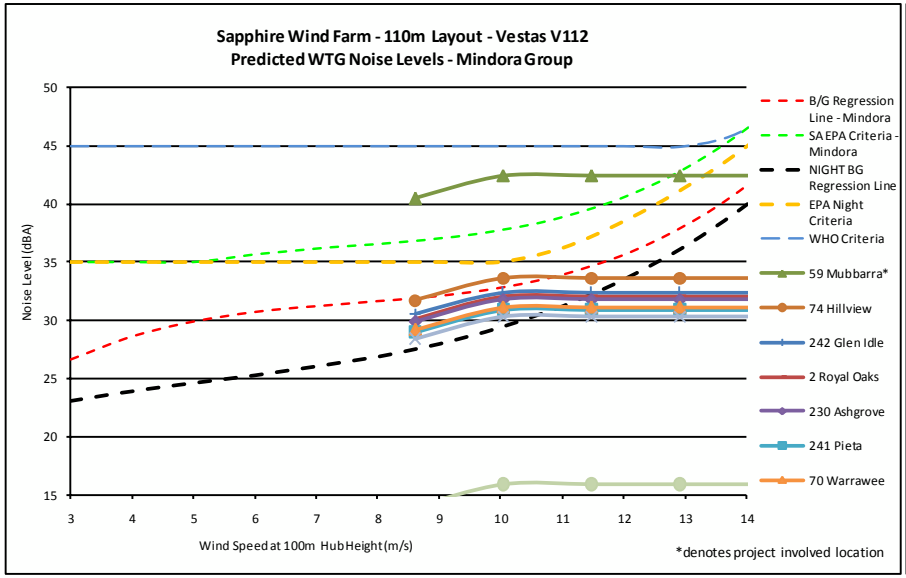

Sapphire Wind Farm - 110m Layout - Vestas V112
Predicted WTG Noise Levels - Downfield Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Downfield
SA EPA Criteria - Downfield
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
234 House #2
194 Down Field*
145 Karoola
139 Fruin Glen*
137 Tarana
219 Maids Valley
220 Quabadee
115 Evergreen
118 Fassifern
170 Tauraurga*
235 Waterloo Cottage
179 Waterloo
*denotes project involved location

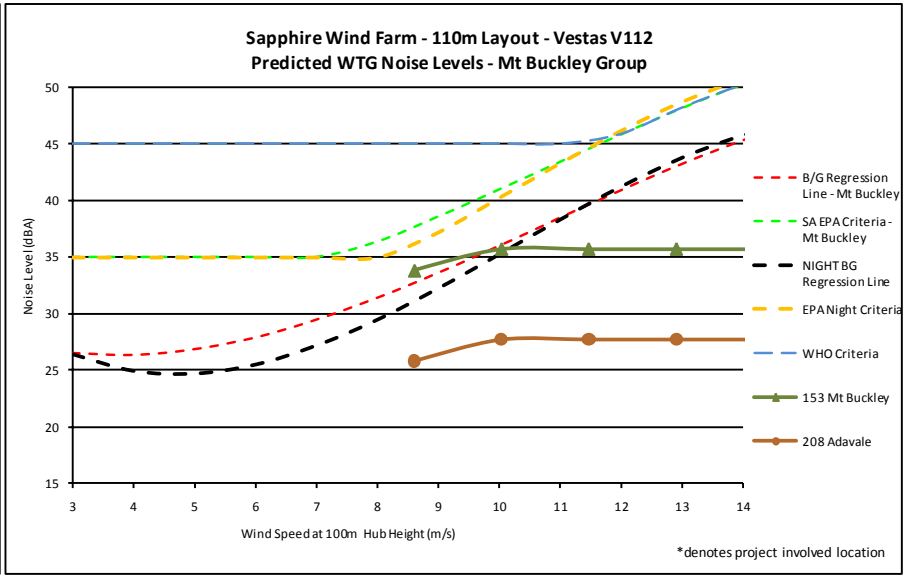

Sapphire Wind Farm - 110m Layout - Vestas V112
Predicted WTG Noise Levels - Carinya Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Carinya
SA EPA Criteria - Carinya
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
91 Derra Downs*
54 Carinya*
26 Coleraine
34 Croye
24 Millie
0 Woodlands
*denotes project involved location

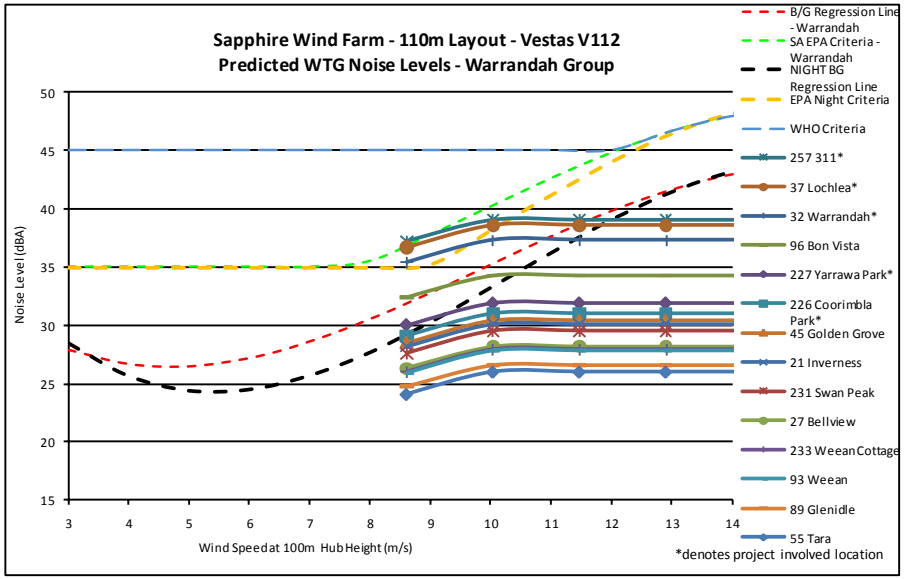

Sapphire Wind Farm - 110m Layout - Vestas V112
Predicted WTG Noise Levels - Kingshill Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Kingshill
SA EPA Criteria - Kingshill
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
11 Kingshill*
16 Narren Vale*
109 Strathdarr
38 Yarrandoo*
111 Kia-Tami*
8 Woodstock*
*denotes project involved location


Sapphire Wind Farm - 110m Layout - Vestas V112
Predicted WTG Noise Levels - Tralee Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Tralee
SA EPA Criteria - Tralee
WHO Criteria
NIGHT BG Regression Line
EPA Night Criteria
71 Tralee*
63 Spring Creek
240 Krystal Blue
239 Frasers Creek
261 Wirra Willa
84 Argyle
1 Rock Leigh
238 Tomali Park
87 The Knoll
65 Roseana
29 Swamp Oak
53 Lochbore
19 Wongajong
*denotes project involved location

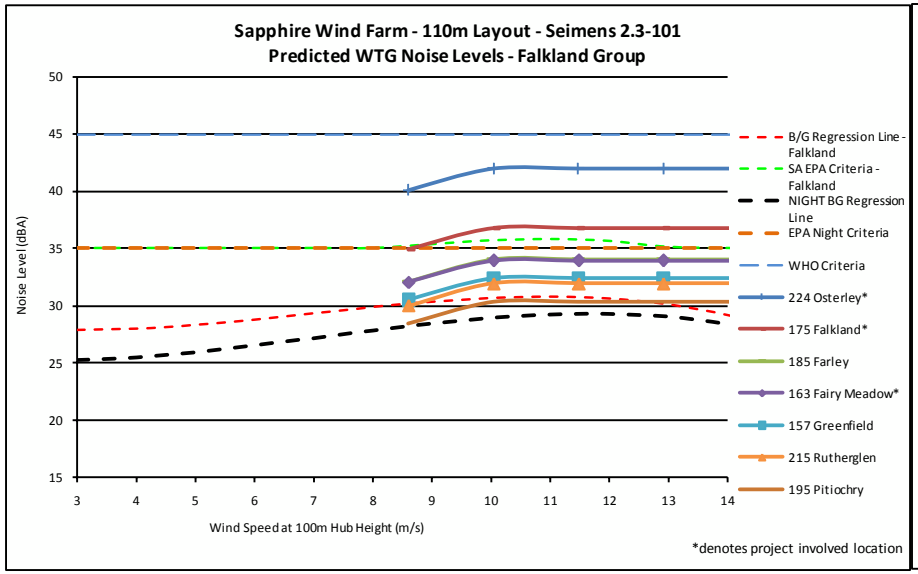

Sapphire Wind Farm - 110m Layout - Vestas V112
Predicted WTG Noise Levels - Yarrawah Park Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Yarrawa Park
SA EPA Criteria - Yarrawa Park
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
96 Bon Vista
227 Yarrawa Park*
226 Coorimbla Park*
*denotes project involved location

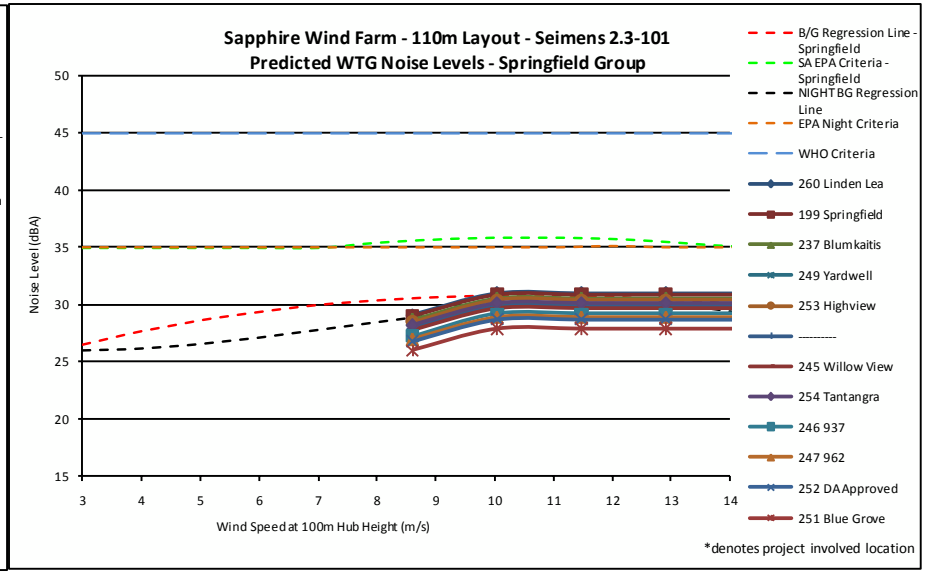

Sapphire Wind Farm - 110m Layout - Vestas V112
Predicted WTG Noise Levels - Mindora Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Mindora
SA EPA Criteria - Mindora
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
59 Mubbarra*
74 Hillview
242 Glen Idle
2 Royal Oaks
230 Ashgrove
241 Pieta
70 Warrawee
*denotes project involved location

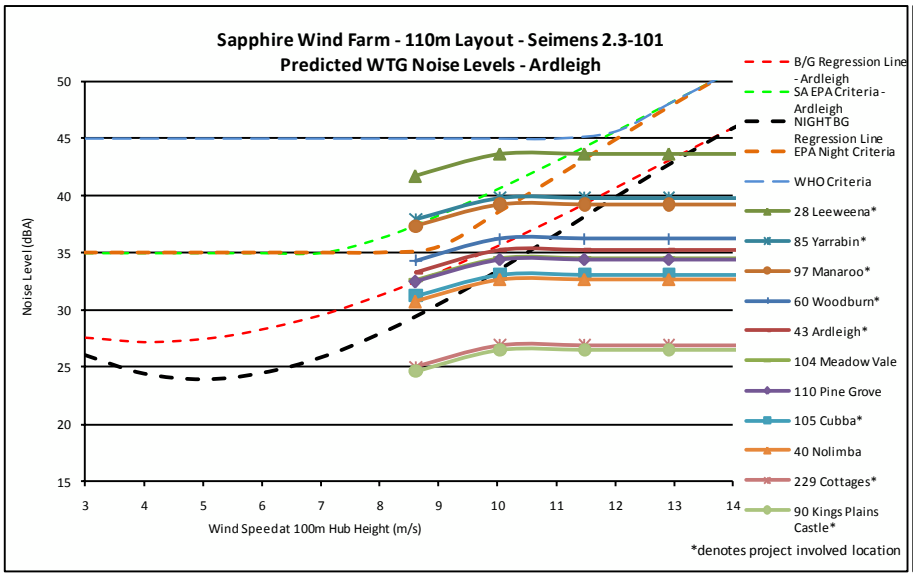

Sapphire Wind Farm - 110m Layout - Vestas V112
Predicted WTG Noise Levels - Mt Buckley Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Mt Buckley
SA EPA Criteria - Mt Buckley
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
153 Mt Buckley
208 Adavale
*denotes project involved location

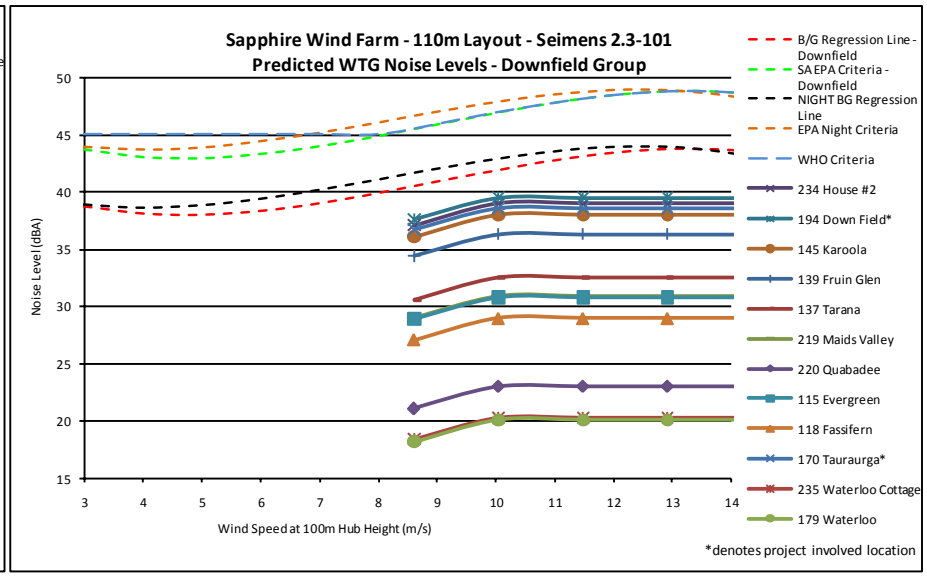

Sapphire Wind Farm - 110m Layout - Vestas V112
Predicted WTG Noise Levels - Warrandah Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Warrandah
SA EPA Criteria - Warrandah
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
257 311*
37 Lochlea*
32 Warrandah*
96 Bon Vista
227 Yarrawa Park*
226 Coorimbla Park*
45 Golden Grove
21 Inverness
231 Swan Peak
27 Bellview
233 Weean Cottage
93 Weean
89 Glenidle
55 Tara
*denotes project involved location

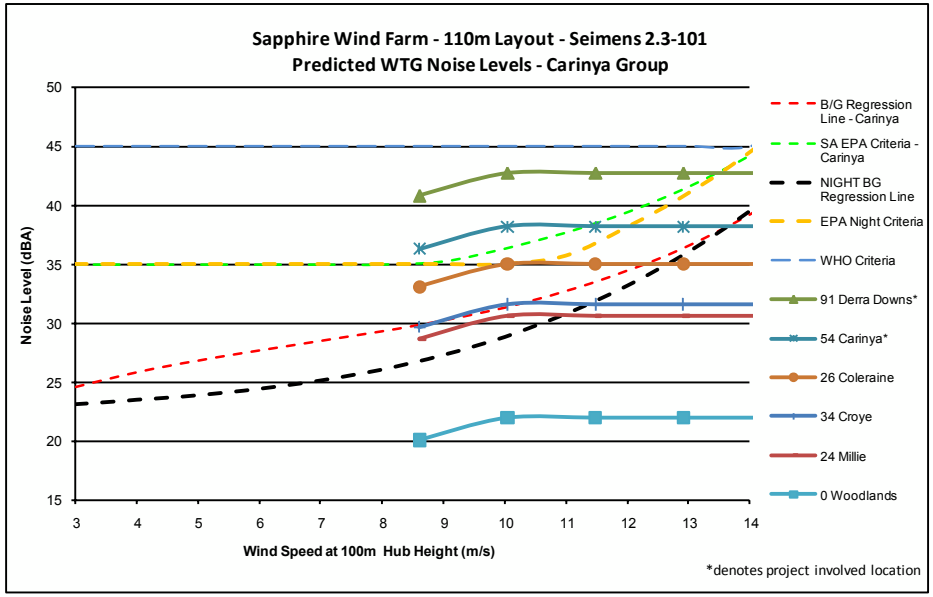
Appendix A-4
WTG Noise Assessment Curves
Seimens 2.3-101

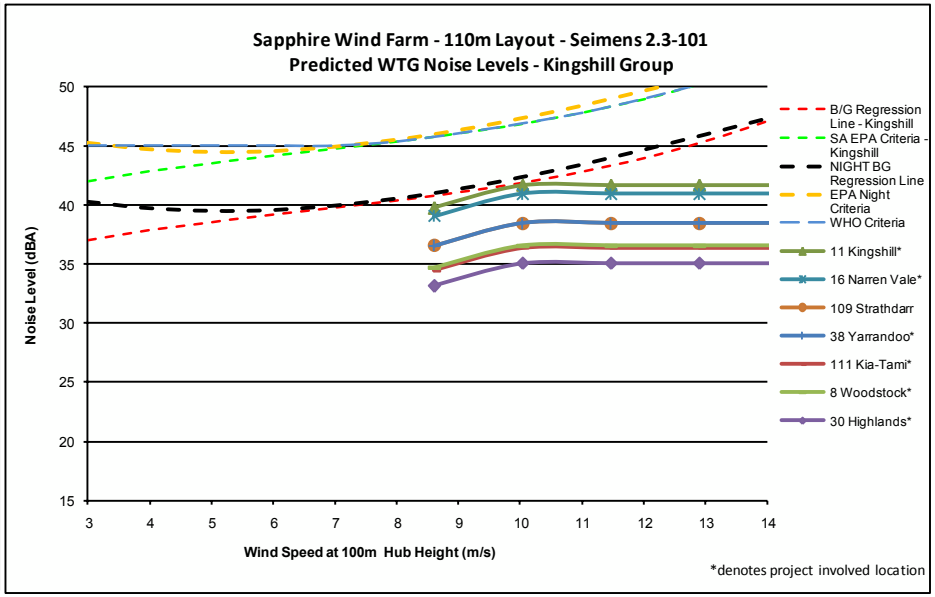

Sapphire Wind Farm - 110m Layout - Seimens 2.3-101
Predicted WTG Noise Levels - Falkland Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Falkland
SA EPA Criteria - Falkland
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
224 Osterley*
175 Falkland*
185 Farley
163 Fairy Meadow*
157 Greenfield
215 Rutherglen
195 Pitiochry
*denotes project involved location

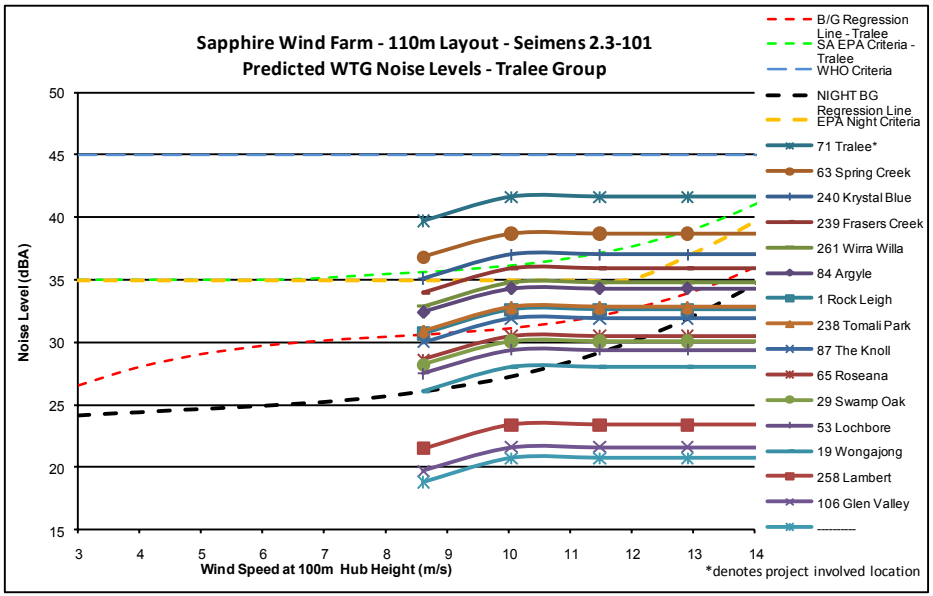

Sapphire Wind Farm - 110m Layout - Seimens 2.3-101
Predicted WTG Noise Levels - Springfield Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Springfield
SA EPA Criteria - Springfield
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
260 Linden Lea
199 Springfield
237 Blumkaitis
249 Yardwell
253 Highview
245 Willow View
254 Tantangra
246 937
247 962
252 DA Approved
251 Blue Grove
*denotes project involved location

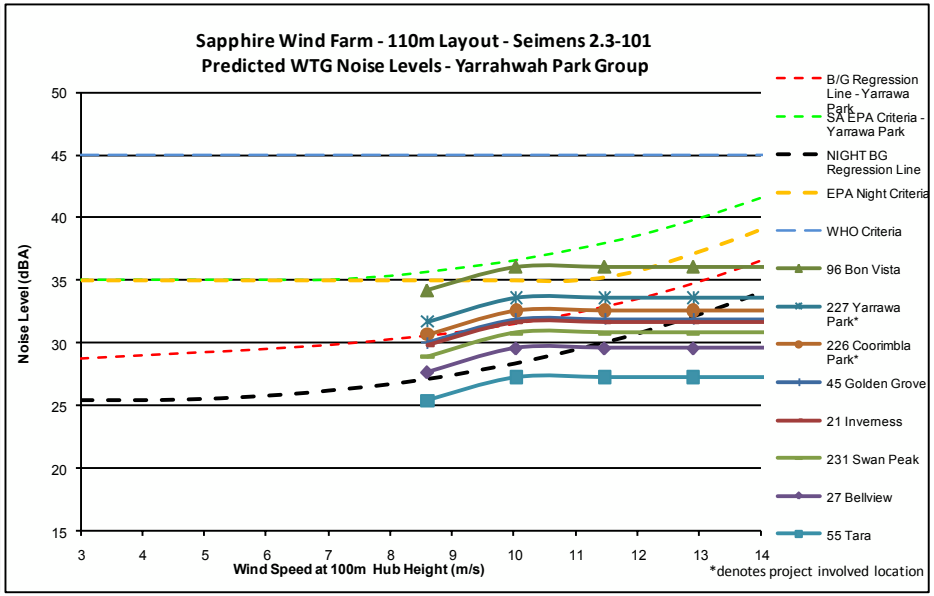

Sapphire Wind Farm - 110m Layout - Seimens 2.3-101
Predicted WTG Noise Levels - Ardleigh
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Ardleigh
SA EPA Criteria - Ardleigh
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
28 Leeweena*
85 Yarrabin*
97 Manaroo*
60 Woodburn*
43 Ardleigh*
104 Meadow Vale
110 Pine Grove
105 Cubba*
40 Nolimba
229 Cottages*
90 Kings Plains Castle*
*denotes project involved location

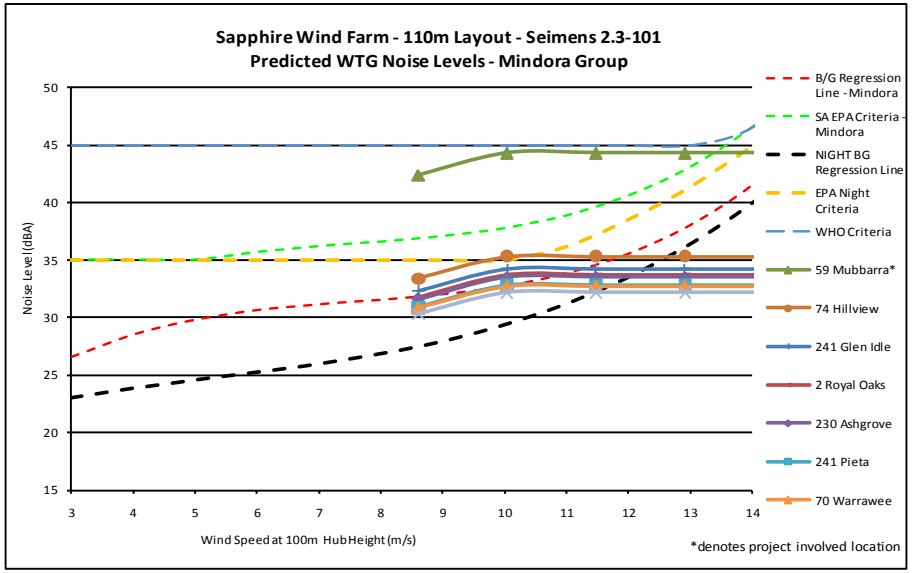

Sapphire Wind Farm - 110m Layout - Seimens 2.3-101
Predicted WTG Noise Levels - Downfield Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Downfield
SA EPA Criteria - Downfield
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
234 House #2
194 Down Field*
145 Karoola
139 Fruin Glen
137 Tarana
219 Maids Valley
220 Quabadee
115 Evergreen
118 Fassifern
170 Taurauga*
235 Waterloo Cottage
179 Waterloo
*denotes project involved location

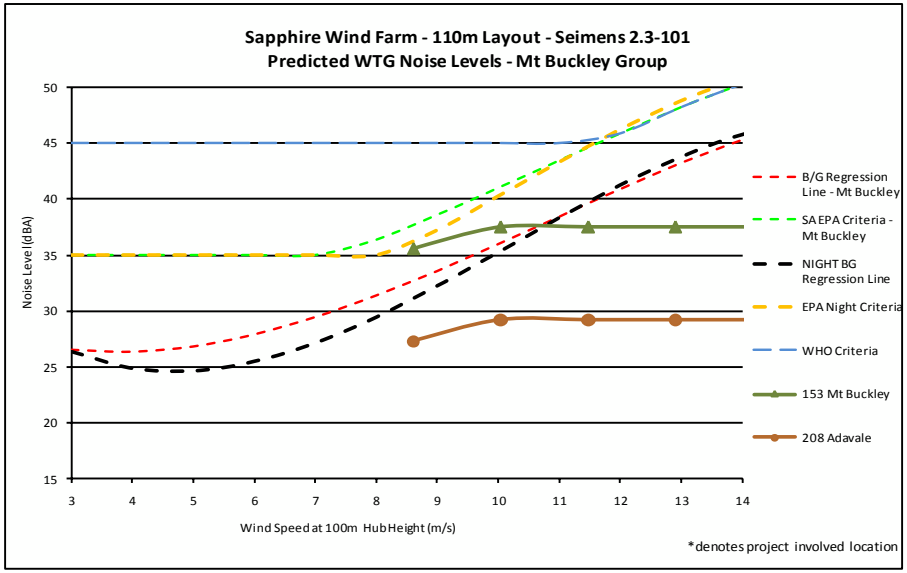

Sapphire Wind Farm - 110m Layout - Seimens 2.3-101
Predicted WTG Noise Levels - Carinya Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Carinya
SA EPA Criteria - Carinya
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
91 Derra Downs*
54 Carinya*
26 Coleraine
34 Croye
24 Millie
0 Woodlands
*denotes project involved location

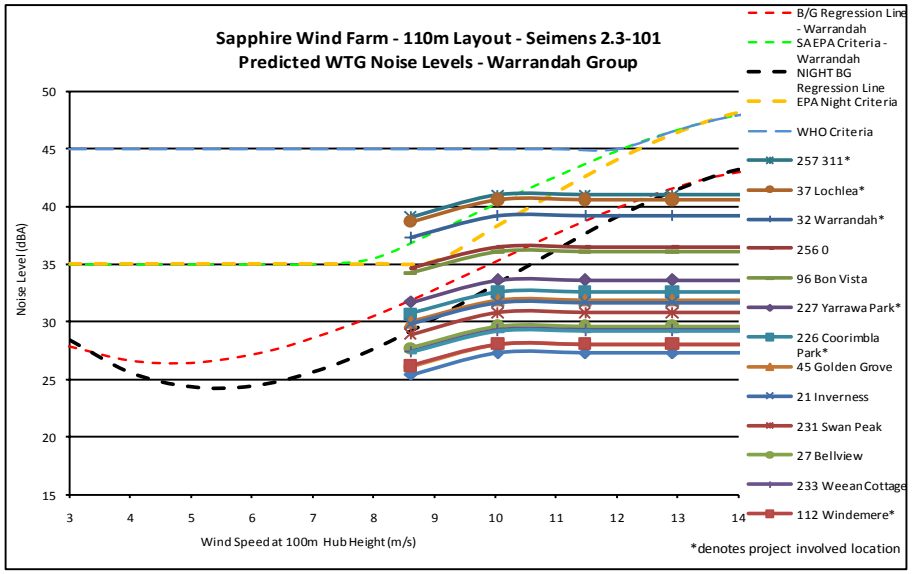

Sapphire Wind Farm - 110m Layout - Seimens 2.3-101
Predicted WTG Noise Levels - Kingshill Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Kingshill
SA EPA Criteria - Kingshill
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
11 Kingshill*
16 Narren Vale*
109 Strathdarr
38 Yarrandoo*
111 Kia-Tami*
8 Woodstock*
30 Highlands*
*denotes project involved location


Sapphire Wind Farm - 110m Layout - Seimens 2.3-101
Predicted WTG Noise Levels - Tralee Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Tralee
SA EPA Criteria - Tralee
WHO Criteria
NIGHT BG Regression Line
EPA Night Criteria
71 Tralee*
63 Spring Creek
240 Krystal Blue
239 Frasers Creek
261 Wirra Willa
84 Argyle
1 Rock Leigh
238 Tomali Park
87 The Knoll
65 Roseana
29 Swamp Oak
53 Lochbore
19 Wongajong
258 Lambert
106 Glen Valley
*denotes project involved location


Sapphire Wind Farm - 110m Layout - Seimens 2.3-101
Predicted WTG Noise Levels - Yarrahwah Park Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Yarrawa Park
SA EPA Criteria - Yarrawa Park
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
96 Bon Vista
227 Yarrawa Park*
226 Coorimbla Park*
45 Golden Grove
21 Inverness
231 Swan Peak
27 Bellview
55 Tara
*denotes project involved location


Sapphire Wind Farm - 110m Layout - Seimens 2.3-101
Predicted WTG Noise Levels - Mindora Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Mindora
SA EPA Criteria - Mindora
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
59 Mubbarra*
74 Hillview
241 Glen Idle
2 Royal Oaks
230 Ashgrove
241 Pieta
70 Warrawee
*denotes project involved location


Sapphire Wind Farm - 110m Layout - Seimens 2.3-101
Predicted WTG Noise Levels - Mt Buckley Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Mt Buckley
SA EPA Criteria - Mt Buckley
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
153 Mt Buckley
208 Adavale
*denotes project involved location


Sapphire Wind Farm - 110m Layout - Seimens 2.3-101
Predicted WTG Noise Levels - Warrandah Group
Noise Level (dBA)
Wind Speed at 100m Hub Height (m/s)
B/G Regression Line - Warrandah
SA EPA Criteria - Warrandah
NIGHT BG Regression Line
EPA Night Criteria
WHO Criteria
257 311*
37 Lochlea*
32 Warrandah*
256 0
96 Bon Vista
227 Yarrawa Park*
226 Coorimbla Park*
45 Golden Grove
21 Inverness
231 Swan Peak
27 Bellview
233 Weean Cottage
112 Windemere*
*denotes project involved location

Appendix B-1
Gamesa G87 Sound Power Data

9.3. Wind turbine G87

H = 67 m

W_{10} [m/s]	W_S [m/s]	101.6dB(A)	102.1dB(A)	102.8dB(A)	103.6dB(A)	104.6dB(A)	106.4dB(A) FP
3	4.1	92.8	92.8	92.8	92.8	92.8	92.8
4	5.4	96.5	96.5	96.5	96.5	96.5	96.5
5	6.8	101.6	101.6	101.6	101.6	101.6	101.6
6	8.1	101.6	102.1	102.8	103.6	104.6	105.5
7	9.5	101.6	102.1	102.8	103.6	104.6	106.4
8	10.8	101.6	102.1	102.8	103.6	104.6	106.4
9	12.2	101.6	102.1	102.8	103.6	104.6	106.4
10	13.6	101.6	102.1	102.8	103.6	104.6	106.4
11	14.9	106.4	106.4	106.4	106.4	106.4	106.4
12	16.3	106.4	106.4	106.4	106.4	106.4	106.4

Table 9

H = 78 m

W_{10} [m/s]	W_S [m/s]	101.6dB(A)	102.1dB(A)	102.8dB(A)	103.6dB(A)	104.6dB(A)	106.4dB(A) FP
3	4.2	92.8	92.8	92.8	92.8	92.8	92.8
4	5.6	97.3	97.3	97.3	97.3	97.3	97.3
5	6.9	101.6	102.1	102.1	102.1	102.1	102.1
6	8.3	101.6	102.1	102.8	103.6	104.6	106.0
7	9.7	101.6	102.1	102.8	103.6	104.6	106.4
8	11.1	101.6	102.1	102.8	103.6	104.6	106.4
9	12.5	101.6	102.1	102.8	103.6	104.6	106.4
10	13.9	101.6	102.1	102.8	103.6	104.6	106.4
11	15.3	106.4	106.4	106.4	106.4	106.4	106.4
12	16.7	106.4	106.4	106.4	106.4	106.4	106.4

Table 10

H = 100m

W_{10} [m/s]	W_S [m/s]	101.6 dB(A)	102.1 dB(A)	106.4dB(A) FP
3	4.3	92.8	92.8	92.8
4	5.8	98.1	98.1	98.1
5	7.2	101.6	102.1	103.0
6	8.7	101.6	102.1	106.4
7	10.1	101.6	102.1	106.4
8	11.6	101.6	102.1	106.4
9	13	101.6	102.1	106.4
10	14.5	101.6	102.1	106.4
11	15.9	106.4	106.4	106.4
12	17.3	106.4	106.4	106.4

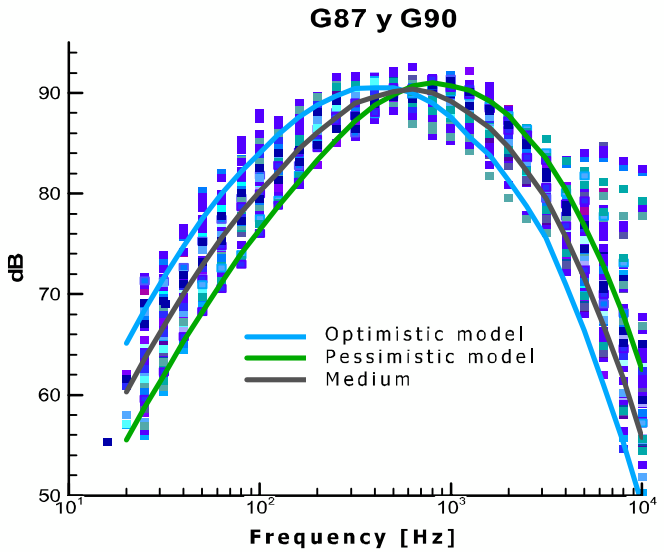
Table 11

2. Model proposed for G87 and G90

Table 2 shows three standardized models at 100dB of spectral noise distribution for the G87 and G90 wind turbines, based on the noise measurements in third octaves for the G87 wind turbines taken by accredited centers:

Optimistic model		Pessimistic model		Medium	
f [Hz]	dB	f [Hz]	dB	f [Hz]	dB
20.0	55.5	20.0	65.1	20.0	60.3
25.0	58.8	25.0	68.5	25.0	63.7
31.5	61.9	31.5	71.6	31.5	66.8
40.0	65.3	40.0	74.7	40.0	70.0
50.0	68.2	50.0	77.4	50.0	72.8
63.0	71.1	63.0	79.9	63.0	75.5
80.0	74.0	80.0	82.2	80.0	78.1
100.0	76.4	100.0	84.0	100.0	80.2
125.0	78.7	125.0	85.5	125.0	82.1
160.0	80.9	160.0	87.6	160.0	84.4
200.0	83.3	200.0	88.8	200.0	86.1
250.0	85.3	250.0	89.7	250.0	87.5
315.0	87.2	315.0	90.7	315.0	89.0
400.0	88.8	400.0	90.5	400.0	89.7
500.0	89.8	500.0	90.5	500.0	90.2
630.0	90.7	630.0	90.0	630.0	90.4
800.0	91.0	800.0	89.0	800.0	90.0
1000.0	90.7	1000.0	87.6	1000.0	89.2
1250.0	90.3	1250.0	85.6	1250.0	87.9
1600.0	89.2	1600.0	83.8	1600.0	86.5
2000.0	87.8	2000.0	81.3	2000.0	84.6
2500.0	85.7	2500.0	78.7	2500.0	82.2
3150.0	83.5	3150.0	75.6	3150.0	79.6
4000.0	80.4	4000.0	71.0	4000.0	75.7
5000.0	76.8	5000.0	66.4	5000.0	71.6
6300.0	72.8	6300.0	61.0	6300.0	66.9
8000.0	67.9	8000.0	55.3	8000.0	61.6
10000.0	62.5	10000.0	49.0	10000.0	55.8
$L_{Aeq,ref}$	100		100		100

Table 2: Spectral distribution model for G87 and G90 wind turbines



Graph 43: Spectral distribution model for G87 and G90 wind turbines

Extract WT 6166/08 from report no. WT 6165/08
acoustical emissions of a wind turbine generator system of the type G87 DFM 2000kW, 50Hz (Mode: full power) near Bordecorex

General Data		Technical data (provided by customer)	
Manufacturer:	**Gamesa Eólica S.A.**	**Rated power (Generator):**	**2000 kW**
	Avenida de la Innovación 9-11	**Rotor diameter:**	**87 m**
	31621 Sarraiguren - Parque Tecnológico	**Hub height above ground:**	**78 m**
Turbine serial number:	**6640**	**Tower type:**	**tapered tubular**
WT-coordinates:	**RW: 526127 HW: 4586260**	**Power control:**	**variable pitch and speed**

Additional data of the rotor (provided by customer)		Additional data of the gear box and the generator (provided by customer)	
Rotor manufacturer:	**Fiberblade Eólica, S.A.**	**Gearbox manufacturer:**	**Hansen**
Rotor blade type:	**G43 P**	**Gearbox type:**	**Hansen 2MW**
Rotor blade pitch angle:	**variabel (Optitip)**	**Generator manufacturer:**	**INDAR**
Number of rotor blades:	**3**	**Generator type:**	**INDAR TAR-500-L/4R**
Rotor speed(s) or range:	**9,0 - 18,9 rpm**	**Generator speed(s):**	**1680 rpm**

Report of the power curve: calculated by the manufacturer

	Measurement at reference point		Noise emission data		Remarks
	Windspeed at 10 m hight	Power			
Sound power level $L_{WA,P}$ [dB(A)]	6 ms^{-1}	851 kW	101,7		
	7 ms^{-1}	1268 kW	105,0		
	8 ms^{-1}	1622 kW	105,9		
	9 ms^{-1}	1834 kW	104,9		
	10 ms^{-1}	1935 kW	103,7		
Tonality ΔL_k [dB]	6 ms^{-1}	851 kW	-19,47	at 1706 Hz	
	7 ms^{-1}	1268 kW	-18,76	at 1468 Hz	
	8 ms^{-1}	1622 kW	-16,37	at 622 Hz	
	9 ms^{-1}	1834 kW	-16,37	at 670 Hz	
	10 ms^{-1}	1935 kW	-13,27	at 114 Hz	
Tonal audibility $\Delta L_{a,k}$ [dB]	6 ms^{-1}	851 kW	-16,08	at 1706 Hz	
	7 ms^{-1}	1268 kW	-15,55	at 1468 Hz	
	8 ms^{-1}	1622 kW	-13,88	at 622 Hz	
	9 ms^{-1}	1834 kW	-13,89	at 670 Hz	
	10 ms^{-1}	1935 kW	-11,26	at 114 Hz	

Third octave sound power spectrum, v10 = 8,0 ms^{-1} in dB(A)

Frequency	50	63	80	100	125	160	200	250	315	400	500	630
$L_{WA,P}$	75,3	79,4	83,6	87,6	91,0	92,5	94,8	97,0	96,7	95,6	96,2	94,2
Frequency	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
$L_{WA,P}$	93,9	93,4	93,1	92,6	91,7	89,7	87,2	82,9	80,1	74,7	68,5	65,9

These data are only valid in connection with manufacturer certificate dated 2008-01-08 and the report no. WT 6165/08.
Remarks: -/-

Measured by: WINDTEST Kaiser-Wilhelm-Koog GmbH
Sommerdeich 14 b
25709 Kaiser-Wilhelm-Koog

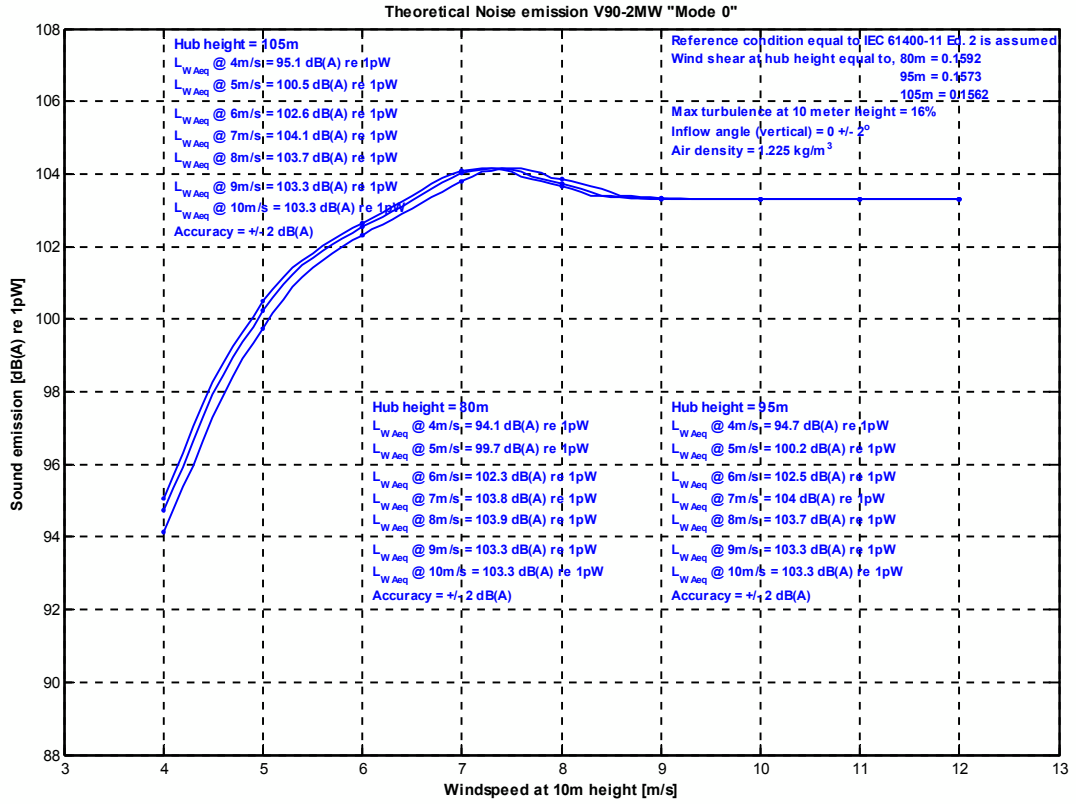
Date: 2008-01-25

Dipl.-Ing. J. Dedert

Dipl.-Ing. A. Trautsch

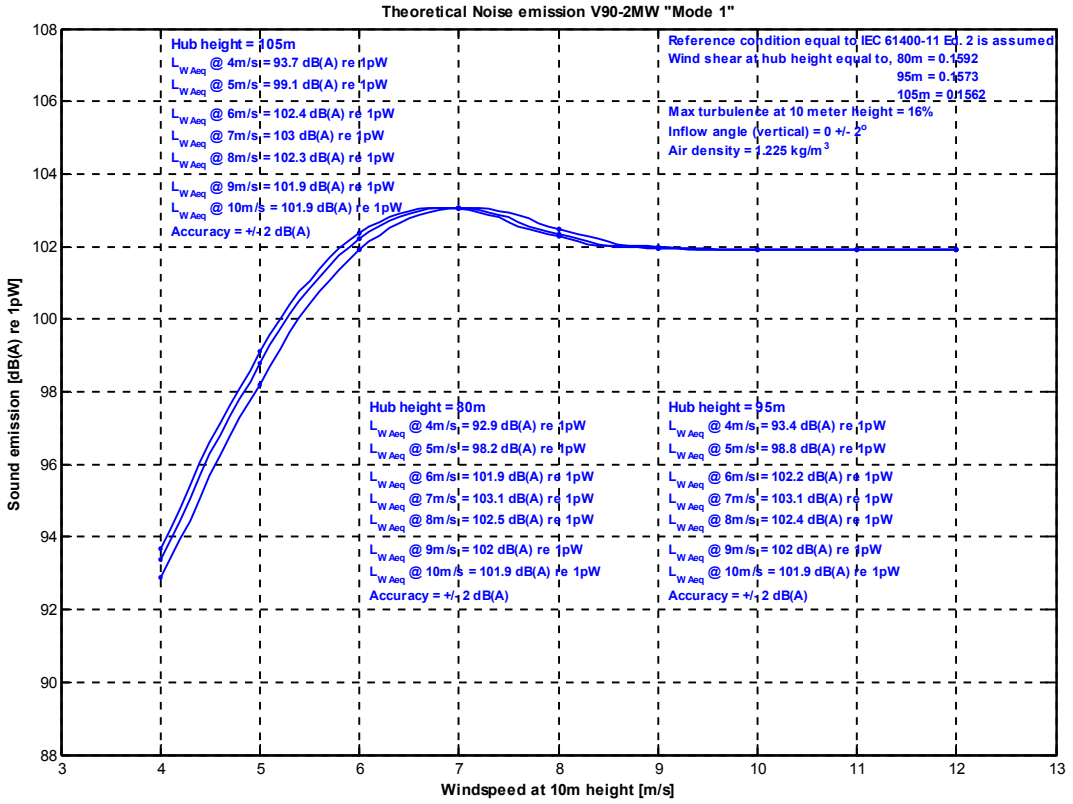
Extracts may be copied from this report only with the written consent of WINDTEST Kaiser-Wilhelm-Koog GmbH.

Appendix B-2
Vestas V90 Sound Power Data



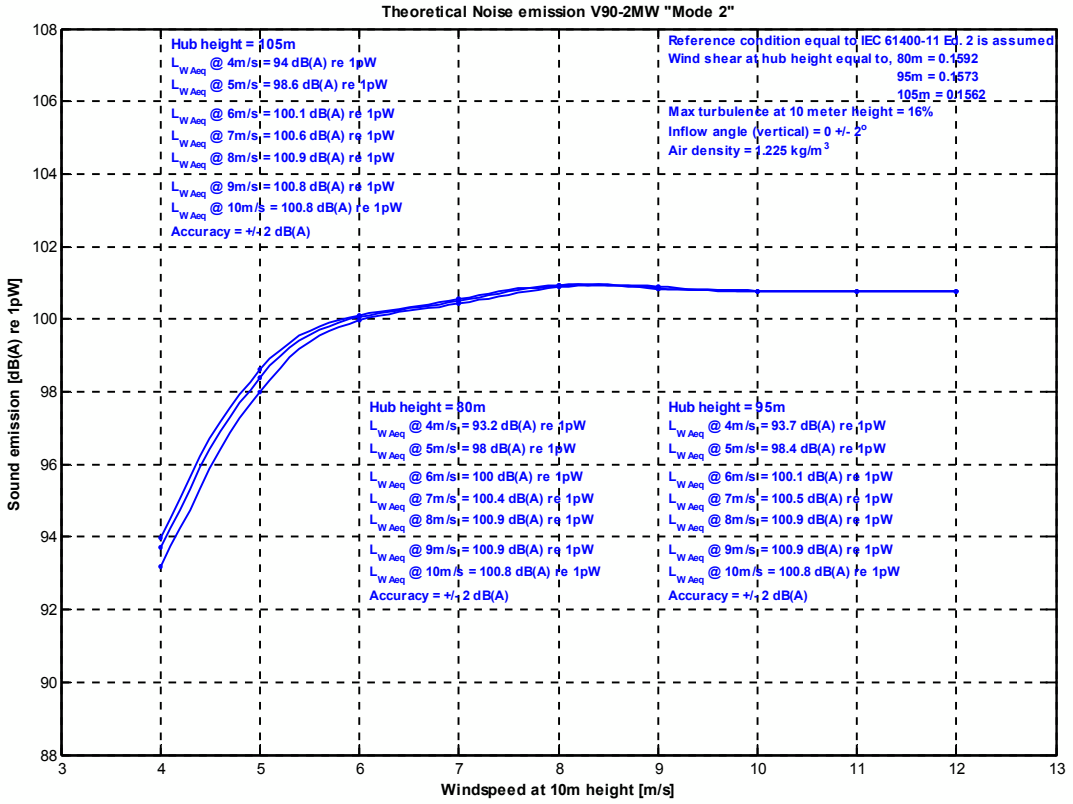
Theoretical Sound Power Level at Hub Height, V90-2MW "Mode 0"

	Conditions for Sound Power Level	Verification standard : IEC 61400-11 Ed. 2 Wind shear as described in table below. Max turbulence at 10 meter height: 16% Inflow angle (vertical): 0 ± 2° Air density: 1.225 kg/m^3 Accuracy: ± 2 dB(A)			
	Hub height	HH 80 m	HH 95 m	HH 105 m	
	Wind shear	0.1592	0.1573	0.1562	
	Verification Report: "Theoretical"				
		dB(A) re 1pW	dB(A) re 1pW	dB(A) re 1pW	
	L_{WA} @ 4m/s (10 meter above ground)	94.1	94.7	95.1	
	L_{WA} @ 5m/s (10 meter above ground)	99.7	100.2	100.5	
	L_{WA} @ 6m/s (10 meter above ground)	102.3	102.5	102.6	
	L_{WA} @ 7m/s (10 meter above ground)	103.8	104.0	104.1	
	L_{WA} @ 8m/s (10 meter above ground)	103.9	103.7	103.7	
	L_{WA} @ 9m/s (10 meter above ground)	103.3	103.3	103.3	
	L_{WA} @ 10m/s (10 meter above ground)	103.3	103.3	103.3	
	L_{WA} @ 11m/s (10 meter above ground)	103.3	103.3	103.3	
	L_{WA} @ 12m/s (10 meter above ground)	103.3	103.3	103.3	
	L_{WA} @ 95% Rated Power (7.9 m/s, 10 meter above ground)	103.9			
	L_{WA} @ 95% Rated Power (7.7 m/s, 10 meter above ground)		103.9		
	L_{WA} @ 95% Rated Power (7.6 m/s, 10 meter above ground)			103.9	



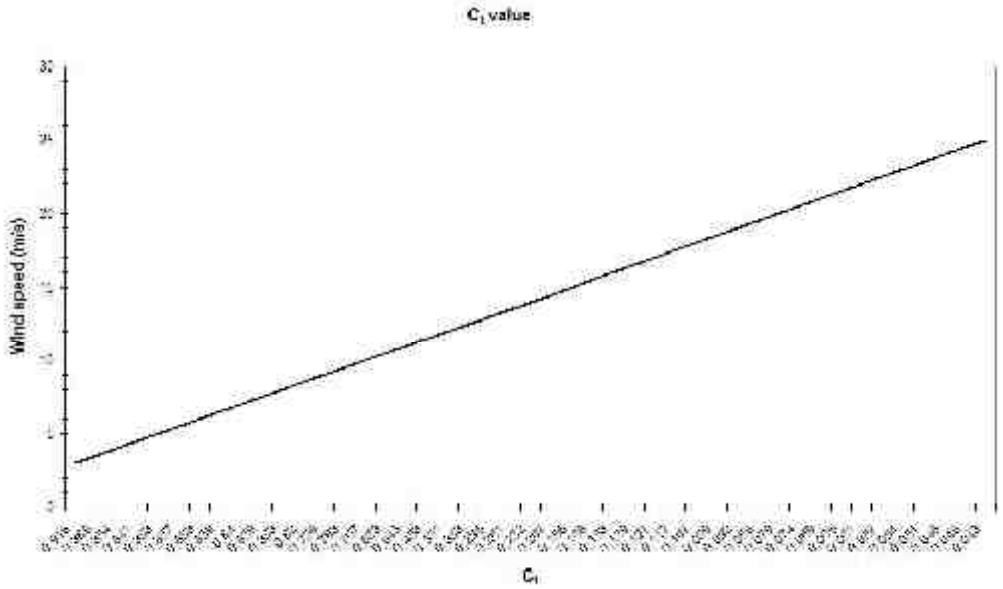
Theoretical Sound Power Level at Hub Height, V90-2MW "Mode 1"

	Conditions for Sound Power Level	Verification standard : IEC 61400-11 Ed. 2 Wind shear as described in table below. Max turbulence at 10 meter height: 16% Inflow angle (vertical): 0 ± 2° Air density: 1.225 kg/m^3 Accuracy: ± 2 dB(A)			
	Hub height	HH 80 m	HH 95 m	HH 105 m	
	Wind shear	0.1592	0.1573	0.1562	
	Verification Report: "Theoretical"				
		dB(A) re 1pW	dB(A) re 1pW	dB(A) re 1pW	
	L_{WA} @ 4m/s (10 meter above ground)	92.9	93.4	93.7	
	L_{WA} @ 5m/s (10 meter above ground)	98.2	98.8	99.1	
	L_{WA} @ 6m/s (10 meter above ground)	101.9	102.2	102.4	
	L_{WA} @ 7m/s (10 meter above ground)	103.1	103.1	103.0	
	L_{WA} @ 8m/s (10 meter above ground)	102.5	102.4	102.3	
	L_{WA} @ 9m/s (10 meter above ground)	102.0	102.0	101.9	
	L_{WA} @ 10m/s (10 meter above ground)	101.9	101.9	101.9	
	L_{WA} @ 11m/s (10 meter above ground)	101.9	101.9	101.9	
	L_{WA} @ 12m/s (10 meter above ground)	101.9	101.9	101.9	
	L_{WA} @ 95% Rated Power (8.1 m/s, 10 meter above ground)	102.4			
	L_{WA} @ 95% Rated Power (7.9 m/s, 10 meter above ground)		102.4		
	L_{WA} @ 95% Rated Power (7.8 m/s, 10 meter above ground)			102.4	



	Theoretical Sound Power Level at Hub Height, V90-2MW "Mode 2"				
	Conditions for Sound Power Level	Verification standard : IEC 61400-11 Ed. 2 Wind shear as described in table below. Max turbulence at 10 meter height: 16% Inflow angle (vertical): 0 ± 2° Air density: 1.225 kg/m^3 Accuracy: ± 2 dB(A)			
	Hub height	HH 80 m	HH 95 m	HH 105 m	
	Wind shear	0.1592	0.1573	0.1562	
	Verification Report: "Theoretical"				
		dB(A) re 1pW	dB(A) re 1pW	dB(A) re 1pW	
	L_{WA} @ 4m/s (10 meter above ground)	93.2	93.7	94.0	
	L_{WA} @ 5m/s (10 meter above ground)	98.0	98.4	98.6	
	L_{WA} @ 6m/s (10 meter above ground)	100.0	100.1	100.1	
	L_{WA} @ 7m/s (10 meter above ground)	100.4	100.5	100.6	
	L_{WA} @ 8m/s (10 meter above ground)	100.9	100.9	100.9	
	L_{WA} @ 9m/s (10 meter above ground)	100.9	100.9	100.8	
	L_{WA} @ 10m/s (10 meter above ground)	100.8	100.8	100.8	
	L_{WA} @ 11m/s (10 meter above ground)	100.8	100.8	100.8	
	L_{WA} @ 12m/s (10 meter above ground)	100.8	100.8	100.8	
	L_{WA} @ 95% Rated Power (8.8 m/s, 10 meter above ground)	100.9			
	L_{WA} @ 95% Rated Power (8.6 m/s, 10 meter above ground)		100.9		
	L_{WA} @ 95% Rated Power (8.5 m/s, 10 meter above ground)			100.9	

Appendix B-3
Vestas V112 Sound Power Data



10.4.2 Sound Power Levels, Mode 0

Item	Value
Conditions for Sound Power Level	Measurement standard IEC 61400-11 ed. 2 2002 Wind shear: 0.16 Max. turbulence at 10 meter height: 16% Inflow angle (vertical): 0 ± 2° Air density: 1.225 kg/m^3
HH	94 m
L_{wA} @ 3 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	95.0 4.3
L_{wA} @ 4 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	97.7 5.7
L_{wA} @ 5 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	102.5 7.2
L_{wA} @ 6 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	105.7 8.6
L_{wA} @ 7 to 25 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	106.5 10
L_{wA} @ 8 to 25 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	106.5 11.5
L_{wA} @ 9 to 25 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	106.5 12.9

T05 0004-7993 Ver 02 - Approved - Exported from DMS: 2009-12-08 by HTTHO

Item	Value
L_{wA} @ 10 to 25 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	106.5 14.3
L_{wA} @ 11 to 25 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	106.5 15.8
L_{wA} @ 12 to 25 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	106.5 17.2
L_{wA} @ 13 to 25 m/s (10 m above ground) [dBA] Wind speed at HH [m/sec]	106.5 18.6

10.4.3 Estimated Power Curve, Mode 0

Wt Speed (m/s)	Air density kg/m³													
	0.97	1.00	1.03	1.06	1.09	1.12	1.15	1.18	1.21	1.225	1.24	1.27	1.30	1.33
3	32	32	34	36	36	40	42	44	46	47	48	50	52	54
4	106	113	119	123	127	132	137	142	147	149	151	155	160	165
5	275	284	293	271	280	289	299	307	318	320	325	334	342	351
6	442	453	470	490	505	520	536	550	566	573	580	595	611	626
7	721	749	772	796	822	844	868	892	919	927	939	963	986	1010
8	1097	1130	1165	1201	1236	1271	1309	1343	1377	1395	1412	1447	1482	1517
9	1558	1600	1657	1708	1753	1805	1854	1903	1952	1977	2001	2052	2099	2148
10	2093	2145	2200	2270	2332	2395	2449	2503	2567	2594	2626	2685	2691	2727
11	2599	2649	2702	2758	2809	2863	2907	2911	2905	2917	2952	2983	2971	2977
12	2812	2829	2941	2998	2972	2987	2990	2993	2999	2998	2998	3000	3000	3000
13	2990	2992	2994	2999	2999	3000	3000	3000	3000	3000	3000	3000	3000	3000
14	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
15	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
16	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
17	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
18	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
19	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
20	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
21	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
22	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
23	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
24	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
25	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000

T05 0004-7993 Ver 02 - Approved - Exported from DMS: 2009-12-08 by HTTHO

Appendix B-4
Seimens 2.3-101 Sound Power Data

SWT-2.3-101
Acoustic Emission

Sound Power Levels

The warranted sound power levels are presented with reference to the code IEC 61400-11:2002 with amendment 1 dated 2006-05 based on a hub height of 80 m and a roughness length of 0.05 m as described in the IEC code. The sound power levels (L_{WA}) presented are valid for the corresponding wind speeds referenced to a height of 10 m above ground level.

Wind speed [m/s]	**6**	**7**	**8**	**9**	**10**
Sound power level	105.1	107.0	107.0	107.0	107.0

Tabel 1: Noise emission, L_{WA} [dB(A) re 1 pW]

Typical Octave Band

Typical, not warranted octave band spectra are tabulated below for 6 and 8 m/s referenced to 10m height.

Octave band, center frequency [Hz]	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Sound power level	81.1	92.3	96.4	100.0	100.2	96.8	89.4	85.1

Table 2: Typical octave band for 6 m/s

Octave band, center frequency [Hz]	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Sound power level	83.5	94.4	98.1	102.1	102.1	98.4	91.2	87.2

Table 3: Typical octave band for 8 m/s

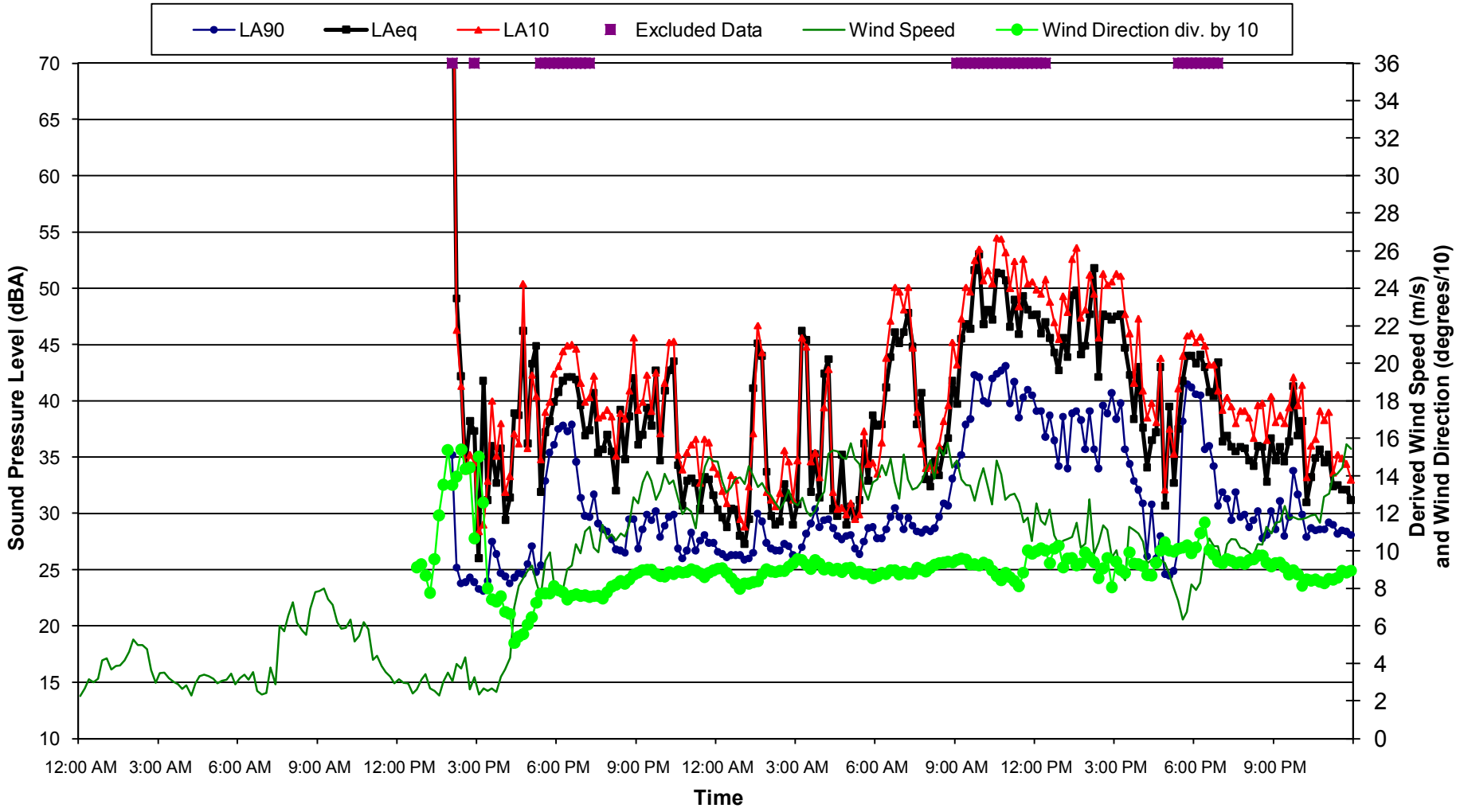
Noise Restricted Operation

Lower sound power levels can be achieved with the SWT-2.3-101 wind turbine by controlling the turbine in noise restricted operation. This noise restricted mode of operation will, depending on the mode, have an impact on the power output of the turbine. Please contact Siemens for further information on this option.

© All Rights Reserved 2009

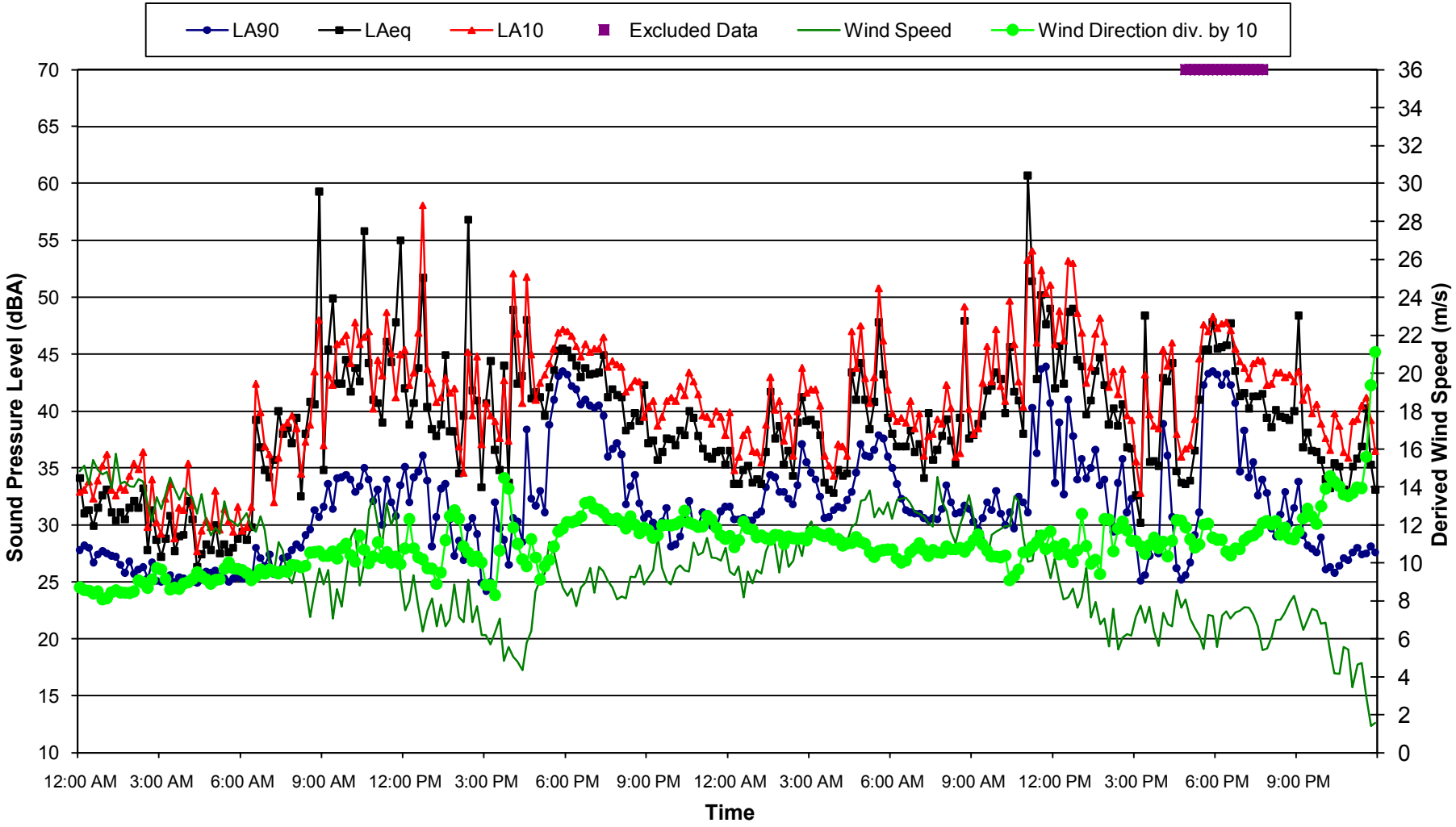
Appendix C
Noise Monitoring Data
Noise Level & Wind vs.Time

Location Falkland - Sapphire Wind Farm
Ambient Noise Data - 7 and 8 July 2009



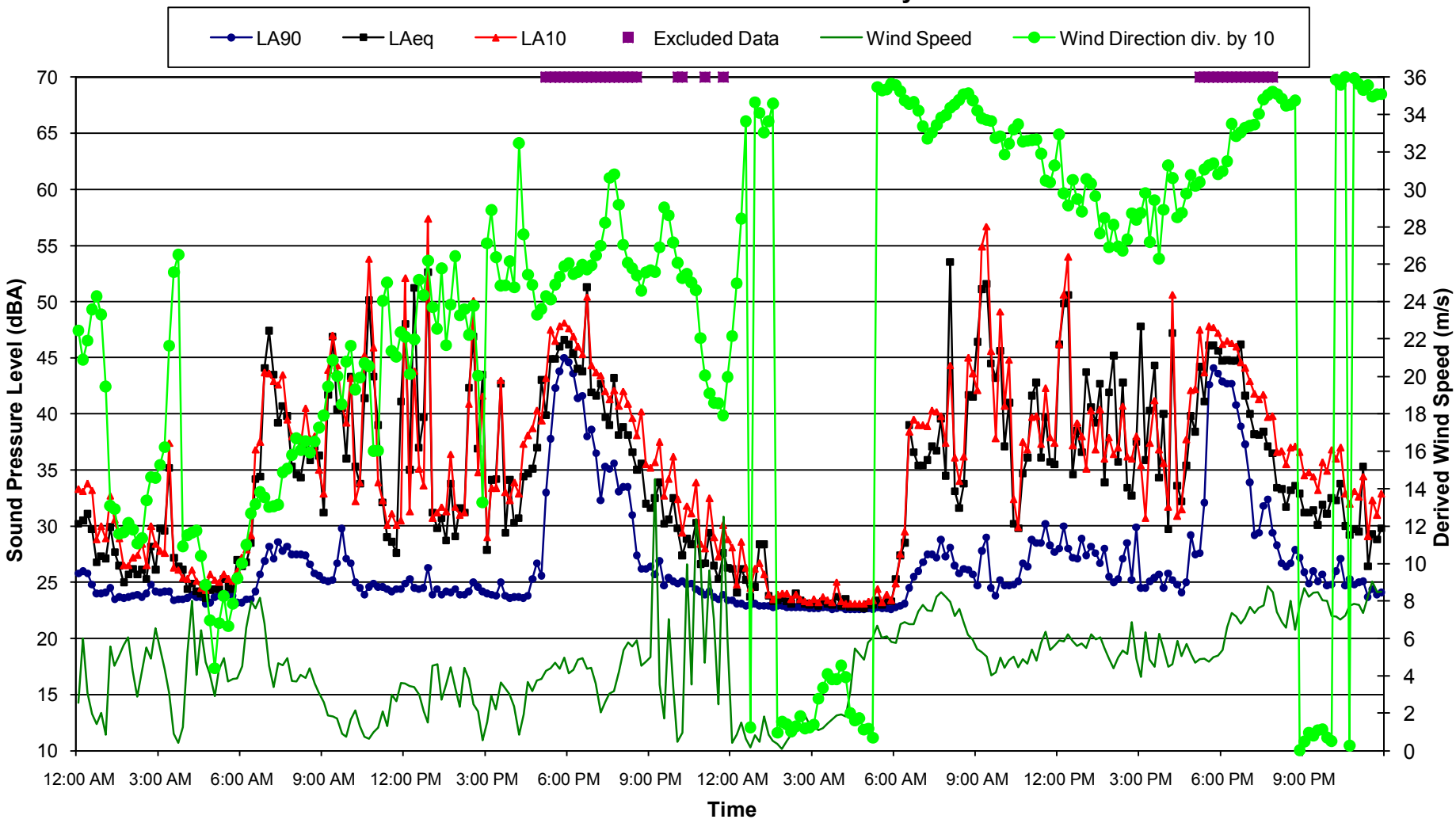
Appendix C1
40-1822
Level Wind vs Time

Location Falkland - Sapphire Wind Farm
Ambient Noise Data - 9 and 10 July 2009

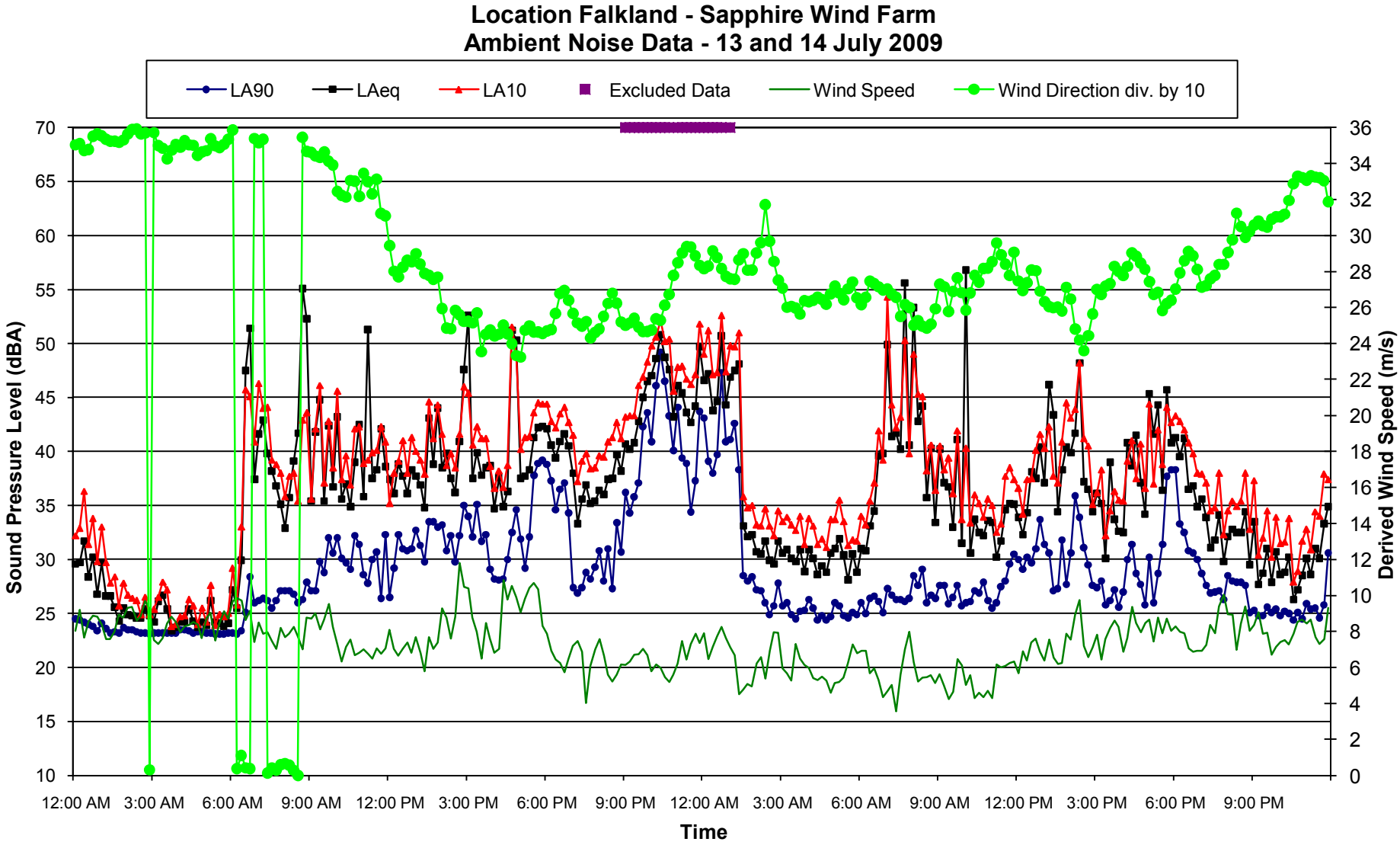


Appendix C1
40-1822
Level Wind vs Time

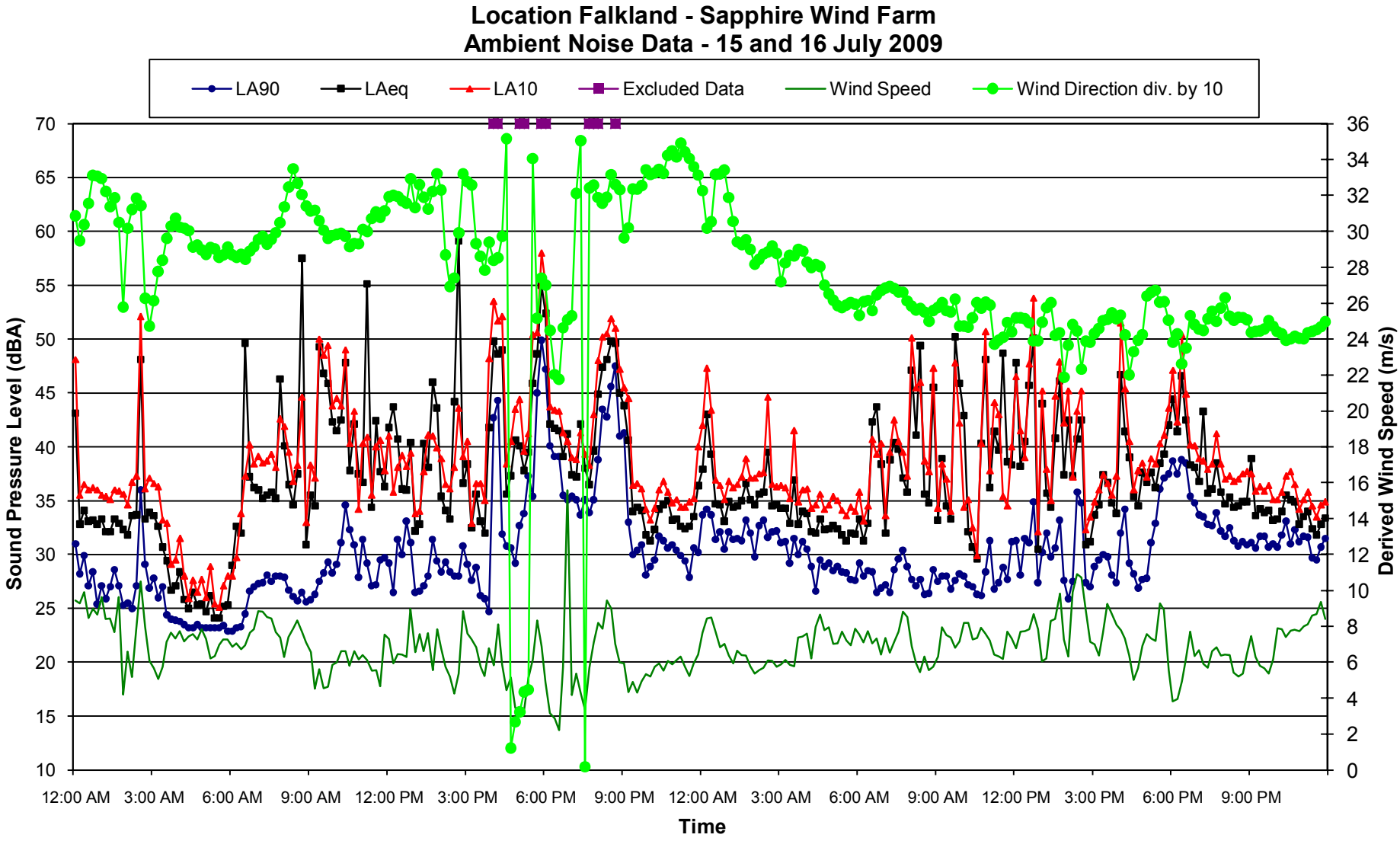
Location Falkland - Sapphire Wind Farm
Ambient Noise Data - 11 and 12 July 2009



Appendix C1
40-1822
Level Wind vs Time

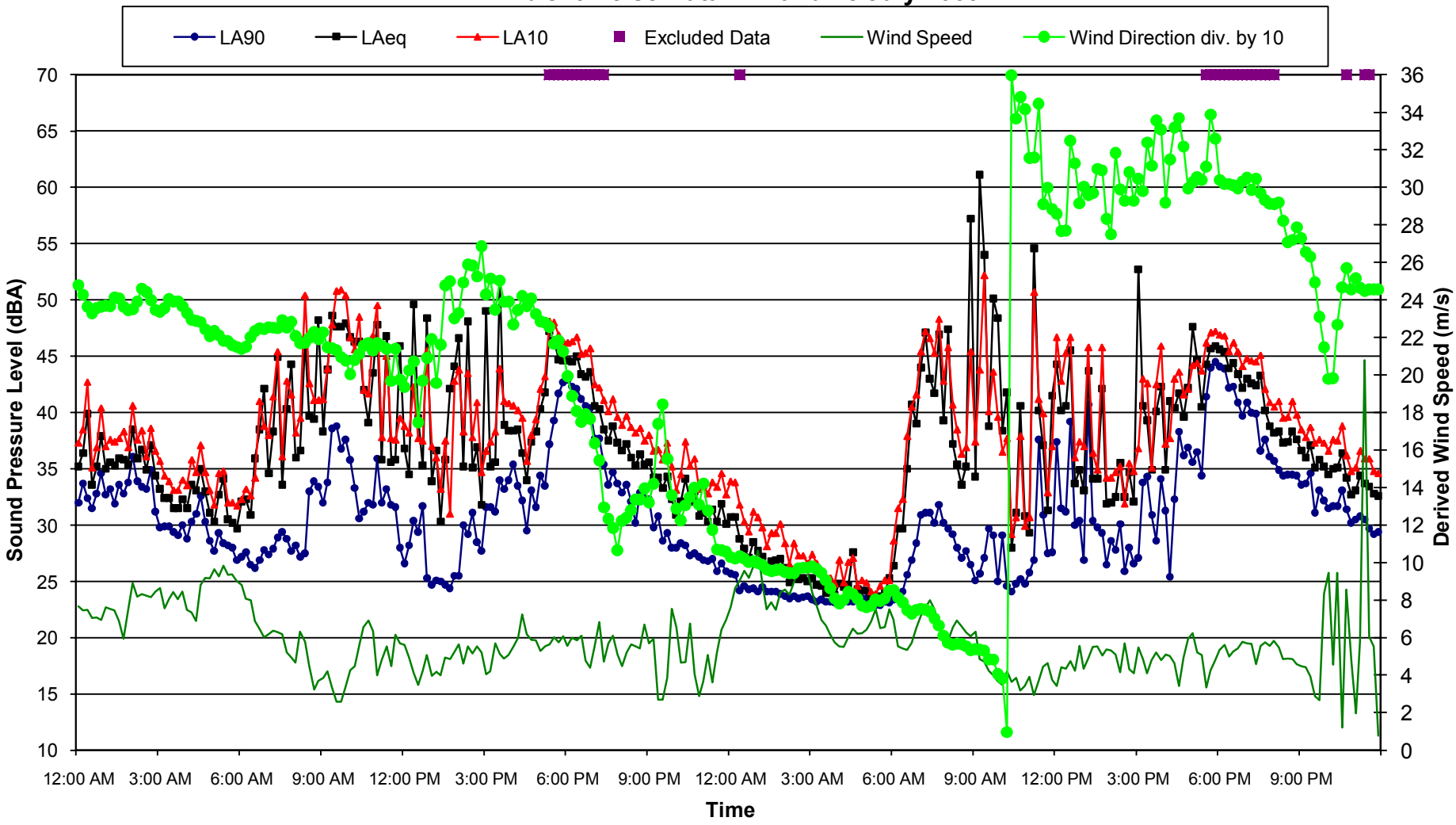


Appendix C1
40-1822
Level Wind vs Time



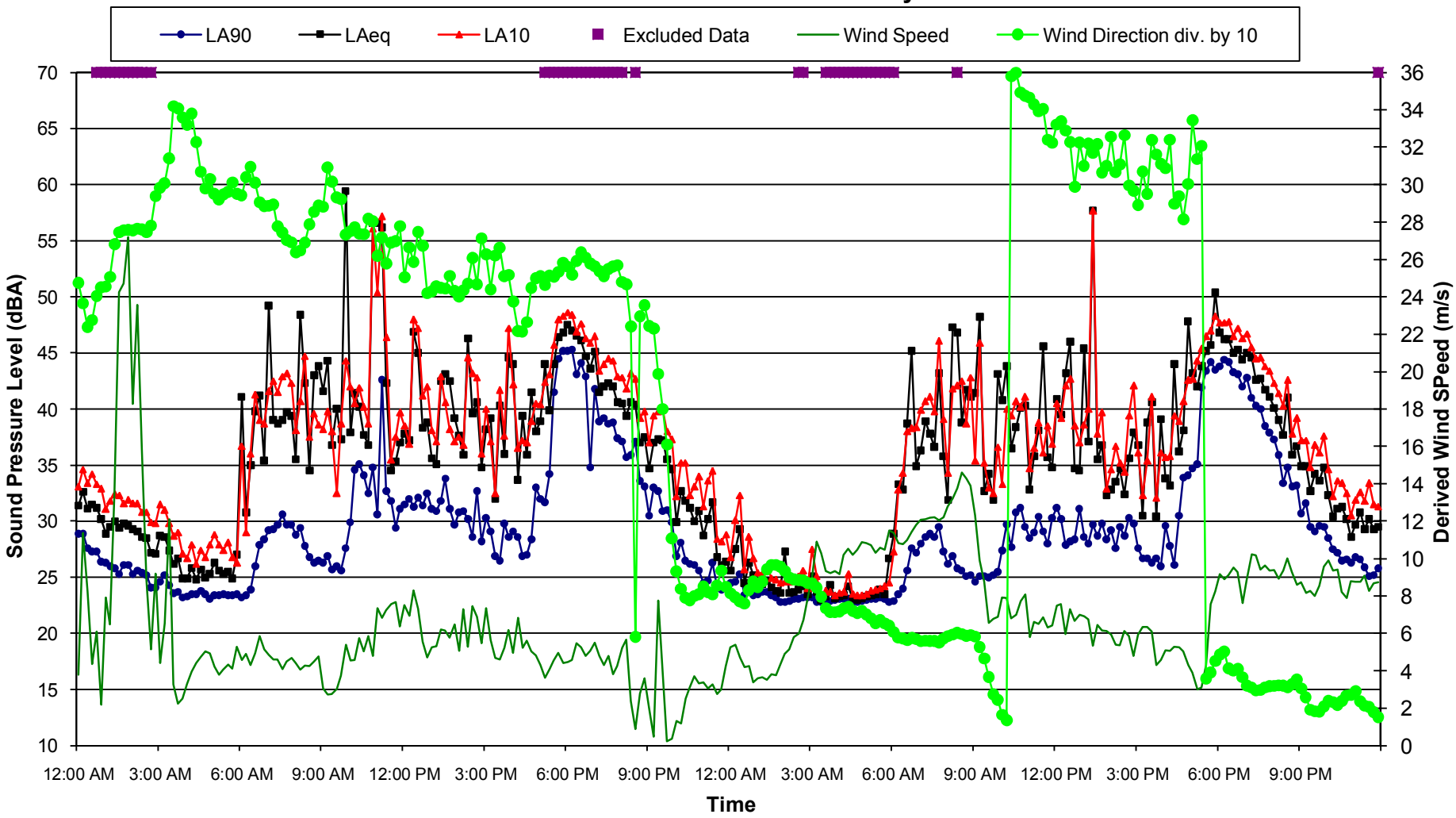
Appendix C1
40-1822
Level Wind vs Time

Location Falkland - Sapphire Wind Farm
Ambient Noise Data - 17 and 18 July 2009

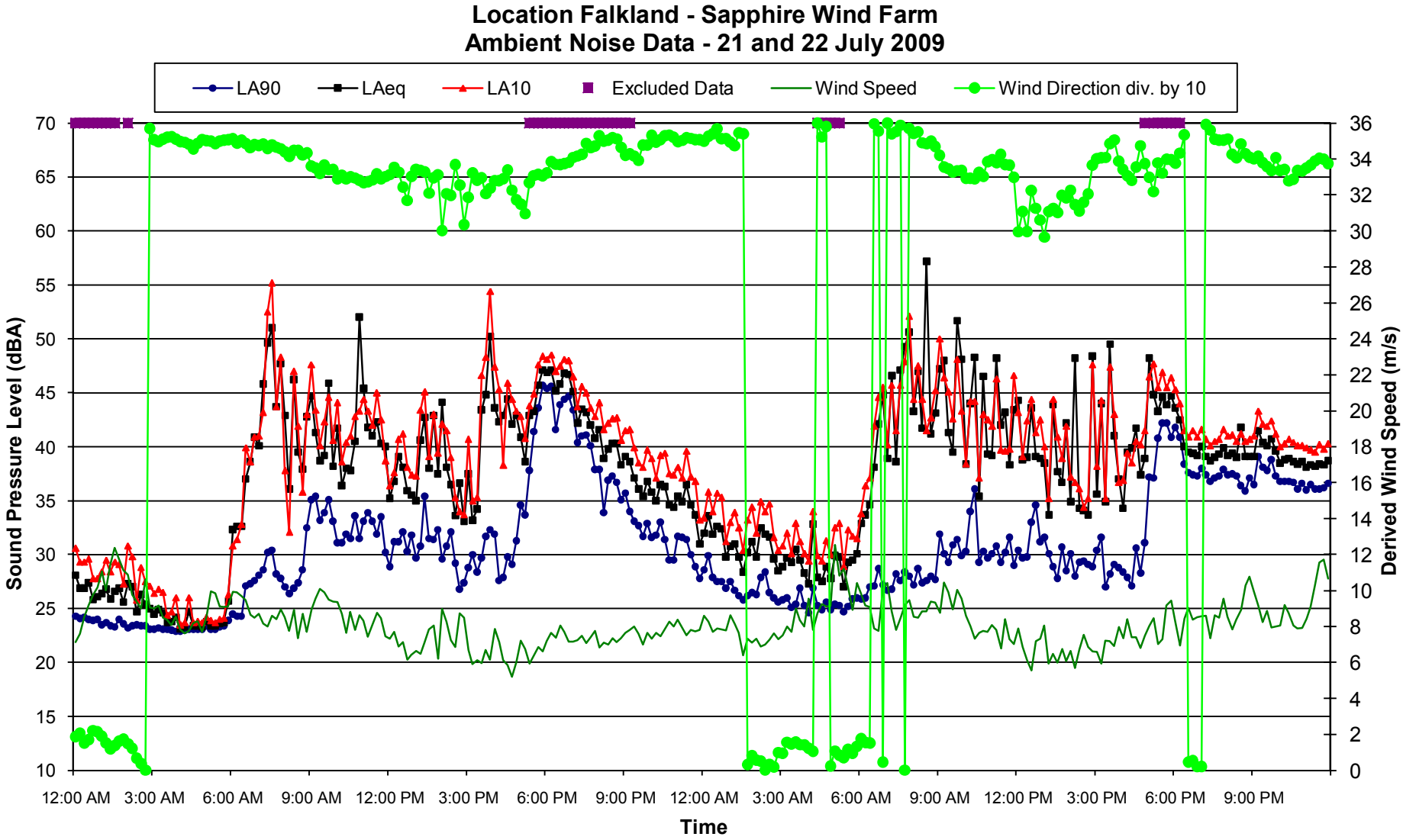


Appendix C1
40-1822
Level Wind vs Time

Location Falkland - Sapphire Wind Farm
Ambient Noise Data - 19 and 20 July 2009

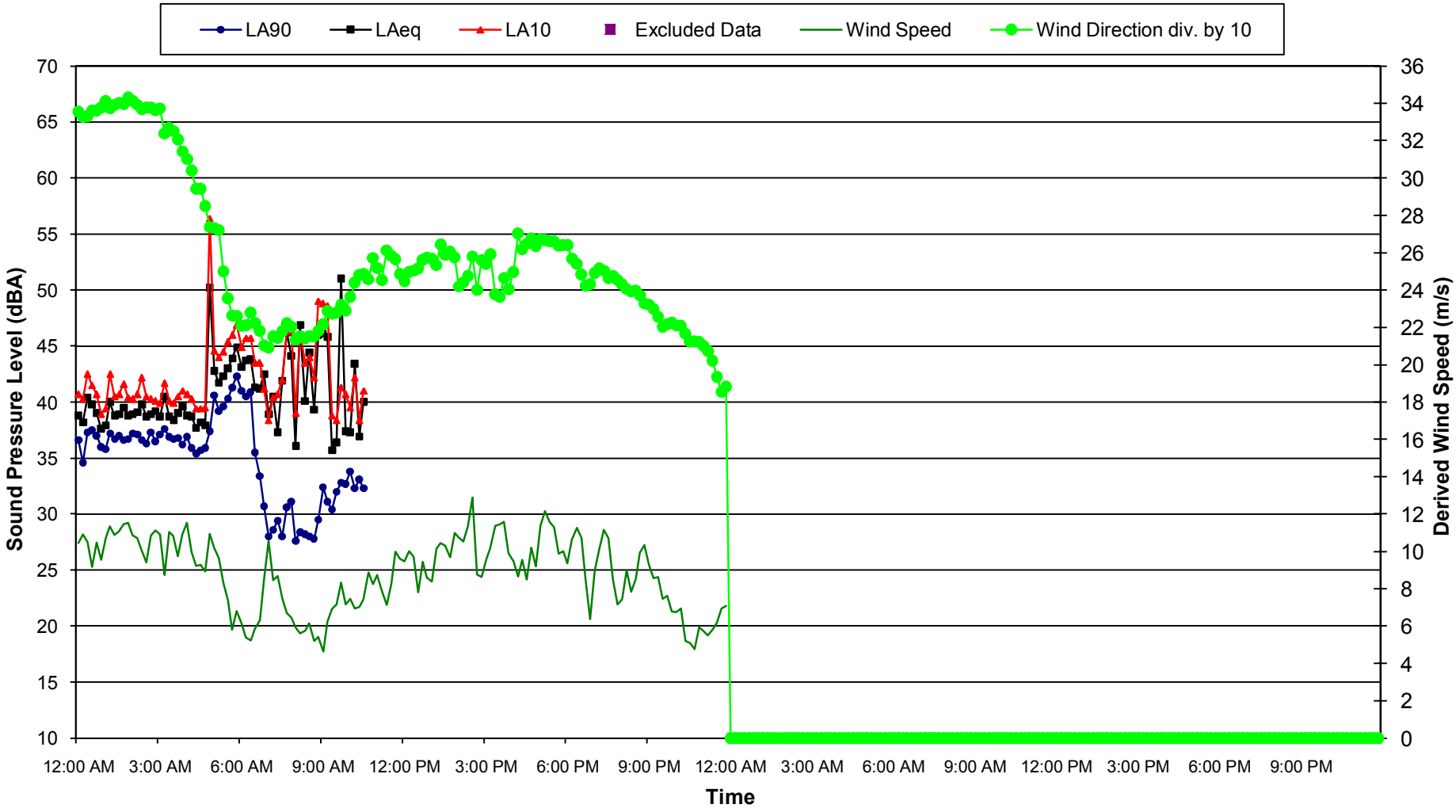


Appendix C1
40-1822
Level Wind vs Time

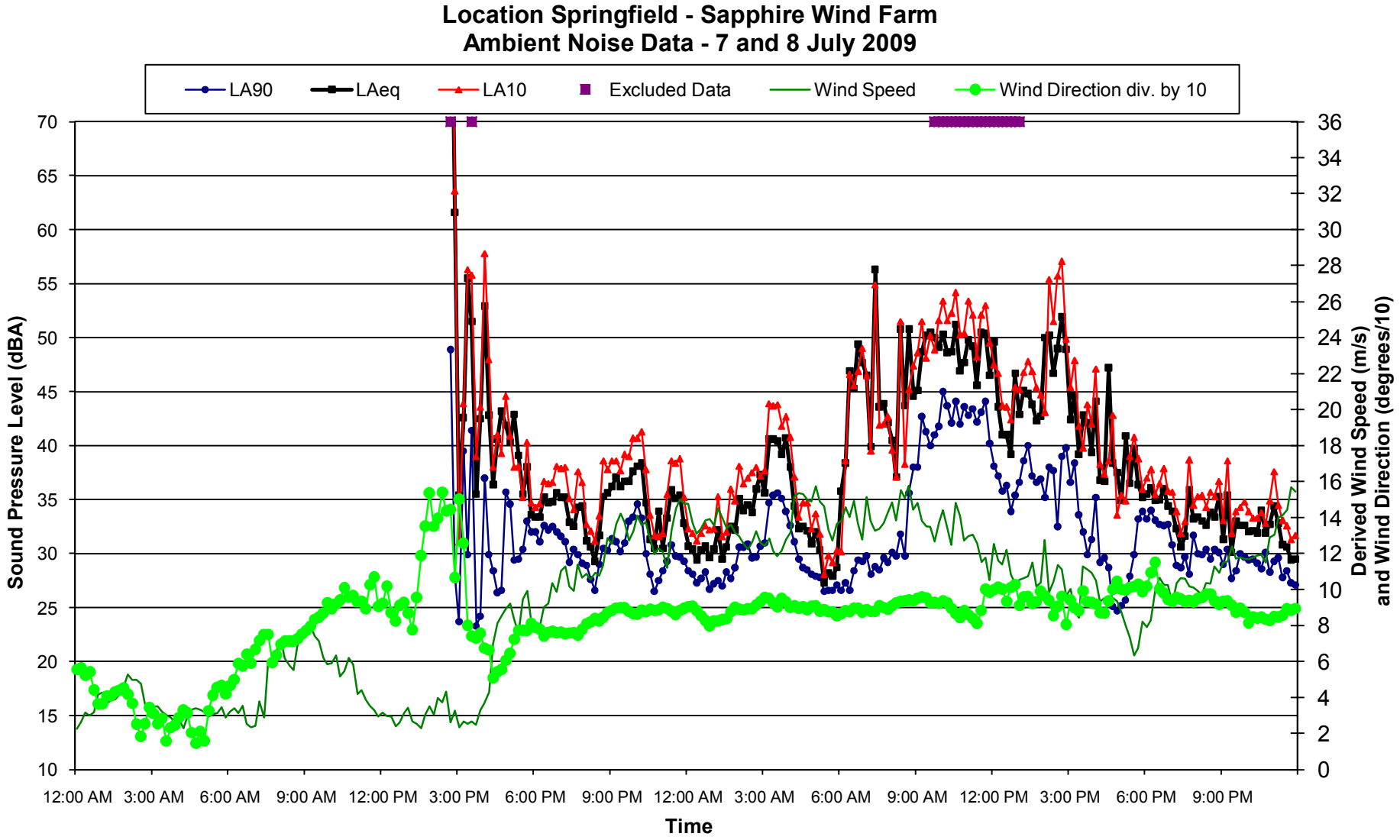


Appendix C1
40-1822
Level Wind vs Time

Location Falkland - Sapphire Wind Farm
Ambient Noise Data - 23 and 24 July 2009

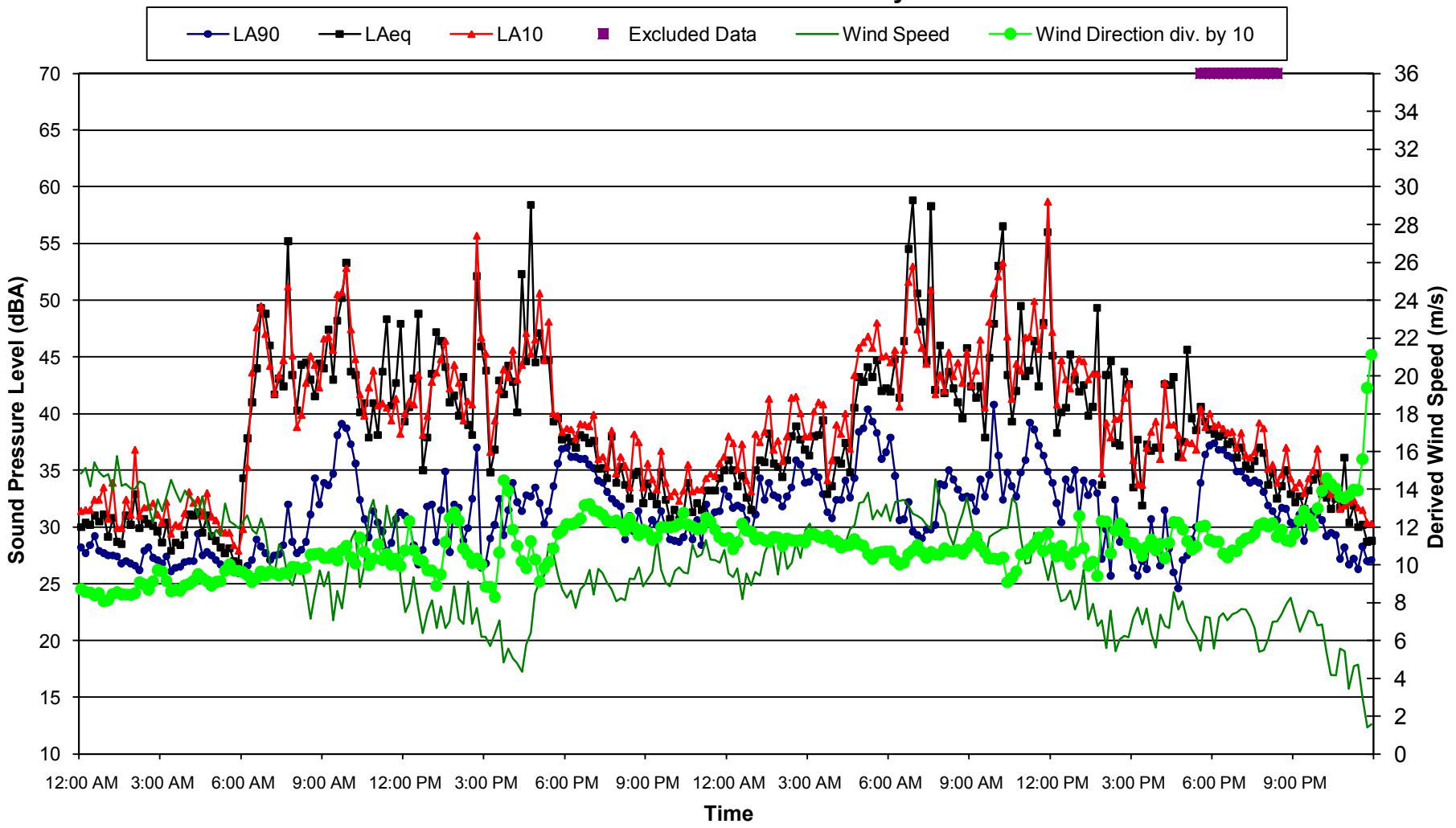


Appendix C1
40-1822
Level Wind vs Time



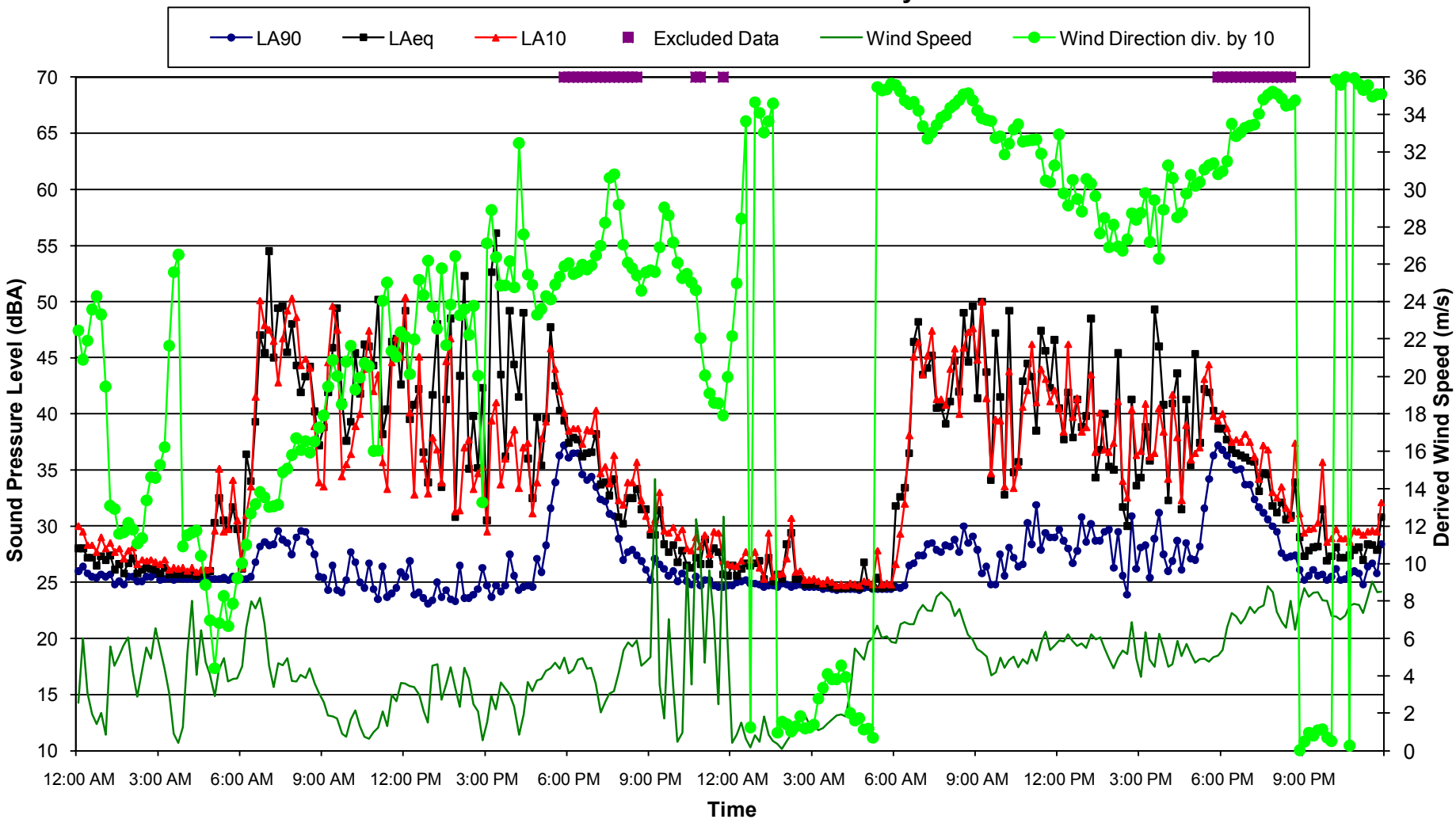
Appendix C1
40-1822
Level Wind vs Time

Location Springfield - Sapphire Wind Farm
Ambient Noise Data - 9 and 10 July 2009

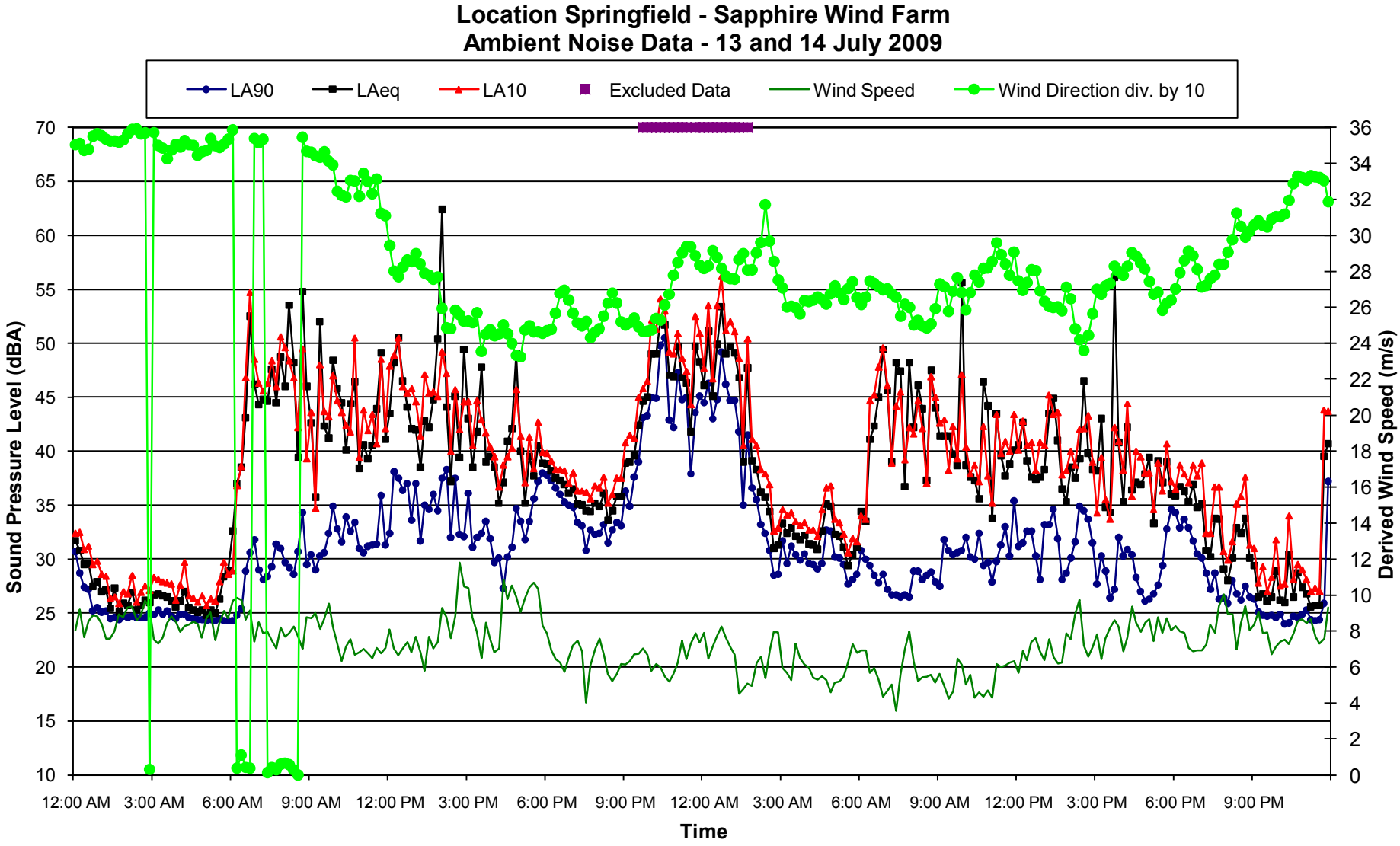


Appendix C1
40-1822
Level Wind vs Time

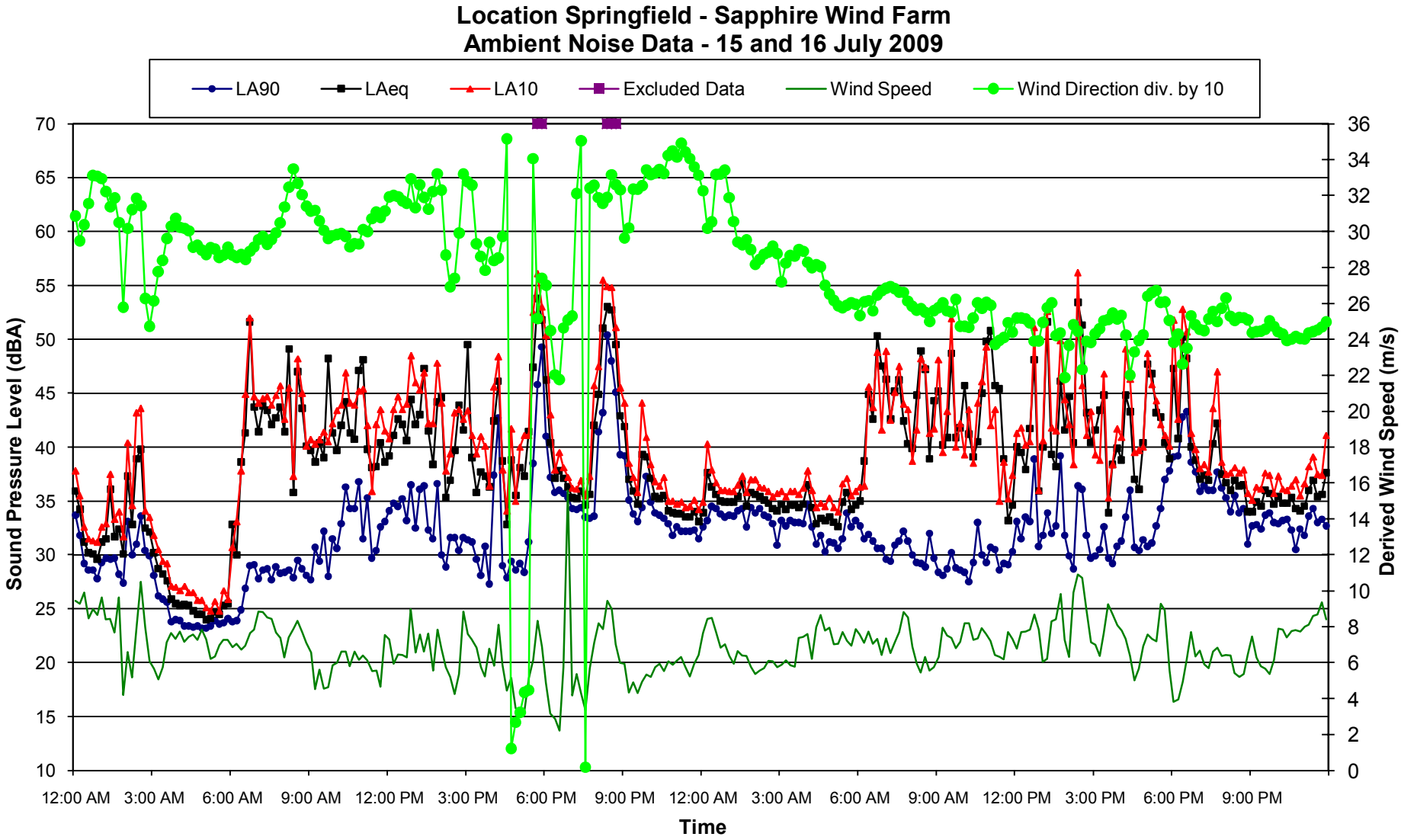
Location Springfield - Sapphire Wind Farm
Ambient Noise Data - 11 and 12 July 2009



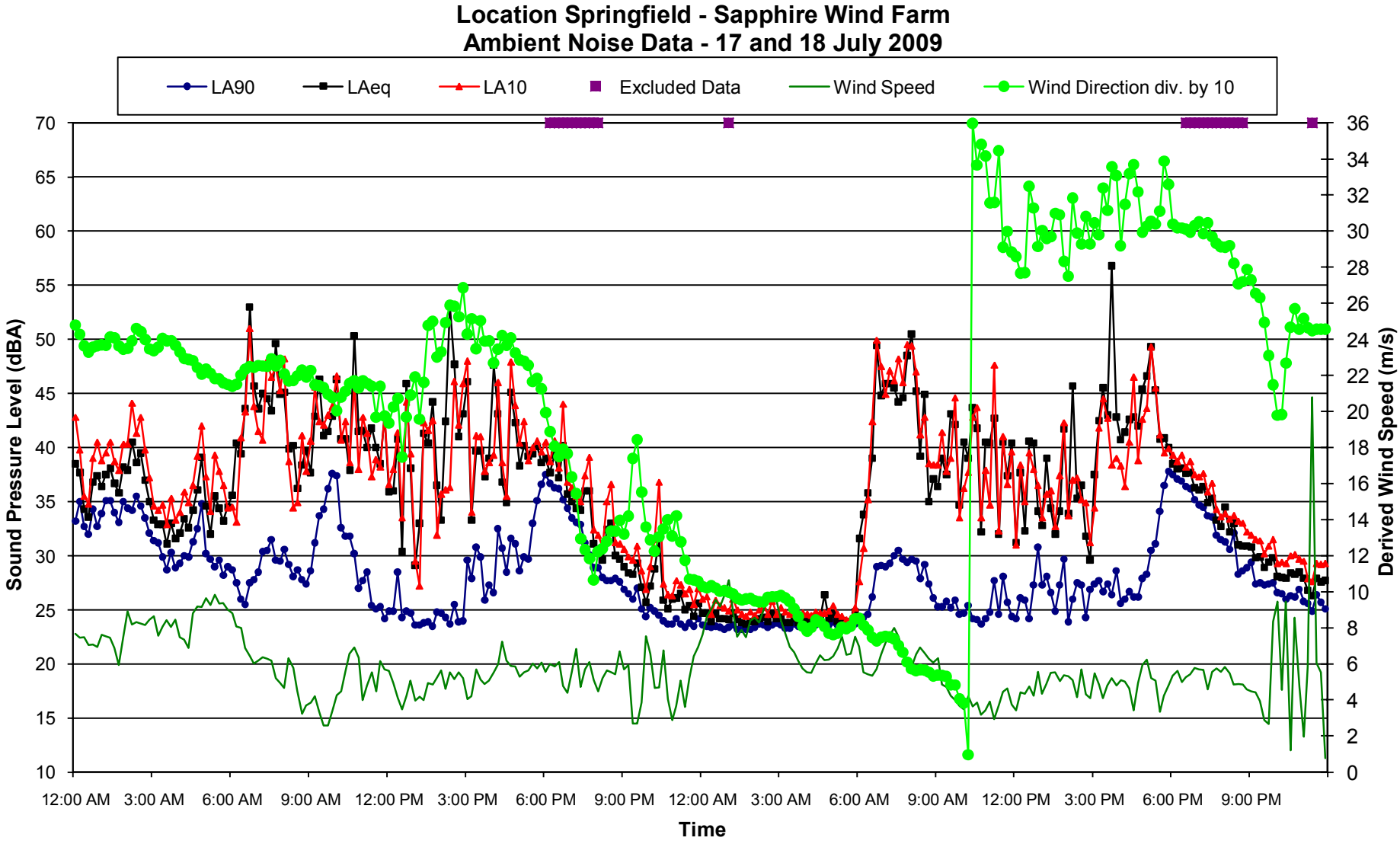
Appendix C1
40-1822
Level Wind vs Time



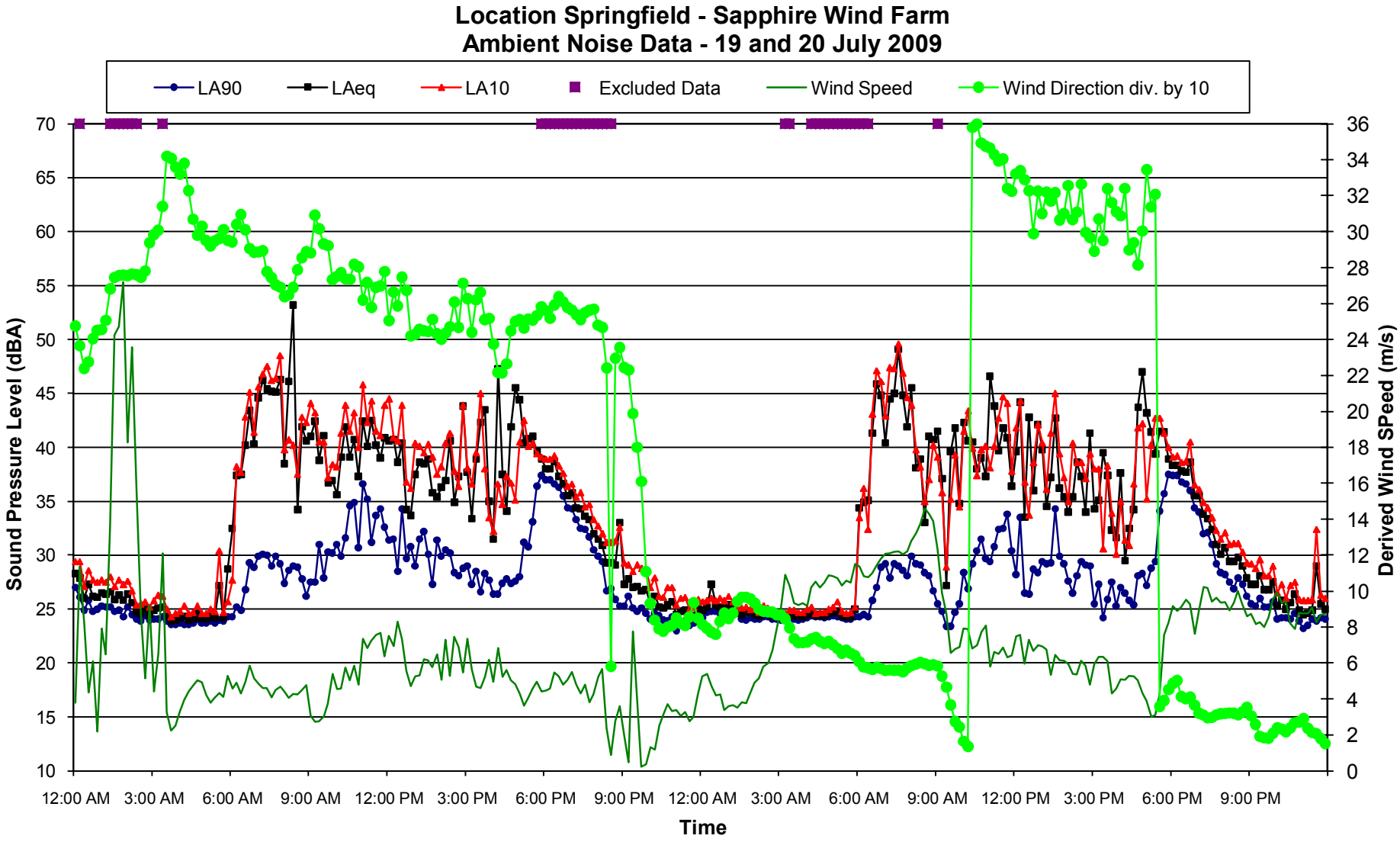
Appendix C1
40-1822
Level Wind vs Time



Appendix C1
40-1822
Level Wind vs Time

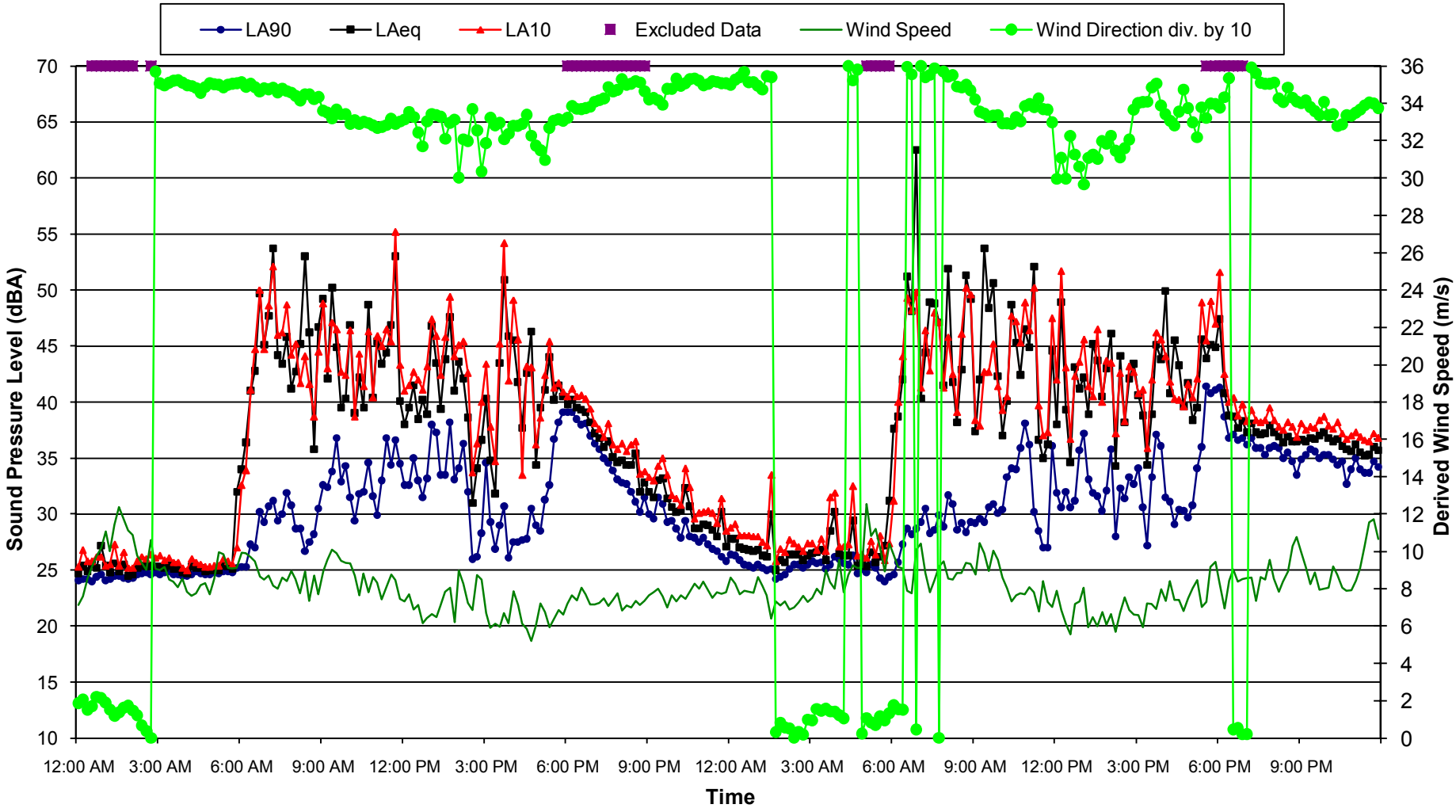


Appendix C1
40-1822
Level Wind vs Time



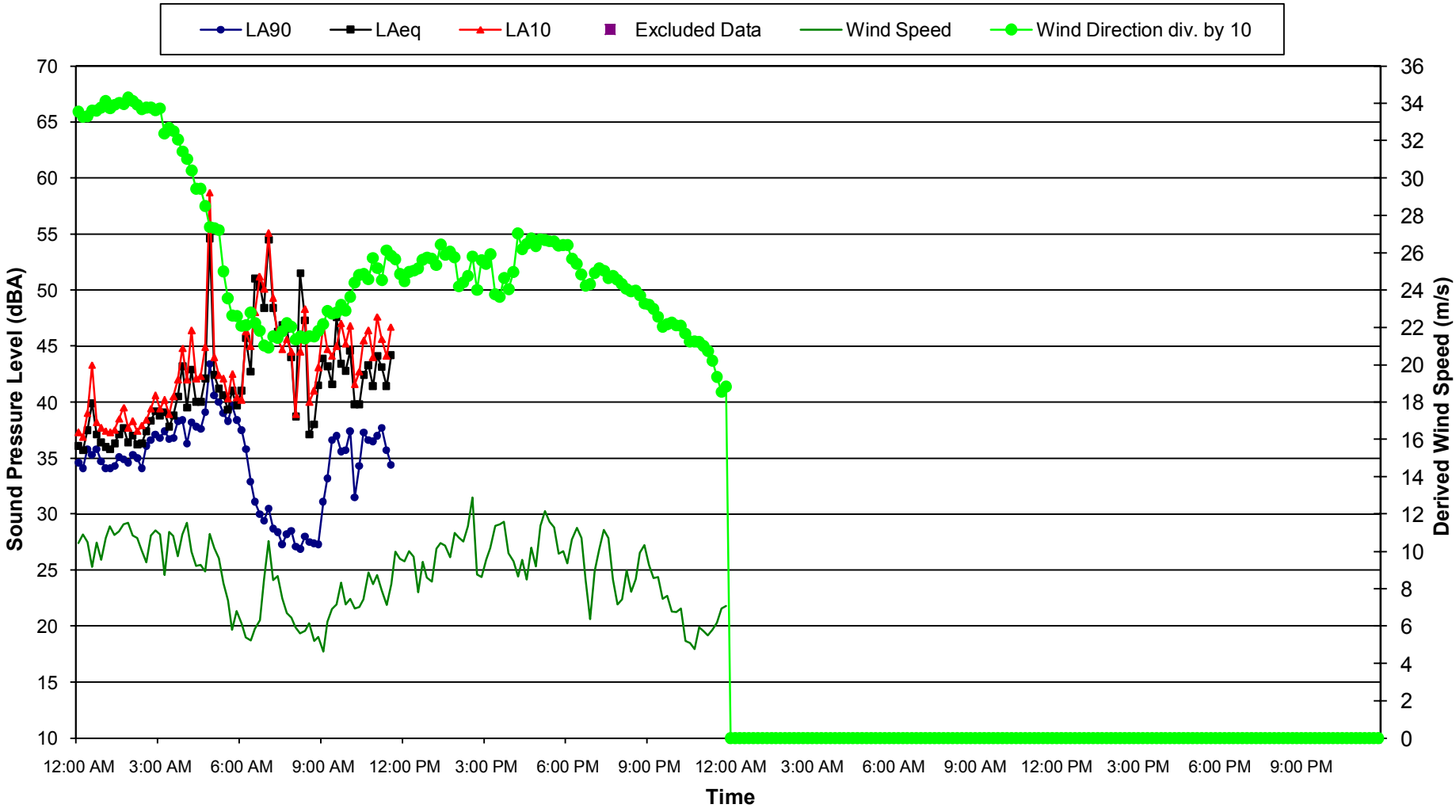
Appendix C1
40-1822
Level Wind vs Time

Location Springfield - Sapphire Wind Farm
Ambient Noise Data - 21 and 22 July 2009

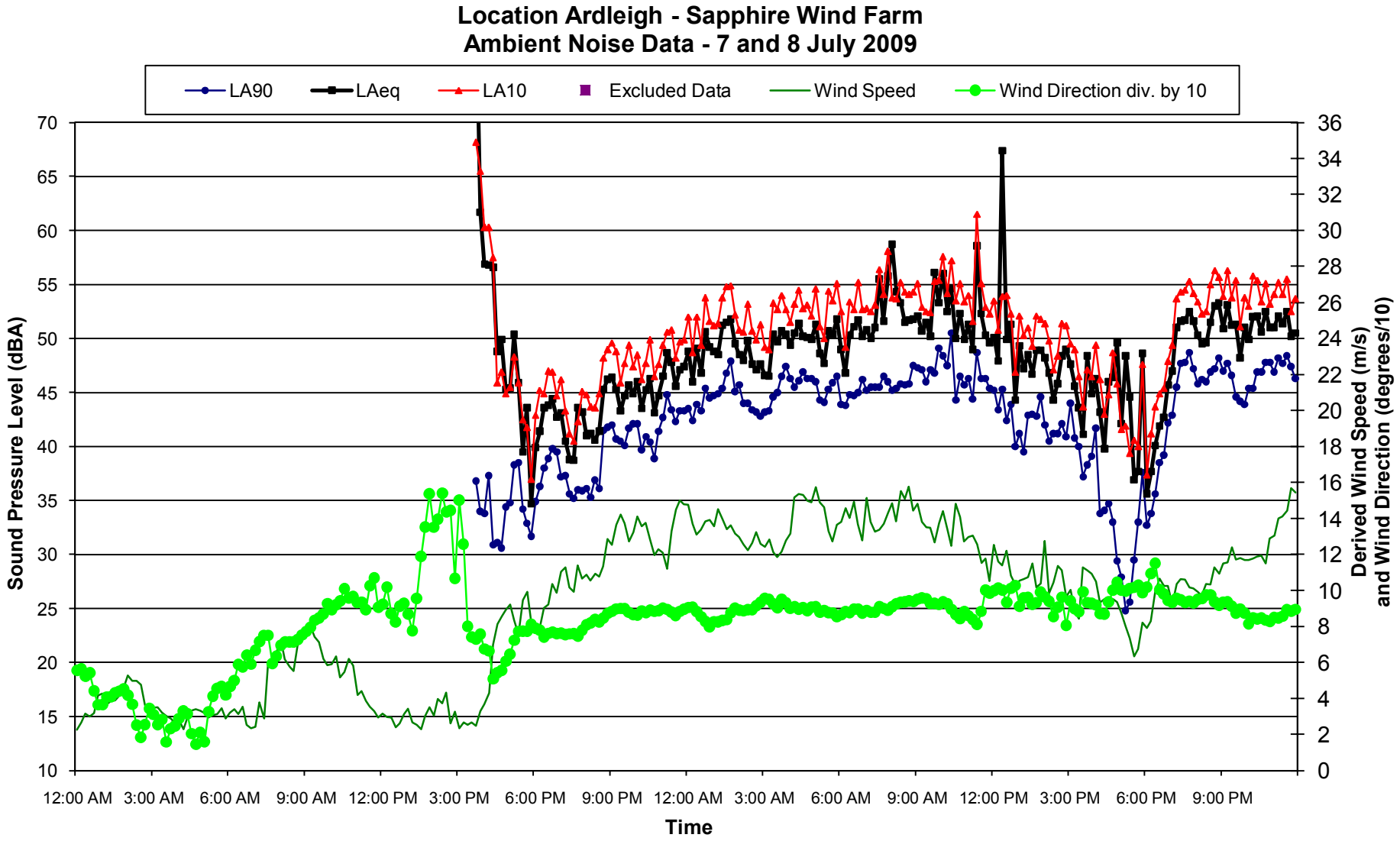


Appendix C1
40-1822
Level Wind vs Time

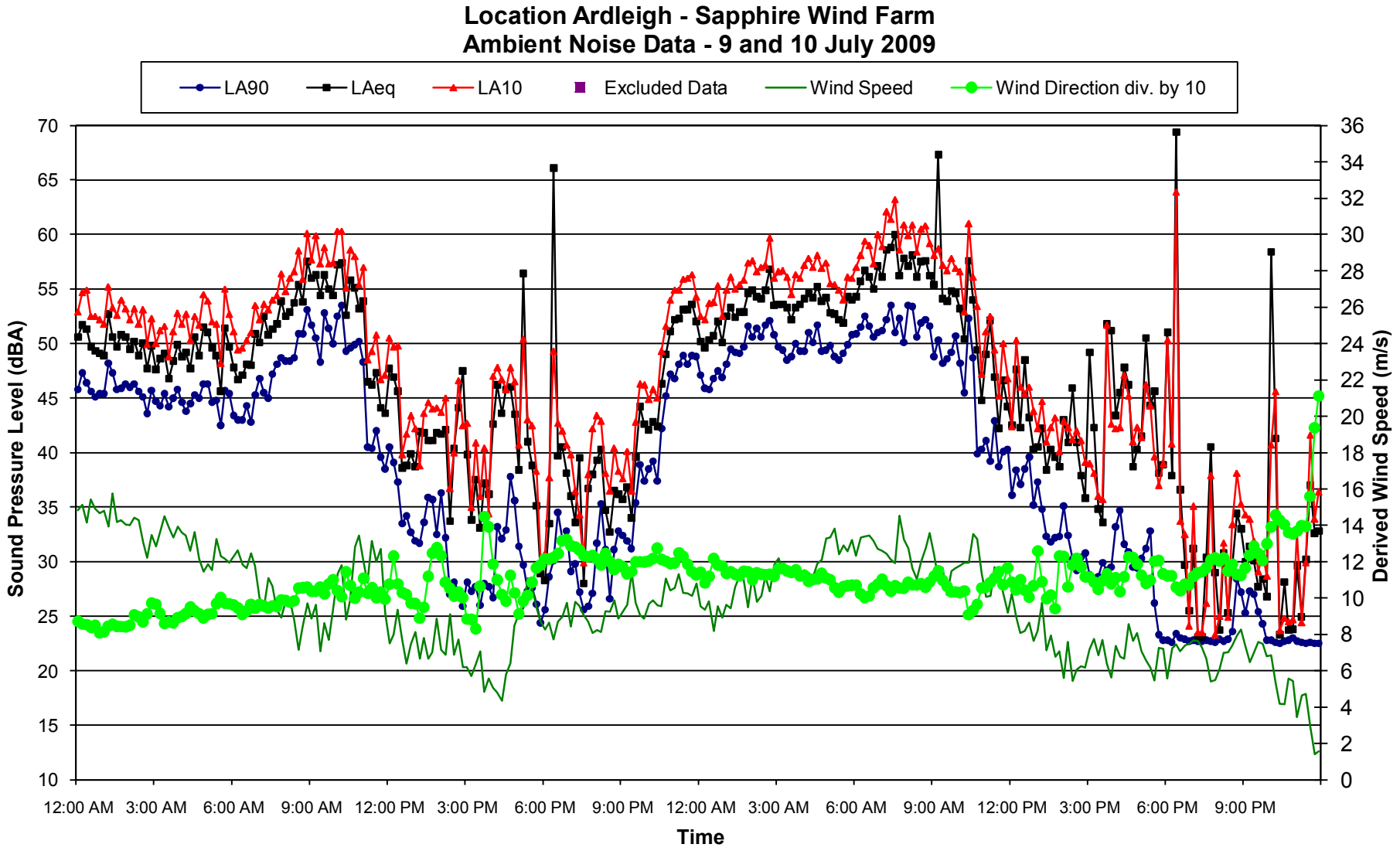
Location Springfield - Sapphire Wind Farm
Ambient Noise Data - 23 and 24 July 2009



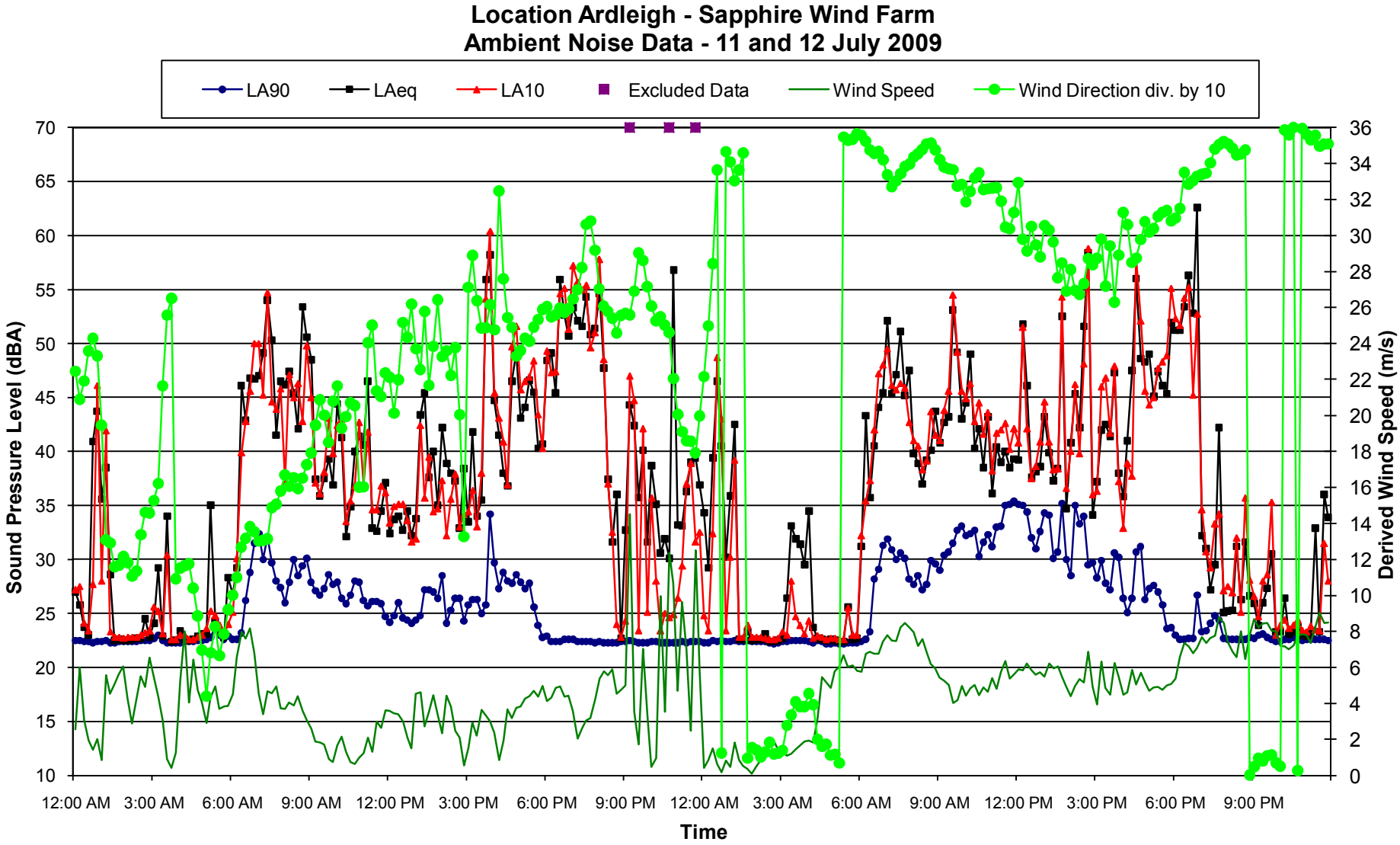
Appendix C1
40-1822
Level Wind vs Time



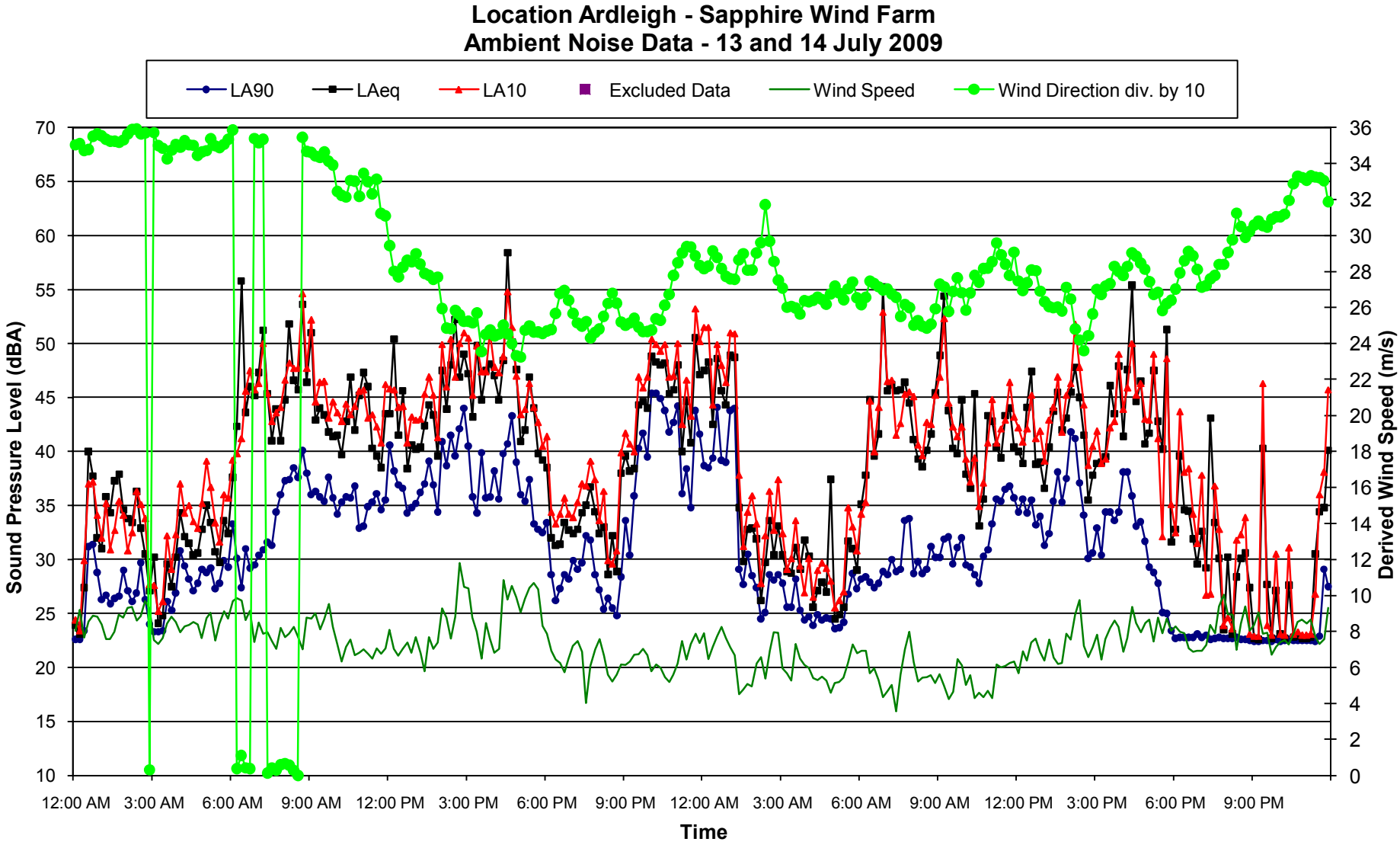
Appendix C1
40-1822
Level Wind vs Time



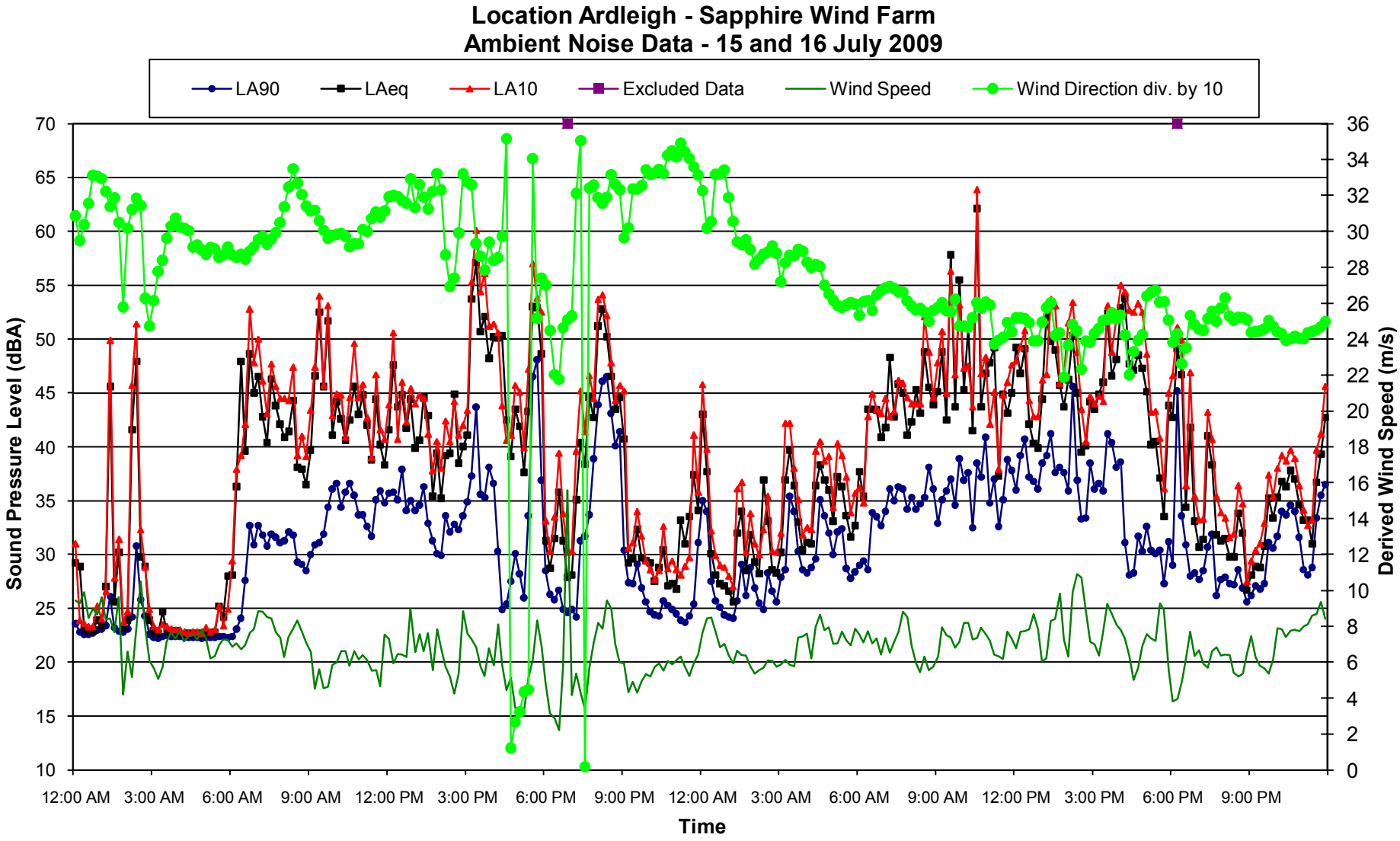
Appendix C1
40-1822
Level Wind vs Time



Appendix C1
40-1822
Level Wind vs Time

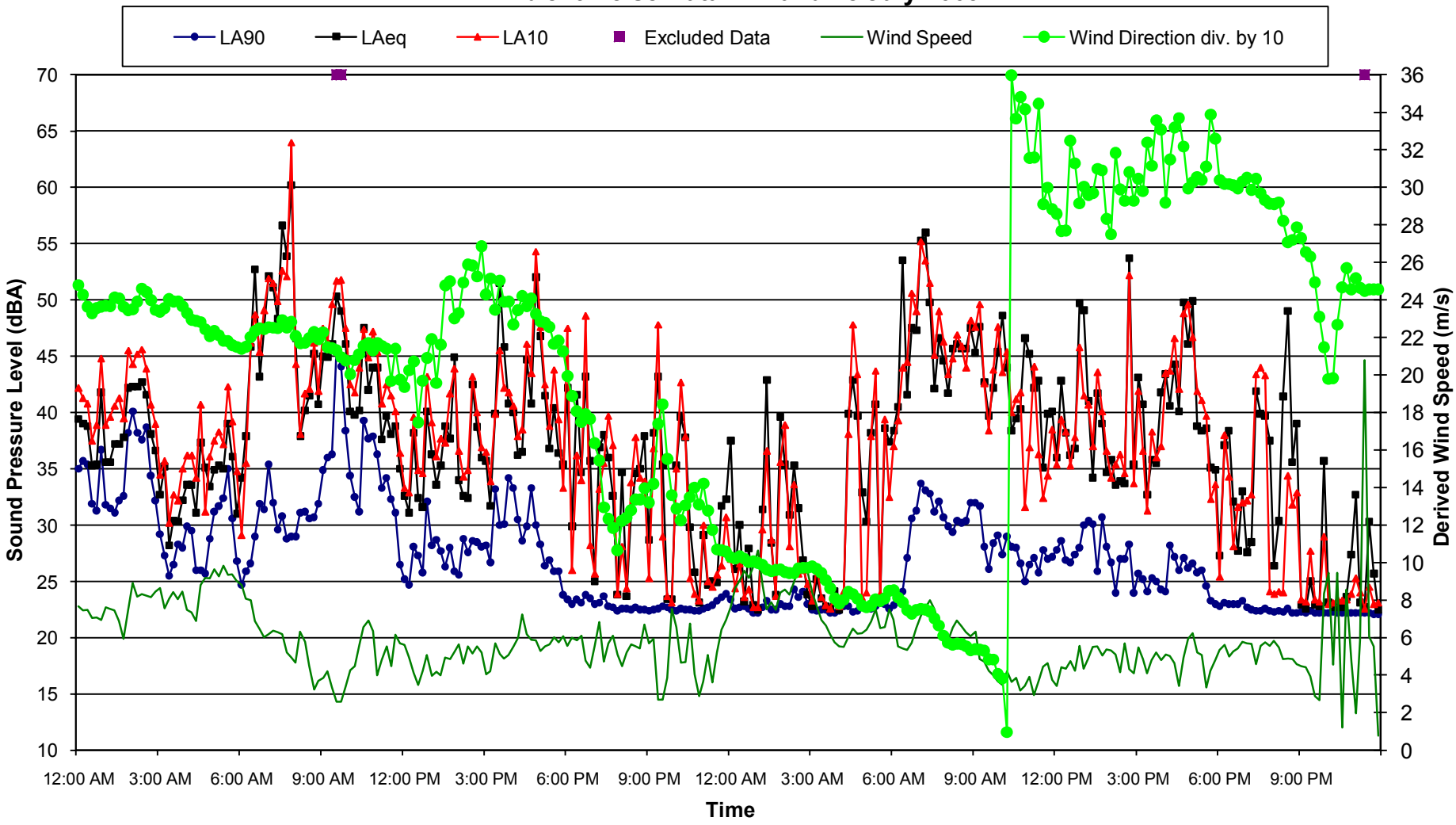


Appendix C1
40-1822
Level Wind vs Time



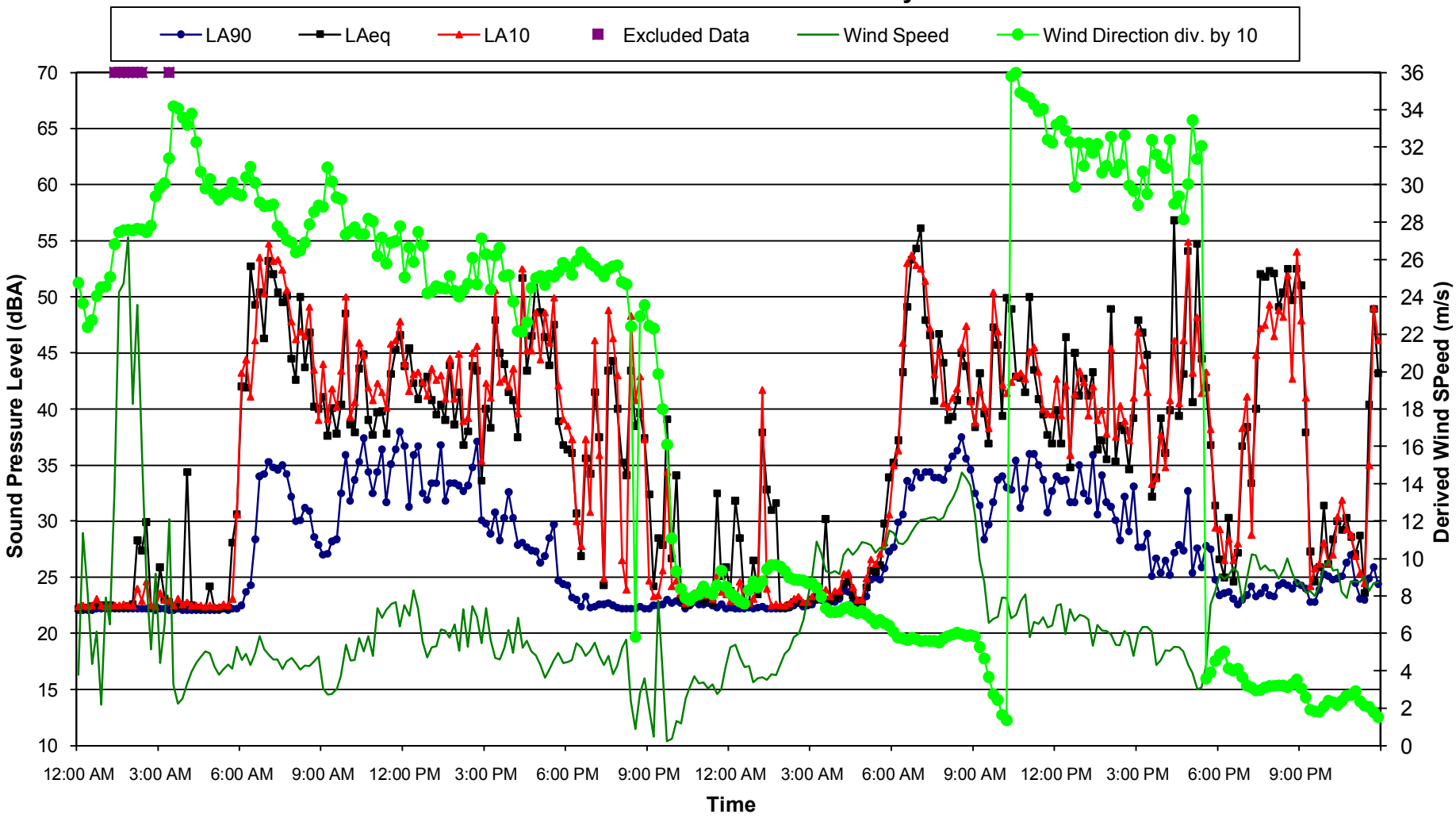
Appendix C1
40-1822
Level Wind vs Time

Location Ardleigh - Sapphire Wind Farm
Ambient Noise Data - 17 and 18 July 2009

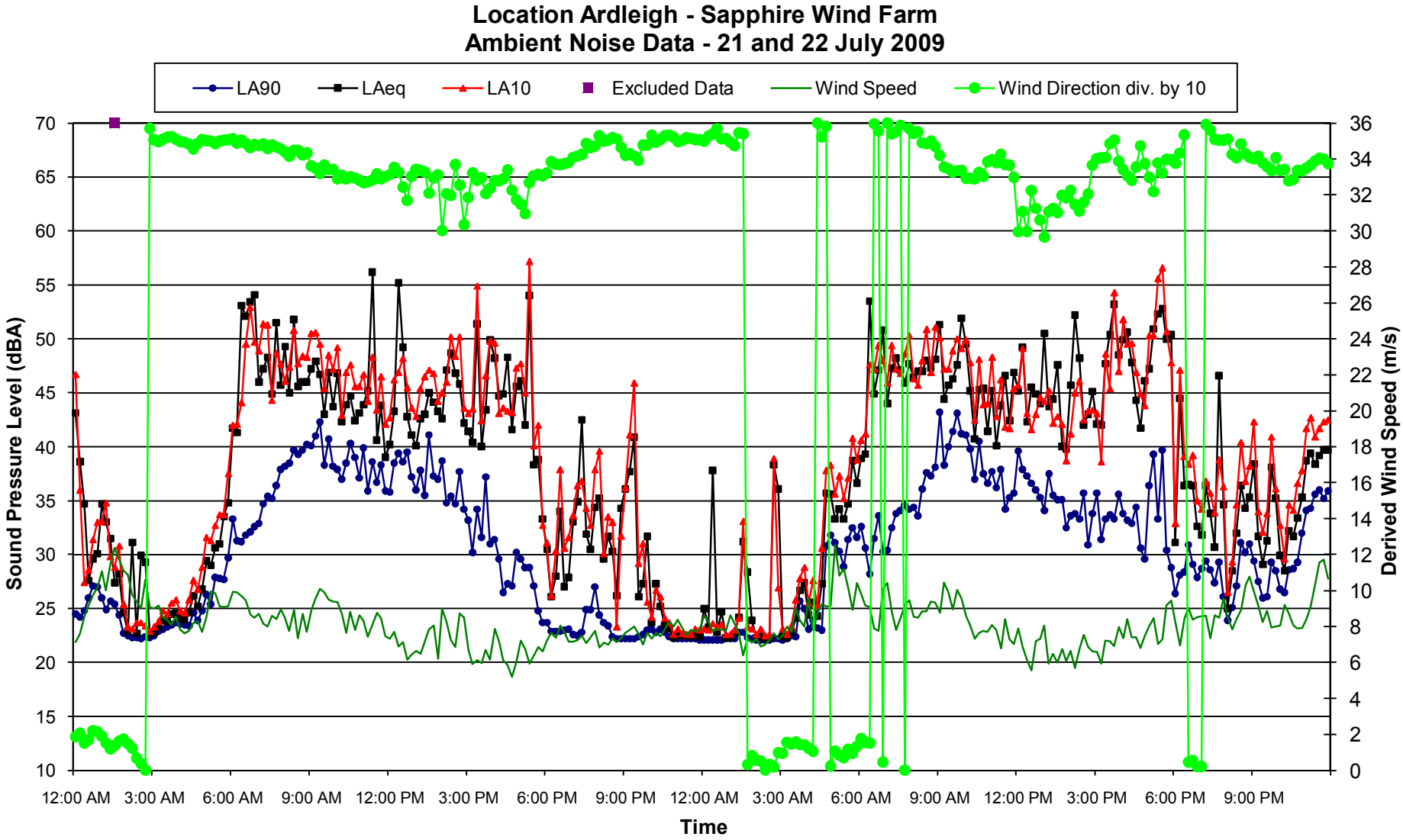


Appendix C1
40-1822
Level Wind vs Time

Location Ardleigh - Sapphire Wind Farm
Ambient Noise Data - 19 and 20 July 2009

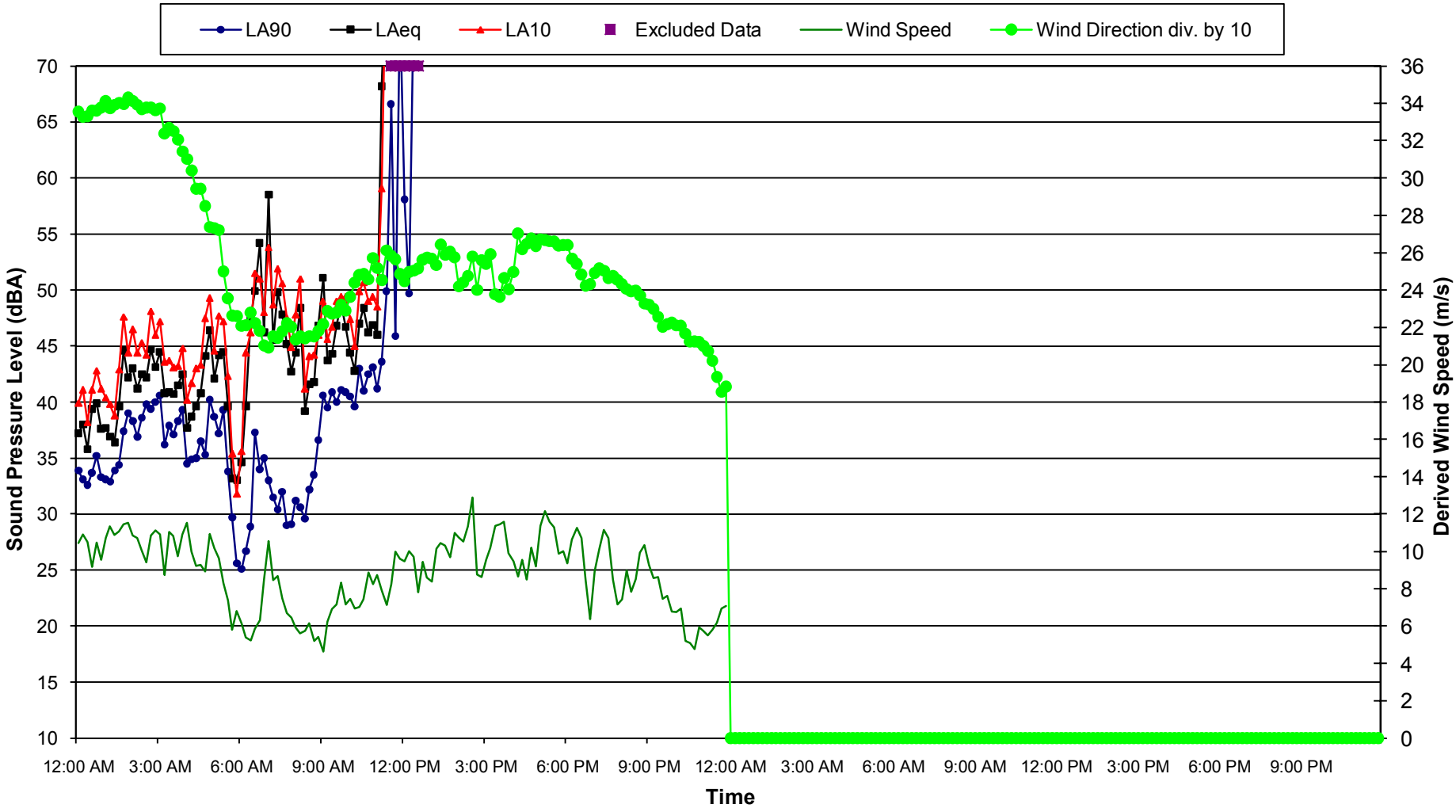


Appendix C1
40-1822
Level Wind vs Time



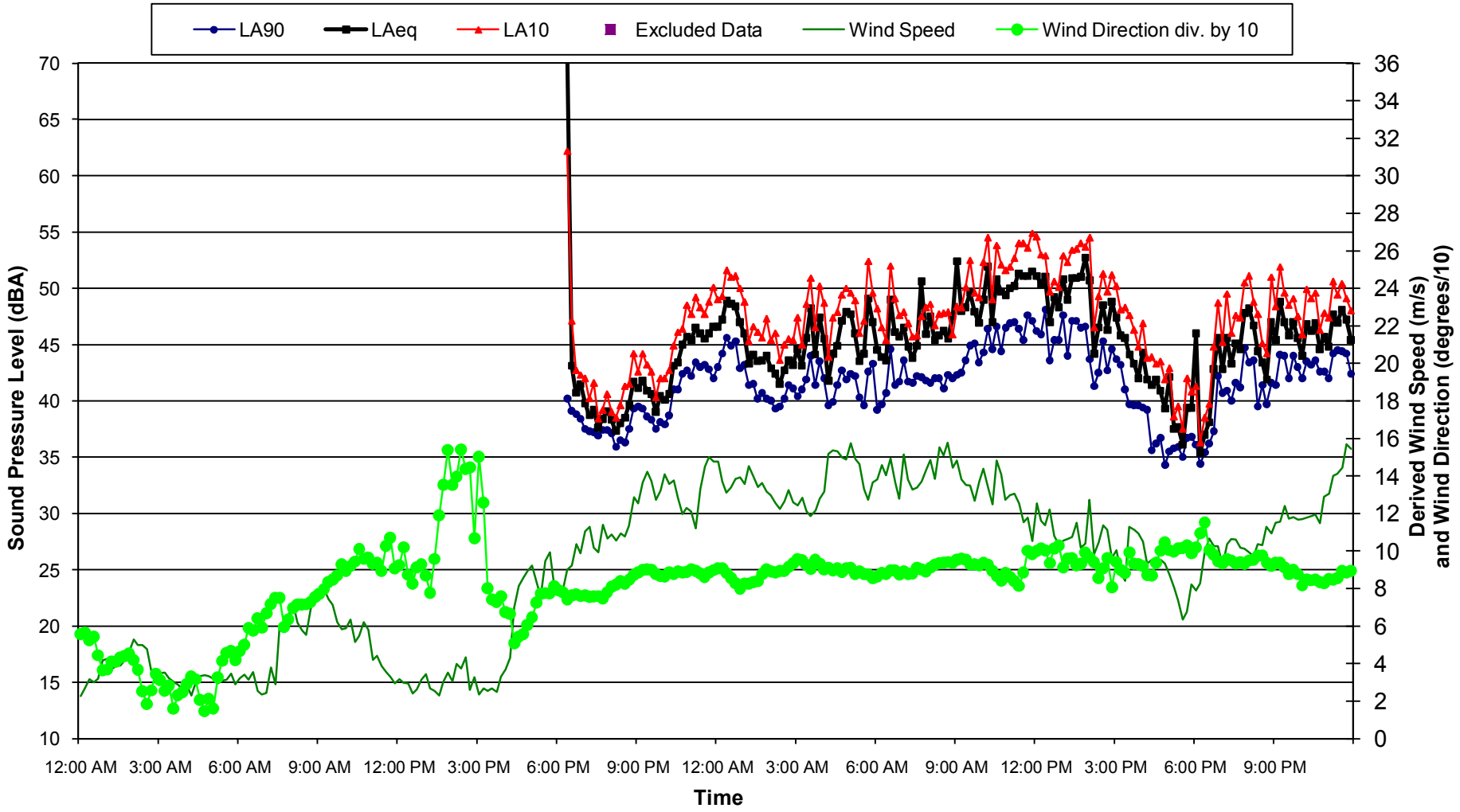
Appendix C1
40-1822
Level Wind vs Time

Location Ardleigh - Sapphire Wind Farm
Ambient Noise Data - 23 and 24 July 2009



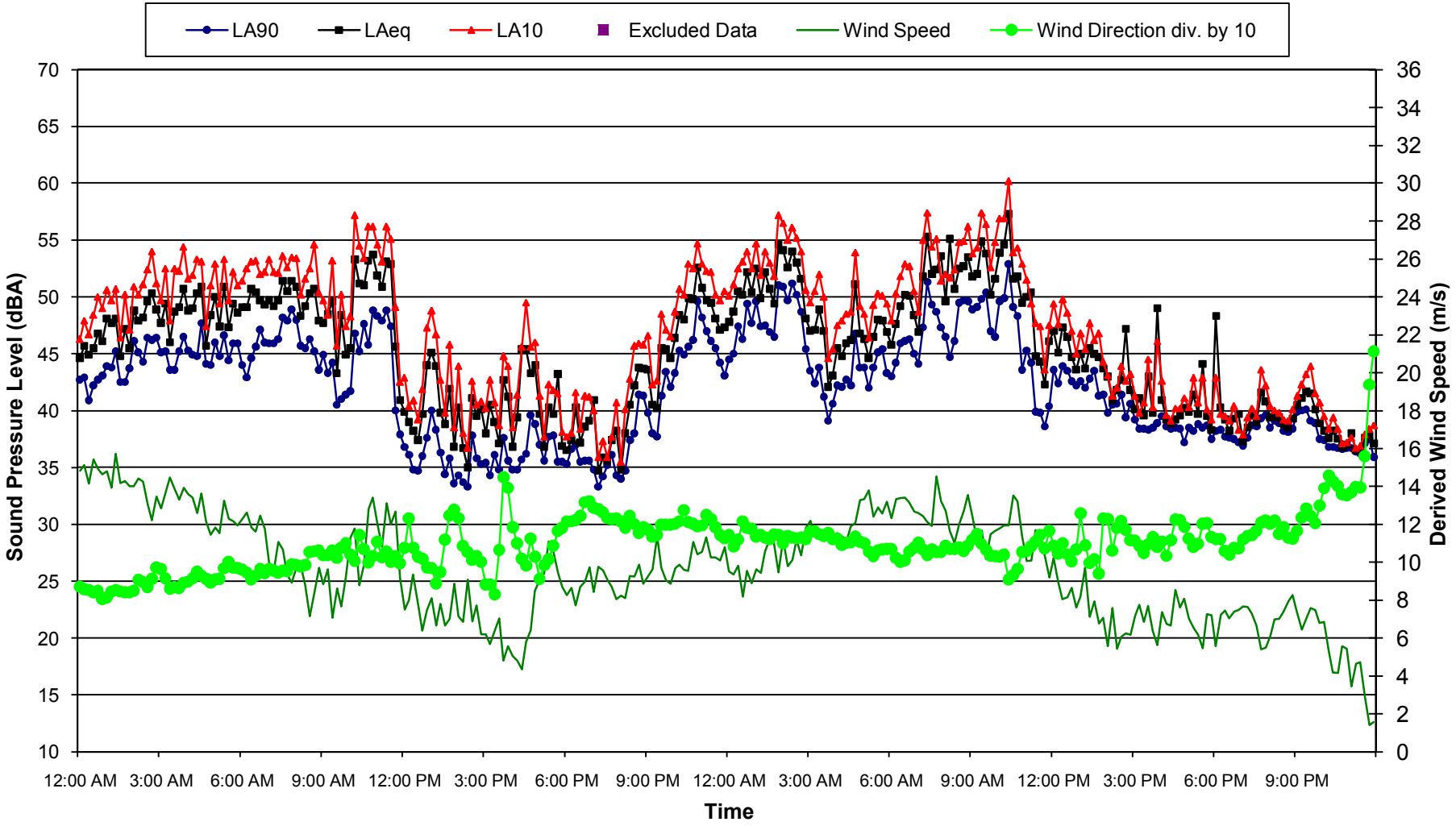
Appendix C1
40-1822
Level Wind vs Time

Location Downfield - Sapphire Wind Farm
Ambient Noise Data - 7 and 8 July 2009

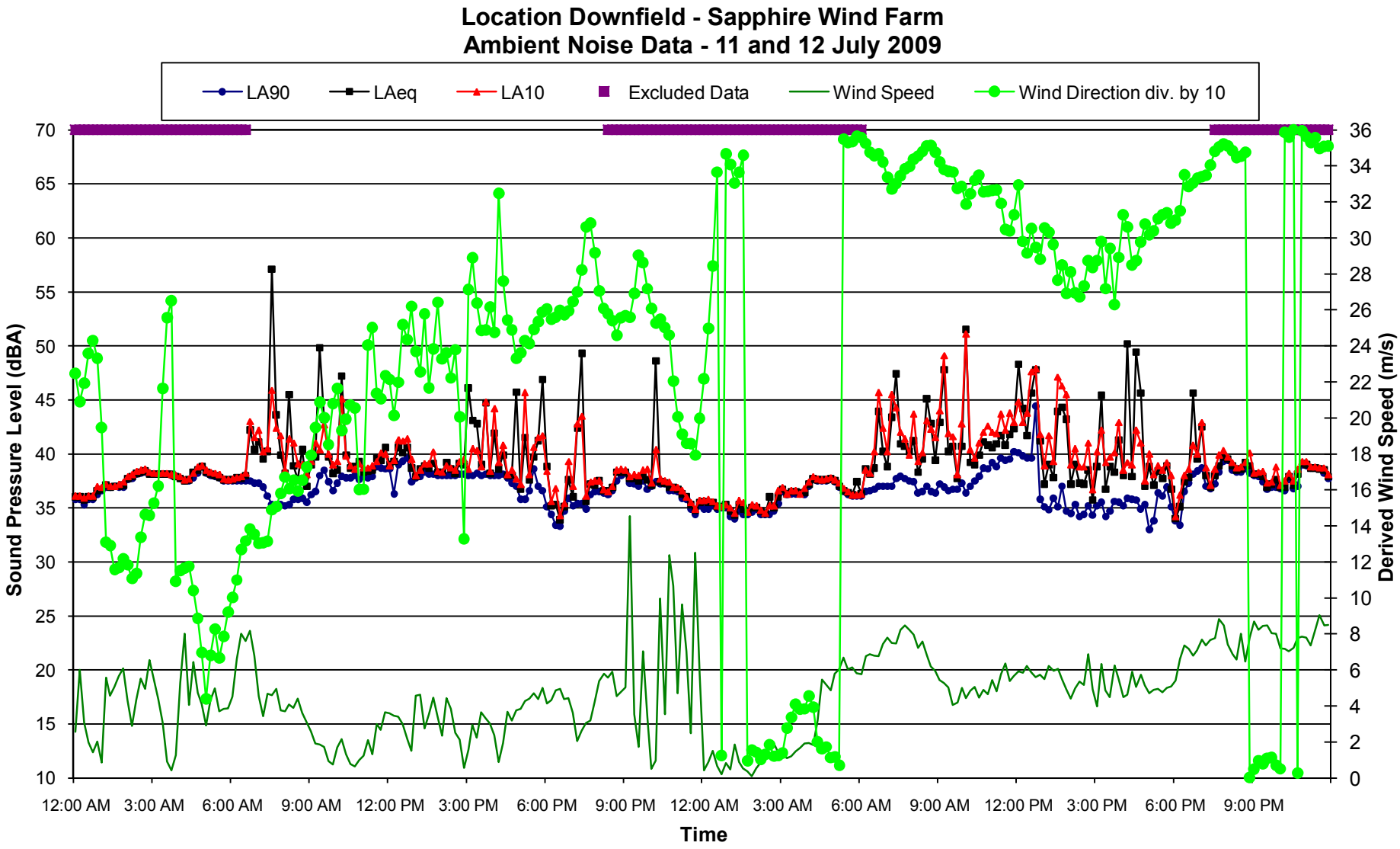


Appendix C1
40-1822
Level Wind vs Time

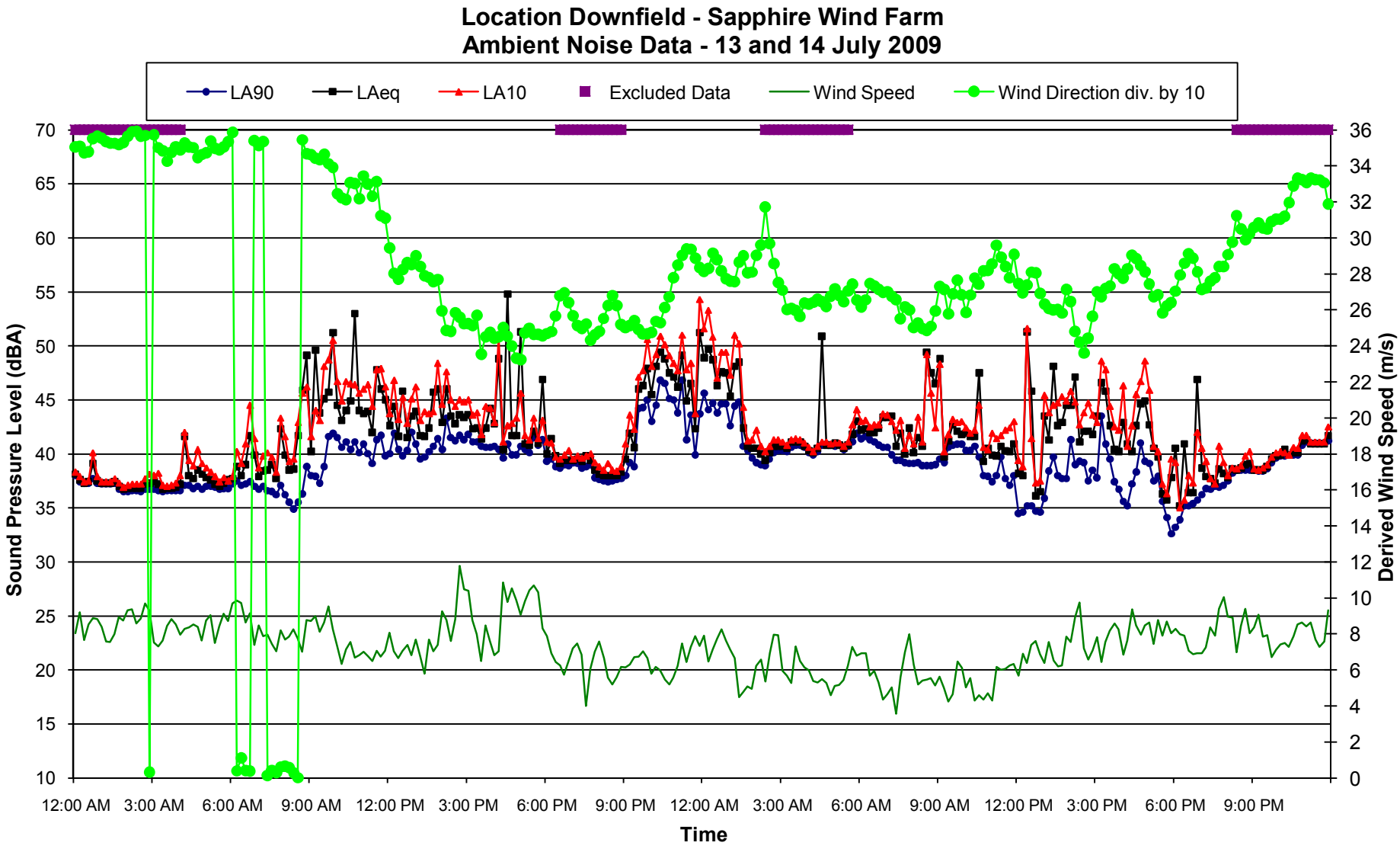
Location Downfield - Sapphire Wind Farm
Ambient Noise Data - 9 and 10 July 2009



Appendix C1
40-1822
Level Wind vs Time

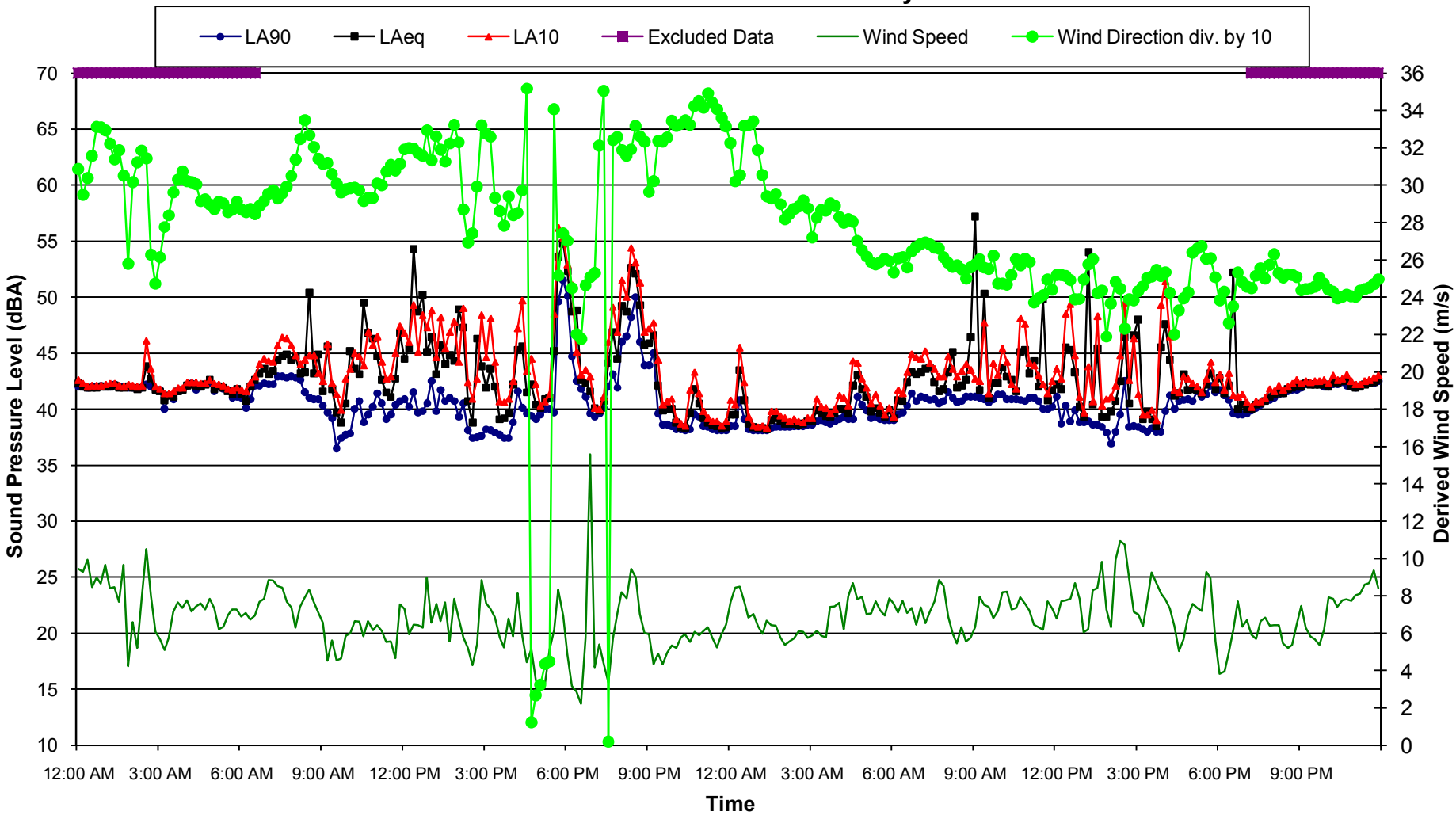


Appendix C1
40-1822
Level Wind vs Time



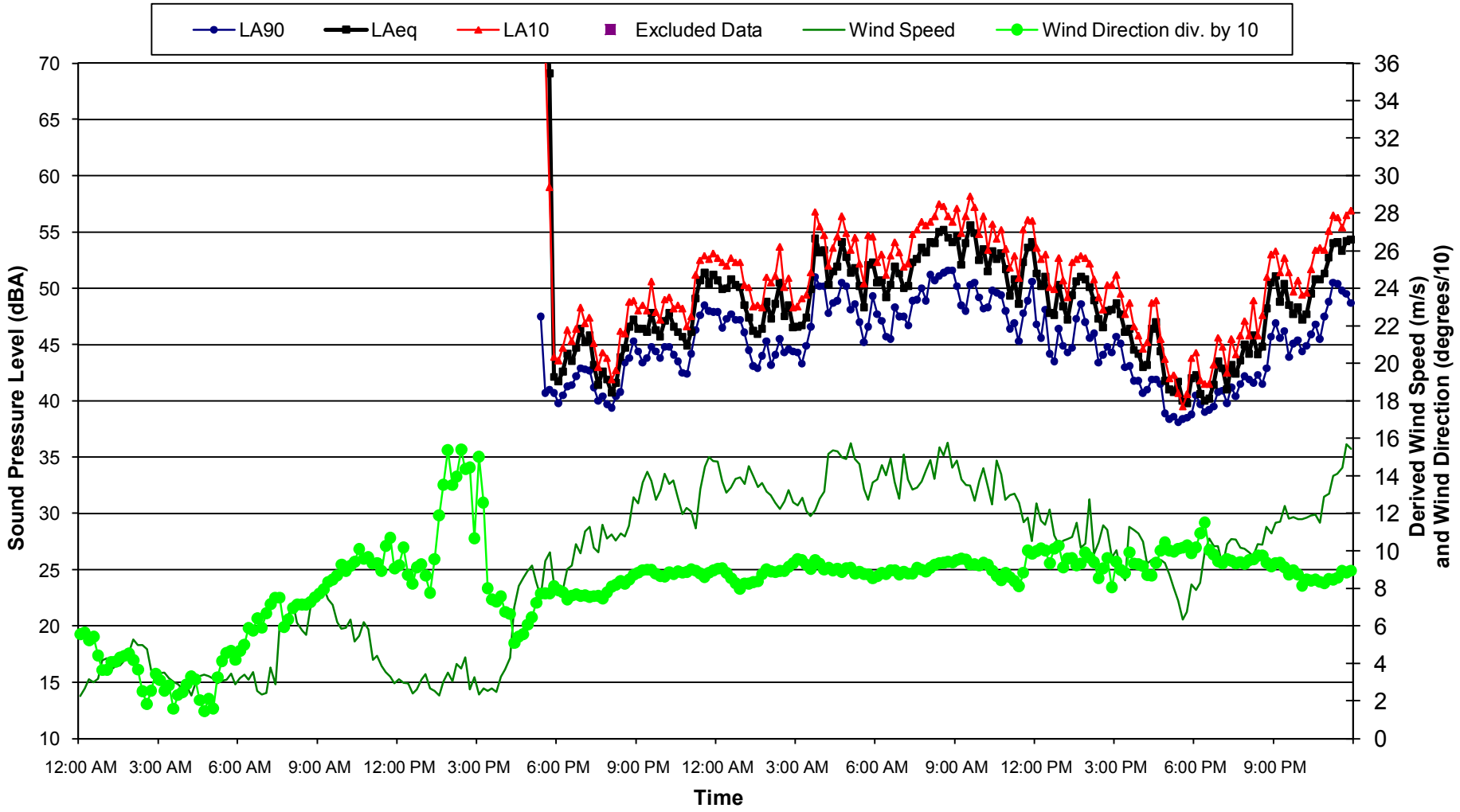
Appendix C1
40-1822
Level Wind vs Time

Location Downfield - Sapphire Wind Farm
Ambient Noise Data - 15 and 16 July 2009



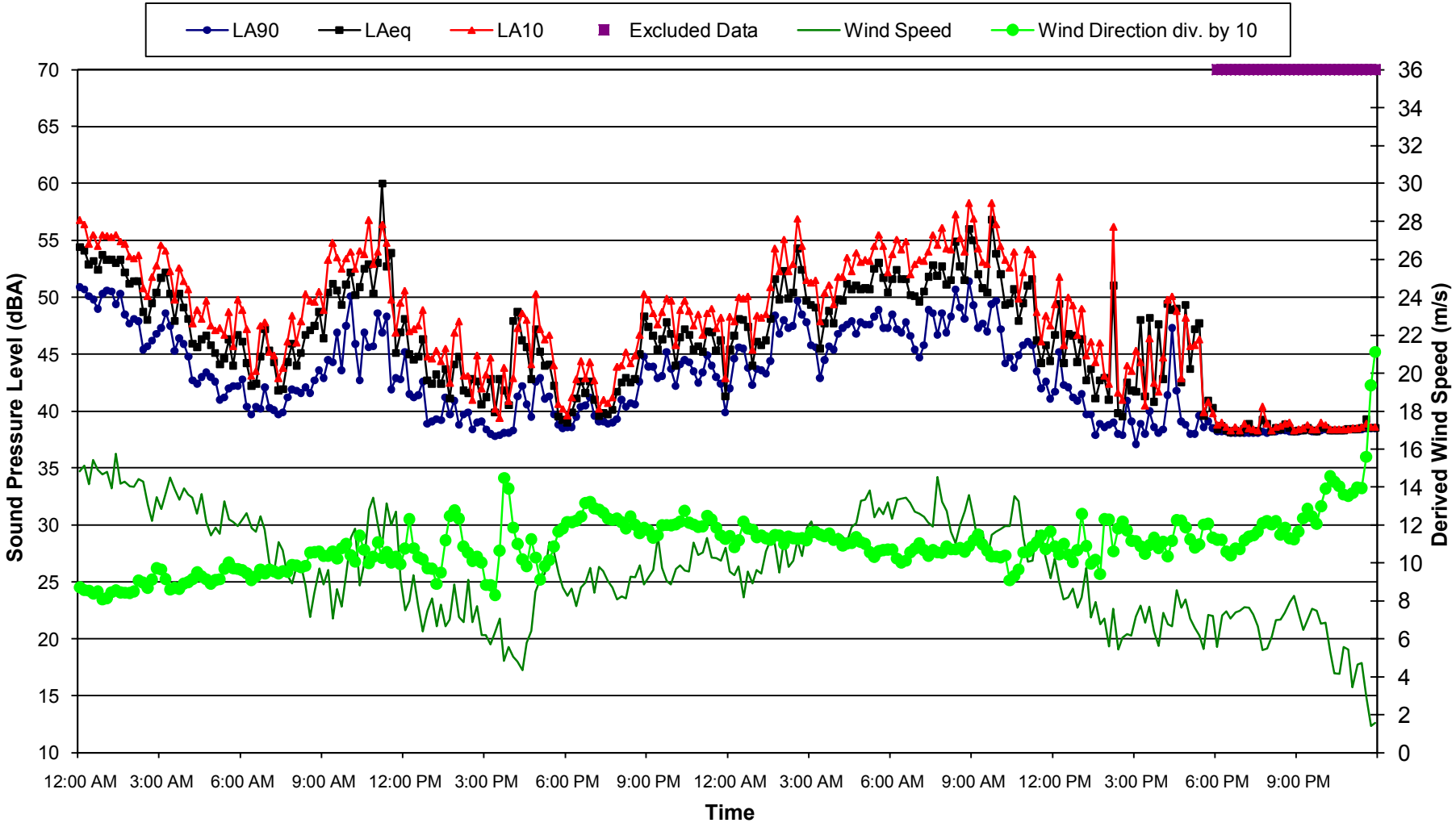
Appendix C1
40-1822
Level Wind vs Time

Location Kingshill - Sapphire Wind Farm
Ambient Noise Data - 7 and 8 July 2009

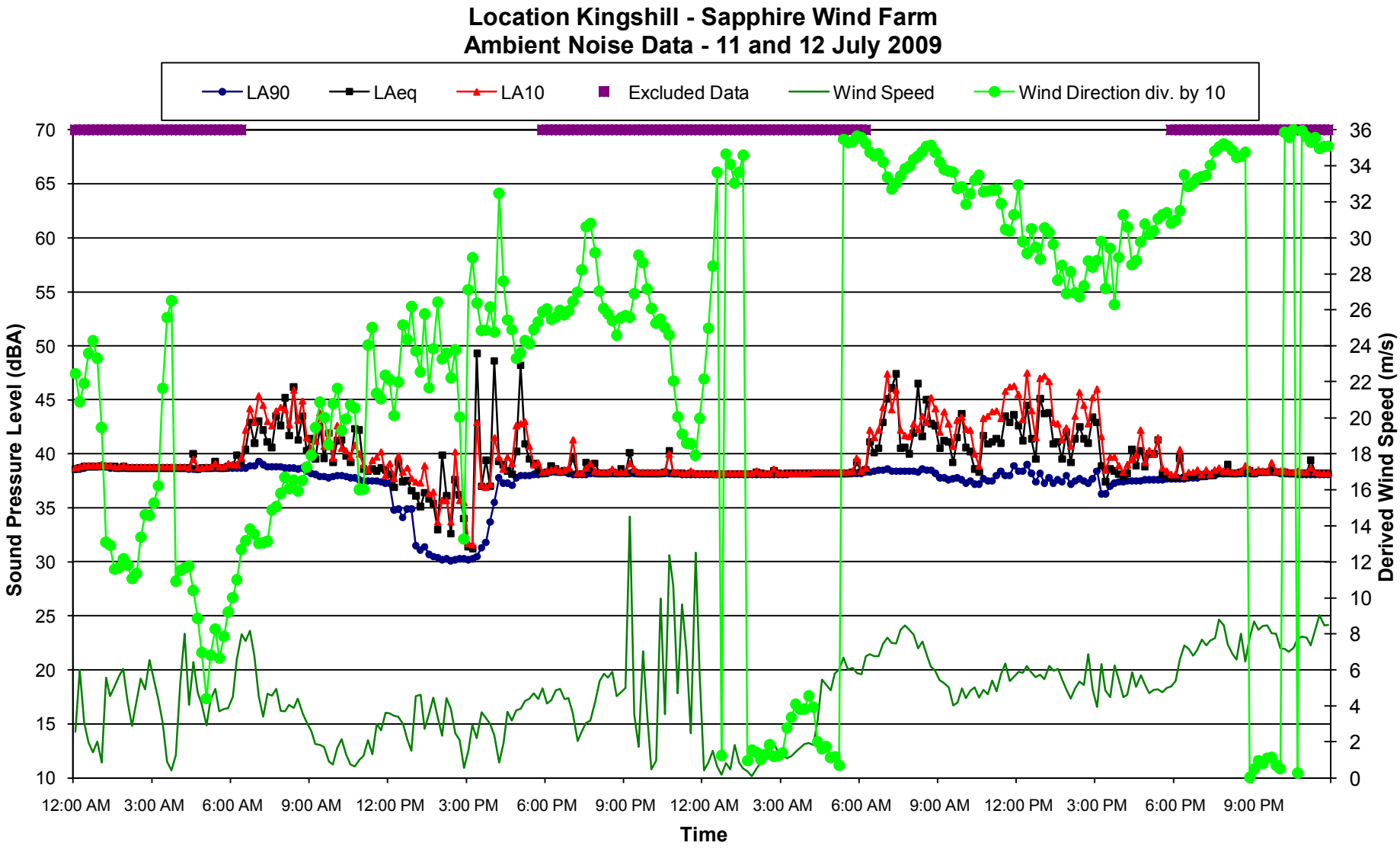


Appendix C1
40-1822
Level Wind vs Time

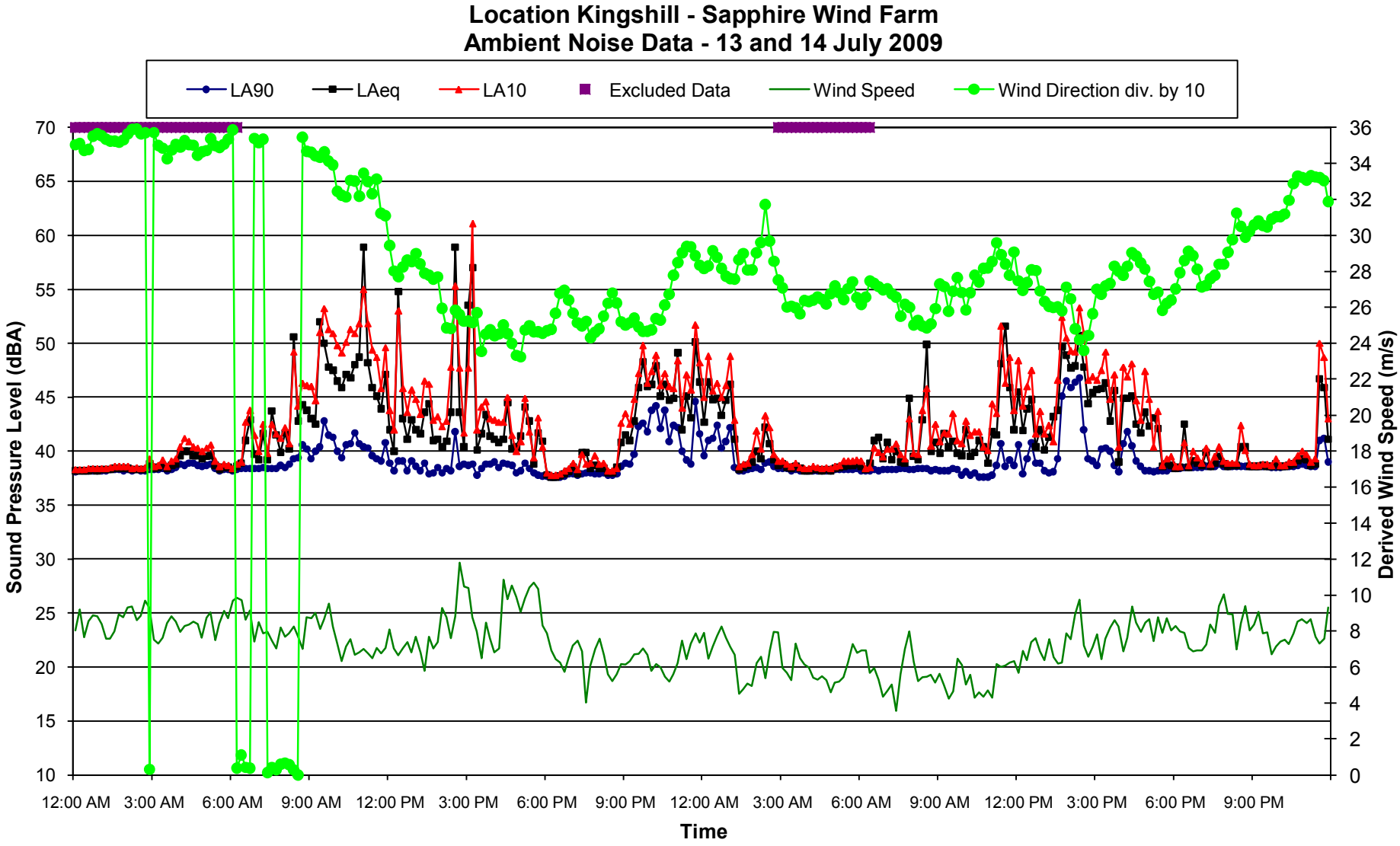
Location Kingshill - Sapphire Wind Farm
Ambient Noise Data - 9 and 10 July 2009



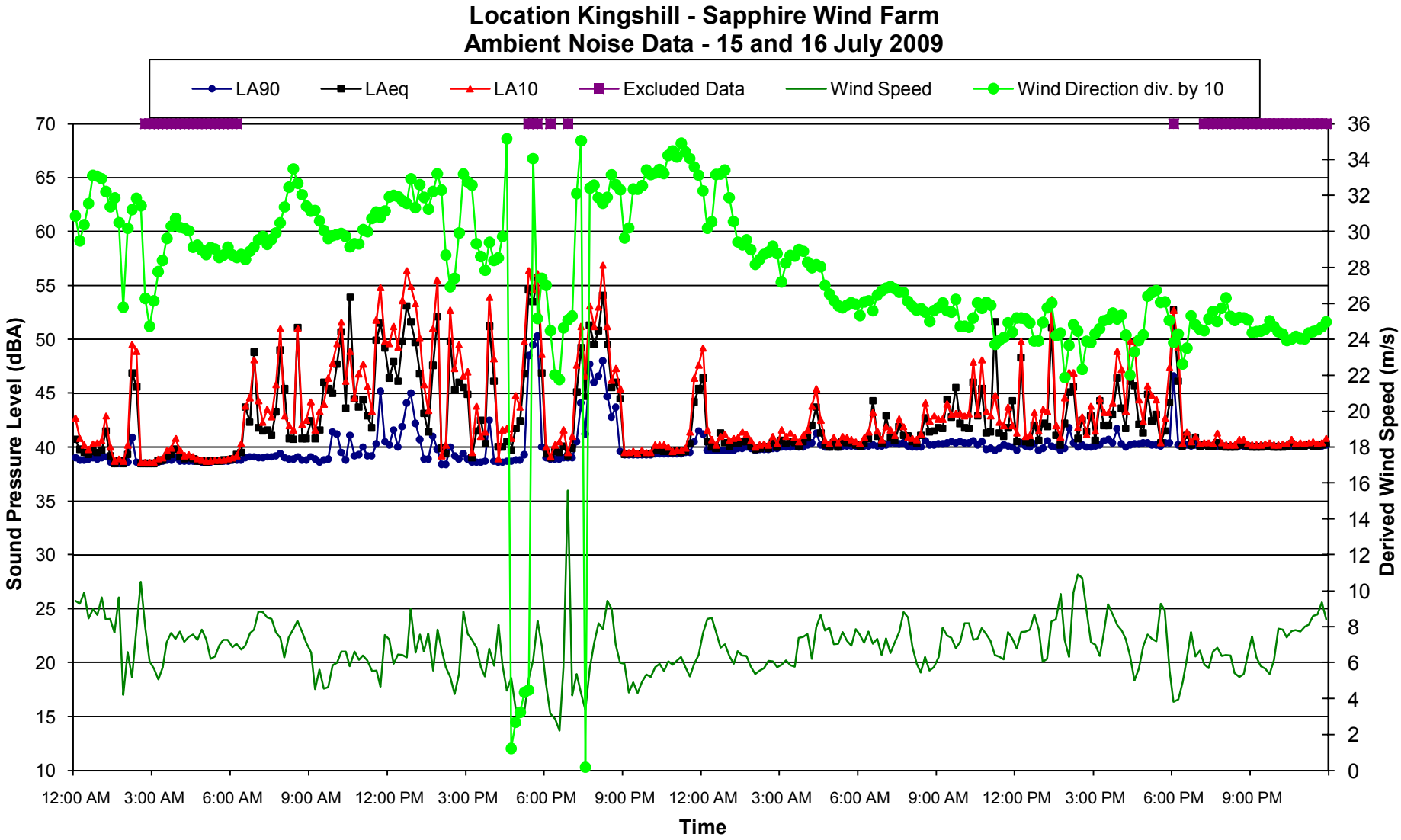
Appendix C1
40-1822
Level Wind vs Time



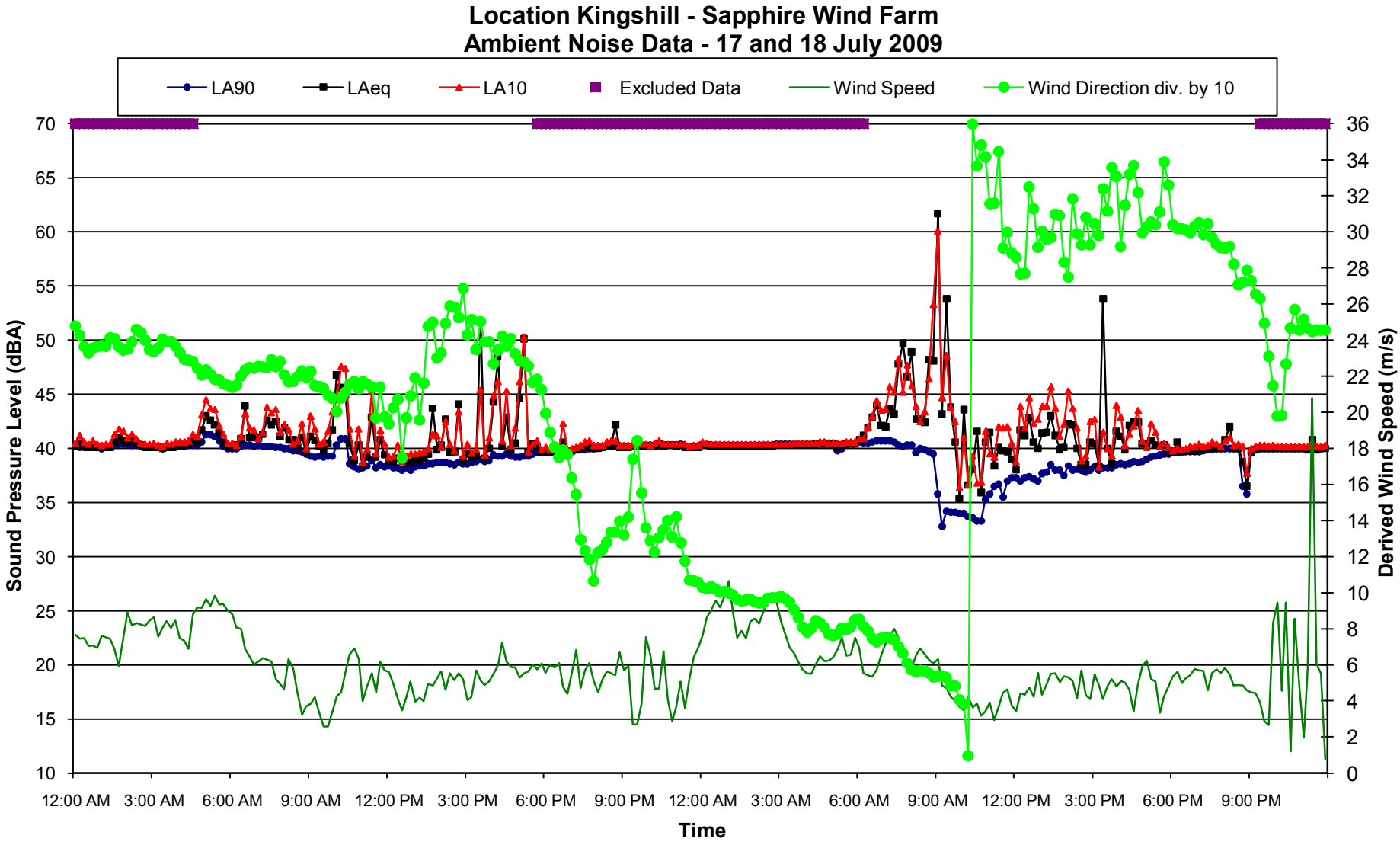
Appendix C1
40-1822
Level Wind vs Time



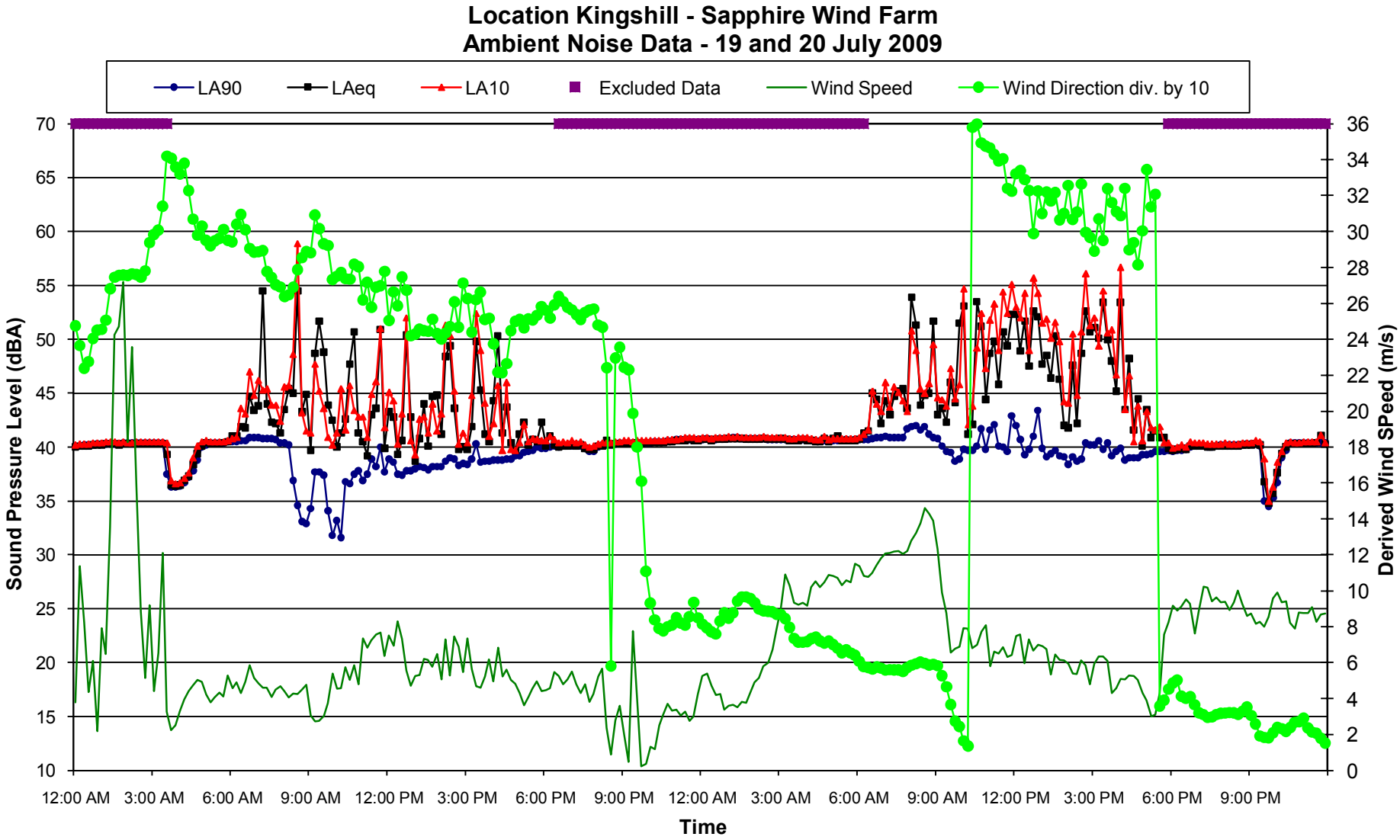
Appendix C1
40-1822
Level Wind vs Time



Appendix C1
40-1822
Level Wind vs Time

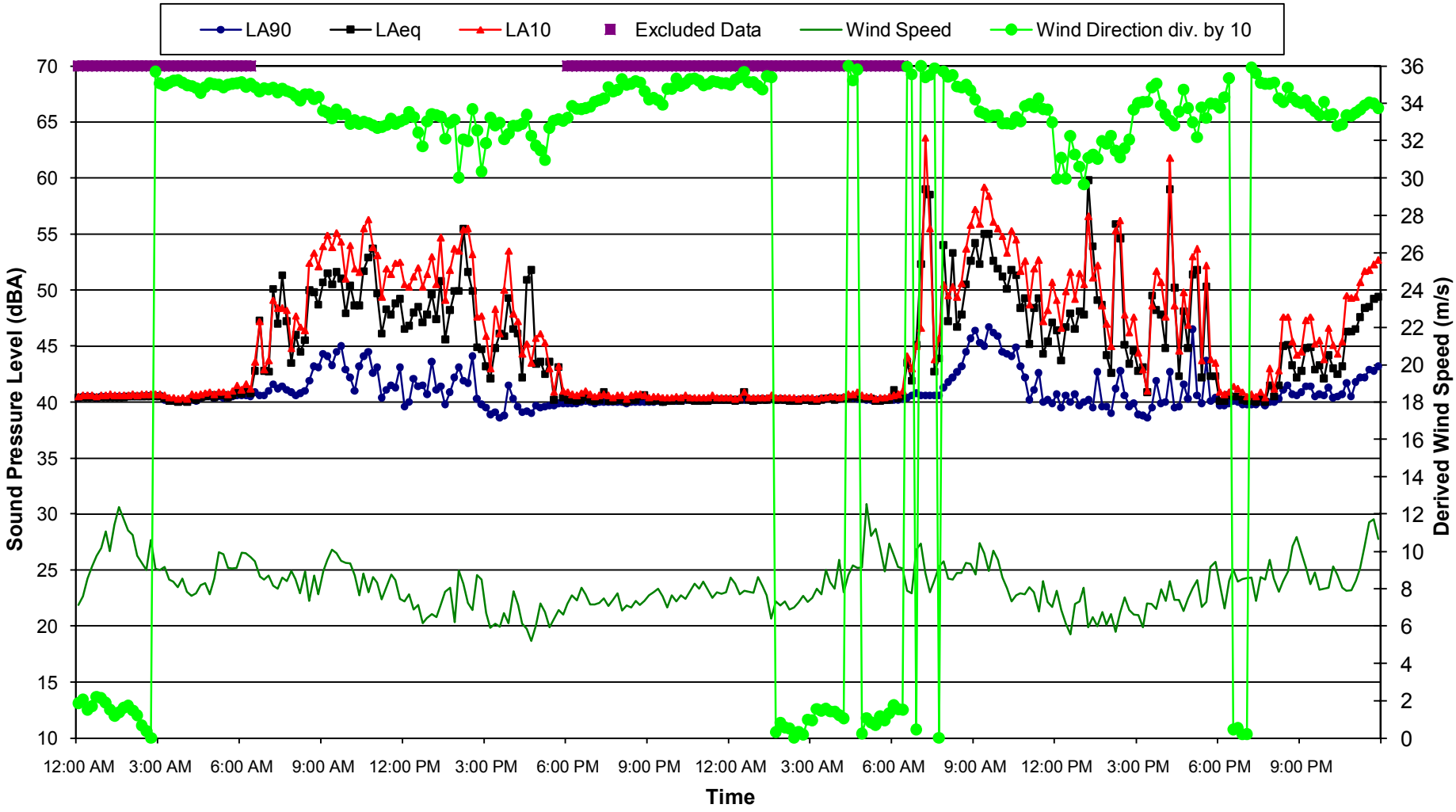


Appendix C1
40-1822
Level Wind vs Time



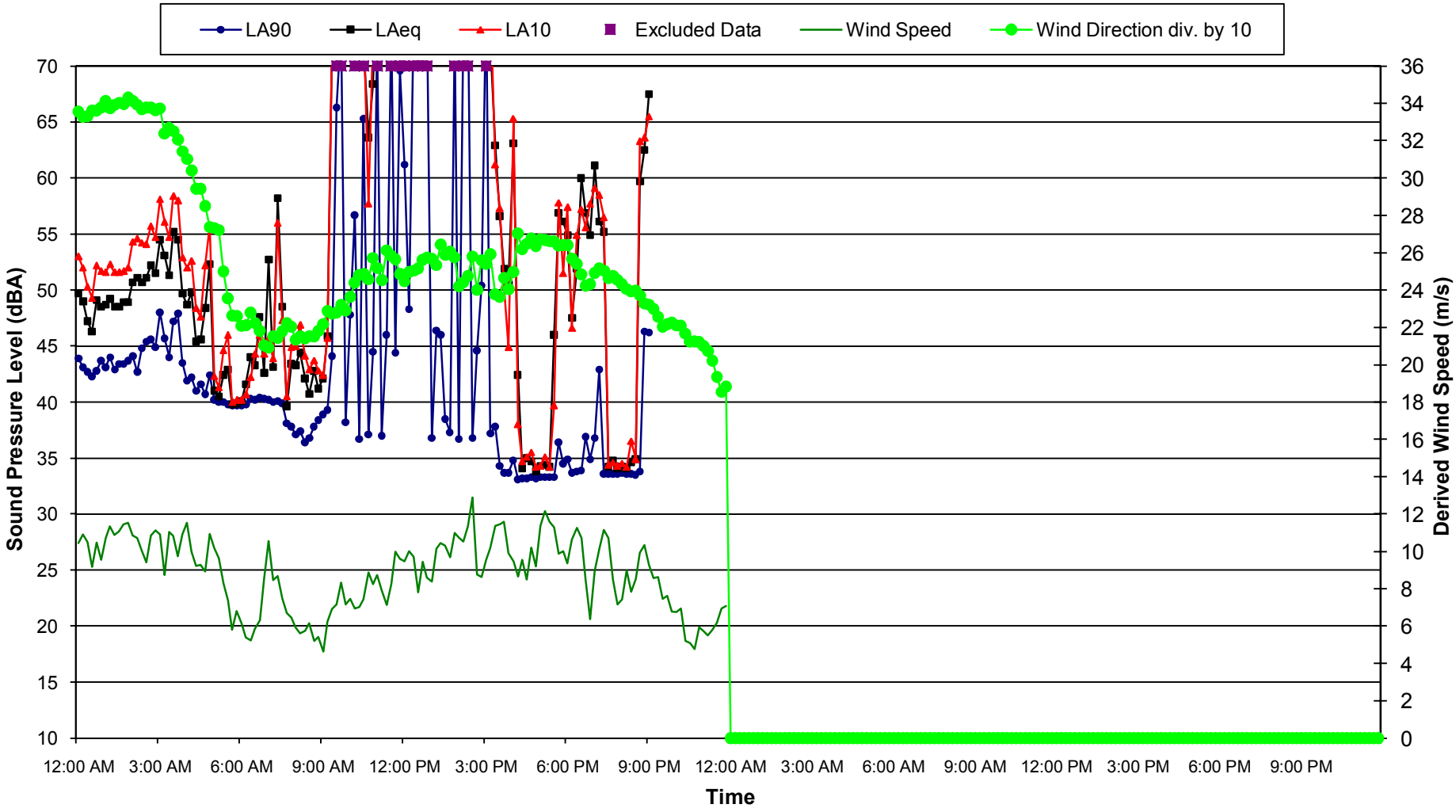
Appendix C1
40-1822
Level Wind vs Time

Location Kingshill - Sapphire Wind Farm
Ambient Noise Data - 21 and 22 July 2009



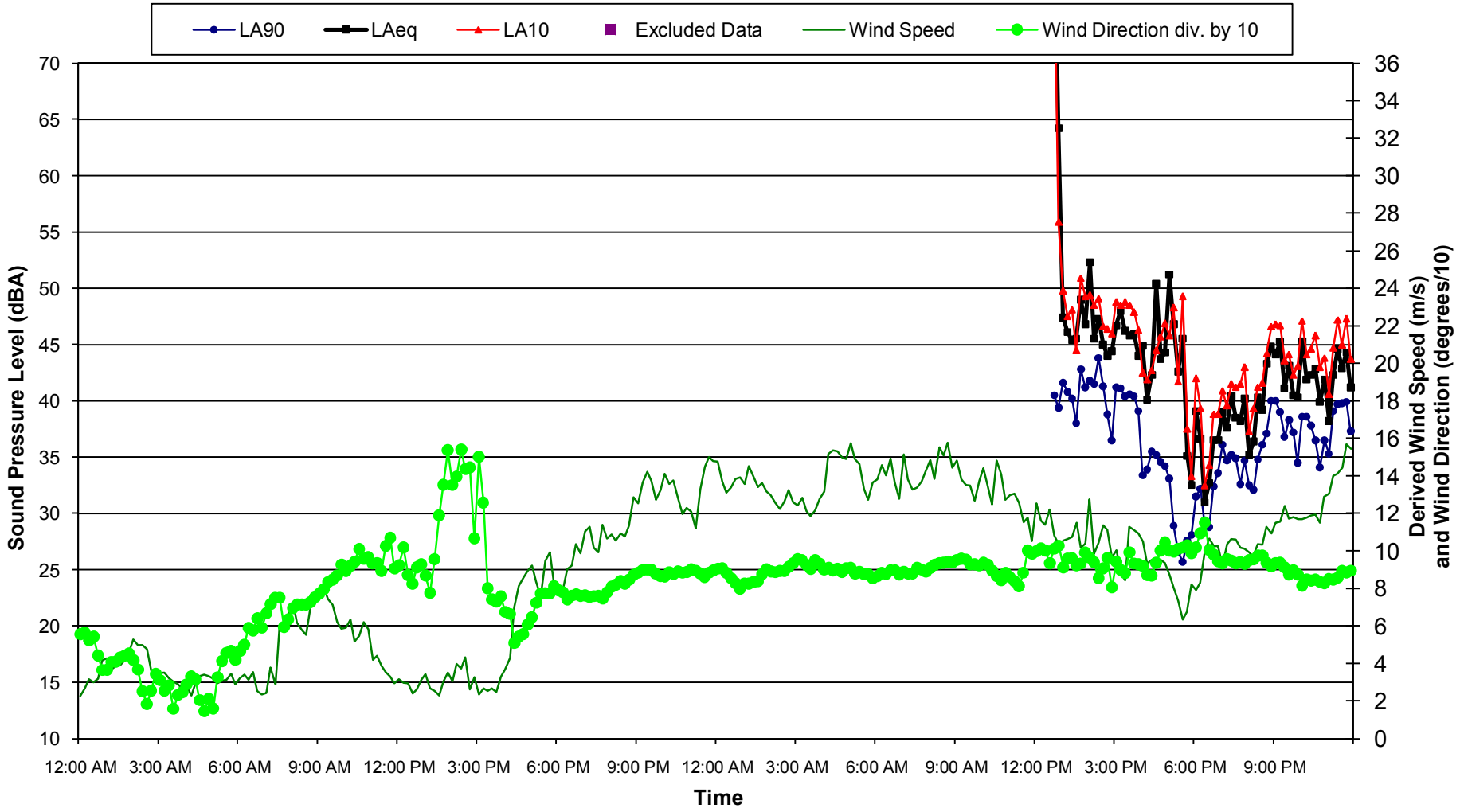
Appendix C1
40-1822
Level Wind vs Time

Location Kingshill - Sapphire Wind Farm
Ambient Noise Data - 23 and 24 July 2009



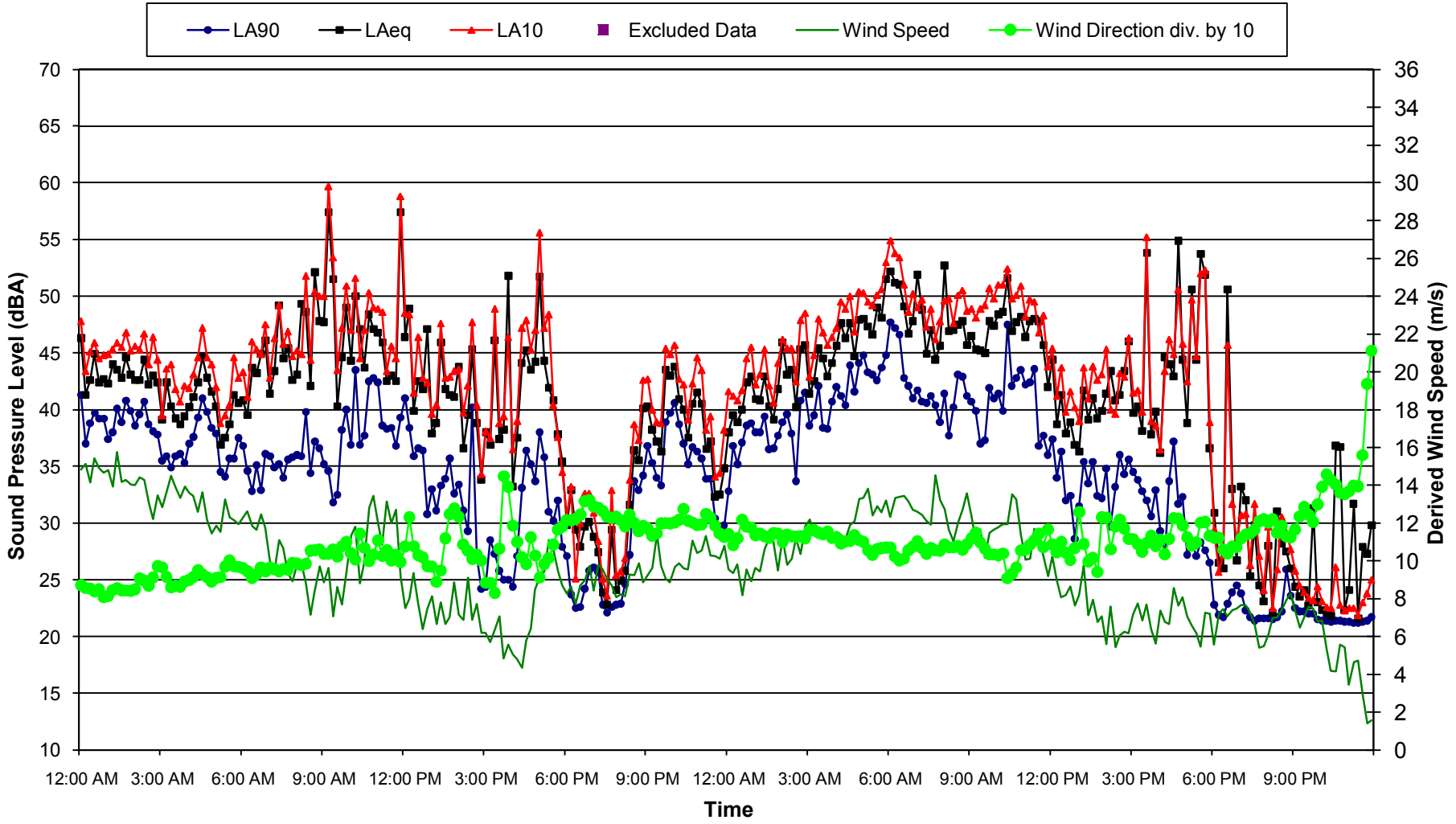
Appendix C1
40-1822
Level Wind vs Time

Location Carinya - Sapphire Wind Farm
Ambient Noise Data - 7 and 8 July 2009



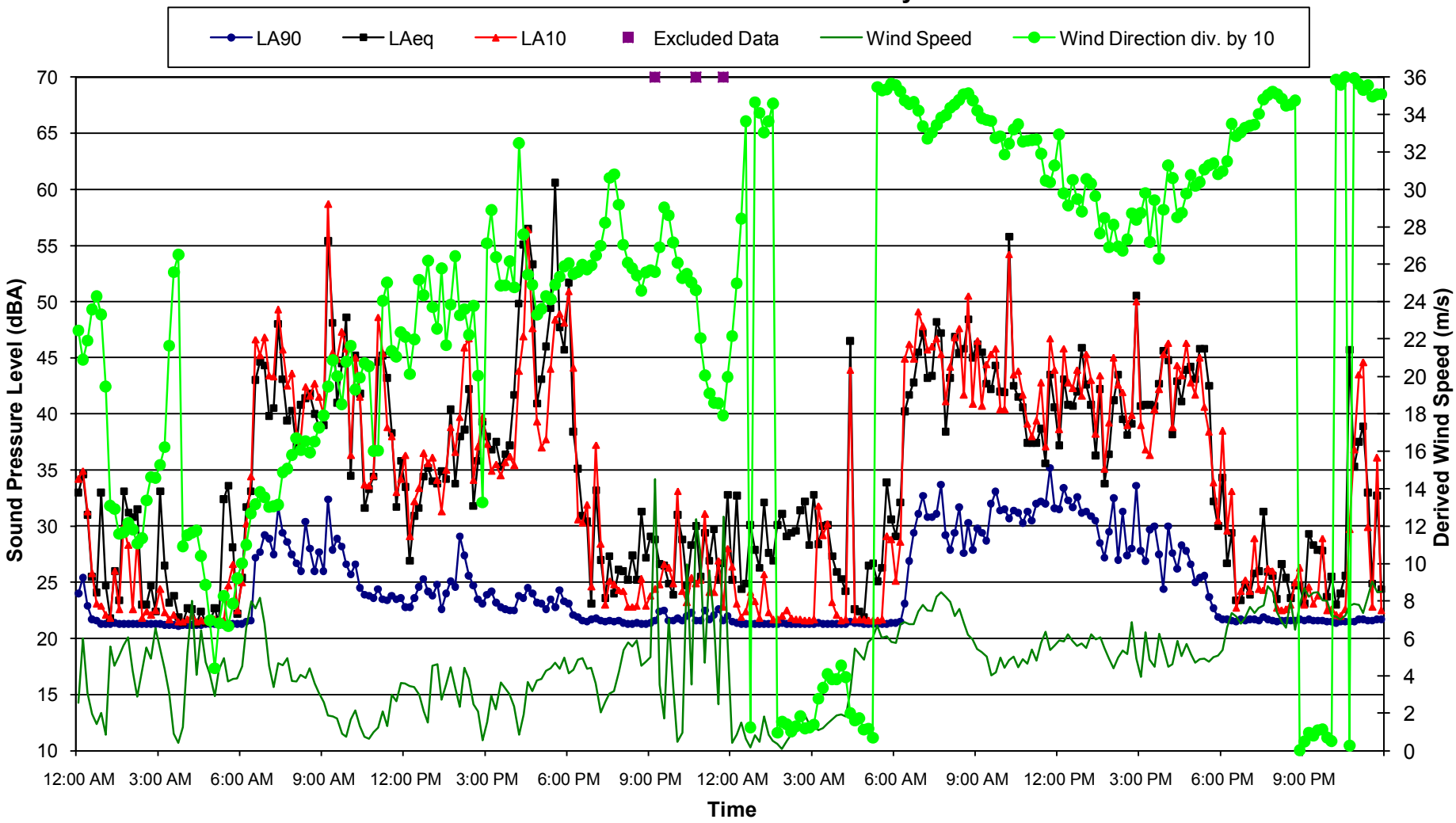
Appendix C1
40-1822
Level Wind vs Time

Location Carinya - Sapphire Wind Farm
Ambient Noise Data - 9 and 10 July 2009

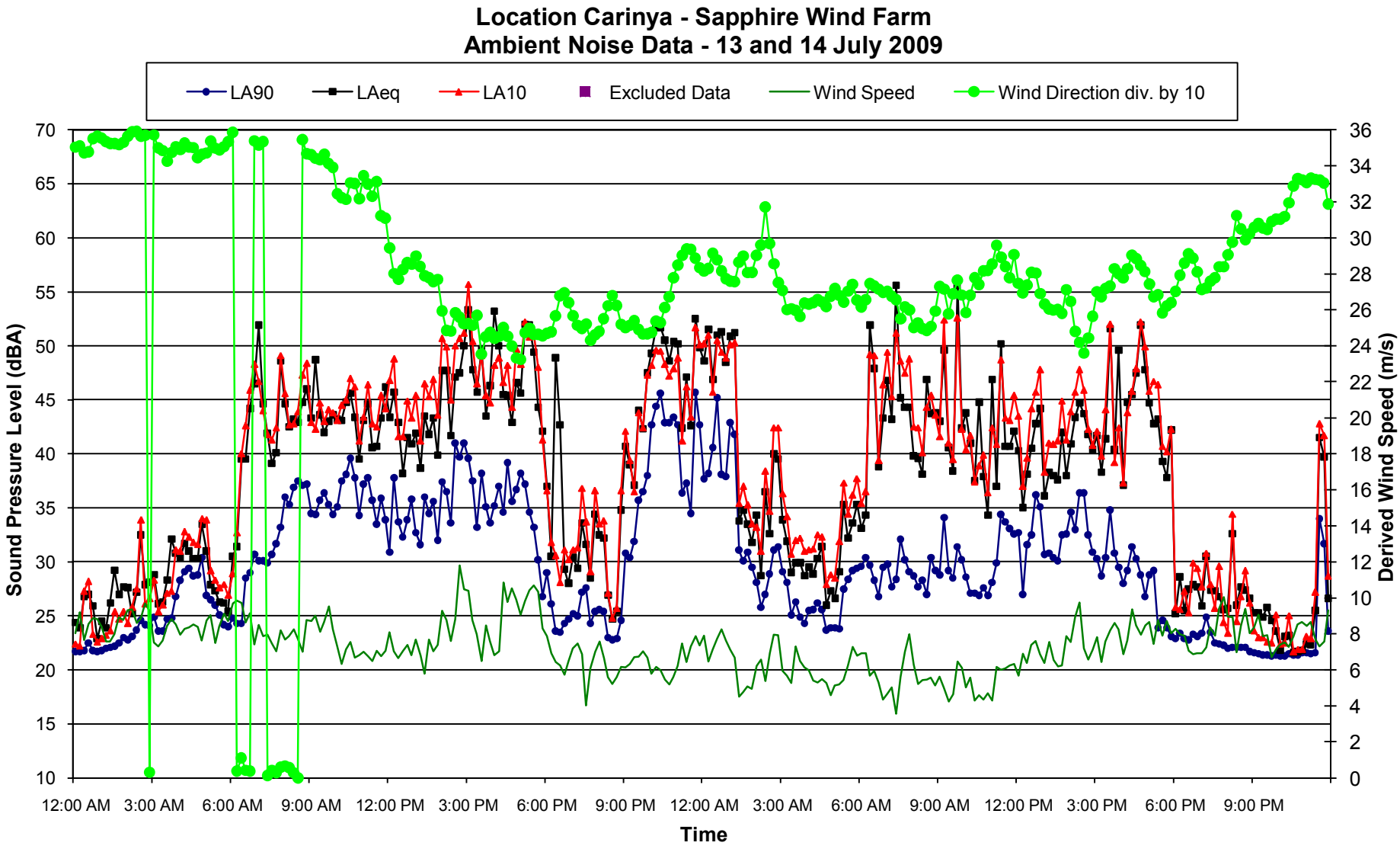


Appendix C1
40-1822
Level Wind vs Time

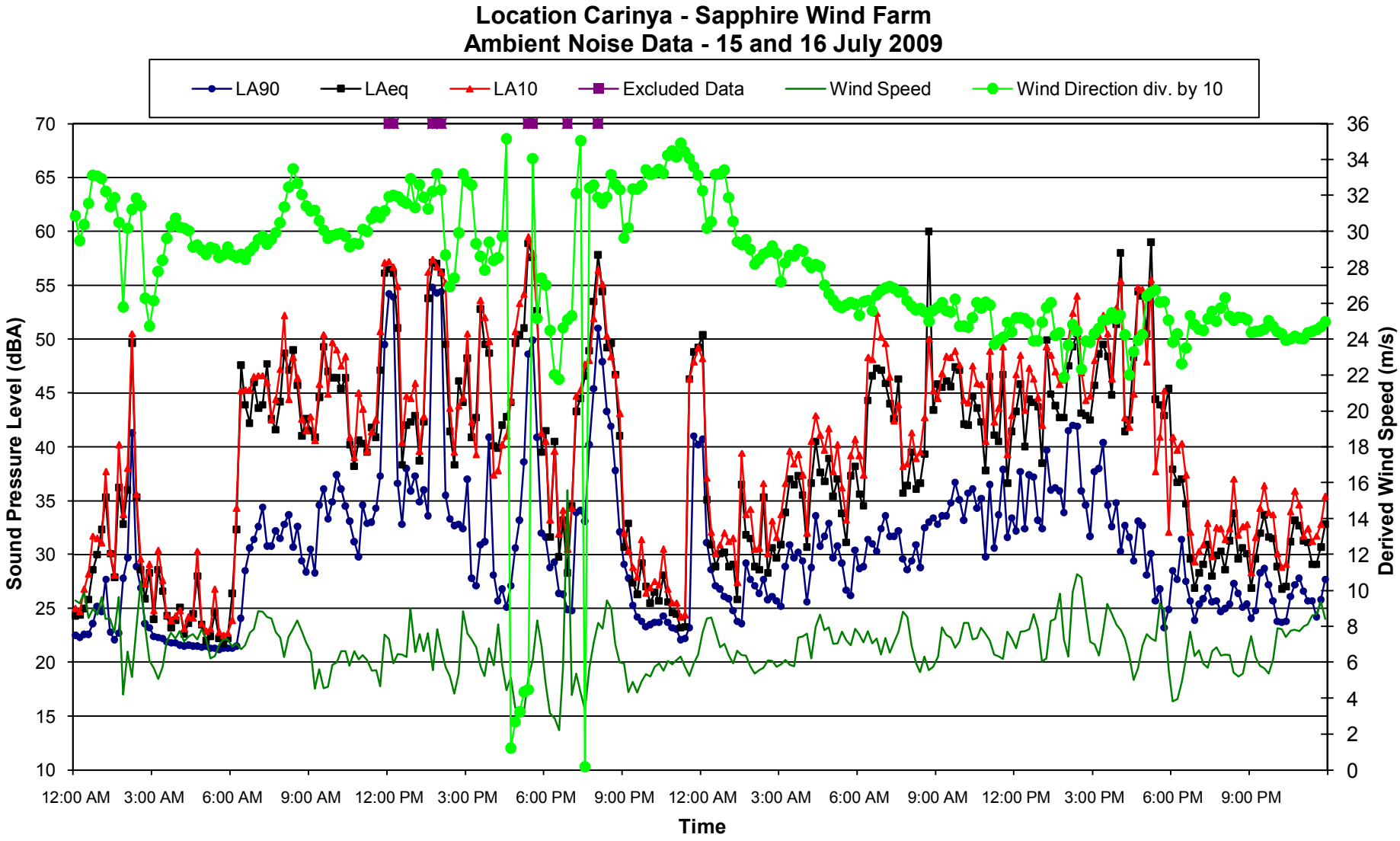
Location Carinya - Sapphire Wind Farm
Ambient Noise Data - 11 and 12 July 2009



Appendix C1
40-1822
Level Wind vs Time

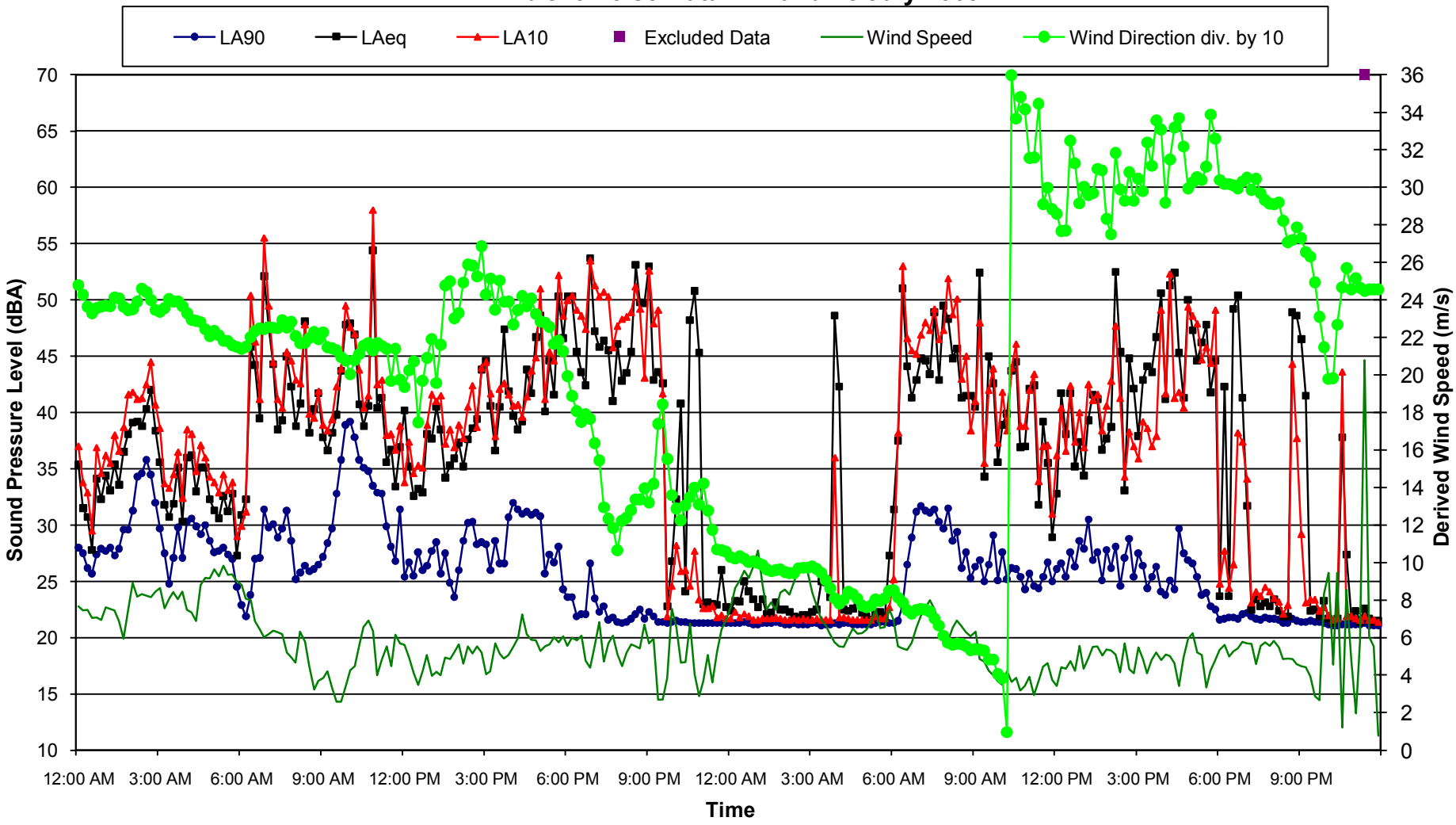


Appendix C1
40-1822
Level Wind vs Time



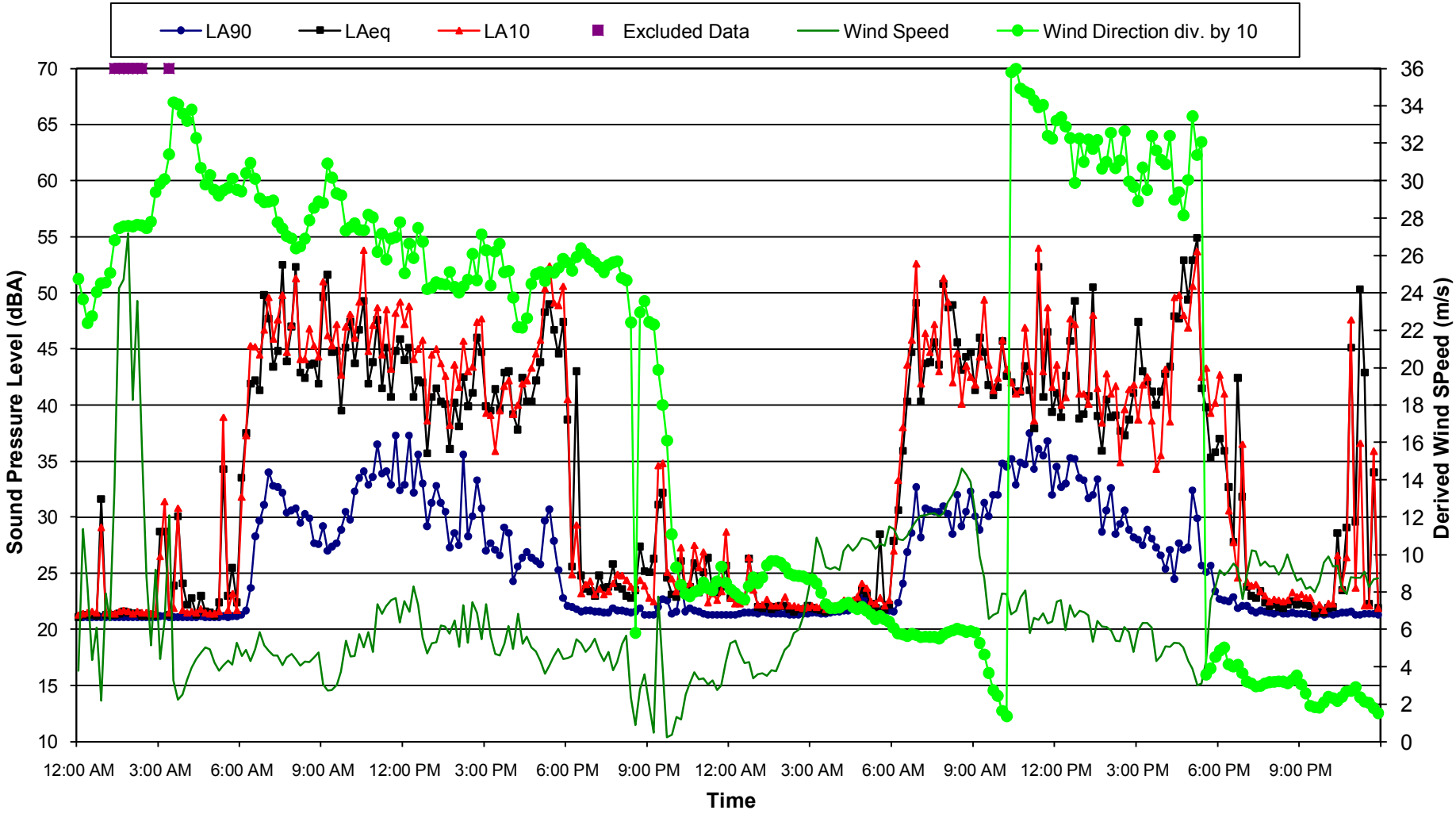
Appendix C1
40-1822
Level Wind vs Time

Location Carinya - Sapphire Wind Farm
Ambient Noise Data - 17 and 18 July 2009

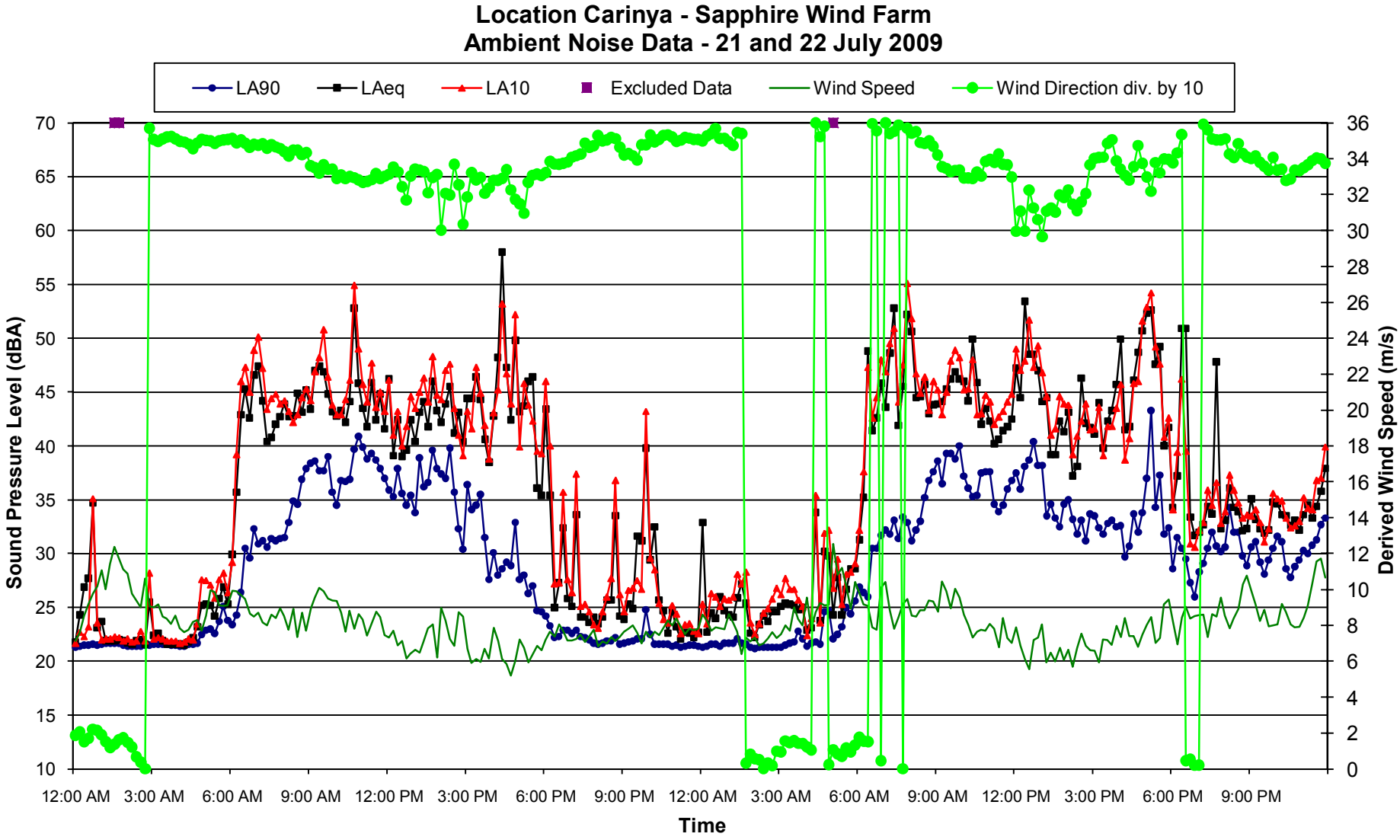


Appendix C1
40-1822
Level Wind vs Time

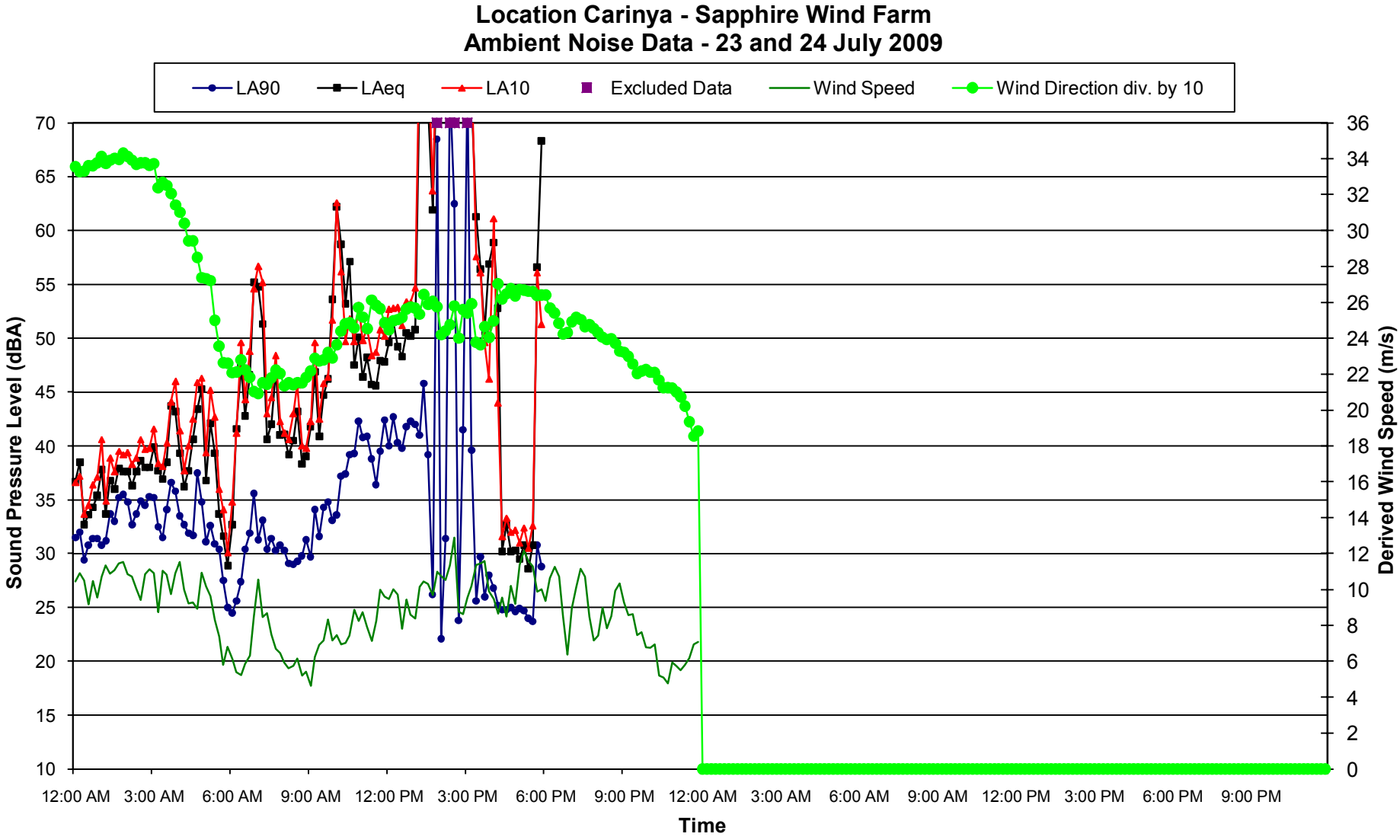
Location Carinya - Sapphire Wind Farm
Ambient Noise Data - 19 and 20 July 2009



Appendix C1
40-1822
Level Wind vs Time

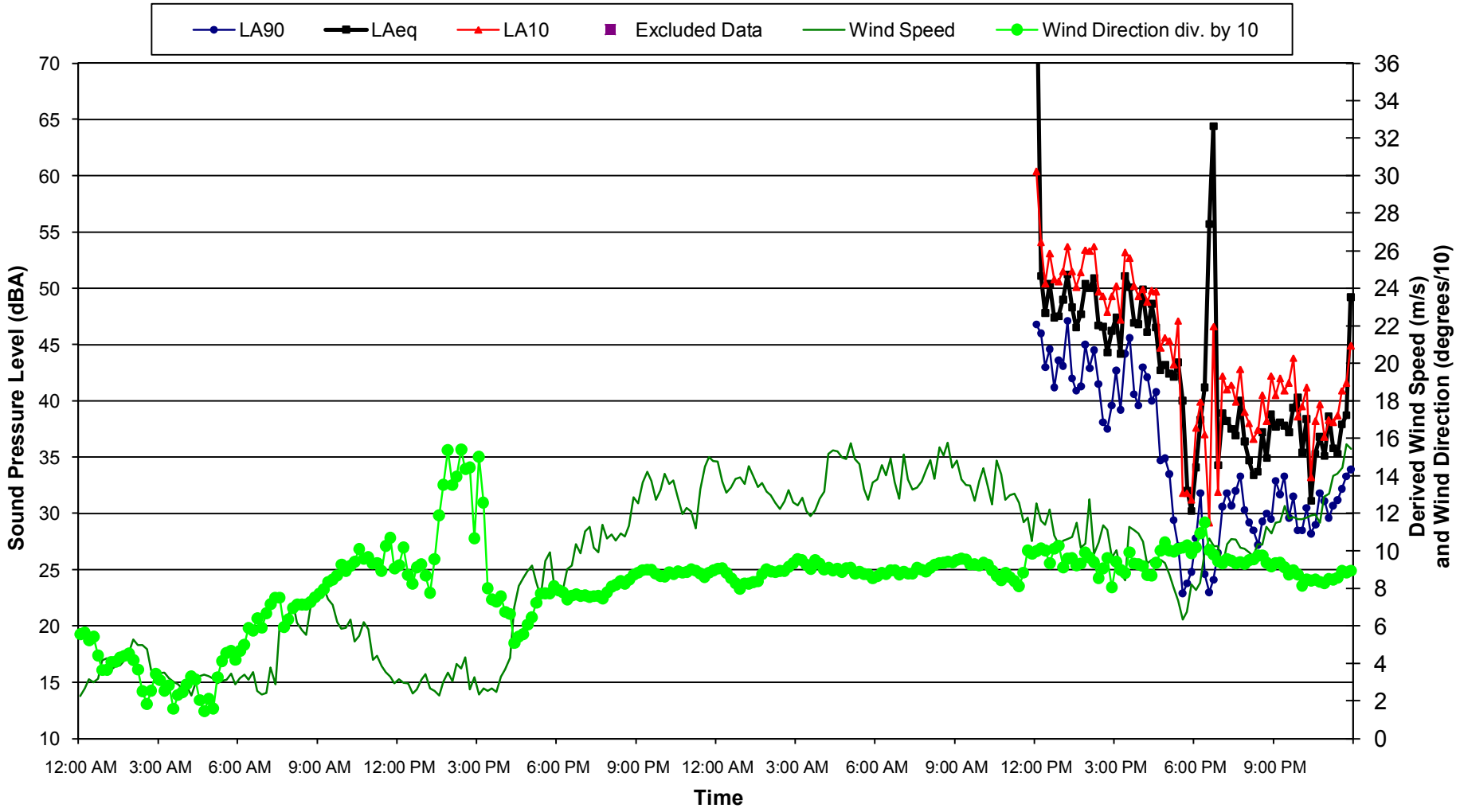


Appendix C1
40-1822
Level Wind vs Time

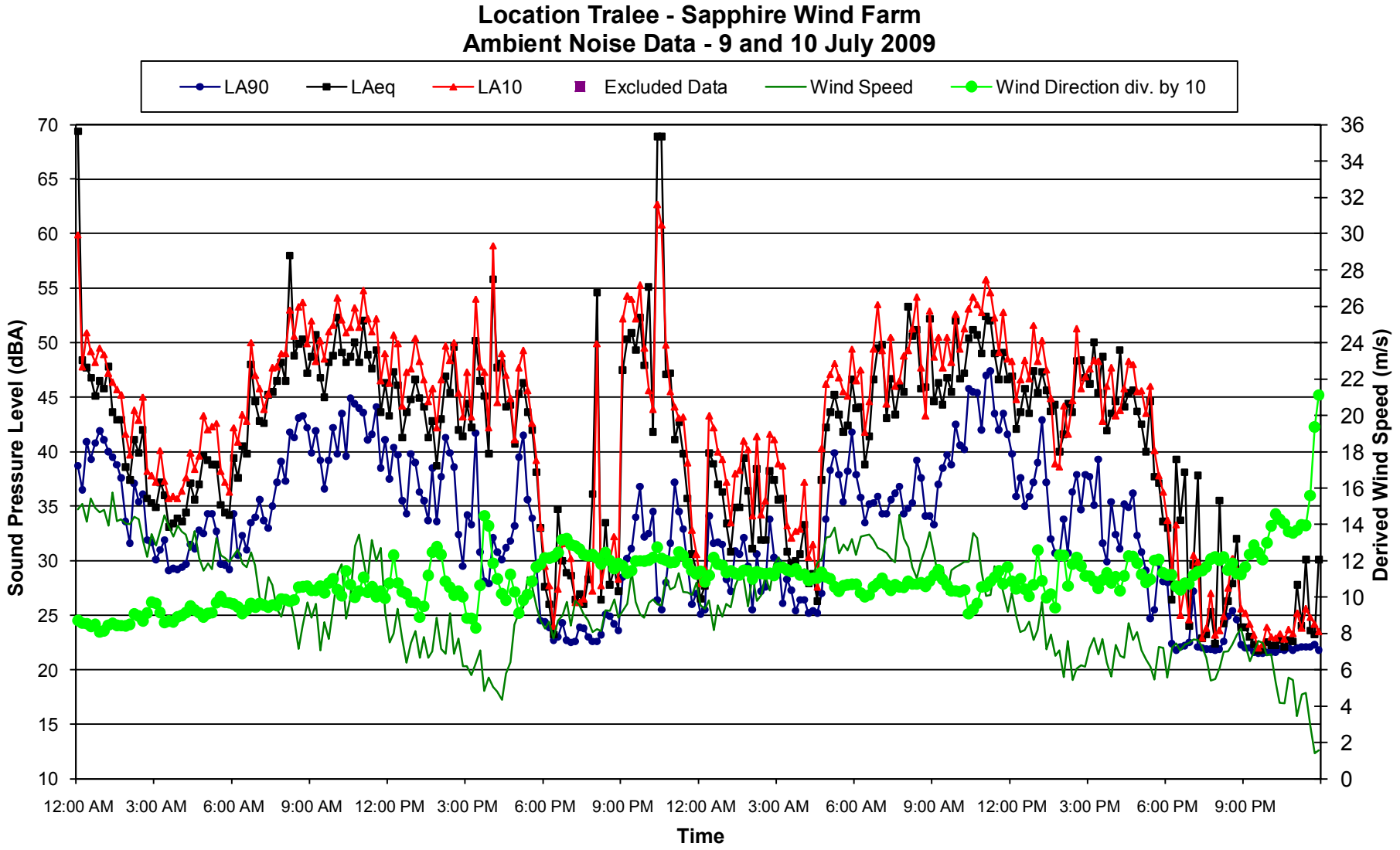


Appendix C1
40-1822
Level Wind vs Time

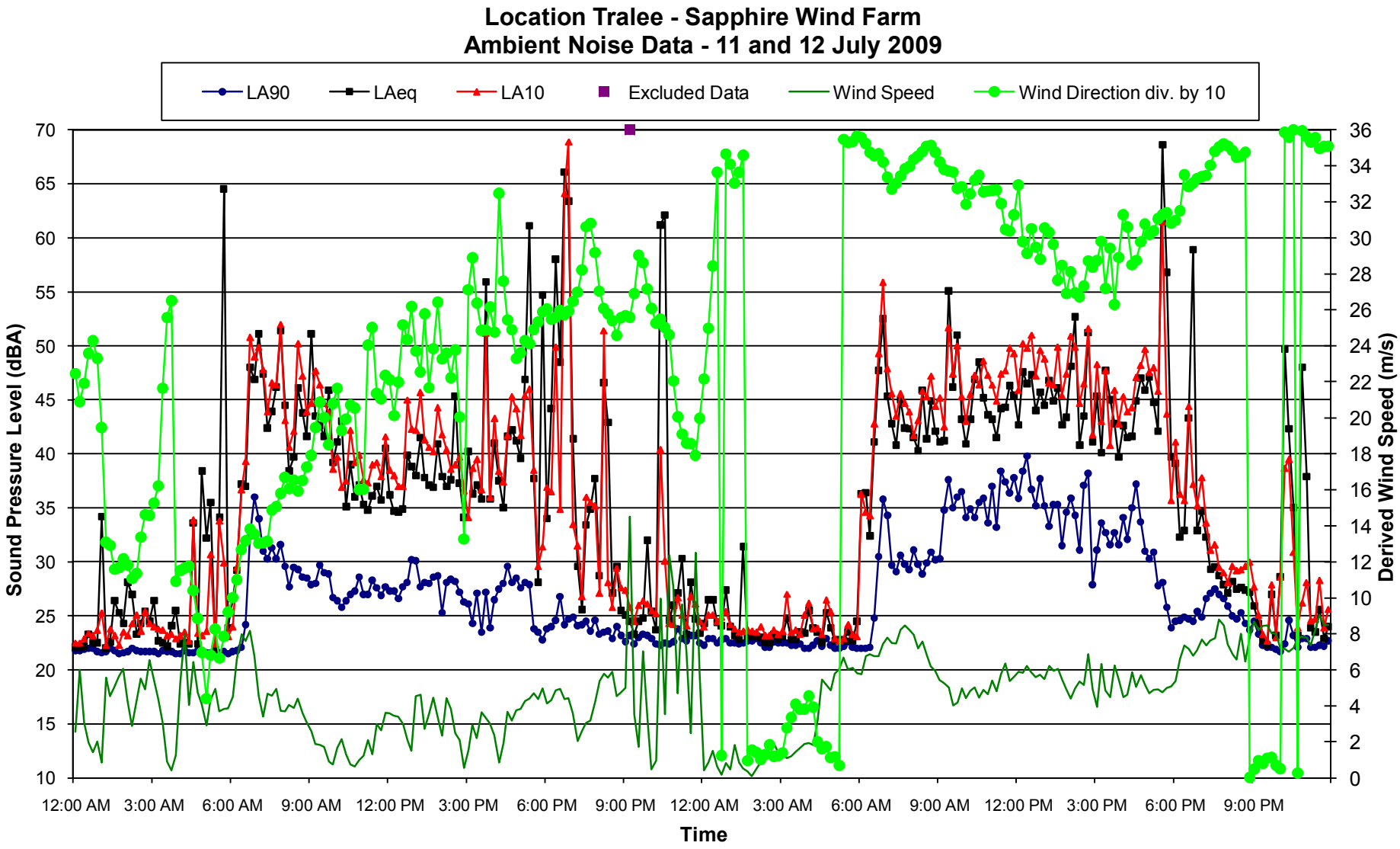
Location Tralee - Sapphire Wind Farm
Ambient Noise Data - 7 and 8 July 2009



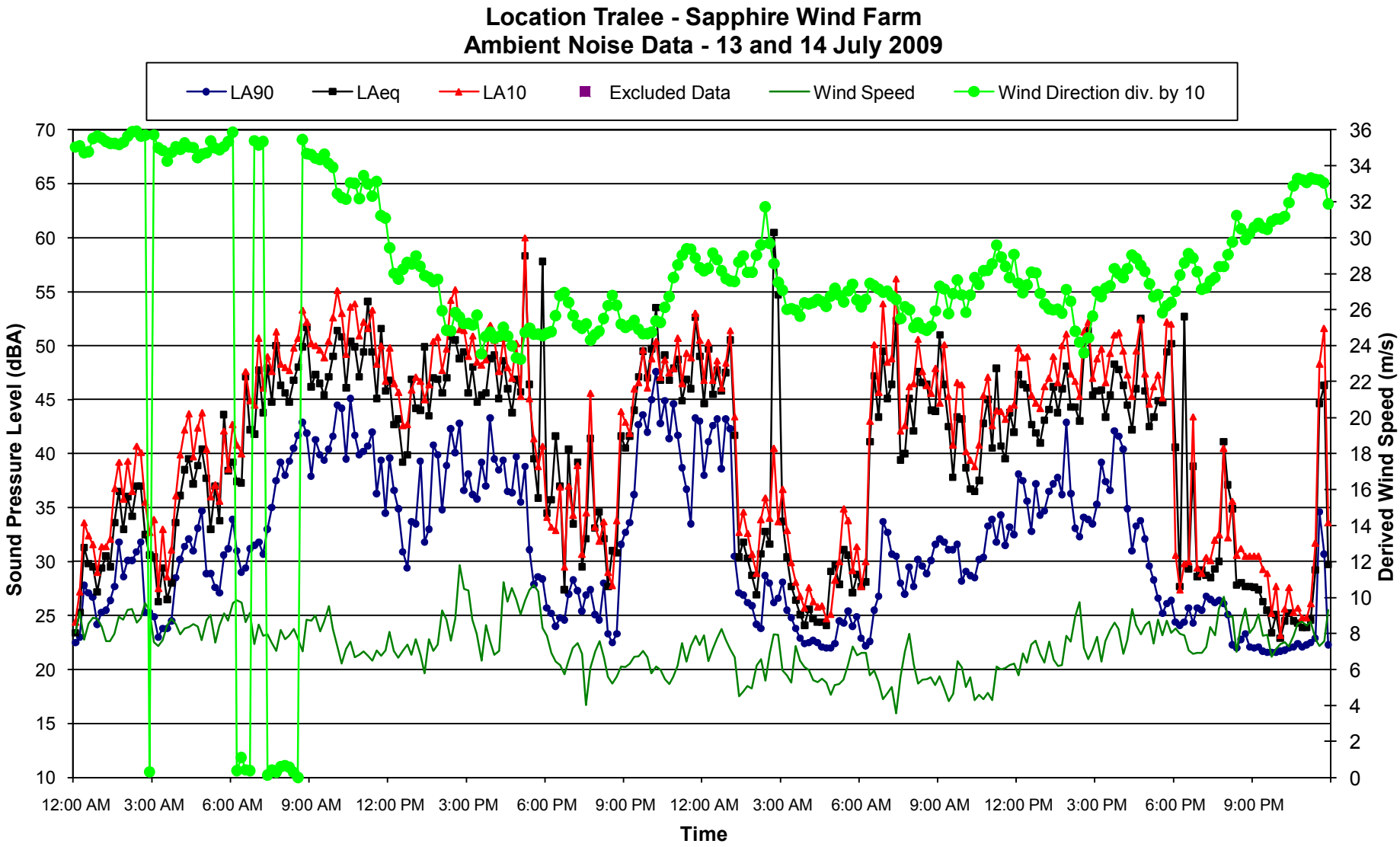
Appendix C1
40-1822
Level Wind vs Time



Appendix C1
40-1822
Level Wind vs Time

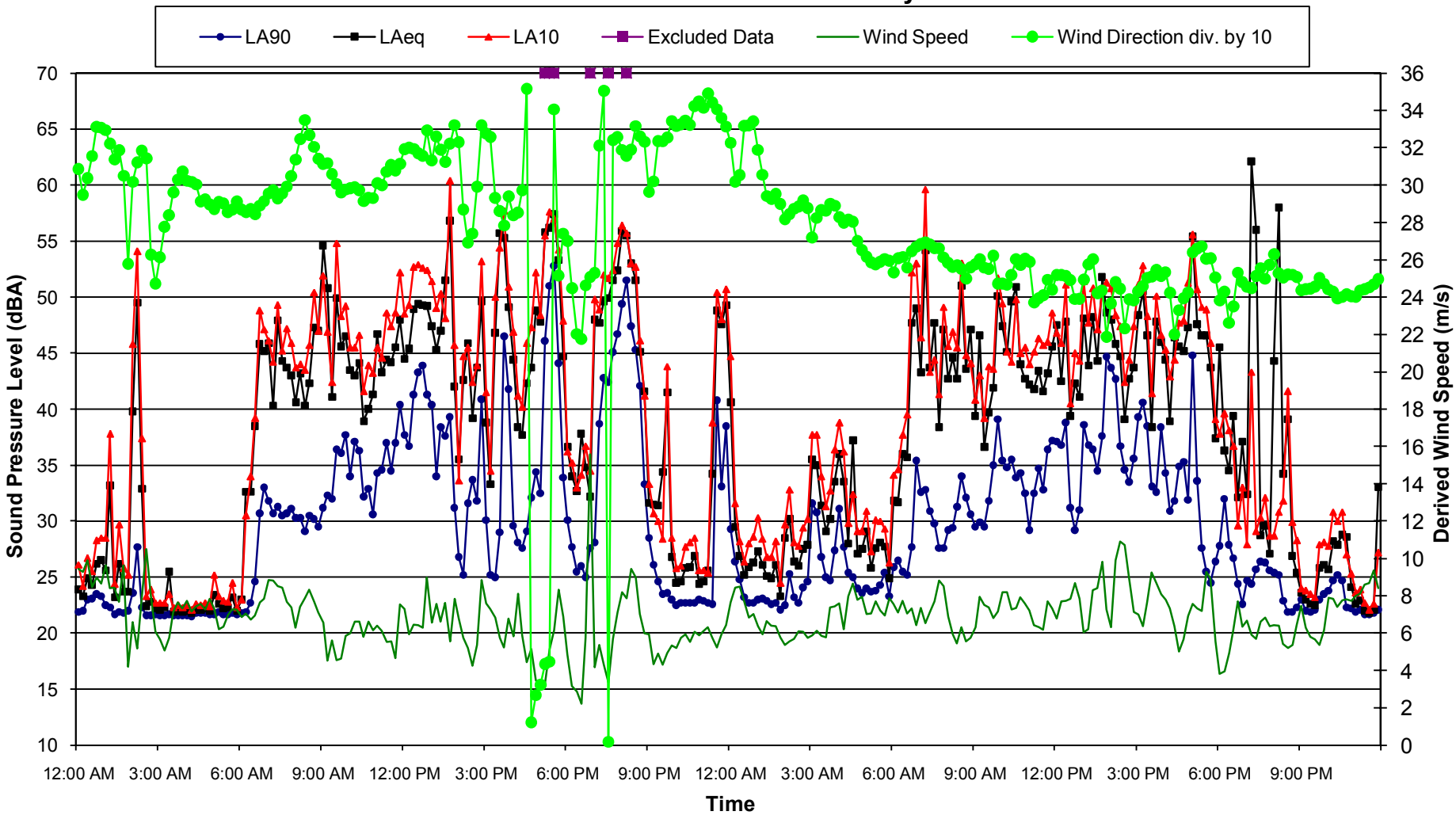


Appendix C1
40-1822
Level Wind vs Time

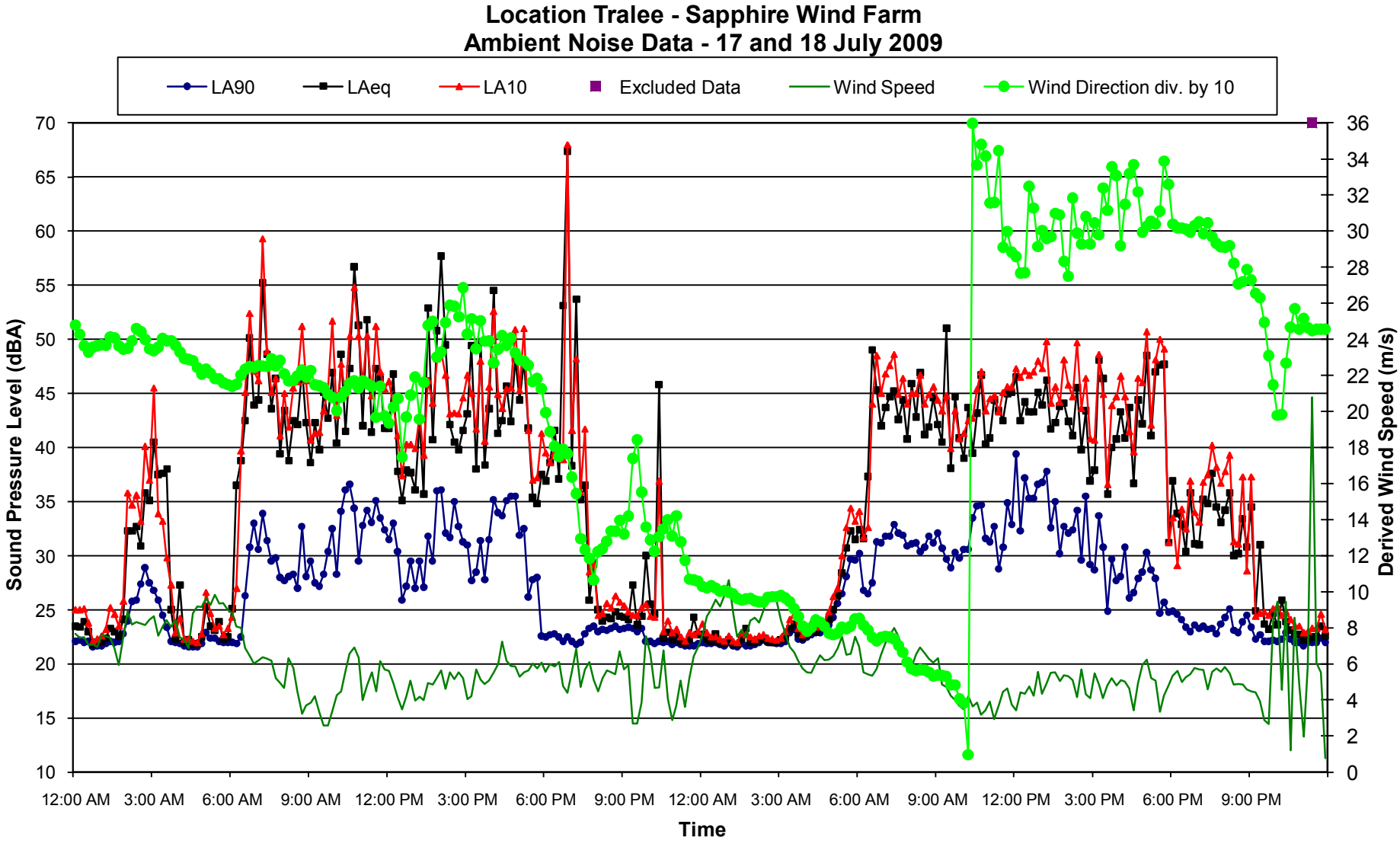


Appendix C1
40-1822
Level Wind vs Time

Location Tralee - Sapphire Wind Farm
Ambient Noise Data - 15 and 16 July 2009

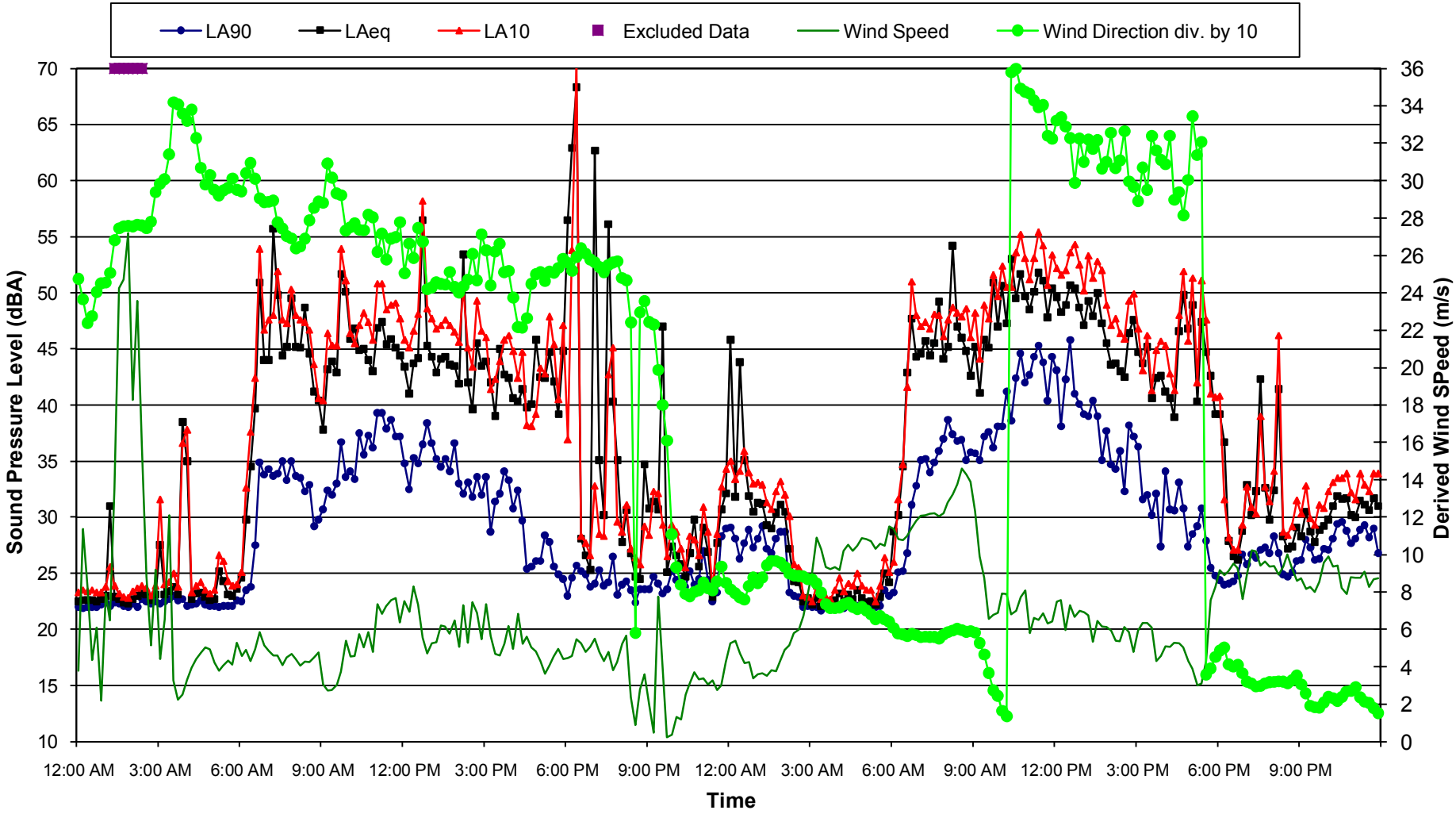


Appendix C1
40-1822
Level Wind vs Time

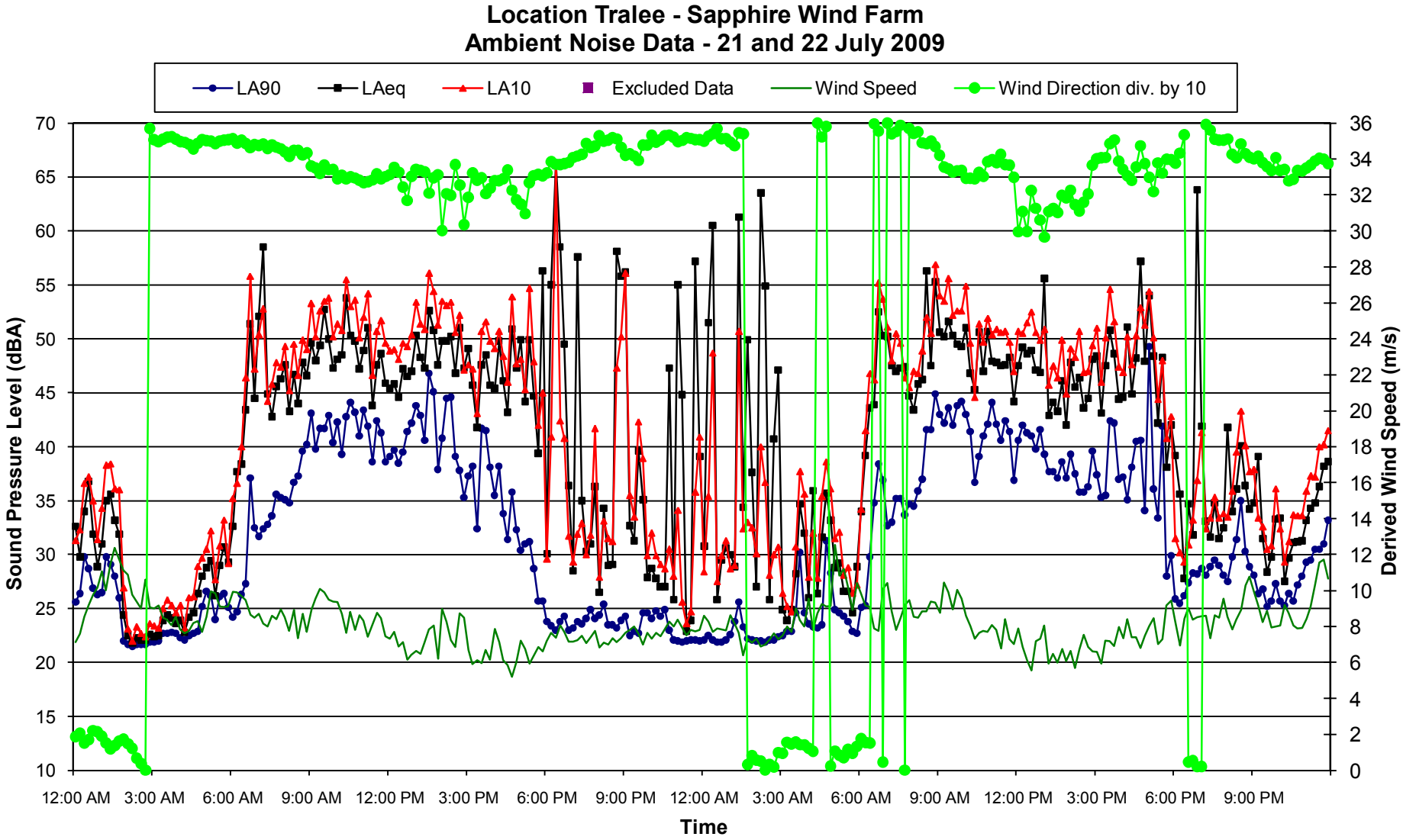


Appendix C1
40-1822
Level Wind vs Time

Location Tralee - Sapphire Wind Farm
Ambient Noise Data - 19 and 20 July 2009

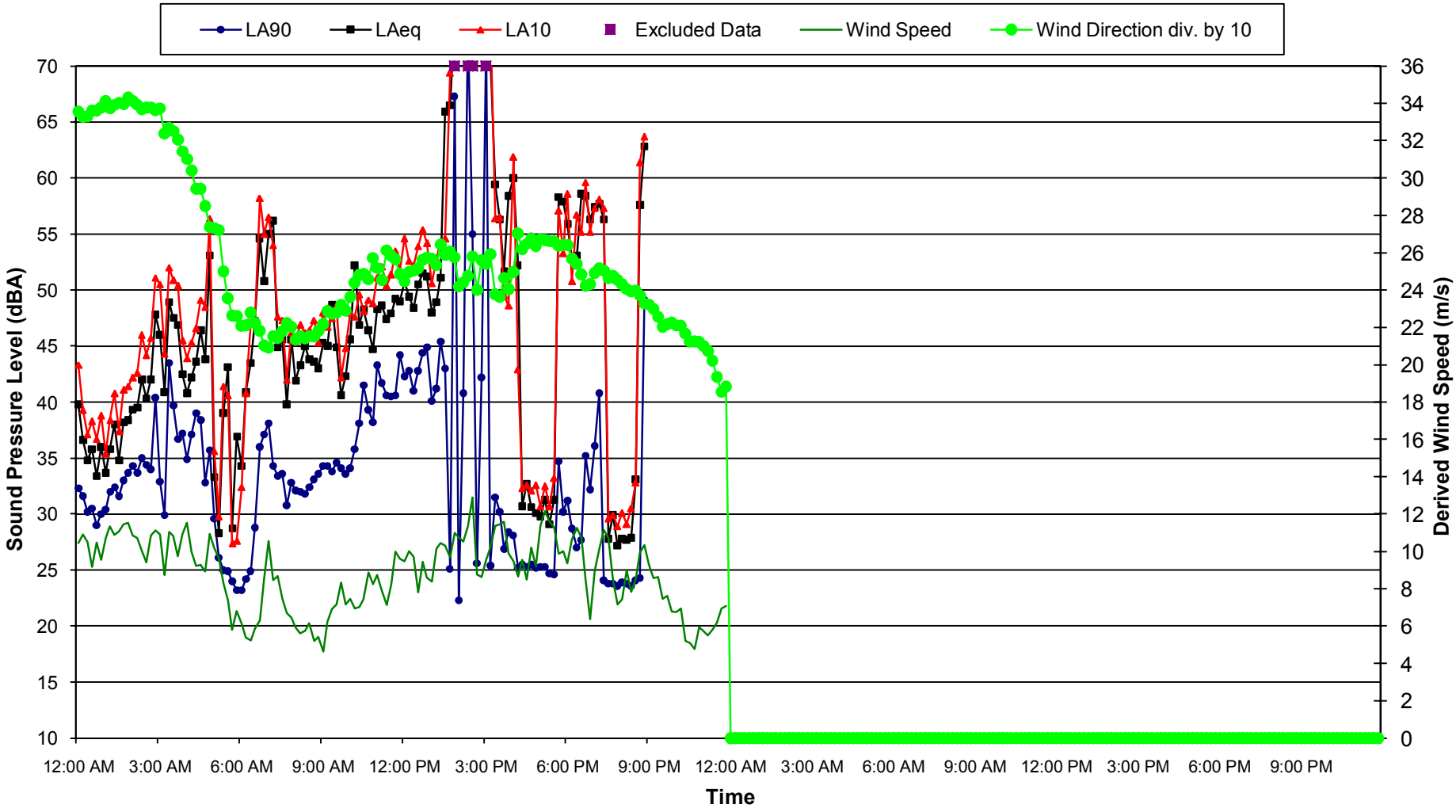


Appendix C1
40-1822
Level Wind vs Time



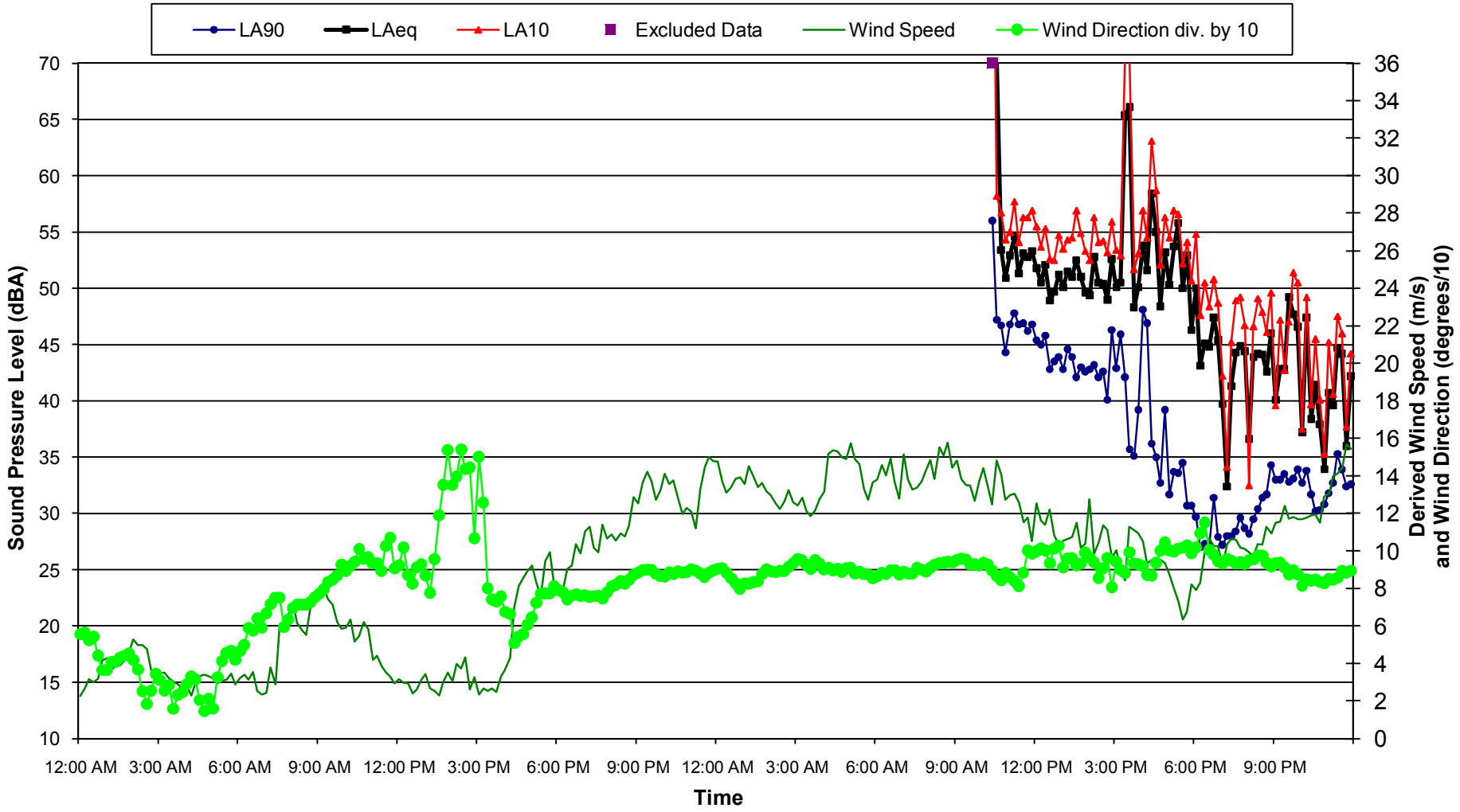
Appendix C1
40-1822
Level Wind vs Time

Location Tralee - Sapphire Wind Farm
Ambient Noise Data - 23 and 24 July 2009

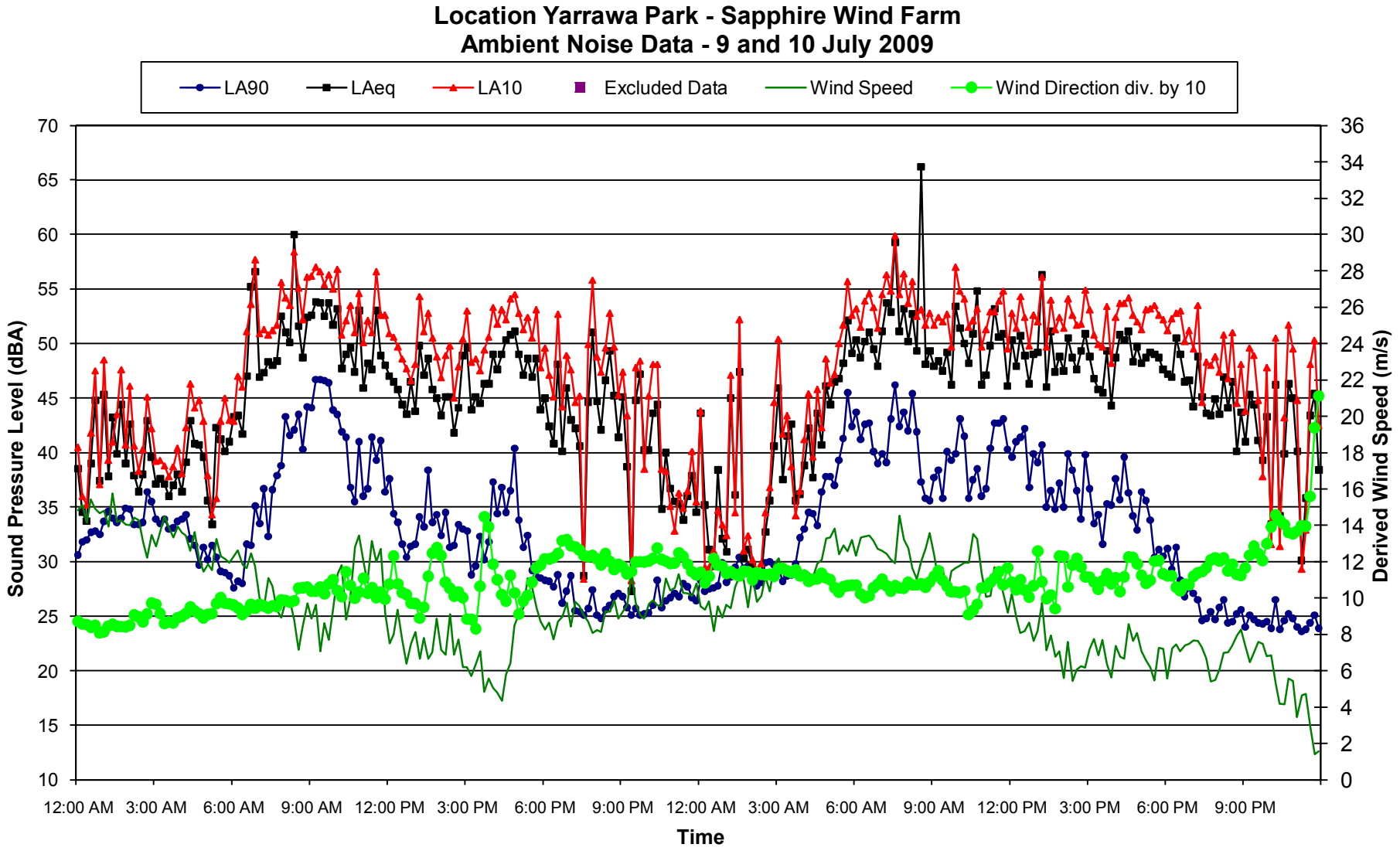


Appendix C1
40-1822
Level Wind vs Time

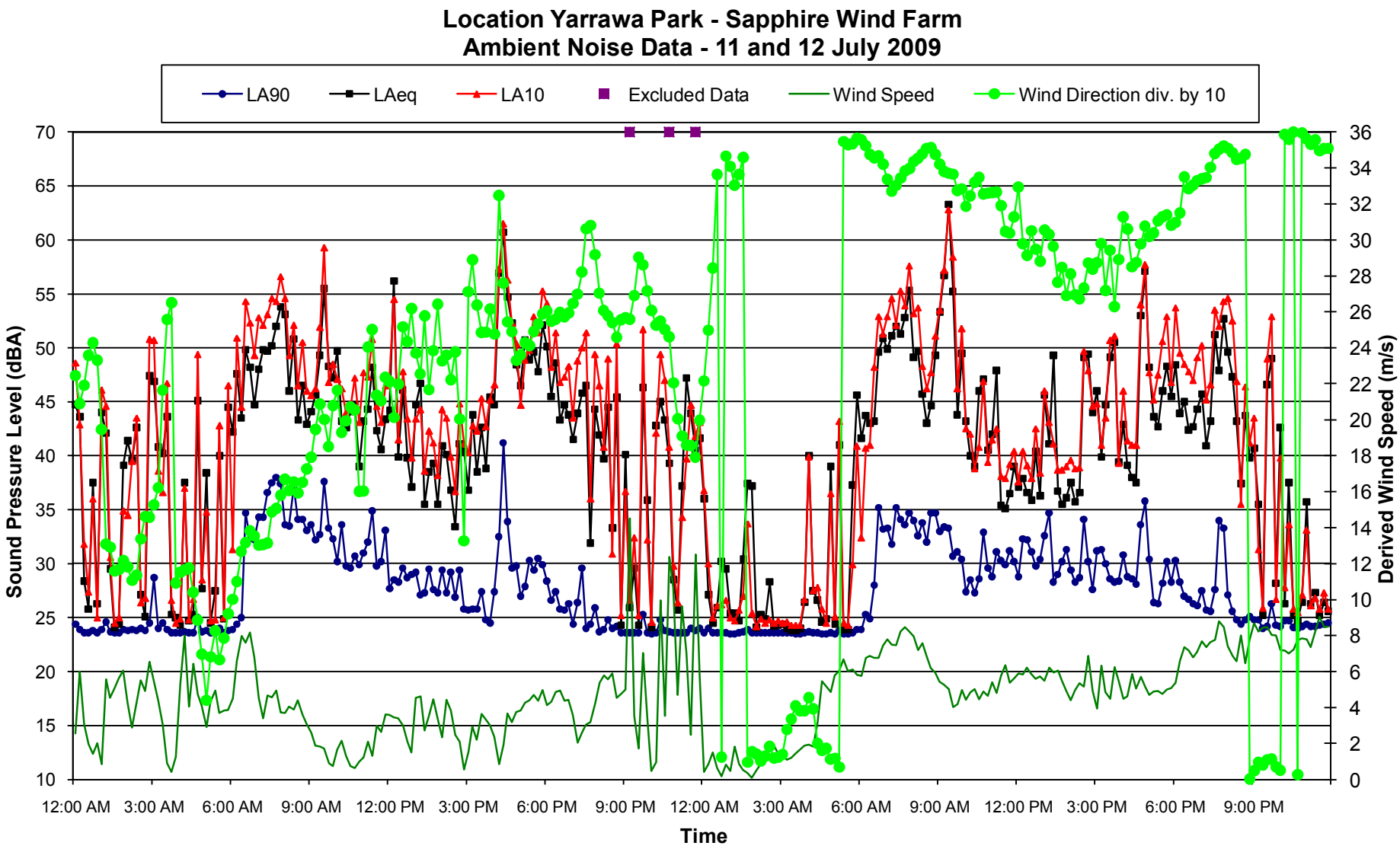
Location Yarrawa Park - Sapphire Wind Farm
Ambient Noise Data - 7 and 8 July 2009



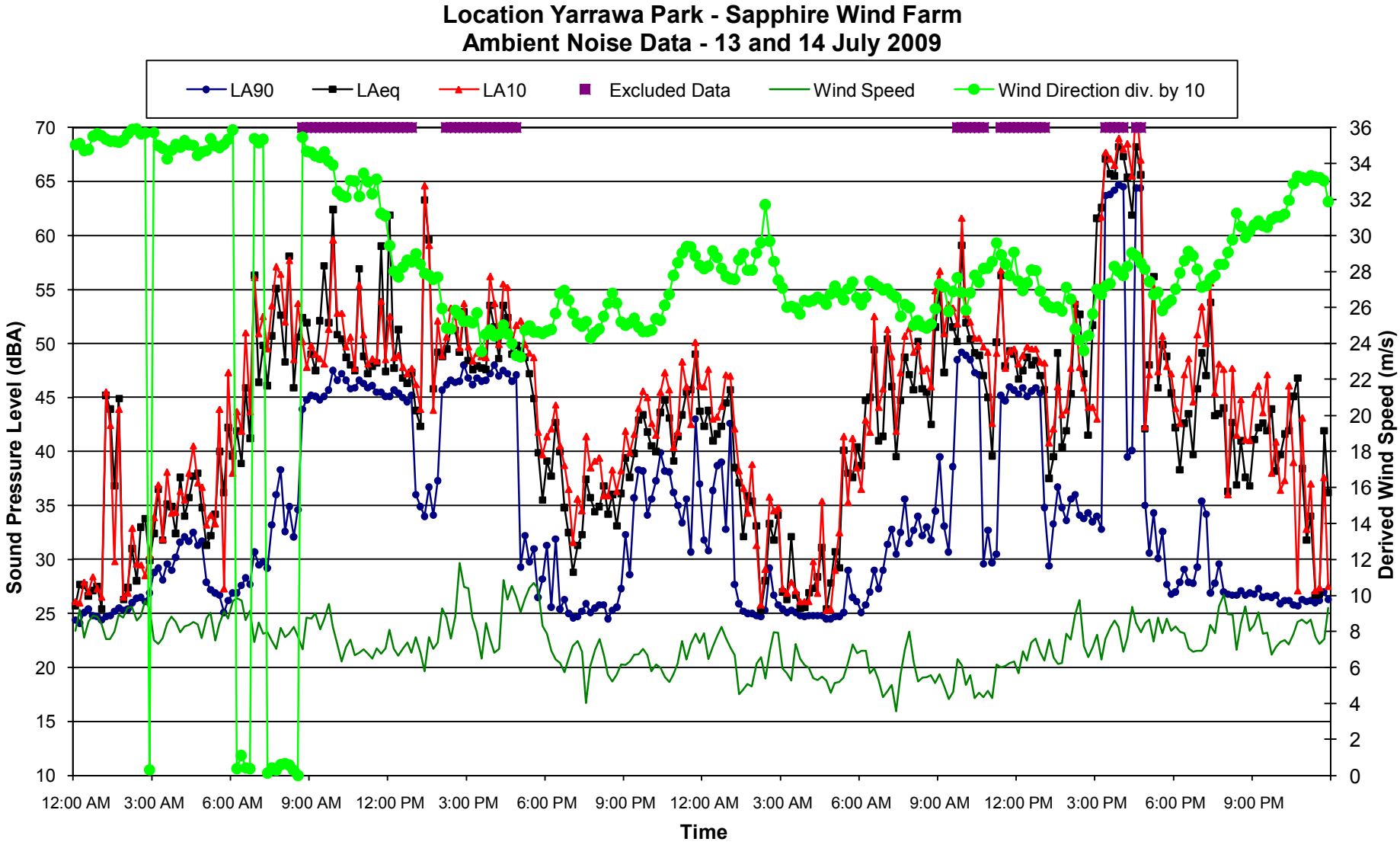
Appendix C1
40-1822
Level Wind vs Time



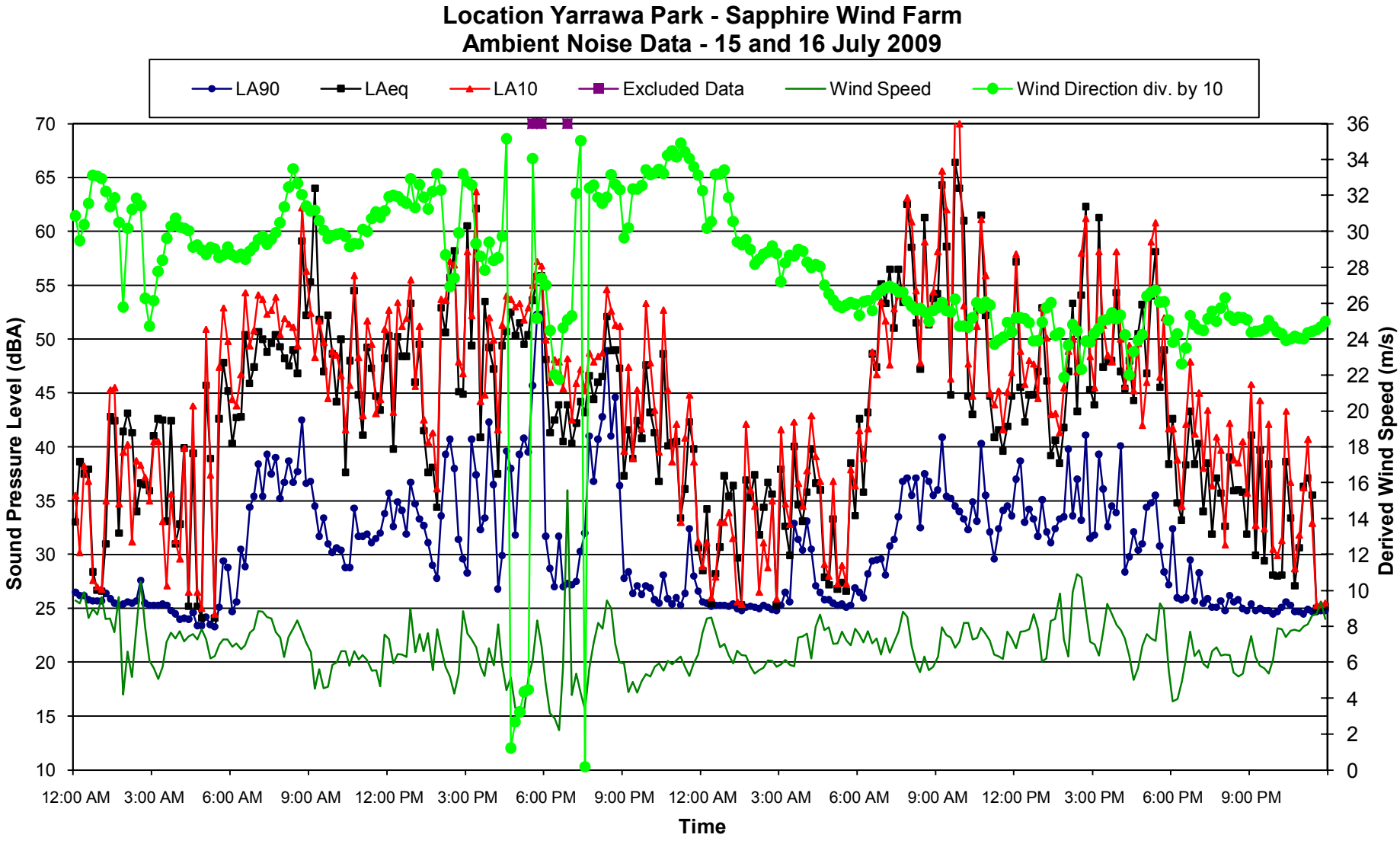
Appendix C1
40-1822
Level Wind vs Time



Appendix C1
40-1822
Level Wind vs Time

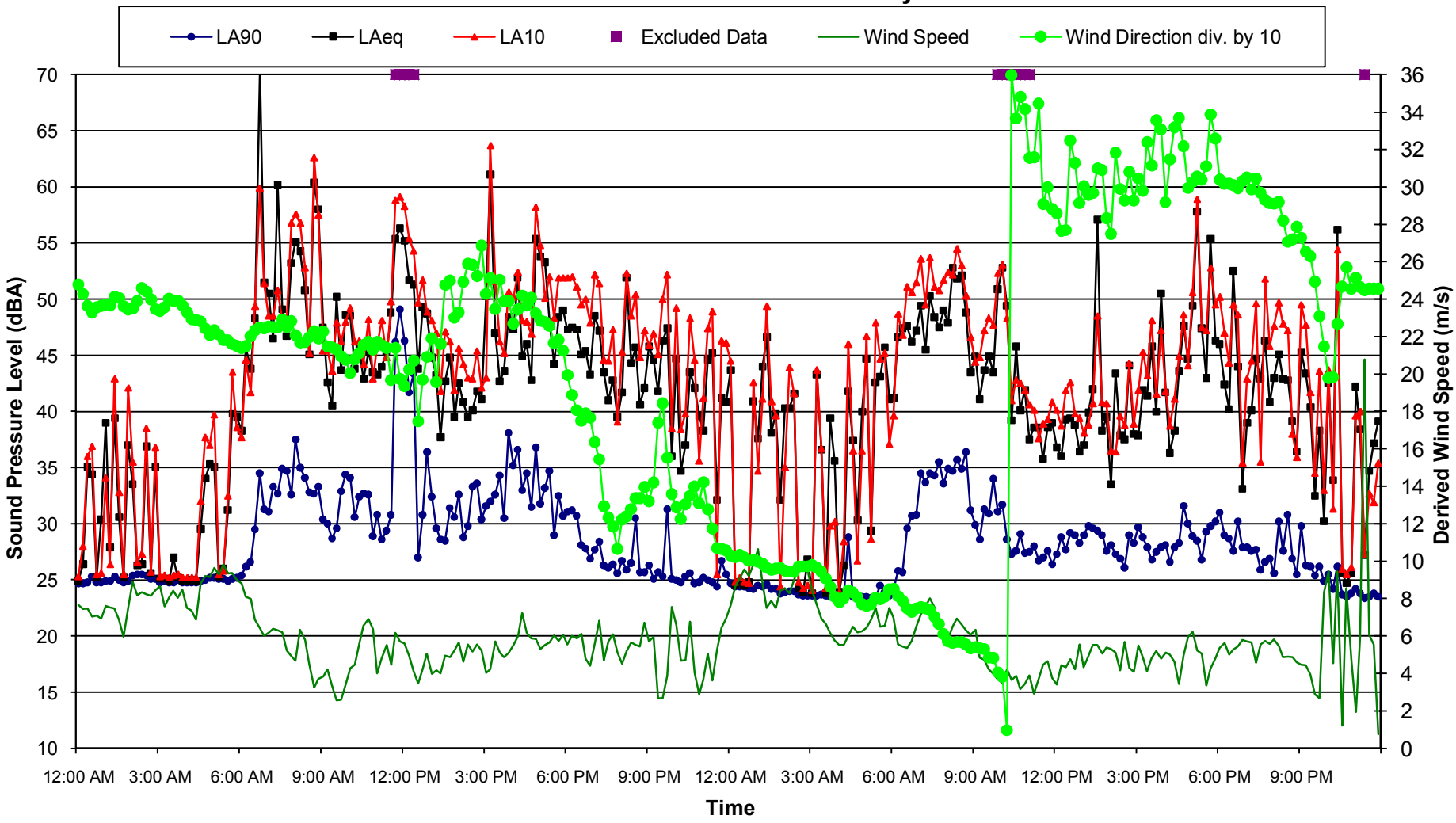


Appendix C1
40-1822
Level Wind vs Time



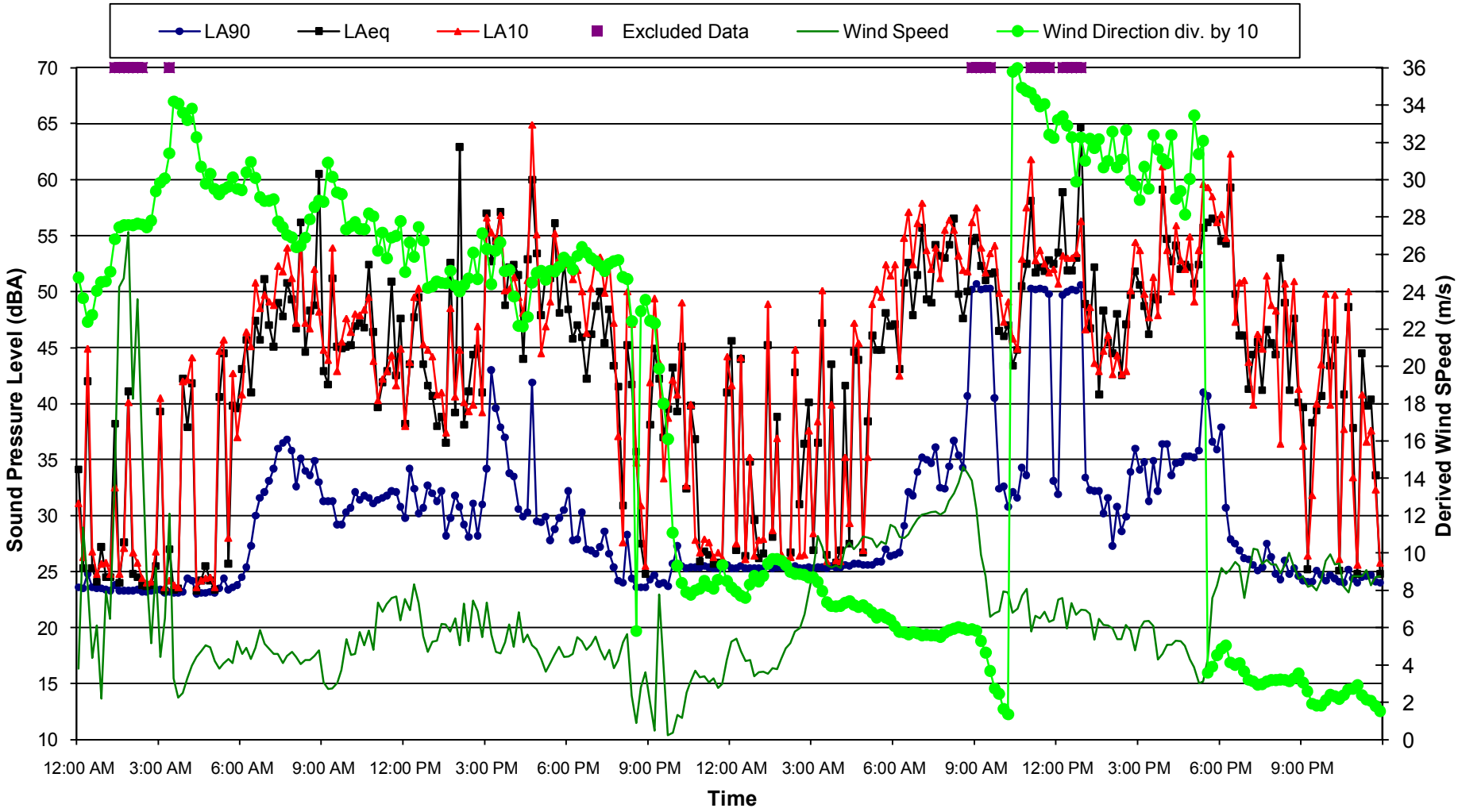
Appendix C1
40-1822
Level Wind vs Time

Location Yarrawa Park - Sapphire Wind Farm
Ambient Noise Data - 17 and 18 July 2009



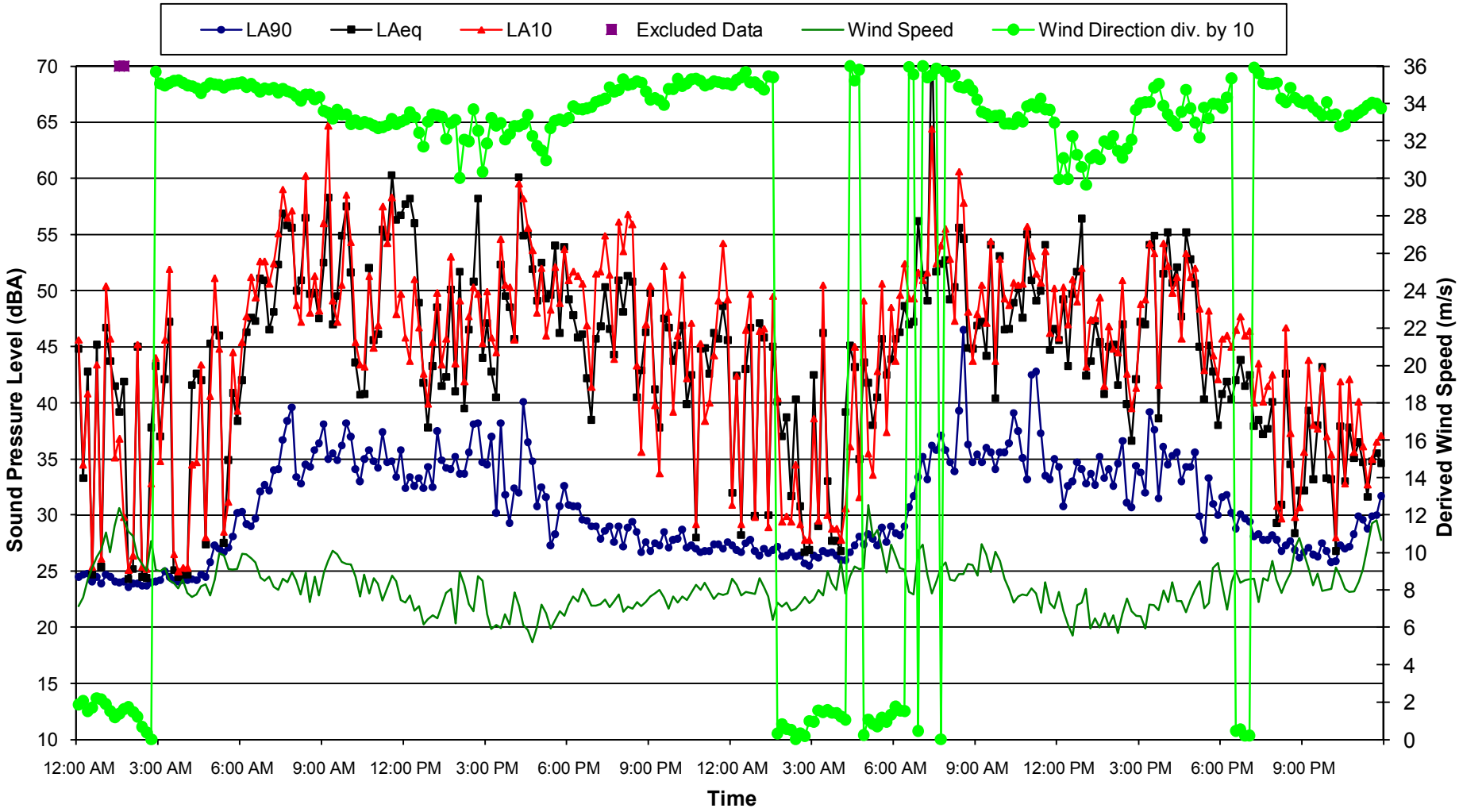
Appendix C1
40-1822
Level Wind vs Time

Location Yarrawa Park - Sapphire Wind Farm
Ambient Noise Data - 19 and 20 July 2009



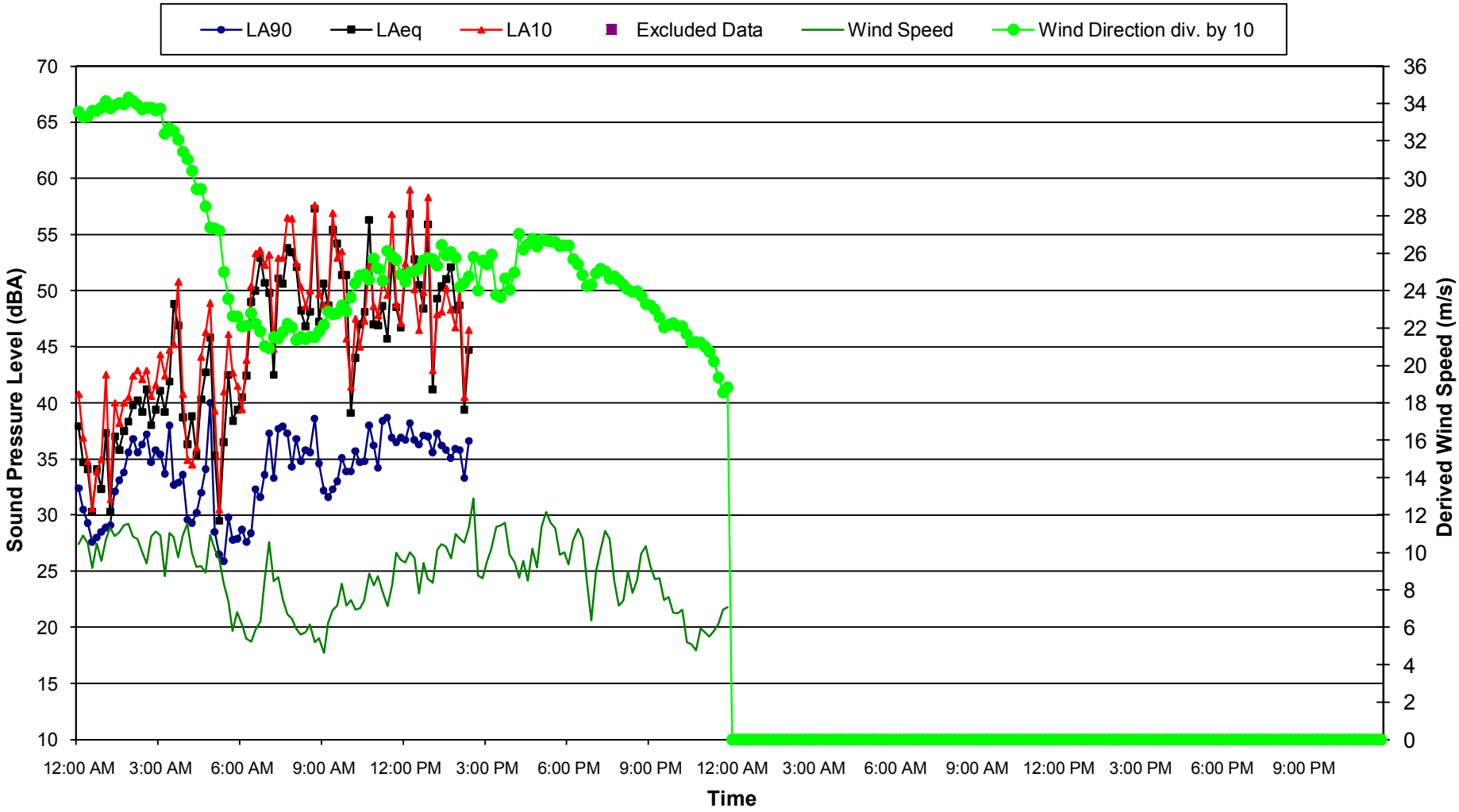
Appendix C1
40-1822
Level Wind vs Time

Location Yarrawa Park - Sapphire Wind Farm
Ambient Noise Data - 21 and 22 July 2009



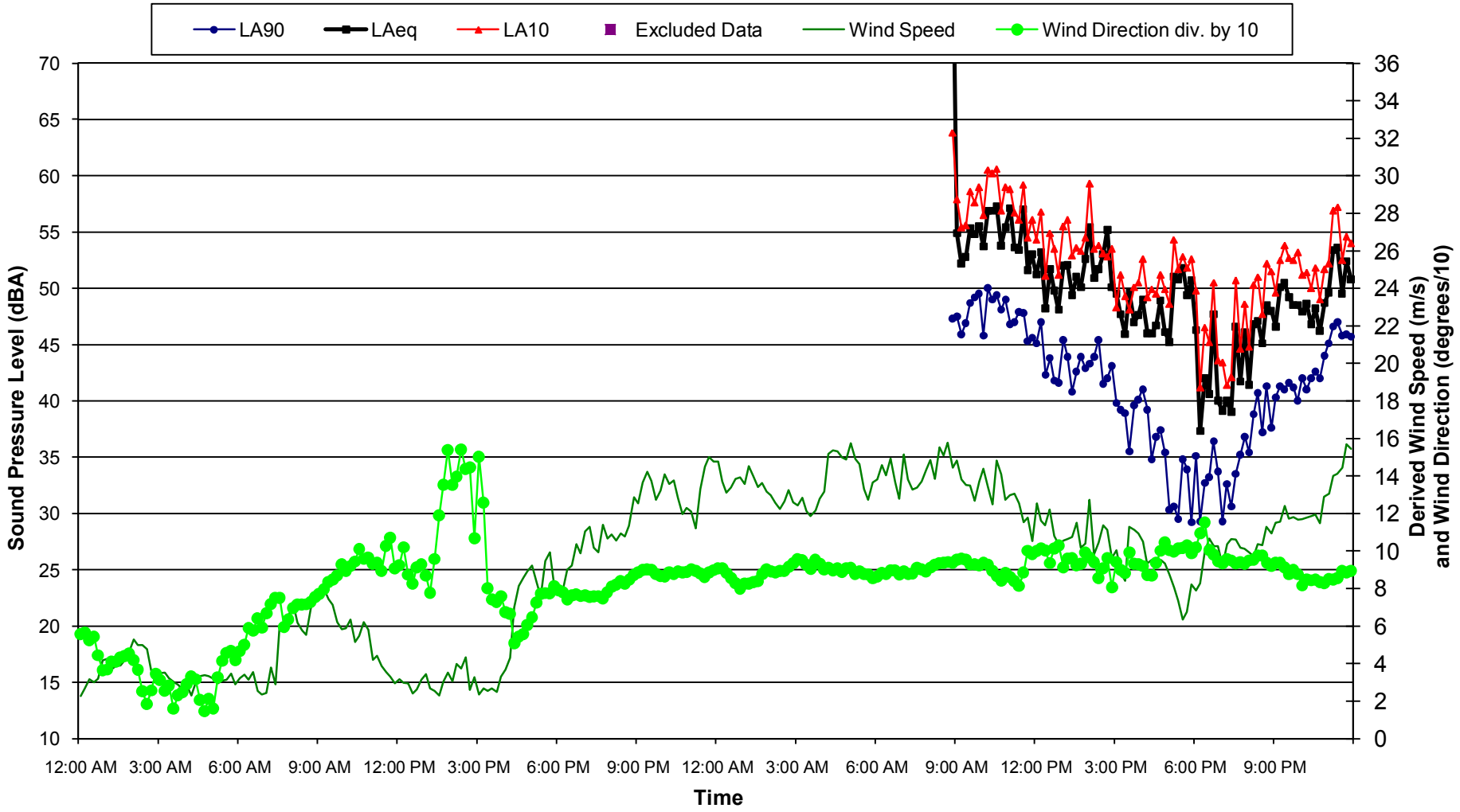
Appendix C1
40-1822
Level Wind vs Time

Location Yarrawa Park - Sapphire Wind Farm
Ambient Noise Data - 23 and 24 July 2009



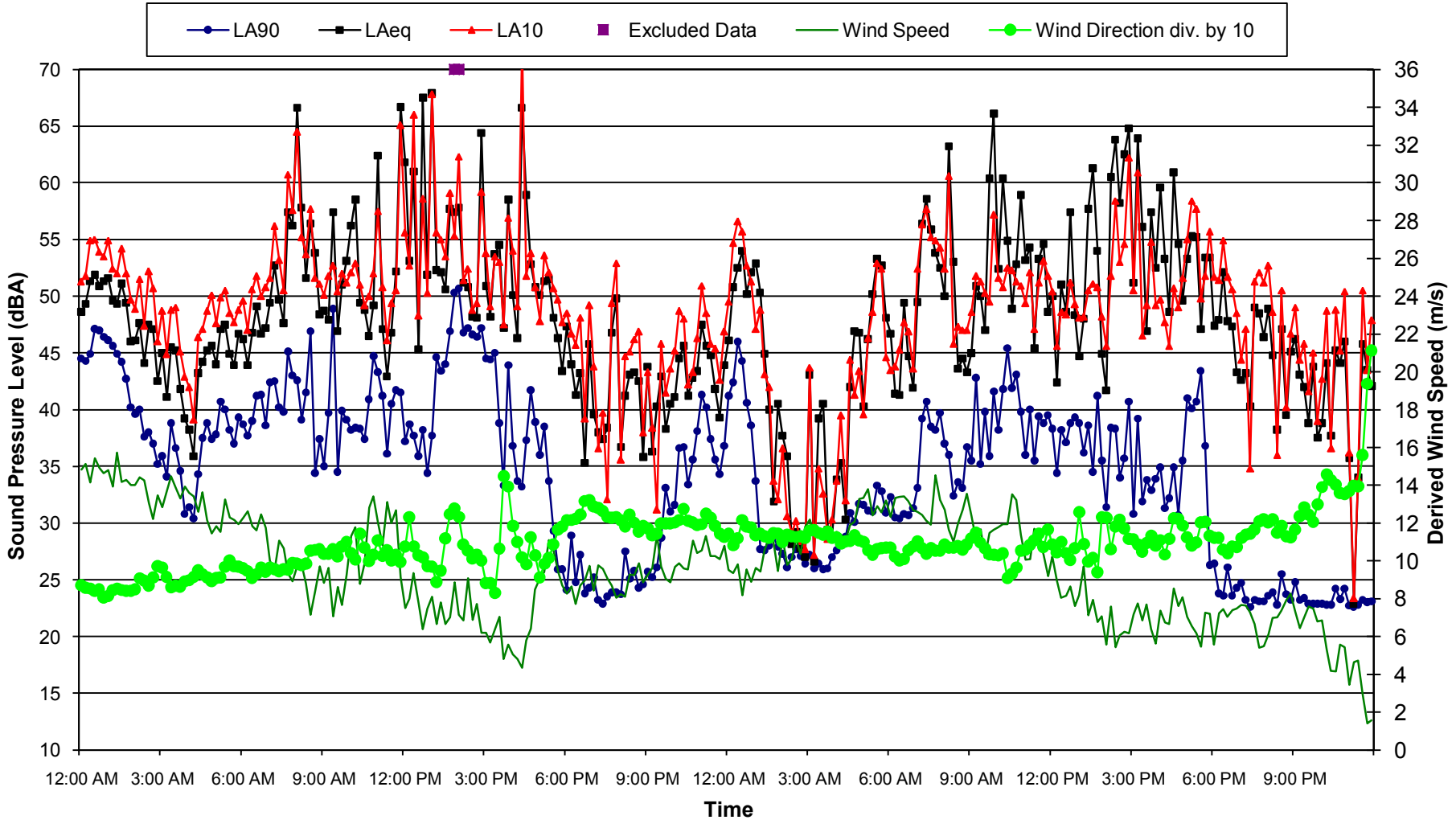
Appendix C1
40-1822
Level Wind vs Time

Location Mindora - Sapphire Wind Farm
Ambient Noise Data - 7 and 8 July 2009

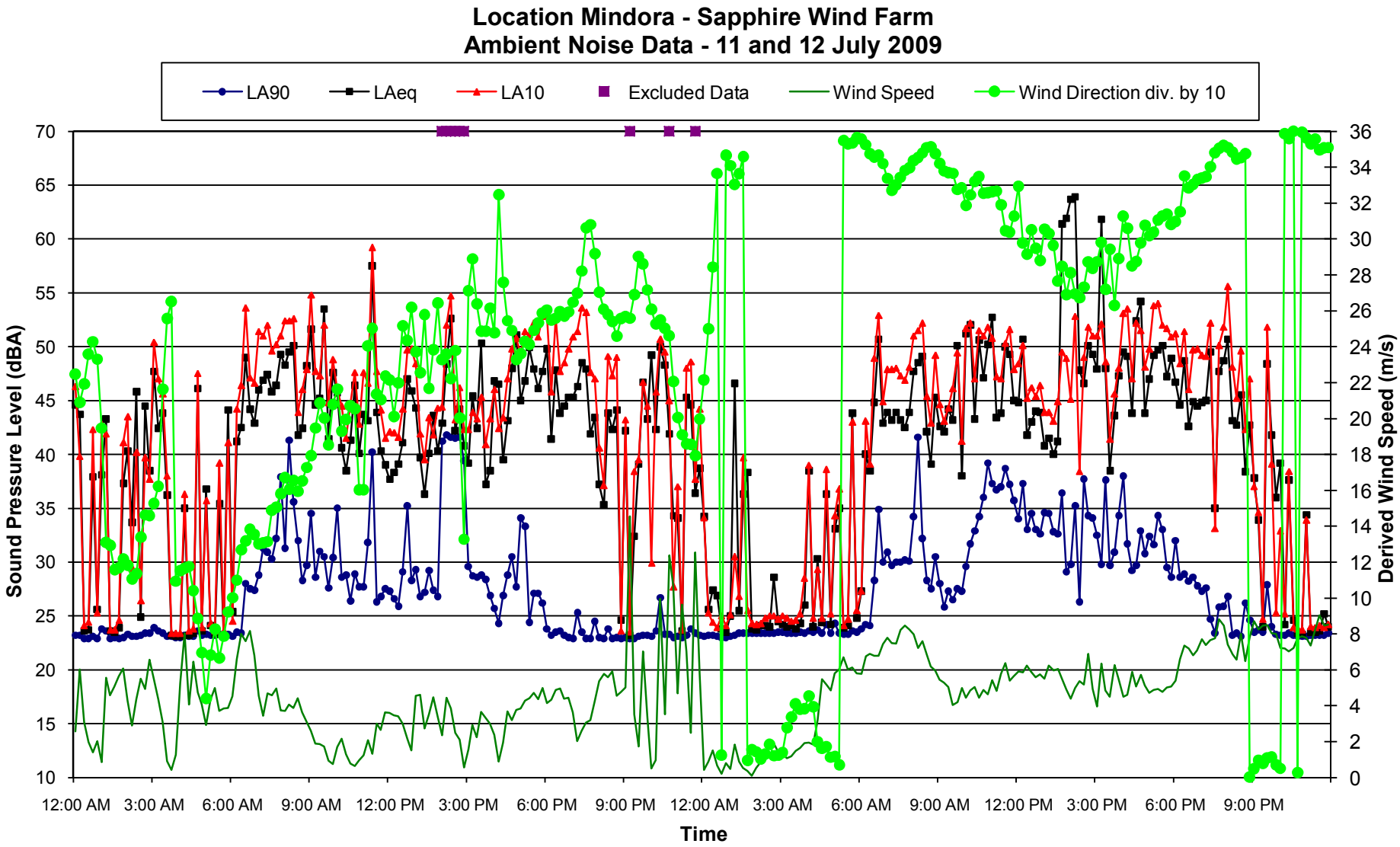


Appendix C1
40-1738
Level Wind vs Time

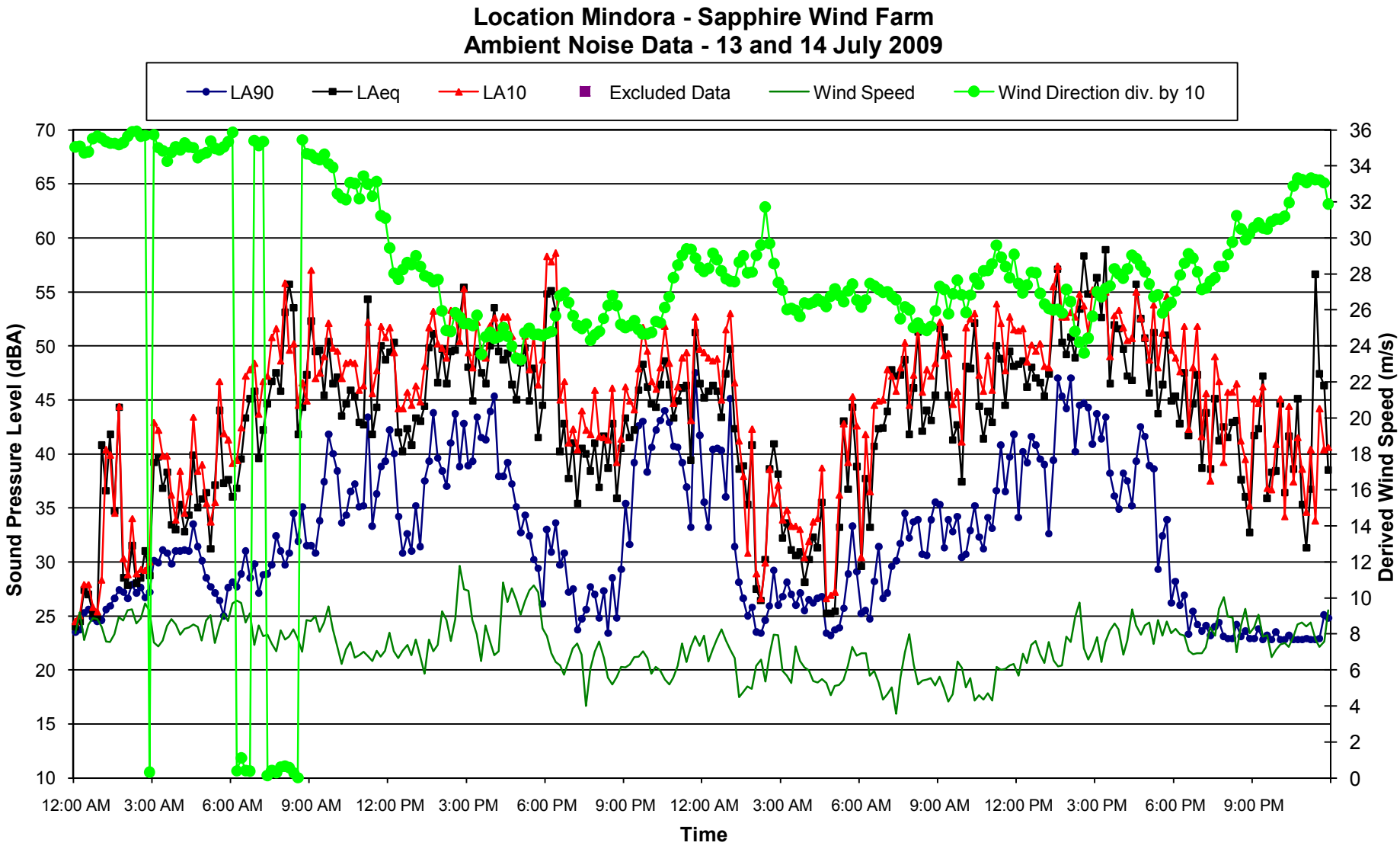
Location Mindora - Sapphire Wind Farm
Ambient Noise Data - 9 and 10 July 2009



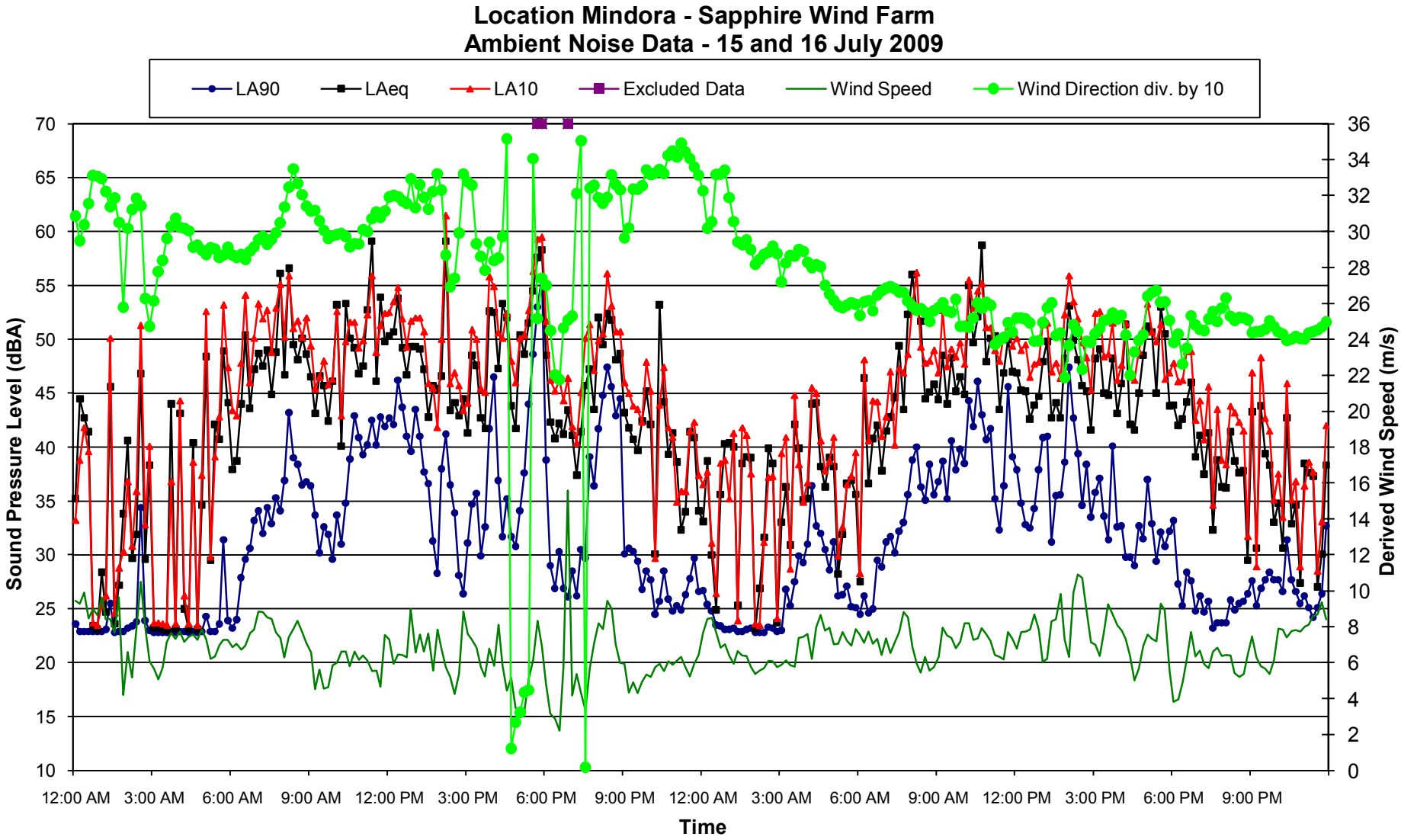
Appendix C1
40-1738
Level Wind vs Time



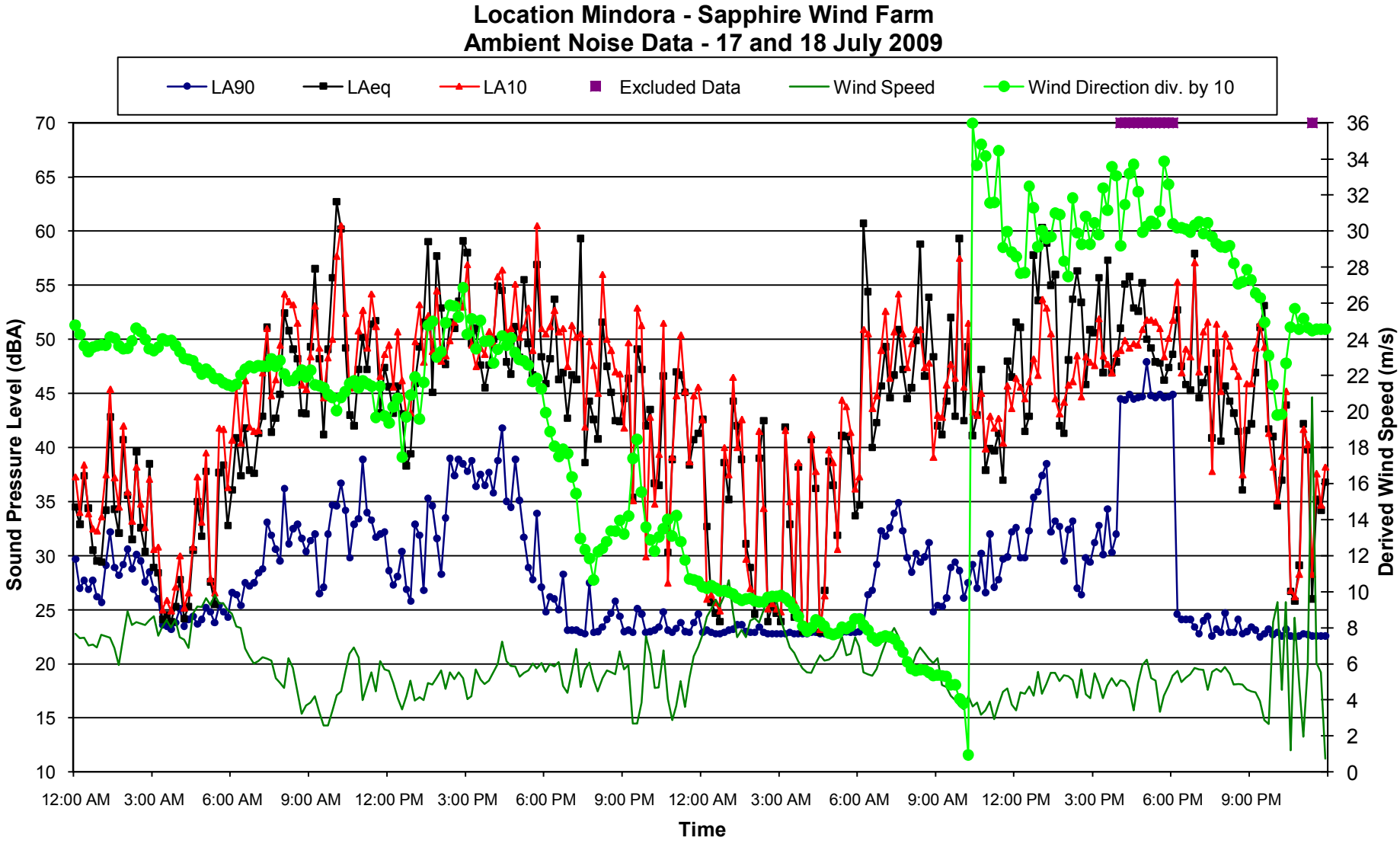
Appendix C1
40-1738
Level Wind vs Time



Appendix C1
40-1738
Level Wind vs Time

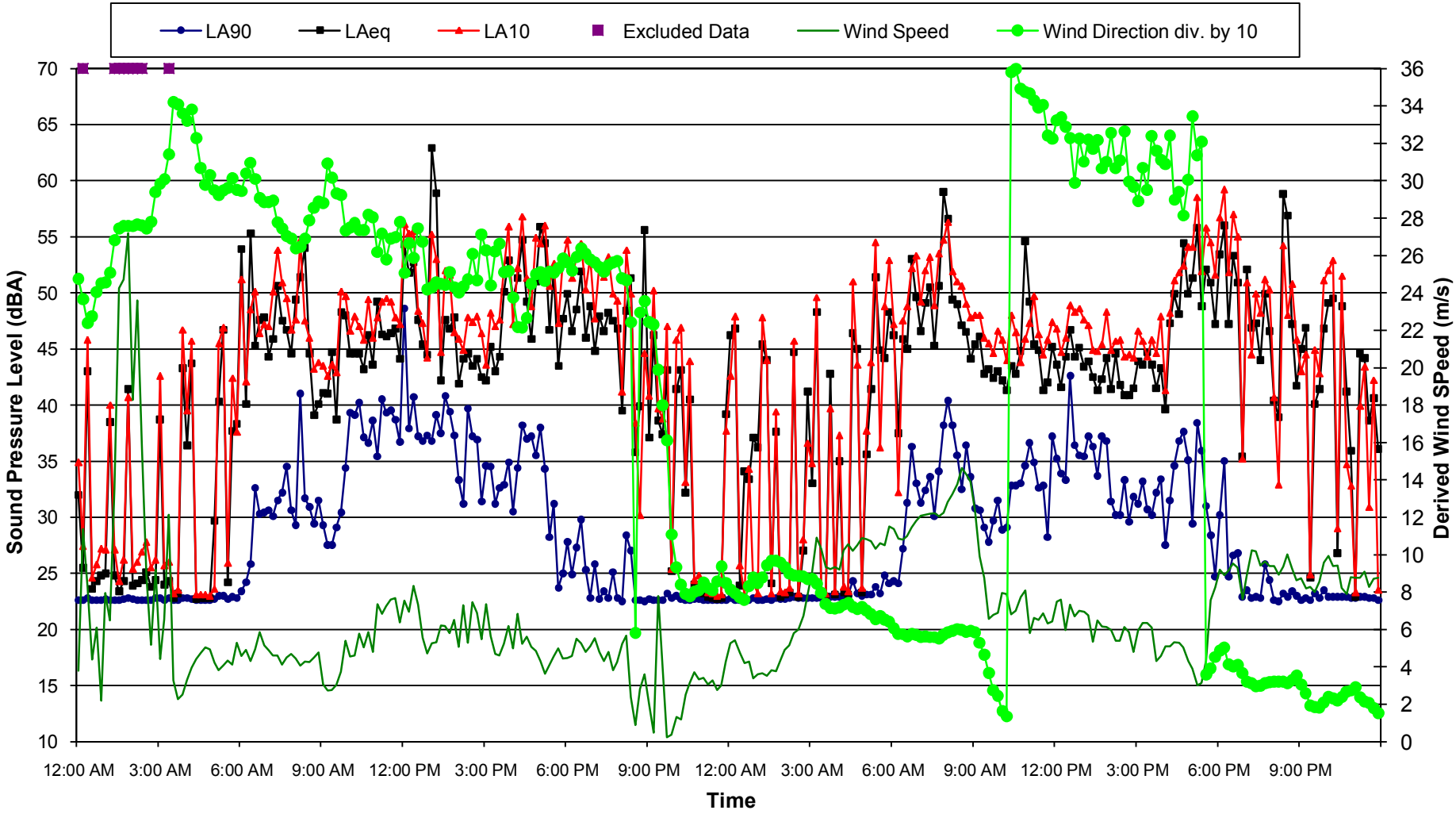


Appendix C1
40-1822
Level Wind vs Time

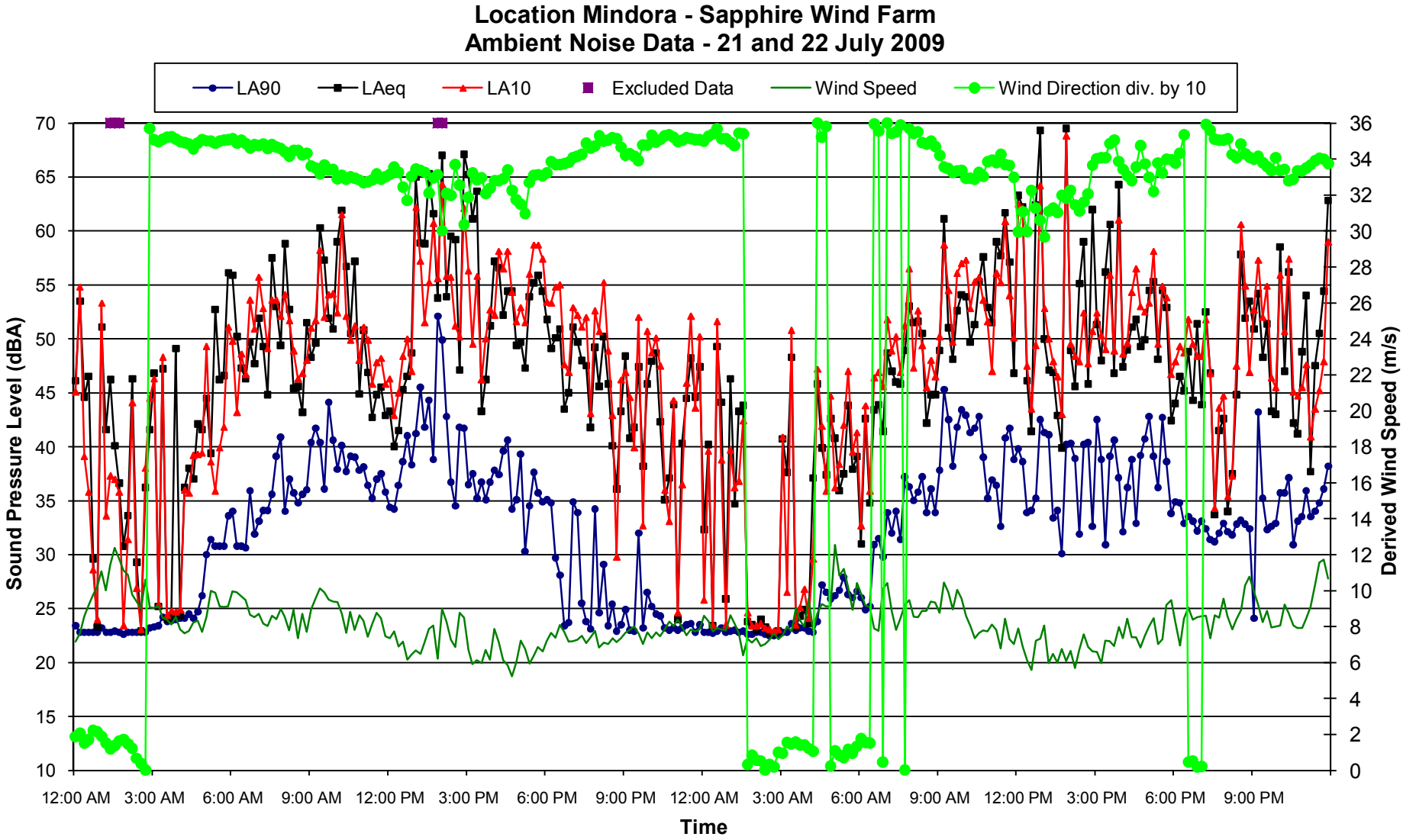


Appendix C1
40-1738
Level Wind vs Time

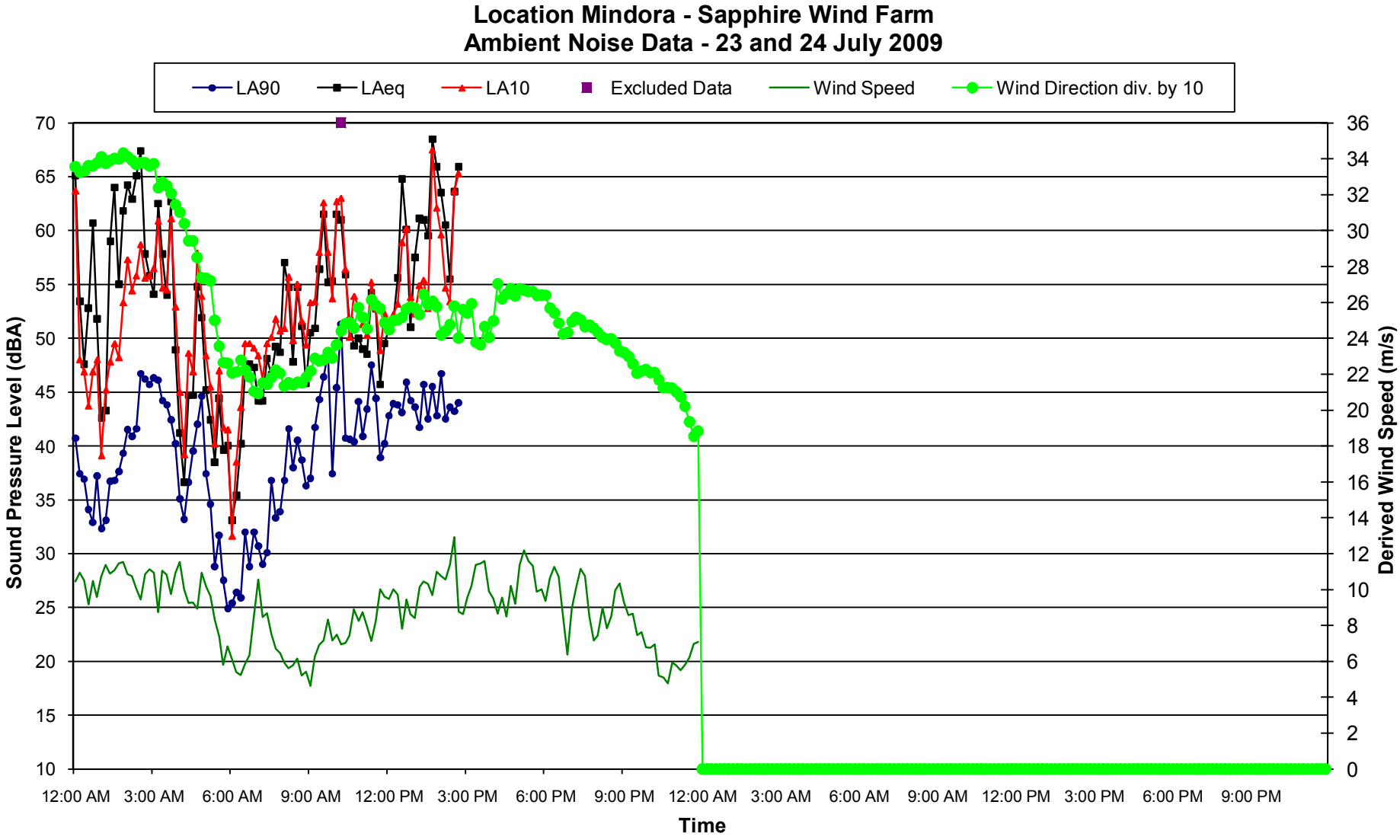
Location Mindora - Sapphire Wind Farm
Ambient Noise Data - 19 and 20 July 2009



Appendix C1
40-1738
Level Wind vs Time

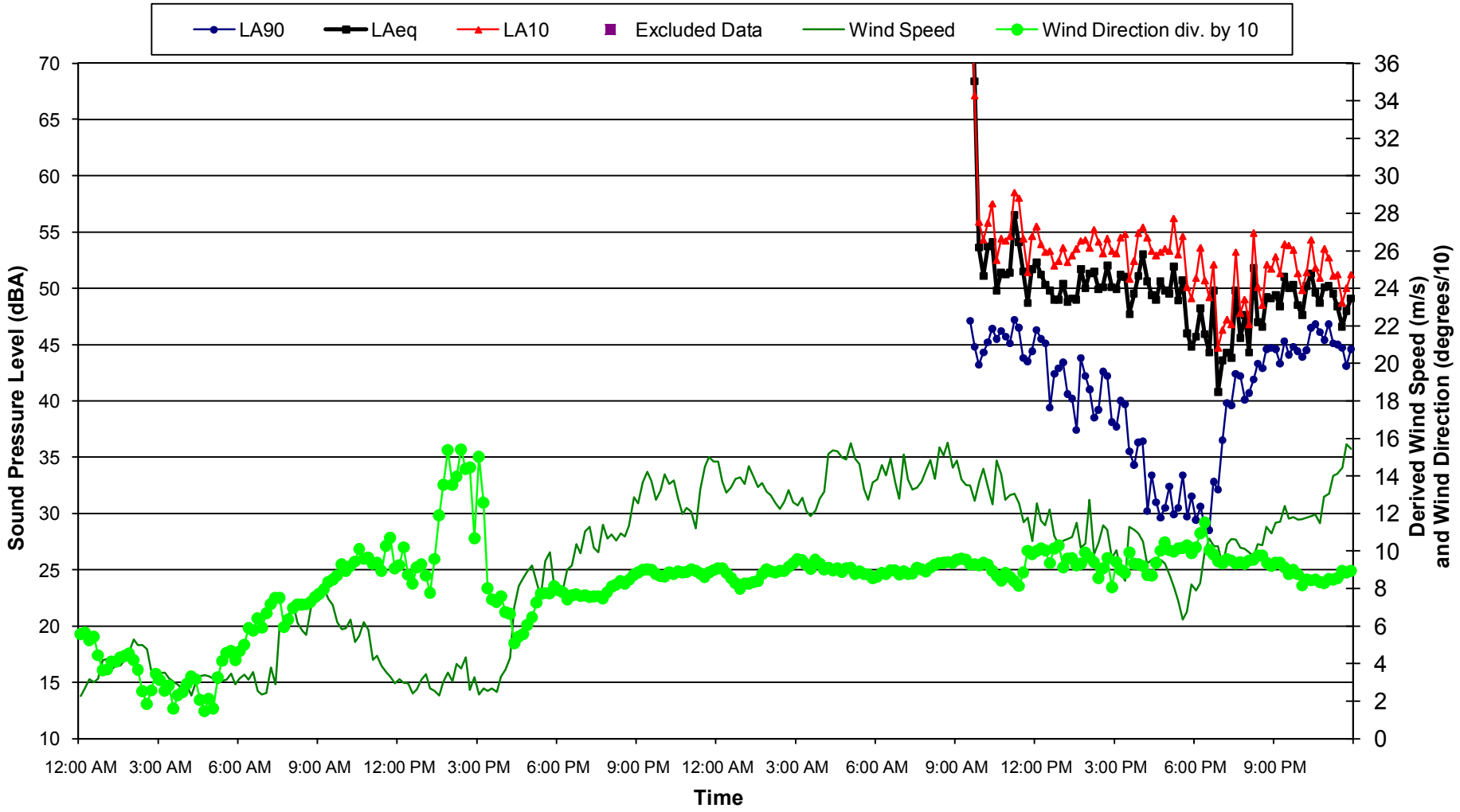


Appendix C1
40-1738
Level Wind vs Time



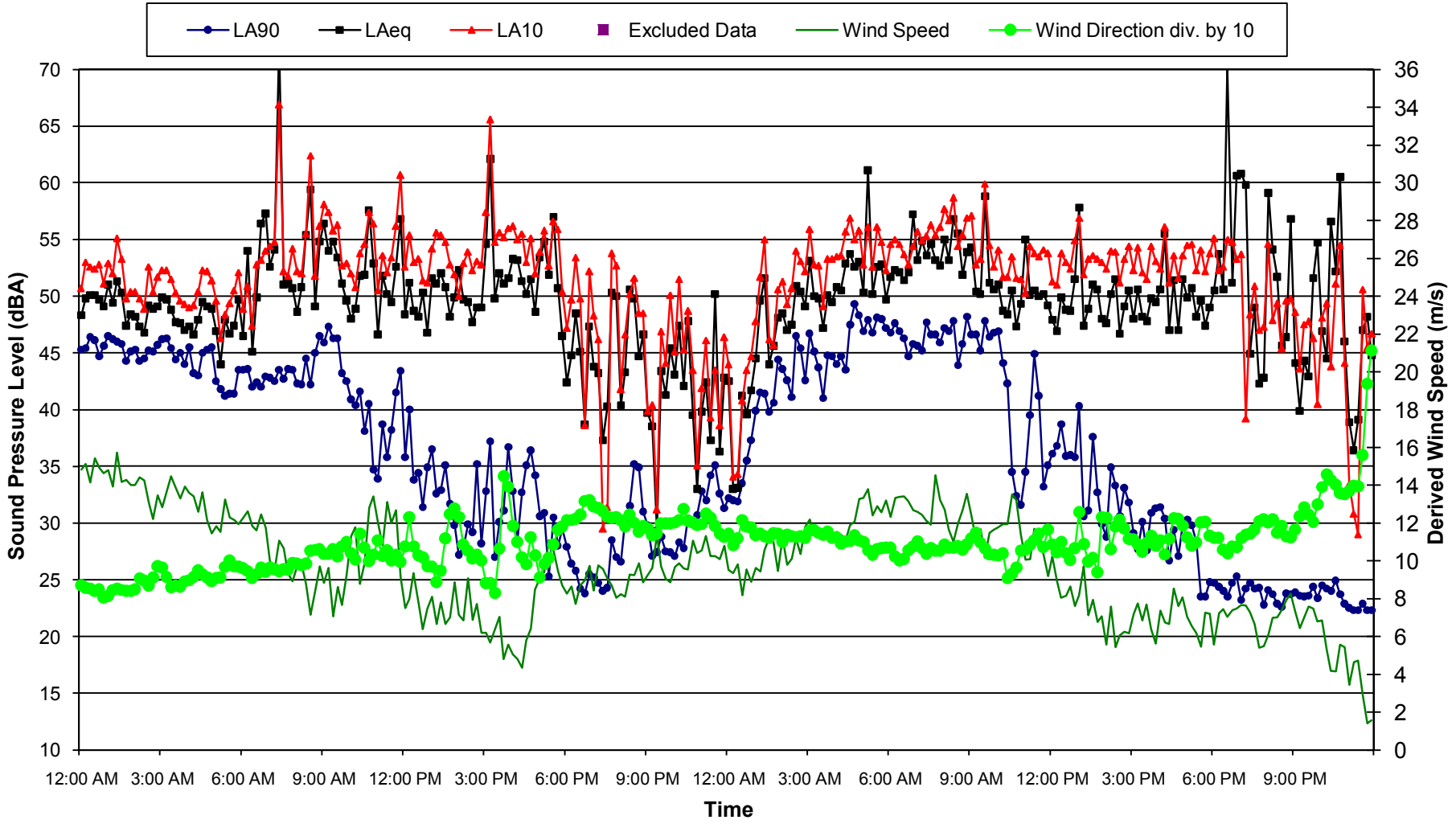
Appendix C1
40-1738
Level Wind vs Time

Location Mt Buckley - Sapphire Wind Farm
Ambient Noise Data - 7 and 8 July 2009

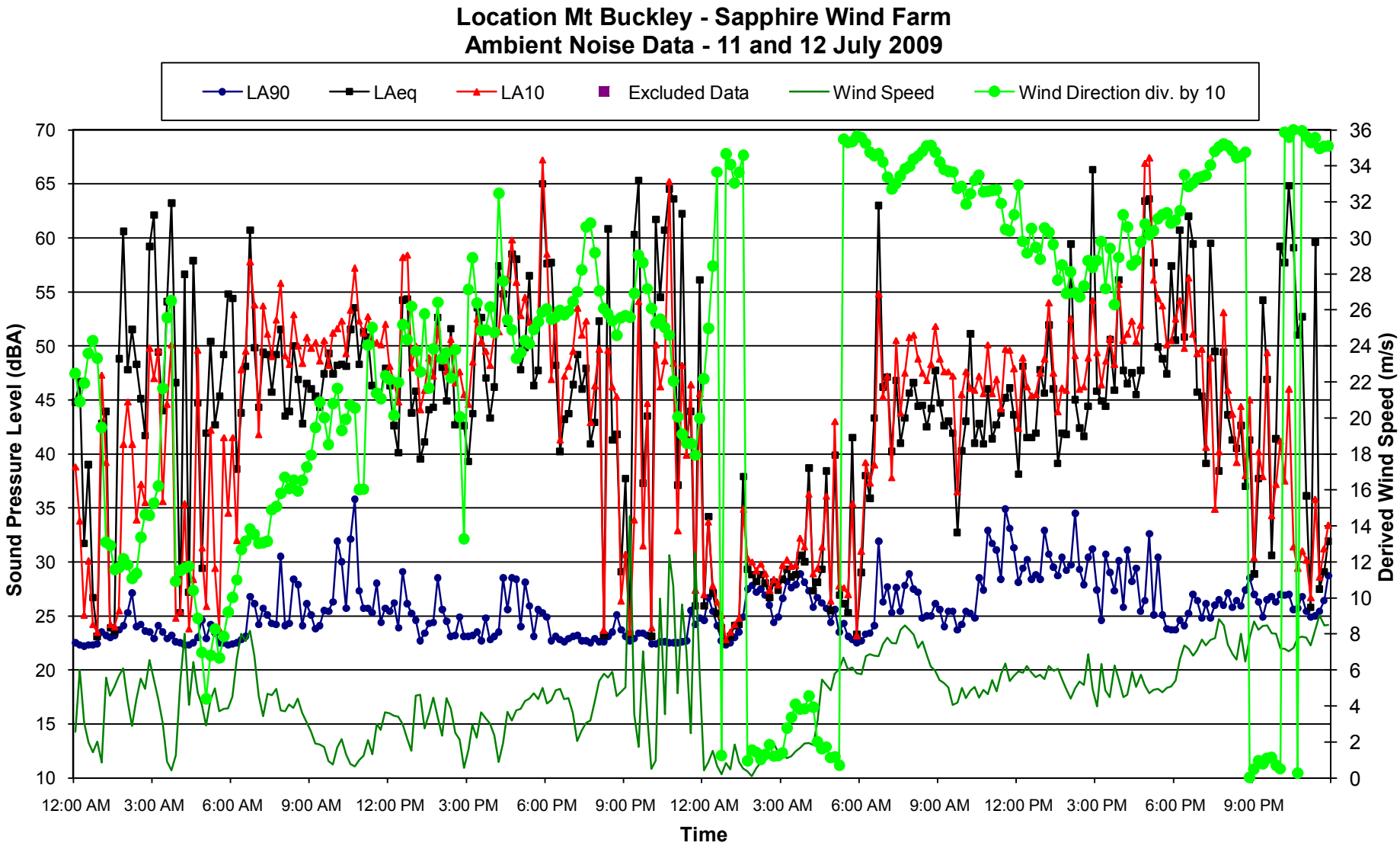


Appendix C1
40-1738
Level Wind vs Time

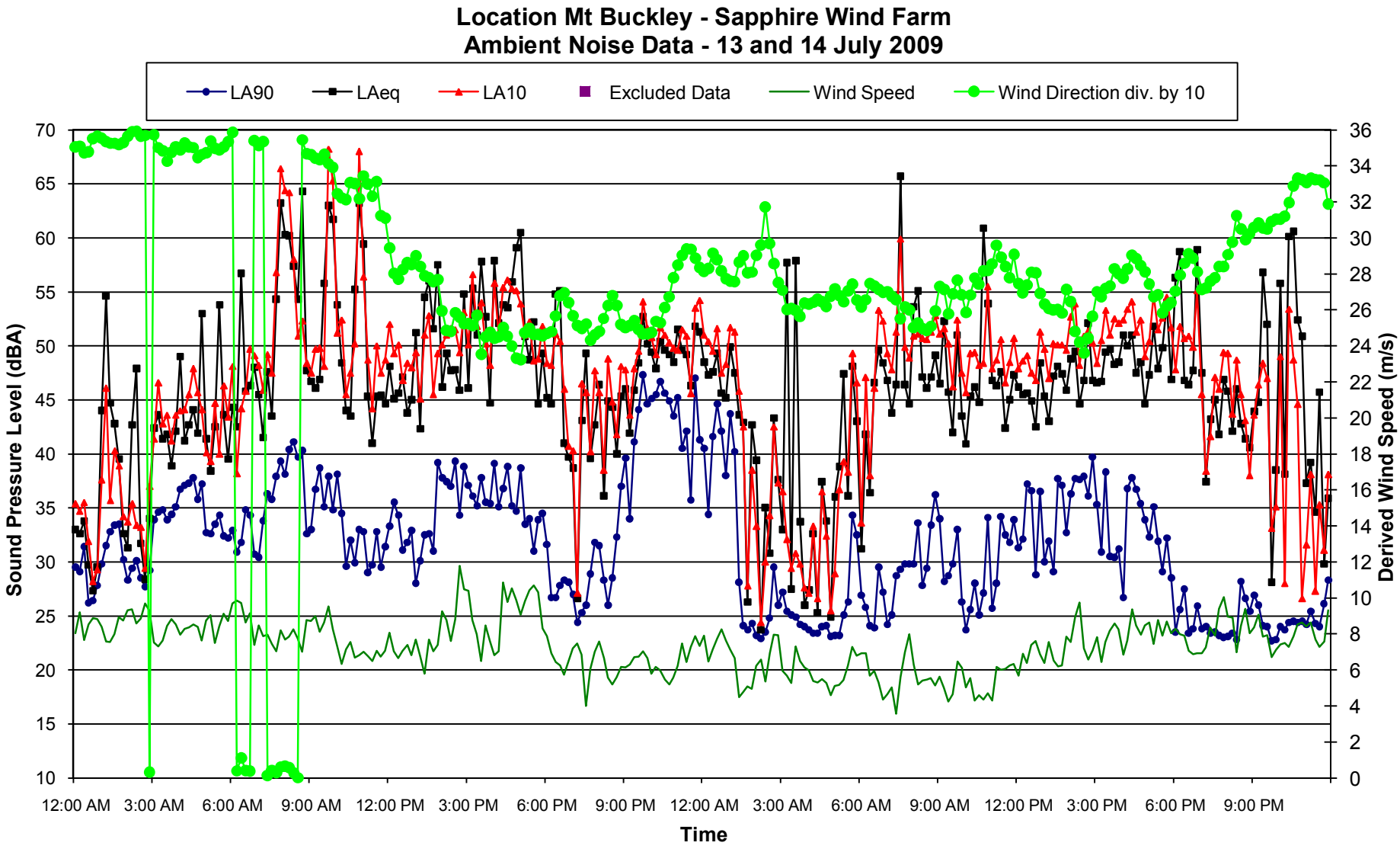
Location Mt Buckley - Sapphire Wind Farm
Ambient Noise Data - 9 and 10 July 2009



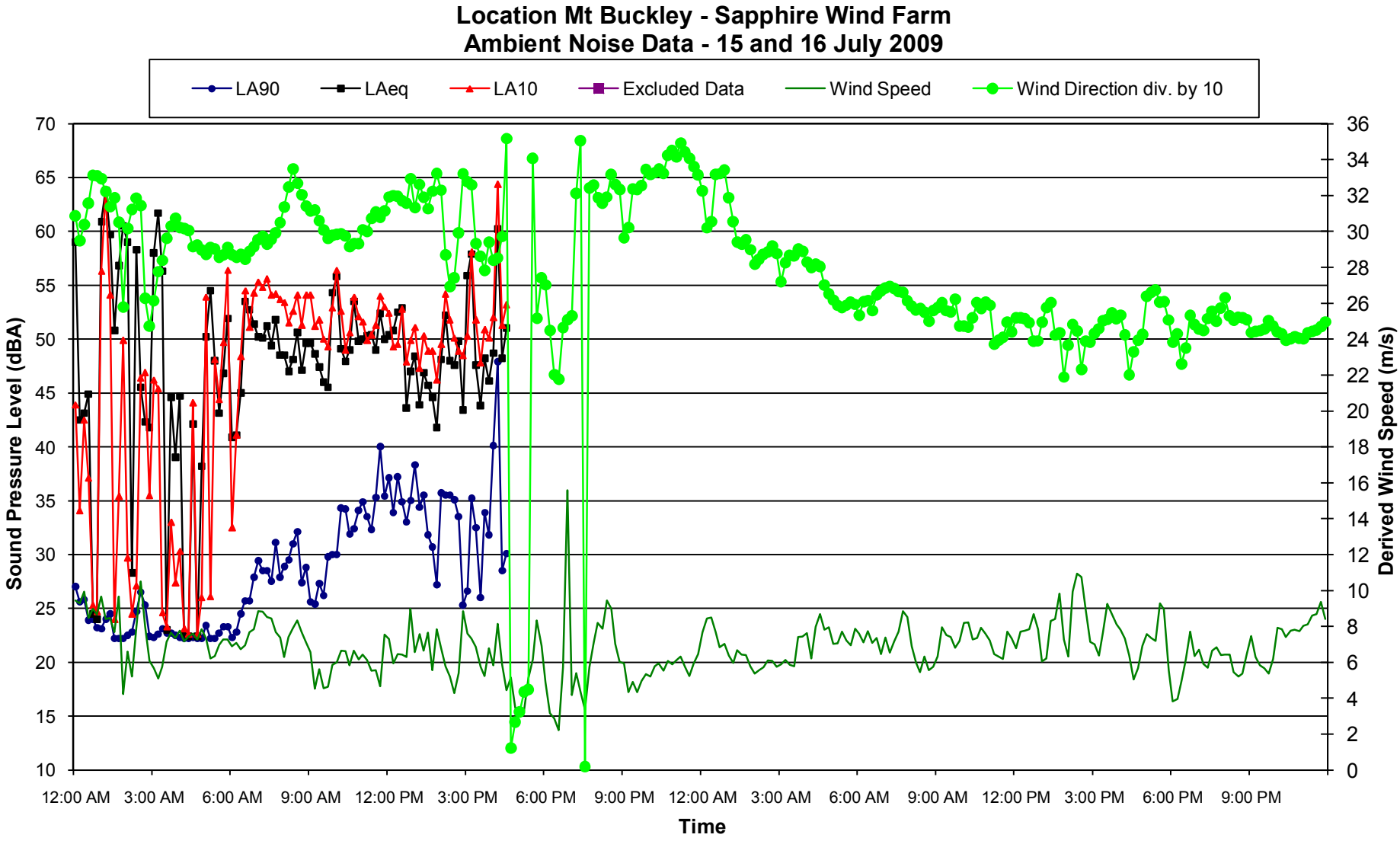
Appendix C1
40-1822
Level Wind vs Time



Appendix C1
40-1738
Level Wind vs Time

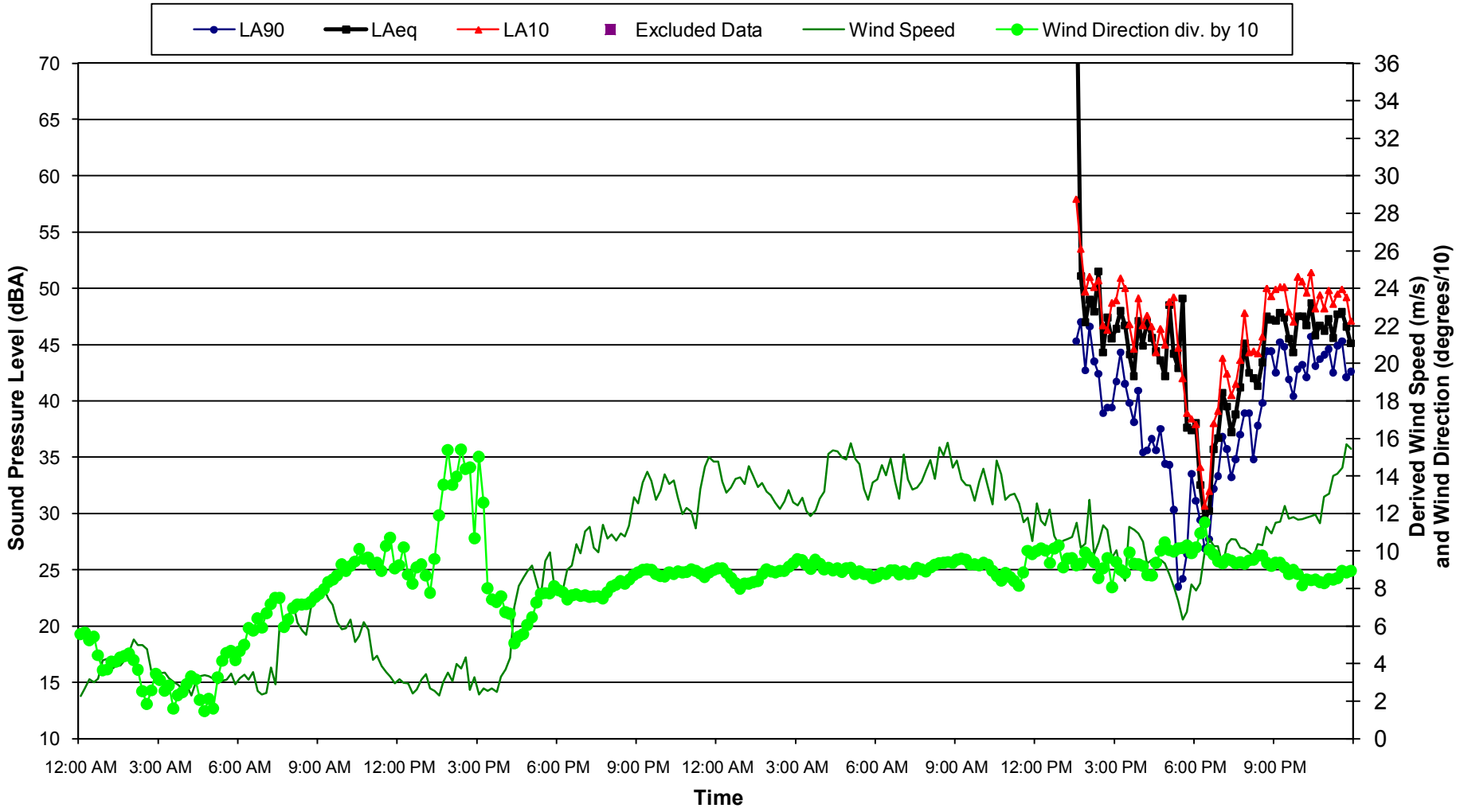


Appendix C1
40-1738
Level Wind vs Time

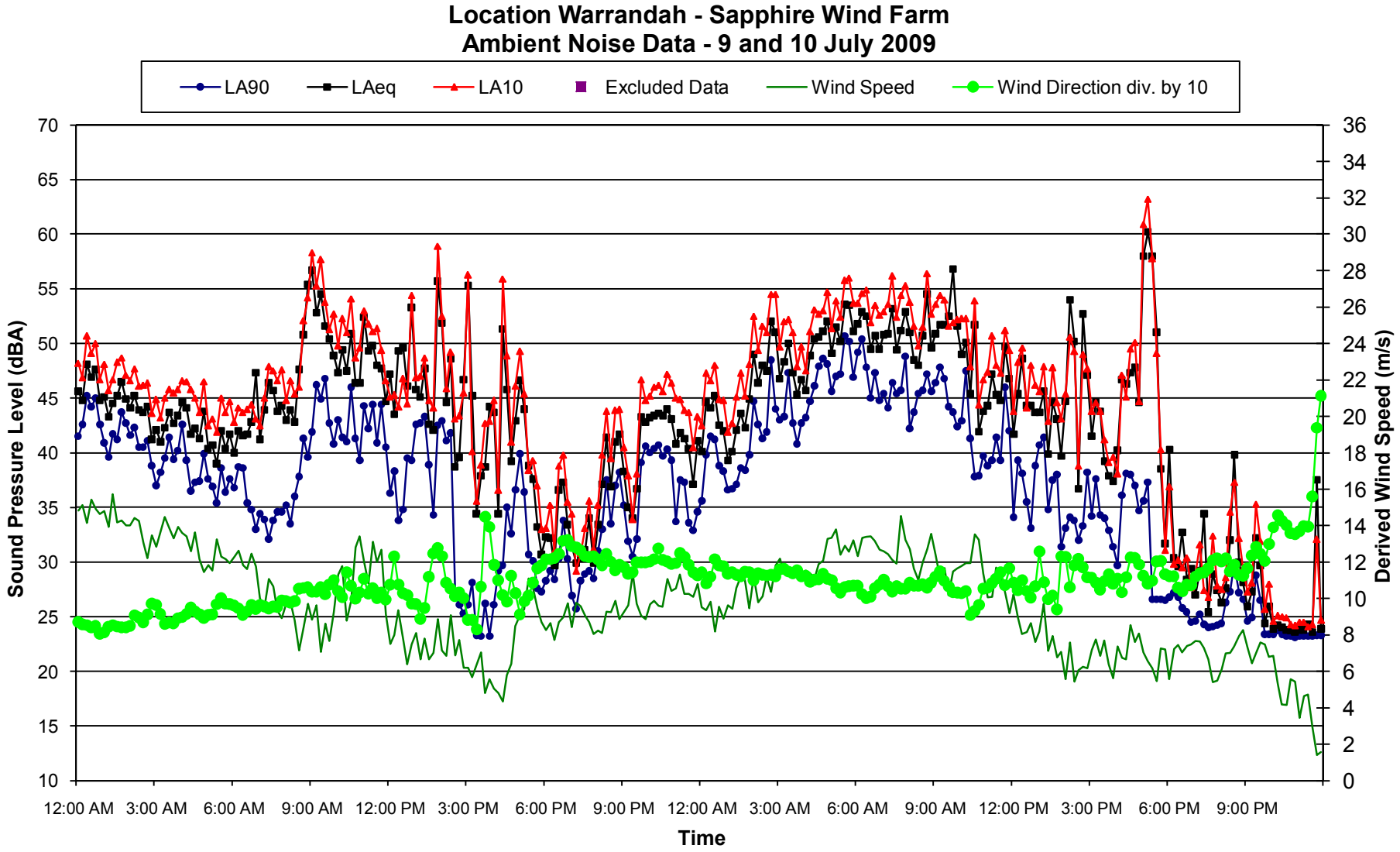


Appendix C1
40-1738
Level Wind vs Time

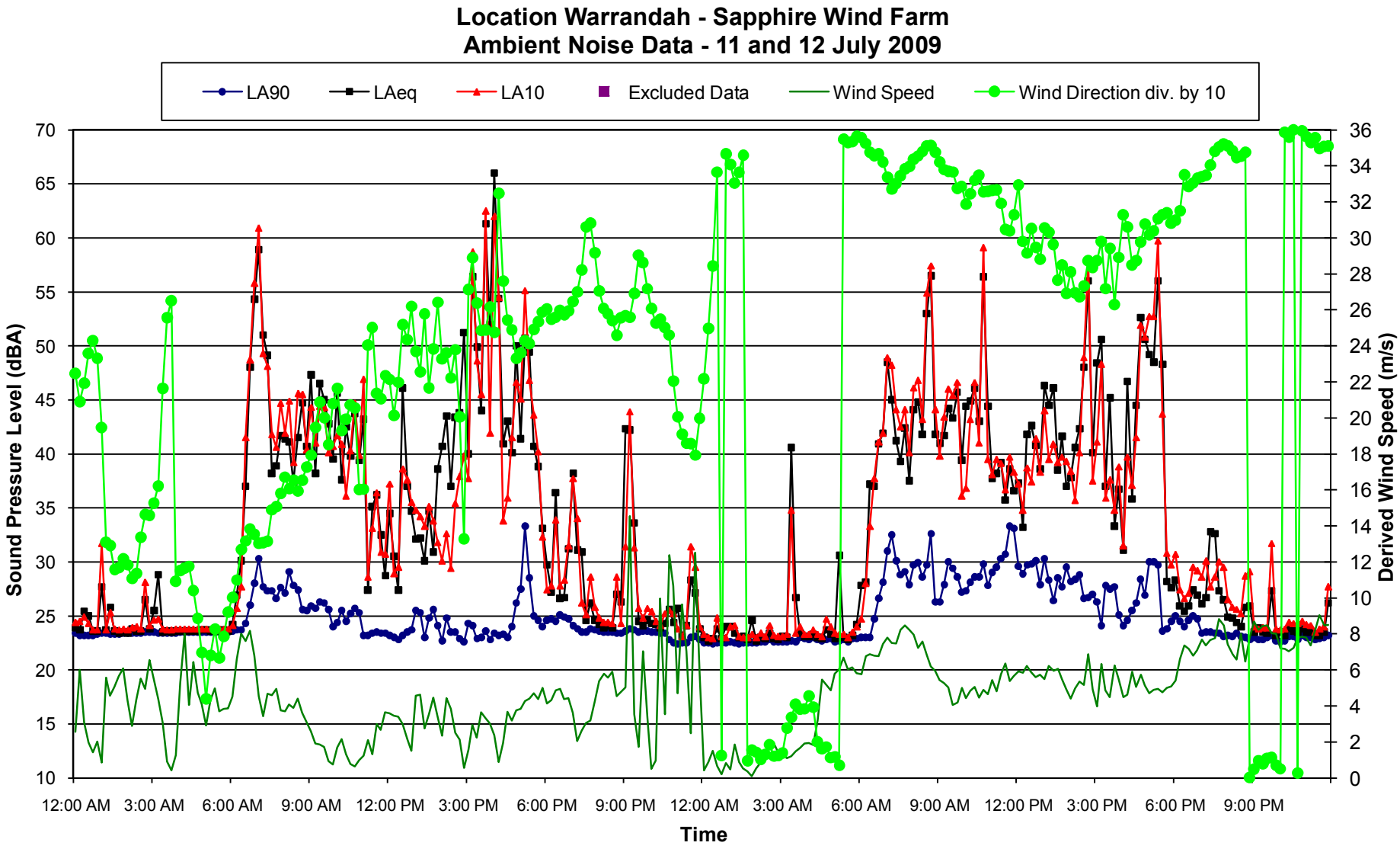
Location Warrandah - Sapphire Wind Farm
Ambient Noise Data - 7 and 8 July 2009



Appendix C1
40-1822
Level Wind vs Time

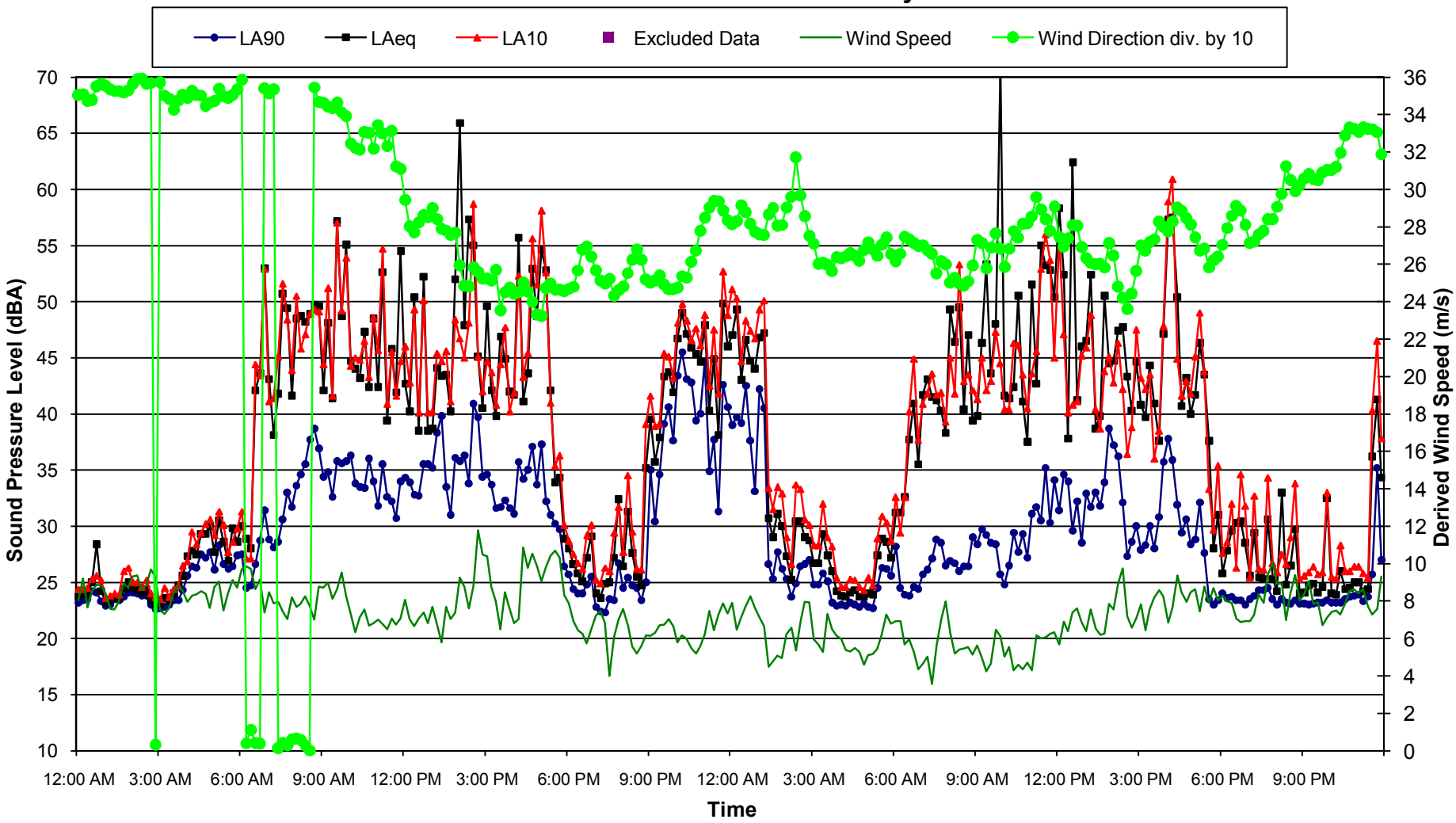


Appendix C1
40-1822
Level Wind vs Time

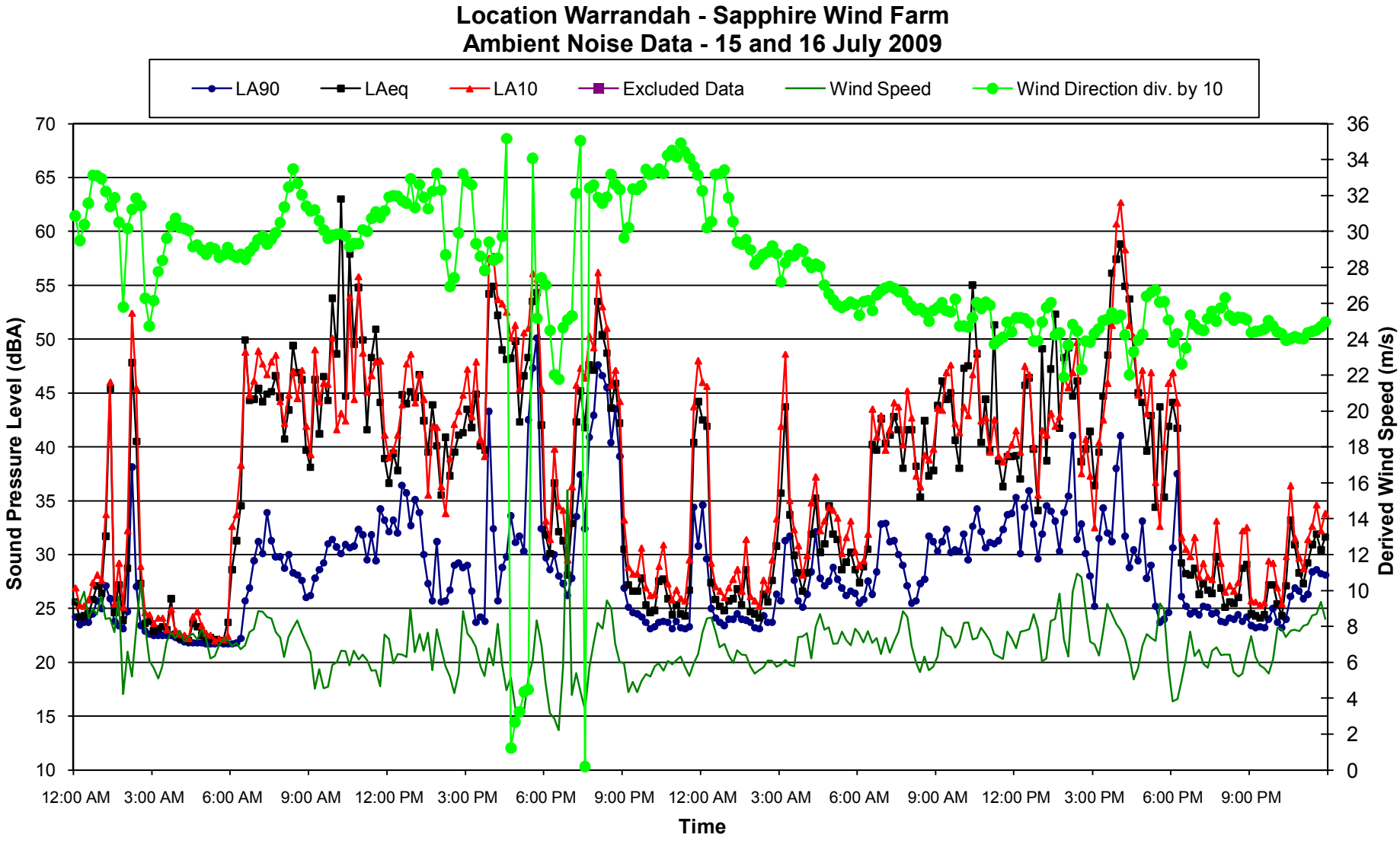


Appendix C1
40-1822
Level Wind vs Time

Location Warrandah - Sapphire Wind Farm
Ambient Noise Data - 13 and 14 July 2009

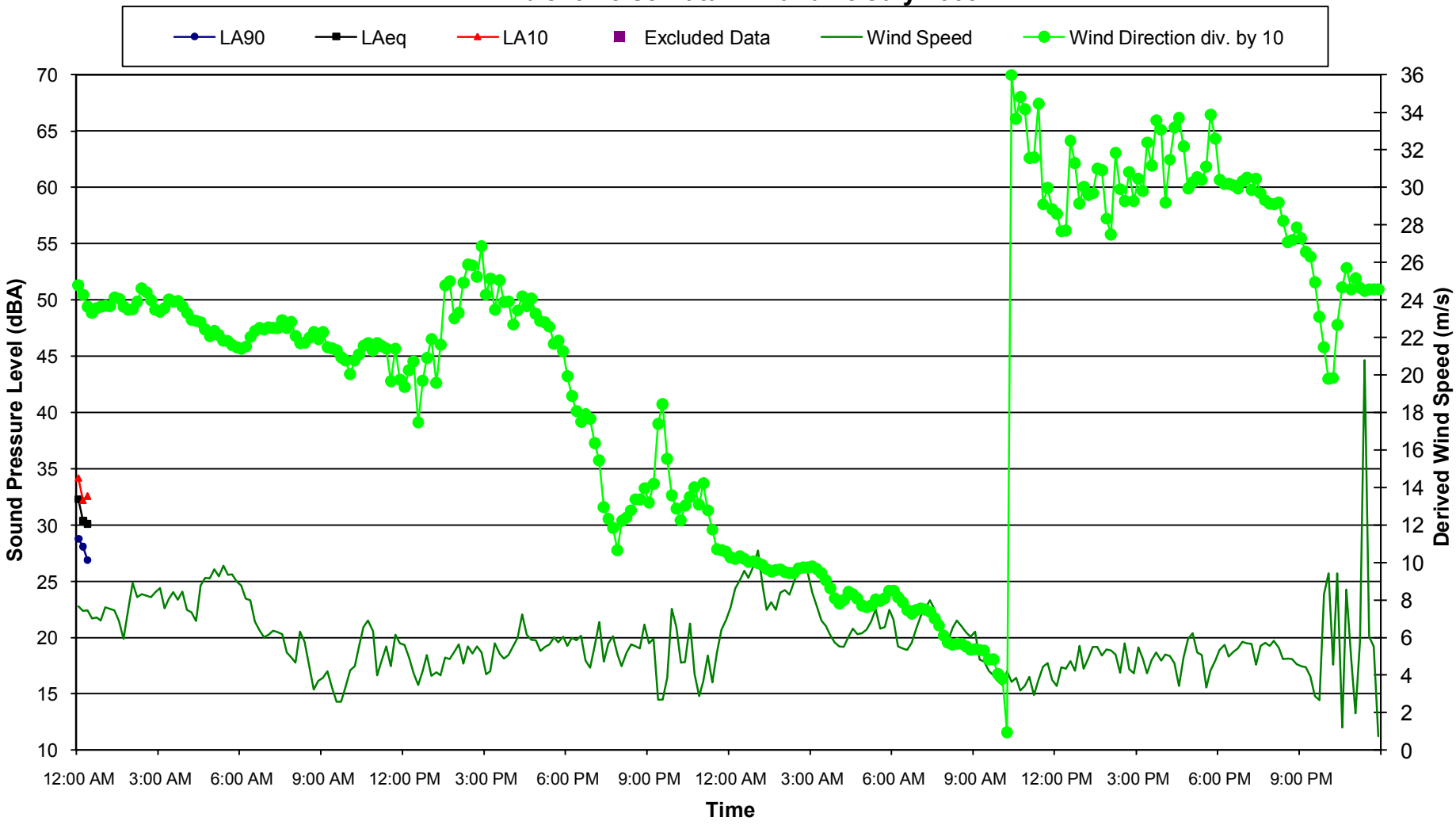


Appendix C1
40-1822
Level Wind vs Time



Appendix C1
40-1822
Level Wind vs Time

Location Warrandah - Sapphire Wind Farm
Ambient Noise Data - 17 and 18 July 2009



Appendix C1
40-1822
Level Wind vs Time

Appendix D
Acoustic terminology

NOISE FUNDAMENTALS

Noise

Hearing is a fundamental human sense and is used constantly for communication and awareness of the environment.

Noise is generally described as being 'unwanted' or 'unfavourable' sound and, to some extent, is an individual or subjective response as what may be sound to one person, may be regarded as noise by another.

The measurement and assessment of sound has been developed steadily over the last century, taking into account human response measures such as hearing damage and other potential health affects such as stress. Complex sound measurement and analytical devices have also been developed.

A-weighting and 'dBA'

The overall level of a sound is usually expressed in terms of dBA, which is measured using the 'A-weighting' filter incorporated in sound level meters. These filters have a frequency response corresponding approximately to that of human hearing. People's hearing is most sensitive to sounds at mid frequencies (typically 500 Hz to 4,000 Hz) and less sensitive at lower and higher frequencies. The level of a sound in dBA is a considered a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally as loud, although the perceived loudness can also be affected by the character of the sound (e.g. the loudness of human speech and a distant motorbike may be perceived differently, although they can be of the same dBA level).

A change of up to 3 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness.

Table 1 below presents examples of typical noise levels.

Table 1 Typical Noise Levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120 110	Heavy rock concert Grinding on steel	Extremely noisy
100 90	Loud car horn at 3 m Construction site with pneumatic hammering	Very noisy
80 70	Kerbside of busy street Loud radio or television	Loud
60 50	Department store General Office	Moderate to quiet
40 30	Inside private office Inside bedroom	Quiet to very quiet
20	Unoccupied recording studio	Almost silent

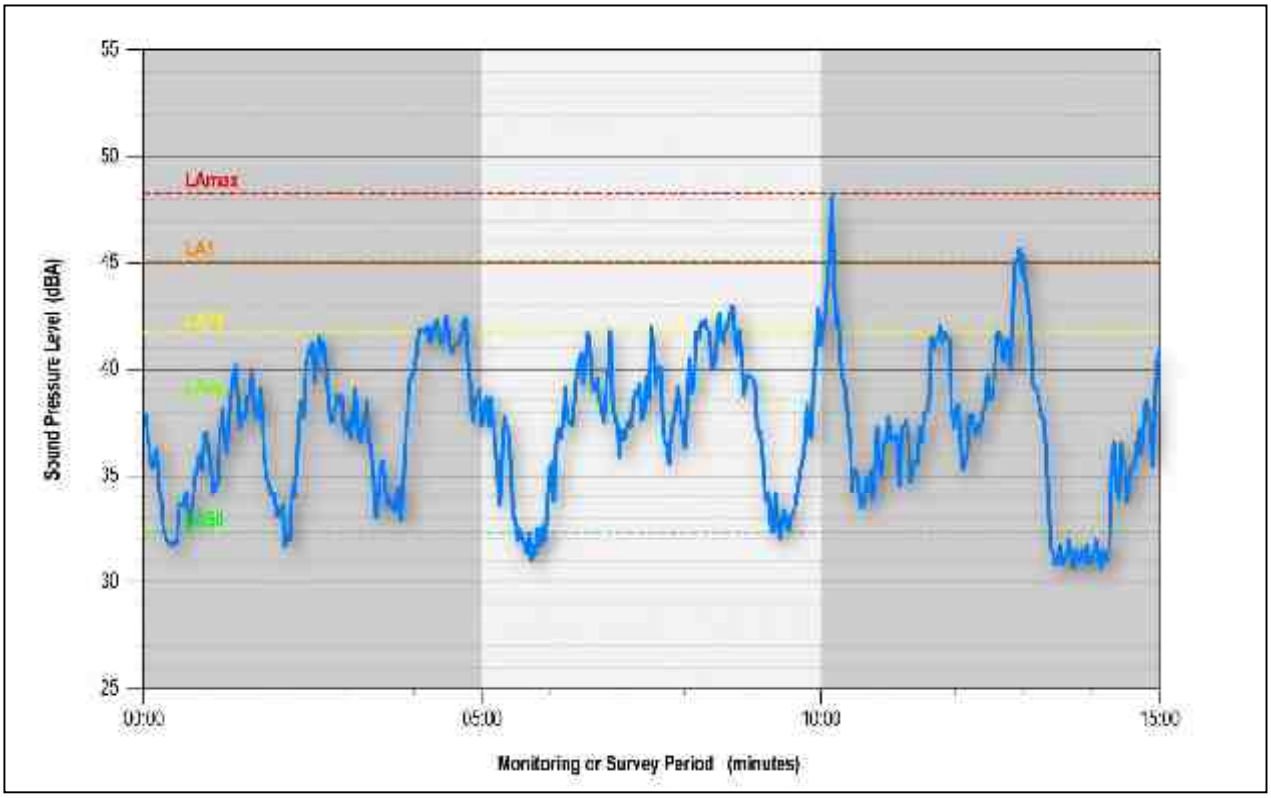
Statistical Noise Level Descriptors

As environmental noise usually varies in level over time, it is common to present the results of environmental noise testing in the form of statistical descriptors.

An explanation of noise level descriptors typically used for assessing the noise environment are illustrated in **Figure 1** and described below.

L_{Amax}	The maximum A-weighted noise level associated with a noise measurement interval.
L_{A1}	The noise level exceeded for 1% of a given measurement period. This parameter is often used to represent the typical maximum noise level in a given interval.
L_{A10}	The A-weighted sound pressure level exceeded 10% of a given measurement interval and is utilised normally to characterise average maximum noise levels.
L_{Aeq}	The A-weighted equivalent continuous sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound over the same measurement interval. Can be loosely thought of as the 'average'.
L_{A90}	The A-weighted sound pressure level exceeded 90% of a given measurement interval and is representative of the average minimum sound level. Often used to describe the 'background' level.

Figure 1 Graphical Display of Typical Noise Descriptors



Character

The A-weighted noise level alone is a simplistic parameter and may not be sufficient in providing a thorough assessment of noise. The subjective character of a sound is also a significant parameter that needs to be considered.

Some basic characteristics of sound which can make a sound more or less intrusive include:

- The frequency content of a sound – i.e. low frequency sound such as exhaust noise or high frequency sound such as birds or insects,
- the 'tonality' of a sound – i.e. sound contains one or more prominent tones such as a horn or a whistle,
- the 'impulsiveness' of a sound – i.e. hammering, dog barking or a intermittently operating power saw.

The above parameters can usually be indicatively subjectively assessed, but more thorough assessment can be made with advanced sound measuring devices (i.e. narrow band or one-third octave analysis). Many noise policies provide an assessment method which applies penalties to sounds that exhibit particular characteristics such as the above.

Frequency Analysis

Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

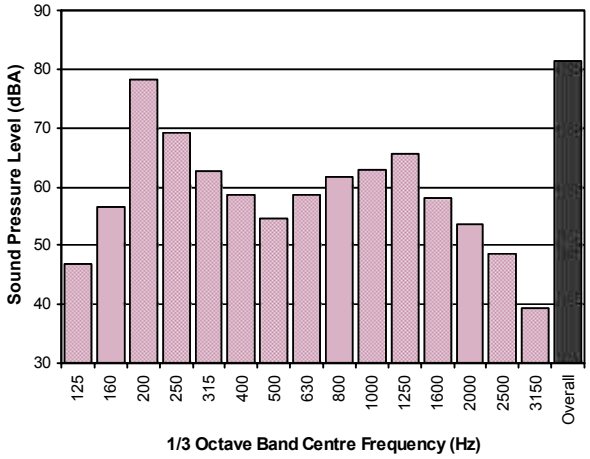
The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

Figure 2 shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.

Figure 2 Representative 1/3 Octave Band Analysis



Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of "peak" velocity or "rms" velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as "peak particle velocity", or PPV. The latter incorporates "root mean squared" averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/V_o), where V_o is the reference level (1E-6 mm/s). Care is required in this regard, as other reference levels are used by some organizations.

Human Perception of Vibration

People are able to "feel" vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as "normal" in a car, bus or train is considerably higher than what is perceived as "normal" in a shop, office or dwelling.

Over-Pressure

The term "over-pressure" is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

Appendix E
Horizontal distance from receptor to WTG

Receivers: 16 Narren Vale, 11 Kingshill, 109 Strathdarr, 38 Yarrabin, 28 Leeweena, 59 Mubbarra, 97 Manaroo, 32 Warrandah, 111 Kia-Tami, 234 House #2, 8 Woodstock, 37 Lochlea, 257 311, 60 Woodburn, 96 Bon Vista, 74 Hillview, 110 Pine Grove, 170 Tauranga, 194 Down Field, 2 Royal Oaks, 23 Mindora, 30 Highlands, 242 Glen Idle, 80 Akoomie, 230 Ashgrove, 63 Spring Creek, 71 Tralee, 104 Meadow Vale, 105 Cubba, 256 Mine, 239 Frasers Creek, 91 Derra Downs, 238 Tomali Park, 240 Krystal Blue, 241 Pieta, 54 Carinya, 261 Wirra Willa, 43 Ardleigh, 70 Warrawee, 227 Yarrawa Park, 26 Coloraine, 226 Coorimbla Park, 34 Argyle, 153 Mt Buckley, 34 Croye, 45 Golden Grove, 21 Inverness, 1 Rock Leigh, 115 Evergreen, 137 Tarana, 139 Fruin Glen, 87 The Knoll, 93 Weean, 233 Weean Cottage, 219 Maids Valley, 145 Karoola, 175 Falkland, 195 Pitlochry, 258 Lambert, 163 Fairy Meadow, 224 Octerley, 185 Farley, 255 Mine, 24 Millie, 65 Roseena, 112 Windemere, 206 Adavale, 89 Glendale, 157 Greenfield, 29 Swamp Oak, 231 Swan Peak, 0 Woodlands, 106 Glen Valley, 118 Fassifern, 40 Nolimba, 215 Rutherglen, 247 962, 27 Bellview, 53, 199 Springfield, 235 Waterloo Cottage, 237 Blumkatis, 179 Waterloo, 138 Hall, 248 Church, 249 Yardwell, 253 Highview, 254 Tantangra, 134 Wangaloo, 220 Quabadee, 250 Junee, 19, 229 Cottages, 236 Church, 245 Willow View, 246 937, 247 962, 252 DA Approved, 51, 55 Tara, 90 Kings Plains Castle

Receiver	Values
Dist. (km) to closest WTG	1.23 1.02 1.66 1.41 1.43 1.07 1.02 1.71 1.33 1.67 1.69 1.37 1.18 1.11 2.68 2.35 2.79 2.94 1.59 1.16 3.38 2.90 2.33 3.13 2.52 3.66 1.82 1.03 3.25 4.00 1.76 2.05 1.11 2.52 1.86 2.44 1.54 2.83 2.24 3.89 2.66 2.13 3.19 2.54 1.21 2.36 3.37 3.85 3.39 3.89 3.21 2.30 3.61 2.52 2.52 3.53 1.89 1.82 4.56 3.77 1.99 1.13 2.52 3.95 3.62 4.08 3.53 4.09 3.91 2.67 4.48 3.86 4.09 4.13 4.45 2.82 3.32 3.50 4.30 4.87 3.25 4.96 3.32 5.05 3.53 3.51 3.59 2.79 2.60 3.24 5.47 4.40 5.65 5.79 5.72 3.69 3.61 3.84 3.60 5.99 5.96 5.85
Number of WTG's<6km	[illegible]
T1	1.2 1.0 2.8 2.5 5.0 6.6 4.4 7.2 4.1 2.4 7.8 3.0 4.4 4.4 6.5 5.9 6.4 6.5 9.0 8.9 7.2 7.3 3.8 7.8 7.8 7.6 7.2 6.4 6.6 6.3 5.3 7.5 7.0 8.2 6.7 8.5 7.4 8.2 7.5 8.6 5.9 9.2 6.5 6.6 10.0 8.8 6.5 7.2 8.1 12.4 12.6 11.7 8.6 7.1 7.0 12.7 11.8 13.3 14.5 8.9 14.0 11.0 14.5 8.7 9.4 9.4 8.9 12.7 8.8 14.7 9.4 6.8 10.6 7.3 13.6 11.2 15.3 15.5 6.5 9.6 15.6 14.0 15.8 14.0 16.1 16.1 15.3 14.5 15.9 14.0 16.4 10.6 10.6 14.6 16.3 16.2 16.5 16.3 11.2 7.8 10.6
T2	[illegible]
T3	[illegible]
T4	[illegible]
T5	[illegible]
T6	[illegible]
T7	[illegible]
T8	[illegible]
T9	[illegible]
T10	[illegible]
T11	[illegible]
T12	[illegible]
T13	[illegible]
T14	[illegible]
T15	[illegible]
T16	[illegible]
T17	[illegible]
T18	[illegible]
T19	[illegible]
T20	[illegible]
T21	[illegible]
T22	[illegible]
T23	[illegible]
T24	[illegible]
T25	[illegible]
T26	[illegible]
T27	[illegible]
T28	[illegible]
T29	[illegible]
T30	[illegible]
T31	[illegible]
T32	[illegible]
T33	[illegible]
T34	[illegible]
T35	[illegible]
T36	[illegible]
T37	[illegible]
T38	[illegible]
T39	[illegible]
T40	[illegible]
T41	[illegible]
T42	[illegible]
T43	[illegible]
T44	[illegible]
T45	[illegible]
T46	[illegible]
T47	[illegible]
T48	[illegible]
T49	[illegible]
T50	[illegible]
T51	[illegible]
T52	[illegible]
T53	[illegible]
T54	[illegible]
T55	[illegible]
T56	[illegible]
T57	[illegible]
T58	[illegible]
T59	[illegible]
T60	[illegible]
T61	[illegible]
T62	[illegible]
T63	[illegible]
T64	[illegible]
T65	[illegible]
T66	[illegible]
T67	[illegible]
T68	[illegible]
T69	[illegible]
T70	[illegible]
T71	[illegible]
T72	[illegible]
T73	[illegible]
T74	[illegible]
T75	[illegible]
T76	[illegible]
T77	[illegible]
T78	[illegible]
T79	[illegible]
T80	[illegible]
T81	[illegible]
T82	[illegible]
T83	[illegible]
T84	[illegible]
T85	[illegible]
T86	[illegible]
T87	[illegible]
T88	[illegible]
T89	[illegible]
T90	[illegible]
T91	[illegible]
T92	[illegible]
T93	[illegible]
T94	[illegible]
T95	[illegible]
T96	[illegible]
T97	[illegible]
T98	[illegible]
T99	[illegible]
T100	[illegible]
T101	[illegible]
T102	[illegible]
T103	[illegible]
T104	[illegible]
T105	[illegible]
T106	[illegible]
T107	[illegible]
T108	[illegible]
T109	[illegible]
T110	[illegible]
T111	[illegible]
T112	[illegible]
T113	[illegible]
T114	[illegible]
T115	[illegible]
T116	[illegible]
T117	[illegible]
T118	[illegible]
T119	[illegible]
T120	[illegible]
T121	[illegible]
T122	[illegible]
T123	[illegible]
T124	[illegible]
T125	[illegible]

159 WTG Layout

Receiver	[illegible]
Dist. (km) to closest WTG	[illegible]
Number of WTG's<6km	[illegible]
WTG no:	
T1	[illegible]
T2	[illegible]
T3	[illegible]
T4	[illegible]
T5	[illegible]
T6	[illegible]
T7	[illegible]
T8	[illegible]
T9	[illegible]
T10	[illegible]
T11	[illegible]
T12	[illegible]
T13	[illegible]
T14	[illegible]
T15	[illegible]
T16	[illegible]
T17	[illegible]
T18	[illegible]
T19	[illegible]
T20	[illegible]
T21	[illegible]
T22	[illegible]
T23	[illegible]
T24	[illegible]
T25	[illegible]
T26	[illegible]
T27	[illegible]
T28	[illegible]
T29	[illegible]
T30	[illegible]
T31	[illegible]
T32	[illegible]
T33	[illegible]
T34	[illegible]
T35	[illegible]
T36	[illegible]
T37	[illegible]
T38	[illegible]
T39	[illegible]
T40	[illegible]
T41	[illegible]
T42	[illegible]
T43	[illegible]
T44	[illegible]
T45	[illegible]
T46	[illegible]
T47	[illegible]
T48	[illegible]
T49	[illegible]
T50	[illegible]
T51	[illegible]
T52	[illegible]
T53	[illegible]
T54	[illegible]
T55	[illegible]
T56	[illegible]
T57	[illegible]
T58	[illegible]
T59	[illegible]
T60	[illegible]
T61	[illegible]
T62	[illegible]
T63	[illegible]
T64	[illegible]
T65	[illegible]
T66	[illegible]
T67	[illegible]
T68	[illegible]
T69	[illegible]
T70	[illegible]
T71	[illegible]
T72	[illegible]
T73	[illegible]
T74	[illegible]
T75	[illegible]
T76	[illegible]
T77	[illegible]
T78	[illegible]
T79	[illegible]
T80	[illegible]
T81	[illegible]
T82	[illegible]
T83	[illegible]
T84	[illegible]
T85	[illegible]
T86	[illegible]
T87	[illegible]
T88	[illegible]
T89	[illegible]
T90	[illegible]
T91	[illegible]
T92	[illegible]
T93	[illegible]
T94	[illegible]
T95	[illegible]
T96	[illegible]
T97	[illegible]
T98	[illegible]
T99	[illegible]
T100	[illegible]
T101	[illegible]
T102	[illegible]
T103	[illegible]
T104	[illegible]
T105	[illegible]
T106	[illegible]
T107	[illegible]
T108	[illegible]
T109	[illegible]
T110	[illegible]
T111	[illegible]
T112	[illegible]
T113	[illegible]
T114	[illegible]
T115	[illegible]
T116	[illegible]
T117	[illegible]
T118	[illegible]
T119	[illegible]
T120	[illegible]
T121	[illegible]
T122	[illegible]
T123	[illegible]
T124	[illegible]
T125	[illegible]
T126	[illegible]
T127	[illegible]
T128	[illegible]
T129	[illegible]
T130	[illegible]
T131	[illegible]
T132	[illegible]
T133	[illegible]
T134	[illegible]
T135	[illegible]
T136	[illegible]
T137	[illegible]
T138	[illegible]
T139	[illegible]
T140	[illegible]
T141	[illegible]
T142	[illegible]
T143	[illegible]
T144	[illegible]
T145	[illegible]
T146	[illegible]
T147	[illegible]
T148	[illegible]
T149	[illegible]
T150	[illegible]
T151	[illegible]
T152	[illegible]
T153	[illegible]
T154	[illegible]
T155	[illegible]
T156	[illegible]
T157	[illegible]
T158	[illegible]
T159	[illegible]